Macroeconomic Shocks and Their Propagation:

Monetary Policy Shocks

Valerie A. Ramey

University of California, San Diego and NBER

October 27, 2015

This paper contains the first three sections of the current draft of my chapter "Macroeconomic Shocks and their Propagation" for the *Handbook of Macroeconomics*. I wish to thank Neville Francis, Peter Karadi, Arvind Krishnamurthy, Karel Mertens, James Stock, Mark Watson and Johannes Wieland for helpful discussions. I would also like to express appreciation to the American Economic Association for requiring that all data and programs for published articles be posted. In addition, I am grateful to researchers who publish in journals without that requirement but still post their data and programs on their websites.

Table of Contents

1. Introduction

At the beginning of the 20th Century, economists seeking to understand business cycle fluctuations recognized the importance of both impulses and propagation as features of business cycle explanations. A key question was how to explain regular fluctuations in a model with dampened oscillations. In 1927, the Russian statistician Eugen Slutsky published a paper titled "The Summation of Random Causes as a Source of Cyclic Processes." In this paper, Slutsky demonstrated the (then) surprising result that moving sums of random variables could produce time series that looked very much like the movements of economic time series – "sequences of rising and falling movements, like waves…with marks of certain approximate uniformities and regularities."[1] This insight, developed independently by British mathematician Yule in 1926 and extended by Frisch (1933) in his paper "Propagation Problems and Impulse Problems in Dynamic Economics," revolutionized the study of business cycles. Their insights shifted the focus of research from developing mechanisms to support a metronomic view of business cycles, in which each boom created conditions leading to the next bust, to a search for the sources of the random shocks. Since then economists have offered numerous candidates for these "random causes," such as crop failures, wars, technological innovation, animal spirits, government actions, and commodity shocks.

Research from the 1940s through the 1970s emphasized fiscal and monetary policy shocks, identified from large-scale econometric models or single equation analyses. The 1980s witnessed two important innovations that fundamentally changed the direction of the research. First, Sims' (1980) paper "Macroeconomics and Reality" revolutionized the study of systems driven by random impulses by introducing vector autoregressions (VARs). Sims' VARs made

[1] Page 105 of the 1937 English version of the article published in *Econometrica.*

the link between innovations to a linear system and macroeconomic shocks. Using his method, it became easier to talk about identification assumptions, impulse response functions, and to do innovation accounting using forecast error decompositions. The second important innovation was the expansion of the inquiry beyond policy shocks to consider important non-policy shocks, such as technology shocks (Kydland and Prescott (1982) and oil shocks (Hamilton (1983).

These innovations led to a flurry of research on shocks and their effects. In his 1994 paper "Shocks," John Cochrane took stock of the state of knowledge at that time by using the by-then standard VAR techniques to conduct a fairly comprehensive search for the shocks that drove economic fluctuations. Surprisingly, he found that none of the popular candidates could account for the bulk of economic fluctuations. He proffered the rather pessimistic possibility that "we will forever remain ignorant of the fundamental causes of economic fluctuations." (Cochrane (1994), abstract)

Are we destined to remain forever ignorant of the fundamental causes of economic fluctuations? Are Slutsky's "random causes" unknowable? In this chapter, I will summarize the new methodological innovations and what their application has revealed about the propagation of the leading candidates for macroeconomic shocks and their importance in explaining economic fluctuations since Cochrane's speculation.

The chapter progresses as follows. Section 2 begins by defining what a macroeconomic shock is. It then summarizes the many tools used for identifying macroeconomic shocks and computing impulse functions. It also highlights some of the complications and pitfalls, such as the effects of foresight, trends, and tests for asymmetry.

The topic of Section 3 is monetary shocks and their effects on the macroeconomy. The section highlights some of the previous literature and then presents some new results using some leading external instruments – Romer and Romer's (2004) narrative shock and two high frequency shocks. The results show that many specifications produce results that are counter to standard notions of the effects of monetary policy shocks.

Section 4 discusses fiscal shocks. It begins by summarizing results on government spending shocks and then moves on to tax shocks. It also talks about the effects of anticipated policy, which overlaps some of the issues discussed in a later news section.

Section 5 summarizes the literature on technology shocks and uses some of the new innovations from the fiscal literature to produce new results on the effects of technology shocks.

Section 6 summarizes the literature on news shocks.

(Introduction to be completed later.)

2. Summary of Some Methods for Identifying Shocks and Estimating Impulse Responses

2.1. Overview: What is a Shock?

What, exactly, are the macroeconomic shocks that we seek to estimate empirically? There is some ambiguity in the literature about the definition because of some researchers' use of the term *shock* when they mean *innovation* (i.e. the residuals from a reduced form vector autoregression model (VAR)). In his 1972 paper, Sims never used the word *shock*; rather he spoke only of *innovations*, i.e. the part of a variable not explained by lagged values of the other variables in the system. In Sims (1980a), however, he specifically equated innovations with macroeconomic shocks, despite claiming to be atheoretical. In this, I view shocks and VAR innovations to be distinct concepts, although *identification assumptions* may equate them in many cases. I adopt the concept of shocks used by researchers such as Blanchard and Watson (1986), Bernanke (1986), and Stock and Watson (forthcoming). According to Bernanke (1986), the shocks should be *primitive* exogenous forces that are uncorrelated with each other and they should be *economically meaningful* (pp. 52-55).

I view the shocks we seek to estimate as the empirical counterparts to the shocks we discuss in our theories, such as shocks to technology, monetary policy, fiscal policy, etc. Therefore, the shocks should have the following characteristics: (1) they are exogenous with respect to the other current and lagged endogenous variables in the model; (2) they are uncorrelated with other exogenous shocks; otherwise, we cannot identify the unique causal effects of one exogenous shock relative to another; and (3) they represent either unanticipated movements in exogenous variables or they represent *news* about *anticipated* future movements in exogenous variables.[2] To match these theoretical shocks, we want to link the innovations in a structural vector autoregression (SVAR) to these theoretical ("structural") shocks, estimate them in a structural DSGE model, or measure them directly using rich data sources.

2.2. Illustrative Framework

To illustrate the relationship between some of the methods, it is useful to consider a simple trivariate SVAR model with three endogenous variables, Y_1, Y_2, and Y_3.[3] I will call Y_1 the "policy variable" for short, but it should be understood that it can represent any variable from which we want to extract a shock component. In the monetary context, Y_1 could be the federal funds rate and the other two variables could be industrial production and a price index; in the

[2] With regard to condition 92), one might counter with situations in which both fiscal and monetary policy respond to some event and argue that therefore the fiscal and monetary shocks would be correlated. I would respond that these are not primitive shocks, but rather the endogenous responses of policies to a primitive shock. For example, a geopolitical event might lead to a war that causes both fiscal and monetary policy to respond endogenously. The geopolitical event would be the primitive shock from the standpoint of our economic models (though it might be considered an endogenous response from the standpoint of a political science model.)

[3] See Stock and Watson (forthcoming) for a more general and precise analysis of identification using SVARs. I use the same notation they do.

fiscal context, Y_1 could be tax revenue and the other two could be government purchases and real GDP; in the technology shock context, Y_1 could be labor productivity and the other two variables could be output and consumption. Let $Y_t = [Y_{1t}, Y_{2t}, Y_{3t}]$ be the vector of endogenous variables. Following standard procedure, let us model the dynamics with a *p*-th order vector autoregression (VAR),

(2.1) $$A(L)Y_t = \eta_t$$

where A(L) is a polynomial in the lag operator and $A(L) = I - \sum_{k=1}^{p} A_k L^k$. $\eta_t = [\eta_{1t}, \eta_{2t}, \eta_{3t}]$ are the VAR reduced form innovations. We assume that $E[\eta_t] = 0, E[\eta_t \eta_t'] = \Sigma_\eta$ and that $E[\eta_t \eta_s'] = 0 \; for \; s \neq t$. A VAR model assumes that the innovations η are a linear function of the unobserved structural shocks, ε, as follows:

(2.2) $$\eta_t = H\varepsilon_t$$

Part of the identification is obtained with the unit effect and unit standard deviation normalization. The unit standard deviation normalization sets the variances of the ε to unity. The unit effect normalization sets $H_{jj} = 1$. It is useful to write out the system with the normalizations as follows:

(2.3) $$\begin{aligned} \eta_{1t} &= \varepsilon_{1t} + h_{12}\varepsilon_{2t} + h_{13}\varepsilon_{3t} \\ \eta_{2t} &= h_{21}\varepsilon_{1t} + \varepsilon_{2t} + h_{23}\varepsilon_{3t} \\ \eta_{3t} &= h_{31}\varepsilon_{1t} + h_{32}\varepsilon_{2t} + \varepsilon_{3t} \end{aligned}$$

We require three more restrictions for identification of all three shocks, potentially fewer if we want to identify only one shock. We will refer to these equations in the following sections discussing common identification methods.

2.3 Common Identification Methods

In this section, I briefly overview some of the most common methods for identification. This section is not meant to be comprehensive. See Stock and Watson (forthcoming) for more detailed treatments of the methods I summarize, as well as for a few other methods I do not summarize, such as set identification and identification through heteroscedasticity.

2.3.1 Cholesky Decompositions

The most commonly used identification method imposes alternative sets of recursive zero restrictions on the contemporaneous coefficients to identify the shock ε_{1t}. This method was introduced by Sims (1980a) as ”triangularization.” The following are two widely-used alternatives.

A. The "policy" variable does not respond within the period to the other endogenous variables. This could be motivated by decision lags on the part policymakers or other adjustment costs. This scheme involves constraining $h_{12} = h_{13} = 0$ in equation (2.3), which is equivalent to ordering the policy variable first in the Cholesky ordering. For example, Blanchard and Perotti (2002) impose this constraint to identify the shock to government spending; they assume that government spending does not respond to the contemporaneous movements in output or taxes.[4]

B. The other endogenous variables do not respond to the "policy" shock within the period. This could be motivated by sluggish responses of the other endogenous variables to shocks to the policy variable. This scheme involves constraining $h_{21} = h_{31} = 0$, which is equivalent to ordering the policy variable last in the Cholesky ordering. For example, Bernanke and Blinder (1992) were the first to identify shocks to the federal funds rate as monetary policy shocks and used this type of identification.[5]

2.3.2 Other Contemporaneous Restrictions

Another more general approach (that nests the Cholesky decomposition) is what is known as a *Structural VAR*, or SVAR, introduced by Blanchard and Watson (1986) and Bernanke (1986). This approach uses either economic theory or outside estimates to constrain parameters. Consider, for example, Blanchard and Perotti's (2002) identification of government spending and net tax shocks. Let Y_1 be government spending, Y_2 be GDP, and Y_3 be net taxes. They identify the shock to government spending using a Cholesky decomposition in which government spending is ordered first (i.e. $h_{12} = h_{13} = 0$). They identify exogenous shocks to net taxes (the Y_3 in the system above) by setting h_{32}= 2.08, an outside estimate of the cyclical

[4] To implement this identification using ordinary least squares (OLS), one would simply regress government spending on *p* lags of all of the variables in the system and call the residual the government spending shock.
[5] To implement this identification using OLS, one would regress the federal funds rate on contemporaneous values of the other variables in the system, as well as *p* lags of all of the variables, and call the residual the monetary policy shock.

sensitivity of net taxes.[6] These three restrictions are sufficient to identify all of the remaining parameters and hence all three shocks.

2.3.3 Narrative Methods

Narrative methods involve constructing a series from historical documents to identify the reason and/or the quantities associated with a particular change in a variable. The first use of narrative methods for identification was Hamilton (1985) for oil shocks, which was further extended by Hoover and Perez (1994). These papers isolated political events that led to disruptions in world oil markets. Other examples of the use of narrative methods are Romer and Romer's (1989, 2004) monetary shock series based on FOMC minutes, Ramey and Shapiro (1998) and Ramey's (2011) series of expected changes in future government spending caused by military events gleaned from periodicals such as *Business Week*, and Romer and Romer's (2010) narrative series of tax changes based on reading various legislative documents.

Until recently, these series were used either as exogenous shocks in sets of dynamic single equation regressions or embedded in a Cholesky decomposition. For example, in the framework above, we would set Y_1 to be the narrative series and we would constrain $h_{12} = h_{13} = 0$. As a later section details, recent innovations have led to an improved method for incorporating these series.

A cautionary note on the potential of narrative series to identify exogenous shocks is in order. Some of the follow-up research has operated on the principle that the narrative alone

[6] One way to implement the tax shock identification is to construct the variable $\eta_3 - 2.08\eta_2$ from the estimated reduced form residuals. One would then regress η_2 on η_1 and η_3 , using $\eta_3 - 2.08\eta_2$ as the instrument for η_3. (Note that the assumption that $h_{12} = h_{13} = 0$ identifies η_1 as ε_1 , which is uncorrelated with ε_{2t} by assumption) This regression identifies h_{21} and h_{23}. The residual is the estimate of ε_{2t}.

provides exogeneity. It does not. Leeper (1997) made this point for monetary policy shocks. Another example is in the fiscal literature. A series on fiscal consolidations, quantified by narrative evidence on the expected size of these consolidations, is not necessarily exogenous. If the series includes fiscal consolidations adopted in response to bad news about the future growth of the economy, the series cannot be used to establish a causal effect of the fiscal consolidation on future output.

2.3.4 High Frequency Identification

Research by Bagliano and Favero (1999), Kuttner (2001), Cochrane and Piazzesi (2002), Faust, Swanson, and Wright (2004), Gürkaynak et al. (2005), Piazzesi and Swanson (2008), Gertler and Karadi (2015) and others has used high frequency data (such as news announcements around FOMC dates) and the movement of federal funds futures to identify unexpected Fed policy actions. This identification is also based in part on timing, but because the timing is so high frequency (daily or higher), the assumptions are more plausible than those employed at the monthly or quarterly frequency. As I will discuss in the foresight section below, the financial futures data is ideal for ensuring that a shock is unanticipated.

It should be noted, however, that without additional assumptions the unanticipated shock is not necessarily exogenous to the economy. For example, if the implementation does not adequately control for the Fed's private information about the future state of the economy, which might be driving its policy changes, these shocks cannot be used to estimate a causal effect of monetary policy on macroeconomic variables.

2.3.5 External Instruments/Proxy SVARs

The external instrument, or "proxy SVAR," method is a promising new approach for incorporating external series for identification. This method was developed by Stock (2008), Stock and Watson (2012) and Mertens and Ravn (2013). This approach takes advantage of information developed from "outside" the VAR, such as series based on narrative evidence, shocks from estimated DSGE models, or high frequency information. The idea is that these external series are noisy measures of the true shock.

Suppose that Z_t represents one of these external series. Then this series is a valid instrument for identifying the shock ε_{1t} if the following two conditions hold:

(2.4a) $$E[Z_t \varepsilon_{1t}] \neq 0,$$

(2.4b) $$E[Z_t \varepsilon_{it}] = 0 \quad i = 2, 3$$

Condition (2.4a) is the instrument *relevance* condition: the external instrument must be contemporaneously correlated with the structural policy shock. Condition (2.4b) is the instrument *exogeneity* condition: the external instrument must be contemporaneously uncorrelated with the other structural shocks. If the external instrument satisfies these two conditions, it can be used to identify the shock ε_{1t}.

The procedure is very straightforward and takes place with the following steps.[7]

Step 1: Estimate the reduced form system to obtain estimates of the reduced form residuals, η_t.

[7] This exposition follows Merten and Ravn (2013a, online appendix). See Mertens and Ravn (2013a,b) and the associated online appendices for generalizations to additional external instruments and to larger systems.

Step 2: Regress η_{2t} and η_{3t} on η_{1t} using the external instrument Z_t as the instrument. These regressions yield unbiased estimates of $h_{21}$and h_{31}. Define the residuals of these regressions to be ν_{2t} and ν_{3t}.

Step 3: Regress η_{1t}on η_{2t} and η_{3t} , using the ν_{2t} and ν_{3t} estimated in Step 2 as the instruments. This yields unbiased estimates of h_{12} and h_{13}.

As an example, Mertens and Ravn (2013a) reconcile Romer and Romer's (2010) estimates of the effects of tax shocks with the Blanchard and Perotti (2002) estimates by using the Romer's narrative tax shock series as an external instrument Z to identify the structural tax shock. Thus, they do not need to impose parameter restrictions, such as the cyclical elasticity of taxes to output. As I will discuss in section 2.3 below, one can extend this external instrument approach to estimating impulse responses by combining it with Jordà's (2005) method.

2.3.6 Restrictions at Longer Horizons

Rather than constraining the contemporaneous responses, one can instead identify a shock by imposing long-run restrictions. The most common is an infinite horizon long-run restriction, first used by Shapiro and Watson (1988), Blanchard and Quah (1989), and King, Plosser, Stock and Watson (1991). Consider the moving average representation of equation (2.1):

$$Y_t = C(L)\eta_t \tag{2.5}$$

where $C(L) = [A(L)]^{-1}$. Combining equation (2.2) with (2.5), we can write the Y's in terms of the structural shocks:

(2.6) $$Y_t = D(L)\varepsilon_t$$

where D(L) = C(L)H. Suppose we wanted to identify a technology shock as the only shock that affects labor productivity in the long-run. In this case, Y_1 would be the *growth rate* of labor productivity and the other variables would also be transformed to induce stationary (e.g. first-differenced). Letting $C^{ij}(L)$ denote the (i,j) element of the C matrix and $C^{11}(1)$ denote the lag polynomial with L = 1, we impose the long-run restriction by setting $C^{12}(1) = 0$ and $C^{13}(1) = 0$. This restriction constrains the unit root in the policy variable (e.g. labor productivity) to emanate only from the shock that we are calling the technology shock. This is the identification used by Galí (1999).

An equivalent way of imposing this restriction is to use the estimation method suggested by Shapiro and Watson (1988). Let Y_1 denote the first-difference of the log of labor productivity and Y_2 and Y_3 be the stationary transformations of two other variables (such as hours). Then, imposing the long-run restriction is equivalent to identifying the error term in the following equation as the technology shock:

(2.7) $$Y_{1t} = \sum_{j=1}^{p} \beta_{11,j} Y_{1t-j} + \sum_{j=1}^{p-1} \beta_{12,j} \Delta Y_{2t-j} + \sum_{j=1}^{p-1} \beta_{13,j} \Delta Y_{3t-j} + \zeta_t$$

We have imposed the restriction by specifying that only the *first differences* of the other stationary variables enter this equation. Because the current values of those differences might also be affected by the technology shock and therefore correlated with the error term, we use lags 1 through p of Y_2 and Y_3 as instruments for the terms involving the current and lagged values of those variables. The estimated residual is the identified technology shock. We can then identify the other shocks, if desired, by orthogonalizing the error terms with respect to the technology shock.

This equivalent way of imposing long-run identification restrictions highlights some of the problems that can arise with this method. First, identification depends on the relevance of the instruments. Second, it requires additional identifying restrictions in the form of assumptions about unit roots. If, for example, hours have a unit root, then in order to identify the technology shock one would have to impose that only the second difference of hours entered in equation (2.6).[8]

Another issue is the behavior of infinite horizon restrictions in small samples (e.g. Faust and Leeper (1997)). Recently, researchers have introduced new methods that overcome these problems. For example, Francis, Owyang, Roush, and DeCecio (2014) identify the technology shock as the shock that maximizes the forecast error variance share of labor productivity at some finite horizon *h*. A variation by Barsky and Sims (2011) identifies the shock as the one that maximizes the *sum* of the forecast error variances up to some horizon *h*. Both of these methods operate off of the moving average representation in equation (2.5).

2.3.7 Sign Restrictions

A number of authors had noted the circularity in some of the reasoning analyzing VAR specifications in practice. In particular, whether a specification or identification method is deemed "correct" is often judged by whether the impulses they produce are "reasonable," i.e. consistent with the researcher's priors. Faust (1998) and Uhlig (2005) developed a new method to incorporate "reasonableness" without undercutting scientific inquiry by investigating the

[8] To be clear, all of the Y variables must be trend stationary. If hours have a unit root, then Y_2 must take the form of $\Delta hours_t$, so the constraint in (2.6) would take the form $\Delta^2 hours_t$.

effects of a shock on variable Y, where the shock was identified by sign restrictions on the responses of *other* variables (excluding variable Y).

The sign restriction method has been used in many contexts, such as monetary policy, fiscal policy and technology shocks. Recently, however, two contributions by Arias, Rubio-Ramirez, and Waggoner (2013) and by Baumeister and Hamilton (2015) have highlighted some potential problems with sign restriction methods. The Arias et al paper demonstrates problems with particular implementations and offers new computational methods to overcome those problems. Baumeister and Hamilton develop Bayesian methods that highlight and link the relationship between the priors used for identification and the outcomes. See Stock and Watson (forthcoming) for more discussion of sign restrictions as an identification mechanism.

2.3.8 Factor Augmented VARs

A perennial concern in identifying shocks is that the variables included in the VAR do not capture all of the relevant information. The comparison of price responses in monetary VARs with and without commodity prices is one example of the difference a variable exclusion can make. To address this issue more broadly, Bernanke, Boivin, and Eliasz (2005) developed the Factor Augmented VARs (FAVARS) based on earlier dynamic factor models developed by Stock and Watson (2002) and others. The FAVAR, which typically contains over one hundred series, has the benefit that it is much more likely to condition on relevant information for identifying shocks. In most implementations, though, it still typically relies on a Cholesky decomposition. Moreover, one must transform all of the variables to a stationary form, which requires pretesting. See Stock and Watson (forthcoming) for an in depth discussion of dynamic factor models.

2.3.9 Estimated DSGE Models

An entirely different approach to identification is the estimated DSGE model, introduced by Smets and Wouters (2003, 2007). This method involves estimating a fully-specified model (a New Keynesian model with many frictions and rigidities in the case of Smets and Wouters) and extracting a full set of implied shocks from those estimates. In the case of Smets and Wouters, many shocks are estimated including technology shocks, monetary shocks, government spending shocks, wage markup shocks, and risk premium shocks. One can then trace out the impulse responses to these shocks as well as do innovation accounting. Other examples of this method include Justiano, Primiceri, Tambolotti (2010, 2011) and Schmitt-Grohe and Uribe (2012). Christiano, Eichenbaum and Evans (2005) took a different estimation approach by first estimating impulse responses to a monetary shock in a standard SVAR and then estimating the parameters of the DSGE model by matching the impulse responses from the model to those of the data.

These models achieve identification by imposing structure based on theory. It should be noted that identification is less straightforward in these types of models. Work by Canova and Sala (2009), Komunjer and Ng (2011), and others highlight some of the potential problems with identification in DSGE models.

2.4 Estimating Impulse Responses

Suppose that one has identified the economic shock through one of the methods discussed above. How do we measure the effects on the endogenous variables of interest? The most common way to estimate the impulse responses to a shock uses nonlinear (at horizons greater than one) functions of the estimated VAR parameters. In particular, estimation of the reduced form system provides the elements of the moving average representation matrix $C(L) = [A(L)]^{-1}$ in equation (2.5) and identification provides the elements of H. Recalling that D(L) = C(L)H, we write out $D(L) = D_0 + D_1L + D_2L^2 + D_3L^3 + \ldots$, and denoting $D_h = [d_{ijh}]$, we can express the impulse response of variable Y_i at horizon t+h to a shock to ε_{jt} as:

(2.8) $$\frac{\partial Y_{i,t+h}}{\partial \varepsilon_{j,t}} = d_{ijh}$$

These d_{ijh} parameters are nonlinear functions of the reduced form VAR parameters.

If the VAR adequately captures the data generating process, this method is optimal at all horizons. If the VAR is mispecified, however, then the specification errors will be compounded at each horizon. To address this problem, Jordà (2005) introduced a *local projection* method for estimating impulse responses. The comparison between his procedure and the standard procedure has an analogy with direct forecasting versus iterated forecasting (e.g. Marcellino, Stock, and Watson (2006)). In the forecasting context, one can forecast future values of a variable using either a horizon-specific regression ("direct" forecasting) or iterating on a one-period ahead estimated model ("iterated" forecasting). Jordà's method is analogous to the direct forecasting whereas the standard VAR method is analogous to the iterated forecasting method.

Chang and Sakata (2007) introduce a related method they call *long autoregression* and show its asymptotic equivalence to Jordà's method.

To see how Jordà's method works, suppose that ε_{1t} has been identified by one of the methods discussed in the previous section. Then, the impulse response of Y_i at horizon h can be estimated from the following single regression:

$$(2.9) \qquad Y_{i,t+h} = \theta_{i,h} \cdot \varepsilon_{1t} + control\ variables + \xi_{t+h}$$

$\theta_{i,h}$ is the estimate of the impulse response of Y_i at horizon h to a shock ε_{1t}. The control variables do not have to include the other Y's as long as ε_{1t} is exogenous to those other Y's. Typically, the control variables include deterministic terms (constant, time trends), lags t-1 and earlier of the Y_i, and lags of other variables that are necessary to "mop up;" the specification can be chosen using information criteria. One estimates a separate regression for each horizon and the control variables do not necessarily need to be the same for each regression. Note that except for horizon h = 0, the error term ξ_{t+h} will be serially correlated because it will be a moving average of the forecast errors from t to t+h. Thus, the standard errors need to incorporate corrections for serial correlation, such as a Newey-West (1987) correction.

Because the Jordà method for calculating impulse response functions imposes fewer restrictions, the estimates are often less precisely estimated and are sometimes erratic. Nevertheless, this procedure is more robust than standard methods, so it can be very useful as a heuristic check on the standard methods. Moreover, it is much easier to incorporate state-dependence (e.g. Auerbach and Gorodnichenko (2013)).

Ramey and Zubairy (2014) recently proposed a new use for the Jordà method that merges the insights from the external instrument/proxy SVAR literature. To see this, modify equation (2.9) as follows:

(2.10) $$Y_{i,t+h} = \theta_{i,h} \cdot Y_{1,t} + control\ variables + \zeta_{t+h}$$

As discussed above, Y_1 is the policy variable, but may be partly endogenous so it will be correlated with ζ_{t+h}. We can easily deal with this issue, however, by estimating this equation using the external instrument Z_t as an instrument for $Y_{1,t}$. For example, if Y_i is real output and $Y_{1,t}$ is the federal funds rate, we can use Romer and Romer's (2004) narrative-based monetary shock series as an instrument. As I will discuss below, in some cases there are multiple potential external instruments. We can readily incorporate these in this framework by using multiple instruments for Y_1. In fact, these overidentifying restrictions can be used to test the restrictions of the model (using a Hansen's J-statistic, for example).

2.5 The Problem of Foresight

A potential identification problem highlighted recently in multiple literatures is the issue of news or policy foresight.[9] For example, Beaudry and Portier (2006) explicitly take into account that news about future technology may have effects today even though it does not show up in current productivity. Ramey (2011) argues that the results of Ramey and Shapiro (1998) and Blanchard and Perotti (2002) differ because most of the latter's identified shocks to

[9] The general problem was first recognized and discussed decades ago. For example, Sims (1980) states: "It is my view, however, that rational expectations is more deeply subversive of identification than has yet been recognized."

government spending are actually anticipated. Building on work by Hansen and Sargent (1991), Leeper, Walker, and Yang (2013) work out the econometrics of "fiscal foresight" for taxes, showing that foresight can lead to a non-fundamental moving average representation.

Consider the following simple example, based on Leeper et. al. (2013), of a simple growth model with a representative household with log utility over consumption, discount factor β, and a production function $Y_t = A_t K_{t-1}^{\alpha}$, with $\alpha<1$. The government taxes output Y at a rate τ_t and there are i.i.d. shocks, $\hat{\tau}_t$, to the tax rate relative to its mean τ. Shocks to technology, ε_{At}, are also i.i.d. Suppose that agents potentially receive news in period t of what the tax rate will be in t+q, so that $\hat{\tau}_t = \varepsilon_{\tau,t-q}$. If the shocks are unanticipated (q = 0), the rule for capital accumulation is:

$$k_t = \alpha k_{t-1} + \varepsilon_{A,t}$$

which reproduces the well-known result that unanticipated i.i.d. tax rate shocks have no effect on capital accumulation. If the tax rate shock is anticipated two periods in advance (q=2), however, then we have optimal capital accumulation as:

$$k_t = \alpha k_{t-1} + \varepsilon_{A,t} - \kappa\{\varepsilon_{\tau,t-1} + \theta\varepsilon_{\tau,t}\}$$

where $\theta = \alpha\beta(1-\tau) < 1$ and $\kappa = (1-\theta)\frac{\tau}{1-\tau}$. Can we uncover the tax shocks by regressing capital on its own lags? No, we cannot. Because $\theta < 1$, this representation is not invertible in the current and past k's; we say that $\{\varepsilon_{\tau,t-j}\}_{j=0}^{\infty}$ is not *fundamental* for $\{k_{t-j}\}_{j=0}^{\infty}$. If we regress k_t on its own lags and recover the innovations, we would be recovering the discounted sum of tax news observed at date t and earlier, i.e., "old" news. Doing things such as adding lagged taxes to the VAR does not help.

Beaudry, Fève, and Guay (2015) develop a diagnostic to determine whether non-fundamentalness is quantitatively important. They argue that in some cases the non-fundamental representation is close to the fundamental representation.

The principal methods for dealing with the problem of foresight are measuring the expectations with data, time series restrictions, or theoretical model restrictions. For example, Beaudry and Portier (2006) extracted news about future technology from stock prices; Ramey (2011) created a series of news about future government spending by reading *Business Week* and other periodicals; Fisher and Peters (2010) created news about government spending by extracting information from stock returns of defense contractors; Leeper, Richter, Walker (2012) used information from the spread between federal and municipal bond yields for news about future tax changes; and Mertens and Ravn (2012) decomposed Romer and Romer's (2010) narrative tax series into one series in which implementation was within the quarter ("unanticipated") and another series in which implementation was delayed ("news"). In the monetary shock literature, many papers use financial futures prices to try to extract the anticipated versus unanticipated component of interest rates changes (e.g. Rudebusch (1998), Bagliano and Favero (1999), Kuttner (2001), and Gertler and Karadi (2014)).

The typical way that news has been incorporated into VARs is by adding the news series to a standard VAR, and ordering it first. Perotti (2011) has called these "EVARs" for "Expectational VARs." Note that in general one cannot use news as an external instrument in Mertens and Ravn's proxy SVAR framework. The presence of foresight invalidates the interpretation of the VAR reduced form residuals as prediction errors, since the conditioning variables may not span the information set of forward looking agents (Mertens and Ravn (2013, 2014)).

On the other hand, one can use a news series as an instrument in the Jordà framework in certain instances. Owyang, Ramey, and Subairy (2013) and Ramey and Zubairy (2014) estimate what is essentially an instrumental variables regression, but in two steps. In particular, they (i) regress the change in output from t-1 to t+h for various horizons h on current military news; (ii) regress the change in government spending from t-1 to t+h for various horizons h on current military news; and then (iii) estimate the government spending multiplier as the integral of the output responses up to some horizon H divided by the integral of the government spending responses up to some horizon H. They perform their estimation in two steps because of the complexities of the state dependent model they estimate.

In a linear model, one can obtain identical results by conducting an instrumentals variables estimation in one step. Note that the military news variable should be an irrelevant instrument for *current* government spending, since the news is supposed to be about *future* government spending. However, it should be a good instrument for the *integral* of government spending over a horizon that includes the future increase in government spending. To use news as an instrument in this setting, one must first transform the endogenous variables to be integrals of responses up to horizon H, i.e., the changes in output from t-1 to t+h summed from h = 0 to h = H and the similar transformation for government spending. Call each of these $\sum_{h=0}^{H} Y_{i,t+h}$. Then one estimates the following equation using news in period t as an instrument for $\sum_{h=0}^{H} Y_{1,t+h}$:

(2.11) $$\sum_{h=0}^{H} Y_{i,t+h} = \theta_{i,h} \cdot \sum_{h=0}^{H} Y_{1,t+h} + control\ variables + \zeta_{t+h}$$

In the government spending example, Y_i is output, Y_1 is government spending, and Z is military news derived from narrative methods.

2.6 The Problem of Trends

Most macroeconomic variables are nonstationary, exhibiting behavior consistent with either deterministic trends or stochastic trends. A key question is how to specify an SVAR when many of the variables may be trending. Sims, Stock and Watson (1990) demonstrate that even when variables might have stochastic trends and might be cointegrated, the log levels specification will give consistent estimates. While one might be tempted to pretest the variables and impose the unit root and cointegration relationships to gain efficiency, Elliott (1998) shows that such a procedure can lead to large size distortions in theory. More recently, Gospodinov, Herrera, and Pesavento (2013) have demonstrated how large the size distortions can be in practice.

Perhaps the safest method is to estimate the SVAR in log levels (perhaps also including some deterministic trends) as long as the imposition of stationarity is not required for identification. If desired, one can then explore whether the imposition of unit roots and cointegration lead to similar results but increase the precision of the estimates. For years, it was common to include a linear time trend in macroeconomic equations. Many analyses now include a broken trend or a quadratic trend to capture features such as the productivity slowdown in 1974 or the effect of the baby boom moving through the macroeconomic variables (e.g. Perron (1989), Francis and Ramey (2009)).

2.7 Some Brief Notes on Nonlinearities

In the previous sections, we have implicitly assumed that the relationships we are trying to capture can be well-approximated with linear functions. There are many cases in which we believe that nonlinearities might be important. To name just a few possible nonlinearities, positive shocks might have different effects from negative shocks, effects might not be proportional to the size of the shock, or the effect of a shock might depend on the state of the economy when the shock hits.

A thorough analysis of nonlinearities is beyond the scope of this chapter, so I will mention only three items briefly. First, Koop, Pesaran, and Potter (1996) provide a very useful analysis of the issues that arise when estimating impulse responses in nonlinear models. Second, if one is interested in estimating state dependent models, the Jordà (2005) local projection method is a simple way to estimate such a model and calculate impulse response functions. Auerbach and Gorodnichenko (2013) and Ramey and Zubairy (2014) discuss this application and how it relates to another leading method, Smooth Transition VARs.

The third point is a cautionary note when considering the possibility of asymmetries. In some literatures, such as the oil shock literature, it is common to assume that only oil price increases matter and to include a variable in the VAR that captures increases but not decreases. Kilian and Vigfusson (2011) demonstrate the serious biases that can result. Suppose Y is a linear function of X, where X takes on both negative and positive values. If one imposes the restriction that only positive values matter, one is in essence setting all of the negative values to zero. Figure 1 of Kilian and Vigfusson's paper demonstrates how this procedure that truncates on the x variable produces slope coefficients that are biased upward in magnitude. Thus, one would incorrectly conclude that positive X's have a greater impact than negative X's, even when the true relationship is linear. To guard against this faulty inference, one should always make sure that the model nests the linear case when one is testing for asymmetries. If one finds evidence of asymmetries, then one can use Kilian and Vigfusson's (2011) methods for computing the impulse responses correctly.

2.8 DSGE Monte Carlos

Much empirical macroeconomics is linked to testing theoretical models. A question that arises is whether shocks identified in SVARs, often with minimal theoretical restrictions, are capable of capturing the true shocks. This question has been asked most in the literature on the effects of technology shocks. Erceg, Guerrieri, and Gust (2005) were perhaps the first to subject an SVAR involving long-run restrictions to what I will term a "DSGE Monte Carlo." In particular, they generated artificial data from a calibrated DSGE model and applied SVARS with long-restrictions to the data to see if the implied impulse responses matched those of the underlying model.

This method has now been used in several settings. Chari, Kehoe, and McGrattan (2008) used this method to argue against SVARs' ability to test the RBC model, Ramey (2009) used it to show how standard SVARs could be affected by anticipated government spending changes, and Francis, Owyang, Roush, and DiCecio (2014) used this method to verify the applicability of their new finite horizon restrictions method. This method seems to be a very useful tool for judging the ability of SVARs to test DSGE models. Of course, like any Monte Carlo, the specification of the model generating the artificial data is all important.

3. Monetary Policy Shocks

Having discussed the definition of macroeconomic shocks and the leading methods for identifying them, I now turn to the first of the candidate shocks that will be discussed in detail: monetary policy shocks. In this section, I review the main issues and results from the empirical literature seeking to identify and estimate the effects of monetary policy shocks. I begin with a brief overview of the research before and after Christiano, Eichenbaum, and Evan's (1999) *Handbook of Macroeconomics* chapter on the subject. I then focus on two leading externally identified monetary policy shocks, Romer and Romer's (2004) narrative/Greenbook shock and Gertler and Karadi's (2015) shock identified using fed funds futures. I focus on these two shocks in part because they both imply very similar effects of monetary policy on output, despite using different identification methods and different samples. In an empirical exploration of the effects of those shocks in systems that impose fewer restrictions, though, I discovered that relaxing some key over-identifying assumptions yields estimated responses of output and prices that are very different from the standard story.

Before beginning, it is important to clarify that the "shocks" identified in the monetary shock literature are not always the empirical counterparts to the shocks from our theoretical models, as discussed in the introduction to this chapter. Because monetary policy is typically guided by a rule, most movements in monetary policy instruments are due to the *systematic* component of monetary policy rather than to deviations from that rule.[10] We do not have many good economic theories for what a structural monetary policy shock should be. Other than "random coin flipping," the most frequently discussed source of monetary policy shocks is shifts

[10] Milton Friedman argued, however, that most fluctuations in monetary instruments before 1960 were due to nonsystematic components of monetary policy.

in central bank preferences, caused by changing weights on inflation vs. unemployment in the loss function or by a change in the political power of individuals on the FOMC. A few papers explicitly link the empirically identified shocks to shifts in estimated central bank preferences (e.g. Owyang and Ramey (2004) and Lakdawala (2015)), but most treat them as innovations to a Taylor rule, with no discussion of their economic meaning.

If many macroeconomists nowbelieve that monetary policy shocks themselves contribute little to macroeconomic outcomes, why is there such a large literature trying to identify them? The reason is that we want to identify nonsystematic movements in monetary policy so that we can estimate *causal* effects of money on macroeconomic variables. As Sims (1998) argued in his response to Rudebusch's (1998) critique of standard VAR methods, we need instruments in order to identify key structural parameters. Analogous to the supply and demand framework where we need demand shift instruments to identify the parameters of the supply curve, in the monetary policy context we require deviations from the monetary rule to identify the response of the economy to monetary policy. Thus, much of the search for "shocks" to monetary policy is a search for instruments rather than primitive macroeconomic shocks.

3.1 A Brief History through 1999

The effect of monetary policy on the economy is one of the most studied empirical questions in all of macroeconomics. The most important early evidence was Friedman and Schwartz's path-breaking 1963 contribution in the form of historical case studies and analysis of historical data. The rational expectations revolution of the late 1960s and 1970s highlighted the importance of distinguishing the part of policy that was part of a rule versus shocks to that rule, as well as anticipated versus unanticipated parts of the change in the policy variable. Sims (1972, 1980a, 1980b) developed modern time series methods that allowed for that distinction while investigating the effects of monetary policy. During the 1970s and much of the 1980s, shocks to monetary policy were measured as shocks to the stock of money (e.g. Sims (1972), Barro (1977, 1978)). This early work offered evidence that (i) money was (Granger-) causal for income; and (ii) that fluctuations in the stock of money could explain an important fraction of output fluctuations. Later, however, Sims (1980b) and Litterman and Weis (1985) discovered that the inclusion of interest rates in the VAR significantly reduced the importance of shocks to the money stock for explaining output, and many concluded that monetary policy was not important for understanding economic fluctuations.[11]

There were two important rebuttals to the notion that monetary policy was not important for understanding fluctuations. The first rebuttal was by Romer and Romer (1989), who developed a narrative series on monetary policy shocks in the spirit of Friedman and Schwarz's (1963) work. Combing through FOMC minutes, they identified dates at which the Federal Reserve "attempted to exert a contractionary influence on the economy in order to reduce inflation" (p. 134). They found that industrial production decreased significantly after one of these "Romer Dates." The Romers' series rapidly gained acceptance as an indicator of monetary policy shocks.[12] A few years later, though, Shapiro (1994) and Leeper (1997) showed that the Romers' dummy variable was, in fact, predictable from lagged values of output (or unemployment) and inflation. Both argued that the narrative method used by the Romers did not adequately separate *exogenous* shocks to monetary policy, necessary for establishing the strength of the causal channel, from the *endogenous* response of monetary policy to the economy.

[11] Of course, this view was significantly strengthened by Kydland and Prescott's (1982) seminal demonstration that business cycles could be explained with technology shocks.
[12] Boschen and Mills (1995) also extended the Romers' dummy variables to a more continuous indicator.

The second rebuttal to the Sims and Litterman and Weiss argument was by Bernanke and Blinder (1992). Building on an earlier idea by McCallum (1983), Bernanke and Blinder turned the money supply vs. interest rate evidence on its head by arguing that interest rates, and in particular the federal funds rate, were *the* key indicators of monetary policy. They showed that both in Granger-causality tests and in variance decompositions of forecast errors, the federal funds rate outperformed both M1 and M2, as well as the three-month Treasury bill and the 10-month Treasury bond for most variables.

The 1990s saw numerous papers that devoted attention to the issue of the correct specification of the monetary policy function. These papers used prior information on the monetary authority's operating procedures to specify the policy function in order to identify correctly the shocks to policy. For example, Christiano and Eichenbaum (1992) used nonborrowed reserves, Strongin (1995) suggested the part of nonborrowed reserves orthogonal to total reserves, and Bernanke and Mihov (1998) generalized these ideas by allowing for regime shifts in the type of monetary instrument that is targetted.[13] Another issue that arose during this period was the "Price Puzzle," a term coined by Eichenbaum (1992) to describe the common result that a contractionary shock to monetary policy appeared to raise the price level in the short-run. Sims (1992) conjectured that the Federal Reserve used more information about future movements in inflation than was commonly included in the VAR. He showed that the price puzzle was substantially reduced if commodity prices, often a harbinger of future inflation, were included in the VAR.

Christiano, Eichenbaum, and Evans' 1999 *Handbook of Macroeconomics* chapter "Monetary Policy Shocks: What Have We Learned and To What End?" summarized and

[13] An important part of this literature was addressed to the "liquidity puzzle," that is, the failure of some measures of money supply shocks to produce a negative short-run correlation between the supply of money and interest rates.

explored the implications of many of the 1990 innovations in studying monetary policy shocks. Perhaps the most important message of the chapter was the robustness of the finding that monetary policy shocks, however measured, had significant effects on output. On the other hand, the pesky price puzzle continued to pop up in many specifications.

3.2 A Brief Overview of Findings Since 2000

In this section, I will begin by briefly overviewing two important departures from the time-invariant linear modeling that constitutes the bulk of the research. I will then summarize the findings of the most current results from the literature in terms of the effect on output.

3.2.1 Regime Switching Models

In addition to the switch between interest rate targeting and nonborrowed reserve targeting (discussed by Bernanke and Mihov (1998)), several papers have estimated regime switching models of monetary policy. The idea in these models is that monetary policy is driven not just by shocks but also by changes in the policy parameters. In an early contribution to this literature, Owyang and Ramey (2004) estimated a regime switching model in which the Fed's preference parameters could switch between "hawk" and "dove" regimes. They found that the onset of a dove regime leads to a steady increase in prices, followed by decline in output after approximately a year. Primiceri (2005) investigated the roles of changes in systematic monetary policy versus shocks to policy in the outcomes in the last 40 years. While he found evidence for changes in systematic monetary policy, he concluded that they are not an important part of the explanation of fluctuations in inflation and output. Sims and Zha (2006) also considered regime switching models and found evidence of regime switches that correspond closely to changes in the Fed chairmanship. Nevertheless, they also concluded that changes in monetary policy regimes do not explain much of economic fluctuations.

3.2.2 Time-Varying Effects of Monetary Policy

In their summary of the monetary policy literature in their chapter in the *Handbook of Monetary Economics*, Boivin, Kiley, and Mishkin (2010) focus on time variation in the effects of monetary policy. I refer the reader to their excellent survey for more detail. I will highlight two sets of results that emerge from their estimation of a factor-augmented VAR (FAVAR), using the standard Cholesky identification method. First, they confirm some earlier finds that the responses of real GDP were greater in the pre-1979Q3 period than in the post-1984Q1 period. For example, they find that for the earlier period, a 100 basis point increase in the federal funds rate leads to a decline of industrial production of 1.6 percent troughing at 8 months. In the later period, the same increase in the funds rate leads to a -0.7 percent decline troughing at 24 months. The second set of results concerns the price puzzle. They find that in a standard VAR the results for prices are very sensitive to the specification. Inclusion of a commodity price index does not resolve the price puzzle, but inclusion of a measure of expected inflation does resolve it in the post-1984:1 period. In contrast, there is no price puzzle in the results from their FAVAR estimation. This time-variation in the strength of the effect of monetary shocks across periods had also been noted previously, such as by Faust (1998) and Barth and Ramey (2001).

Barakchian and Crowe (2013) estimate many of the standard models, such as by Bernanke and Mihov (1998), CEE (1999), Romer and Romer (2004), and Sims and Zha (2006b), splitting the estimation sample in the 1980s and showing that the impulse response functions change dramatically. In particular, most of the specifications estimated from 1988 – 2008 show that a positive shock to the federal funds rate *raises* output and prices in most cases.

Another source of time variation is state-dependent or sign-dependent effects of monetary shocks on the economy. Cover (1992) was one of the first to present evidence that negative monetary policy shocks had bigger effects (in absolute value) than positive monetary shocks. Follow-up papers such as by Thoma (1994) and Weisse (1999) found similar results. Recent work by Angrist, Jordà, and Kuersteiner (2013) finds related evidence that monetary policy is more effective in slowing economic activity than it is in stimulating economic activity. Tenreyro and Thwaites (2014) also find that monetary shocks seem to be less powerful during recessions.

Since fall 2008, the federal funds rate has been near the zero lower bound. Thus, a key question that has arisen is how to measure shocks in light of this nonlinear constraint. Wu and Xia (forthcoming) use a multifactor Shadow Rate Term Structure Model to estimate a shadow federal funds rate. This shadow rate can capture additional features, such as quantitative easing. Wu and Xia find that unconventional monetary policy has a noticeable impact on the macroeconomy.

3.2.3 Summary of Recent Estimates

Table 3.1 summarizes some of the main results from the literature on the impact of the identified monetary shock on output, the contribution of monetary shocks to output fluctuations, and whether the price puzzle is present. Rather than trying to be encyclopedic in listing all results, I have chosen leading examples obtained with the various identifying assumptions.

As the table shows, the standard CEE (1999) SVAR, the Faust, Swanson, Wright (2004) high frequency identification, Uhlig's (2005) sign restrictions, Smets and Wouters' (2007) estimated DSGE model, and Bernanke, Boivin and Eliasz's (2005) FAVAR all produce rather small effects of monetary policy shocks. Also, most are plagued by the price puzzle to greater or lesser degree. On the other hand, Romer and Romer (2004), Coibion (2012), Barakchian-Crowe (2013), and Gertler-Karadi (2015) all find larger impacts of a given shock on output.

I will also summarize briefly the effects on other variables from some of the leading analyses. A particularly comprehensive examination for many variables is conducted by Boivin, Kiley, and Mishkin's (2010) with their FAVAR. Recall that they obtained different results for the pre- versus post-1980 period. For the period from 1984m1 – 2008m12, they found that a positive shock to the federal funds rate leads to declines in a number of variables, including employment, consumption expenditures, investment, housing starts, and capacity utilization.

3.3 A Discussion of Two Types of Leading External Instruments

3.3.1 Romer and Romer's Narrative/Greenbook Method

In a 2000 paper, Romer and Romer presented evidence suggesting that the Fed had superior information when constructing inflation forecasts compared to the private sector. Romer and Romer (2004) builds on this result and introduces a new measure of monetary policy shocks that seeks to correct some of the limitations of their 1989 monetary policy measure. They construct their new measure as follows. First, they derive a series of *intended* federal funds rate changes around FOMC meetings using narrative methods. Second, in order to separate the endogenous response of policy to the economy from the exogenous shock, they regress the intended funds rate change on the current rate and on the Greenbook forecasts of output growth and inflation over the next two quarters. They then use the estimated residuals in dynamic regressions for output and other variables. They find very large effects of these shocks on output.

John Cochrane's (2004) NBER EFG discussion of the Romer and Romer paper highlights how their method can identify movements in monetary policy instruments that are exogenous to the error term of the model. If the Greenbook forecast of future GDP growth contains all of the information that the FOMC uses to make its decisions, then that forecast is a "sufficient statistic." Any movements in the target funds rate that are not predicted by the Greenbook forecast of future *output* can be used as an instrument to identify the causal effect of monetary policy on *output.* Analogously, any movements in the target funds rate that are not predicted by the Greenbook forecast of *inflation* can be used as an instrument to identify the causal effect of monetary policy on *inflation.* The idea is that if the Fed responds to a shock for reasons other than its effect on future output or future inflation, that response can be used as an instrument for output or inflation. Cochrane states the following proposition in his discussion:

> Proposition 1: To measure the effects of monetary policy on output it is enough that the shock is orthogonal to output forecasts. The shock does not have to be orthogonal to price, exchange rate, or other forecasts. It may be predictable from time t information; it does not have to be a shock to the agent's or the Fed's entire information set. (Cochrane (2004)).

This conceptualization of the issue of identifying movements in monetary policy that are exogenous to the error term in the equation is an important step forward. Note, however, that what Cochrane calls a "shock" is not the same as the definition of shock that I use in this chapter.

Cochrane's notion of a shock is not a primitive structural shock, but rather a useful instrument for estimating the effect of monetary policy on output, etc.

I have one practical concern about the implementation of the idea, though. Because of the data limitations and the preference not to limit their sample too much, Romer and Romer (2004) use forecasts of GDP and inflation only as far as two quarters ahead. This means that the Greenbook forecasts are only a Cochrane "sufficient statistic" for establishing the causal effect for the next two quarters. It seems plausible (as outlined in the news section of this chapter) that the Romer-Romer shocks could include the endogenous response to *news* about changes in inflation and GDP at longer horizons. In fact, the impulse responses from their shocks have no significant negative effect on output and inflation for the first several quarters and then begin to have effects later (often with the wrong sign on inflation). This result is consistent with the traditional "long and variable lags" causal story, but it is also consistent with the following alternative. Suppose that there are no effects of monetary policy shocks on the real economy. Instead, monetary policy reacts now to news about inflation and output at longer horizons and the effects we are seeing on both the funds rate and the economy is the news rather than a causal effect. This alternative story would also answer the question as to how a very temporary shock to the federal funds could have such persistent effects on output. Perhaps we can only be confident of estimates of the effects of a monetary policy shock on output at horizon h if we have controlled for forecasts of output at horizon h when constructing the shocks. I will investigate this issue more below.

Separately, Coibion (2012) has explored a puzzle concerning the Romers' estimates. He notes that the Romers' main estimates produce much larger effects than the shocks identified in a standard VAR, i.e. one in which the monetary policy shock is identified as the residual to the equation for the effective federal funds rate (ordered last). This distinction is important because it implies a very different accounting of the role of monetary policy in historical business cycles. Coibion explores many possible reasons for the differences and provides very satisfactory and revealing answers. In particular, he finds that the Romers' main results, based on measuring the effect of their identified shock using a single dynamic equation, is very sensitive to the inclusion of the period of nonborrowed reserves targeting, 1979 – 1982 and the number of lags (the estimated impact on output is monotonically increasing in the number of lags included in the specification). In addition, their large effects on output are linked to the more persistent effects of their shock on the funds rate. In contrast, the Romers' hybrid VAR specification, in which they substituted their (cumulative) shocks for the federal funds rate (ordered last) in a standard VAR, produces results implying that monetary policy shocks have "medium" effects. Coibion (2012) goes on to show that the hybrid model results are consistent with numerous other specifications, such as GARCH estimates of Taylor Rules (as suggested by Hamilton (2010) and Sims-Zha (2006a)) and time-varying parameter models as in Boivin (2006) and Coibion and Gorodnichenko (2011). Thus, he concludes that monetary policy shocks have "medium" effects. In particular, a 100 basis point rise in the federal funds rate leads industrial production to fall 2 – 3 percent at its trough at around 18 months.

Kliem and Kriwoluzky (2013) take an alternative approach to reconciliation by applying proxy SVARs to reconcile VAR monetary shocks with the Romers' narrative shocks. Their metric is "alignment," which is indicated by both a simple correlation and Mertens-Ravn's "reliability" measure. They find that the proxy SVAR identified shocks are better, but still not well, aligned with the Romer narrative shocks. They then consider several of the modifications advocated by Coibion (2012) and find closer alignment. They do not, however, explore effects on output, prices, or other variables.

3.3.2 High Frequency Identification Methods

Two recent papers use high frequency identification methods (HFI) to estimate the effect of monetary policy shocks on macroeconomic variables. Barakchian and Crowe (2013) use factor analysis to capture the information from fed funds futures across the maturity spectrum to create a new shock. They then cumulate this shock and enter it last in a VAR that also contains industrial production and the CPI. For their estimation period (1988m12 - 2008m6) they find very large effects of monetary policy shocks. A shock that leads the fed funds rate to peak at 100 basis points results in industrial production falling by five percent at its trough at 23 months.[14] Their results also show a strong price puzzle, however, and inclusion of commodity prices and other "fixes" do not eliminate it. They also project their shock on the Romer Greenbook variables and discuss the correlations of the various shock measures. They estimate that monetary policy shocks can account for up to half of the forecast variance of output at three years.

Gertler and Karadi (2014) also use high frequency identification methods for identification, but use the "external instrument" or "proxy SVAR" method discussed in Section 2. Gertler and Karadi have two particular motivations for using these methods. First, they seek to study the effect of monetary policy on variables measuring financial frictions, such as interest rate spreads. The usual Cholesky ordering with the federal funds rate ordered last imposes the restriction that no variables ordered earlier respond to the funds rate shocks within the period.

[14]The authors do not discuss the effect of their shock on the federal funds rate in their paper. I used the estimated from their VAR in a separate dynamic regression of the funds rate on the shock and lags of the funds rate. I then normalized their industrial production responses by the peak of my estimated funds rate response.

This is clearly an untenable assumption for financial market rates. Second, they want to capture the fact that over time the Fed has increasingly relied on communication to influence market beliefs about the future path of interest rates ("forward guidance").

Following Mertens and Ravn (2013), Gertler and Karadi estimate the reduced form residuals from their VARS and then use their HFI series to identify the structural shocks from the reduced form residuals. These shocks are used to calculate the usual VAR impulse responses.

In the implementation, Gertler and Karadi estimate the residuals using monthly data from 1979 to 2012, but then execute the proxy SVAR from 1991-2012 since their favored high frequency instrument is only available for that sample. Their baseline results imply that a monetary policy shock that leads to a 100 basis point increase in the federal funds rate results in a decline of industrial production of -2.2 percent at its trough 18 months later and a small but statistically insignificant decline in the consumer price index.[15]

3.4 New Results Based on Linking Some Recent Innovations

I now explore the effects of monetary policy in more detail using two leading types of external instruments – the Romers' narrative shocks and Barakchian-Crowe and Gertler-Karadi's HFI shocks. I assess how the estimates change when I use less restrictive formulations and I discuss links between the shocks.[16]

[15] The authors' baseline results are for a shock that results in a 25 basis point increase in the one-year bond. I combined the information in Figure 1 and 3 to construct the estimates given in the text to facilitate comparison with other studies.

[16] Smets and Wouter's (2007) monetary shock estimate is another leading candidate for an external instrument. I did not include their shock only because I am working with monthly data, and their shock is estimated on a quarterly frequency. I will use their other shocks in later sections when I examine shocks that are usually estimated on a quarterly basis.

3.4.1 Explorations with Romer and Romer's Shock

I begin by extending Coibion's (2012) analysis of the Romer and Romer (2004) shocks and consider the effects of employing an instrumental variables approach. There are two reasons that an instrumental variables approach is better than the hybrid VAR. First, Romer and Romer's hybrid VAR embeds a cumulative measure of their shocks in a VAR, ordered last in a Cholesky decomposition and thereby imposes a zero restriction on the contemporaneous effects. While it is useful "exogeneity insurance" to purge the Romer's measure from any predictive power based on lagged variables, there is no reason to impose the additional contemporaneous zero restriction. Second, one would expect all external instruments to be noisy measures of the underlying shock, as Stock and Watson (2012) and Mertens and Ravn (2013) have argued. For these two reasons the instrumental variables approach is preferred.

In the first extension, I use Mertens and Ravn's (2013) proxy SVAR method. In the second version, I use Ramey and Zubairy's (2014) external instrument – Jordà (2005) local projection method.

Coibion estimated his systems from 1969 to 1996, whereas I extend the sample through 2007. To determine whether the extended sample changes the results of Romer and Romer's hybrid VAR I first re-estimate Coibion's small hybrid VAR system with the log of industrial production, unemployment, the log of a commodity price index, the log of CPI, and the cumulative Romer shock in a VAR with 12 monthly lags included. The data are monthly updated from 1969m1 through 2007m12. The updated Romer shocks are based on Wieland and Yang's (2015) updates[17] Following Romer and Romer and Coibion, I order the cumulative shock last in the VAR and use the Cholesky decomposition.

[17] The programs are available on Johannes Wieland's UCSD website.

Figure 3.1A shows the estimated impulse responses, with the shaded areas representing 90 percent confidence bands. The results are very similar to those reported by Romer and Romer (2004) and Coibion (2012). A positive shock to the fed funds target leads to a persistent increase in the federal funds rate. Industrial production shows no response for several months and then begins to fall. The point estimates imply that a shock that leads to a peak response of the funds rate of 100 basis points leads to a decline in industrial production of -1 percent at its trough. This response is somewhat smaller in magnitude than those found by Coibion for the shorter sample, where the fall was -1.6 percent. The significant rebound of production above normal after three years does not appear in Romer and Romer's estimates, but does appear in Coibion's estimates. The unemployment rate does nothing for ten months after the shock and then finally rises before falling below normal. Prices do not move for 10 months and then begin to fall. Thus, the responses are roughly similar even in the updated data through 2007. The estimates are less precise, though.

As I discussed in Section 3.3, there is substantial evidence that there might have been a structural break in the 1980s, both in the way that monetary policy was conducted and the impact of monetary policy shocks on the economy. Therefore, I explore the results from estimating the system on a sample that begins in 1983. I use Wieland and Yang's (2015) updated Romer and Romer Greenbook data and re-estimate the Romers' policy rule for 1983 to 2007 to create a new series of shocks. I then re-estimate the model for this shortened period.

Figure 3.1B shows the impulses responses from the hybrid VAR estimated over the post-1983 period. The signs of most of the results change. Interest rates rise, of course, but industrial production also rises persistently, unemployment falls, and the price index falls. The estimates are not very precise, but are nonetheless worrying.

I next estimate a proxy SVAR. In particular, I estimate the reduced form of Coibion's system with the federal funds rate substituted for the cumulative Romer shock and with Romer and Romer's monetary policy shock as an external instrument following Stock and Watson's (2012) and Mertens and Ravn's (2013) proxy SVAR method (see Section 2 for a description).

Figure 3.2A shows the results for the sample from 1969 through 2007. The shaded areas are 90% confidence bands using Mertens and Ravn's wild bootstrap. A shock to monetary policy raises the federal funds rate, which peaks at 1.4 percent by the month after the shock and falls slowly to 0 thereafter. The response of industrial production is different from the one obtained using the hybrid VAR. In particular, industrial production now rises above normal for about 10 months, then begins falling, hitting a trough at about 29 months. Normalized by the funds rate peak, the results imply that a shock that raises the funds rate to a peak of 100 basis points, first raises industrial production by 0.5 percent at its peak a few months after the shock and then lowers it by -0.9 percent by 29 months. The unemployment rate exhibits the same pattern in reverse. After a contractionary monetary policy shock, it falls by 0.1 percentage points in the first year, then begins rising, hitting a peak of about 0.2 percentage points at month 30. The behavior of the CPI shows a pronounced, statistically significant prize puzzle.

Thus, relaxing the zero restriction imposed by Romer and Romer's hybrid VAR leads to very different results. A contractionary monetary policy shock is now expansionary in its first year and the price puzzle is very pronounced.

In fact, the zero restrictions in Romer and Romer's hybrid VAR are statistically rejected by their instrument. A regression of industrial production on the current change in the federal funds rate, instrumented by the Romers' shock, including 12 lags of industrial production, unemployment, CPI, commodity prices and the funds rate, yields a coefficient on the change in the federal funds rate of 0.4 with a robust standard error of 0.2. Similarly, the same regression for unemployment yields a coefficient on the change in the federal funds rate of -0.11 with a robust standard error of 0.06, and for the CPI, a coefficient of 0.10 with a standard error of 0.055. Thus, Romer and Romer's hybrid VAR imposes restrictions that are rejected by their own instrument.

I re-estimated their hybrid VAR, but this time placing their cumulative shock *first* in the ordering. This is the more natural way to run a Cholesky decomposition if one believes that their shock is exogenous. When I do this, I find results (not shown) similar to the proxy SVAR results. In particular, the shock has an expansionary effect on industrial production and unemployment in the first 10 months. There is virtually no price puzzle, though.

The impulse responses for the proxy SVAR estimated for the post-1983 sample are shown in Figure 3.2B. Curiously, the results become more consistent with the standard monetary shock results. For example, the response of the federal funds rate is less persistent. Output starts to fall after only three months, and troughs after 18 months. However, the pointwise estimates are not statistically different from zero.[18] Normalizing for a 100 basis point increase in the funds rate, the decrease in output is -1 percent at the trough. The unemployment rate also behaves more consistently with standard results, doing little for the first 10 months, and then rising during the second year. Some of the pointwise unemployment estimates are statistically different from zero. Prices rise in this shortened sample, though less so than for the full sample and they are not statistically significant.

A concern I discussed earlier is whether the Romer and Romer shocks control for sufficiently long horizons. Recall the discussion above of Cochrane's proposition about the

[18] Since we care more about the statistical significance of the general pattern, ideally we should test the integral of the response for statistical significance rather than each point.

Greenbook forecasts being a sufficient statistic for creating a shock that could be used to make causal statements about monetary shocks on the economy. I pointed out that since the Romers were able to control for Greenbook forecasts of output and inflation for up to two quarters ahead, one could make causal statements using their shocks *only for the horizon covered by the Greenbook forecasts.* The Romers did not control for longer horizons because those projections were not available in the early part of their sample. For the shortened sample I am now considering, longer horizon projections are available. Thus, as a robustness check, I estimate new Romer shocks, adding controls for the projections for growth of GDP and the GDP deflator at the longest horizon available at the time of the FOMC meeting.[19] The dashed lines in Figure 3.2B, which are barely distinguishable from the solid lines, show the impulse responses using this alternative measure. Thus, this quick robustness check suggests that including longer horizon projections does not change the results. This offers an additional degree of confidence that the Romer shock can be used to make causal statements at horizons of a year of more.

I now investigate using the Romer shocks as an external instrument in a system that estimates the impulses using Jordà's (2005) local projection method. As discussed in Section 2, the Jordà method puts fewer restrictions on the impulse responses. Rather than estimating impulse responses based on nonlinear functions of the reduced form parameters, the Jordà method estimates regressions of the dependent variable at horizon t+h on the shock in period t and uses the coefficient on the shock as the impulse response estimate. In my specification, the control variables included are a constant term plus two lags of the Romer shock, the funds rate, log industrial production, log CPI, and the unemployment rate. The point estimates are similar if more lags are included.

[19] This method is not ideal since the horizon varies over time. Sometimes the longest projection is four quarters ahead, sometimes it is five or six quarters ahead. It would be useful to investigate some fixed longer horizon in further research.

Figure 3.3A shows the impulse responses for the full sample.[20] The results show a pattern that is very similar to the one using the proxy SVAR, where the impulse responses are nonlinear functions of the reduced form parameters. It continues to show that industrial production rises significantly for several months before falling. Once we normalize for the peak response of the funds rate, the magnitude of the effects is very similar to those from the proxy SVAR: a shock leading to a rise of the funds rate by 100 basis points results in output falling by 1 percent at its trough.

Figure 3.3B shows the results for the sample starting in 1983. Here the results look more like those from the hybrid VAR on the reduced sample. Industrial production now rises significantly at every horizon and the unemployment rate falls at every horizon. Prices change little until the third year, when they begin to fall. The strange results are not due to low instrument relevance, since the first-stage F-statistics are very high. Furthermore, I tried a few specification changes, such as adding more lags or including a deterministic quadratic trend. None of these changed the basic results.

One would not be so concerned about these results if the confidence bands included zero in all cases. Because the Jordà method imposes fewer restrictions, the impulse estimates are often less precise and more erratic. However, the confidence bands shown, which incorporate Newey-West corrections, often don't include zero and thus suggest that the estimates are statistically different from zero.

This exploration highlights the importance of additional restrictions imposed in standard monetary models, as well as the importance of the sample period. Of the six specifications shown, including the hybrid VAR used by Coibion and Romer and Romer, only three

[20] Note that the confidence bands are based on a HAC procedure that is different from the Mertens and Ravn wild bootstrap used for the proxy SVARs, so the confidence bands should not be compared across procedures.

specifications are consistent with a contractionary monetary policy shock actually being contractionary. Only three specifications do not display a significant price puzzle. Only one specification – the original Romer hybrid VAR with their shock ordered last, estimated over the sample 1969 – 2007 - is consistent with both a contractionary effect on output and no price puzzle.

3.4.2 Explorations with HFI Shocks

I now explore specifications using both Barakchian and Crowe's (2013) and Gertler and Karadi's (2015) shocks based on high frequency identification (HFI). I first study them in isolation and then examine their relationship to my late sample version of the Romer's shock.

I first consider the Barakchian and Crowe (2013) (BC) shock. Recall that this shock is extracted from fed funds futures using factor analysis. As Barakchian and Crowe establish (and I checked), the shock has the correct properties in being mean 0 and not serially correlated. Barakchian and Crowe estimated the effects of their shock in a trivariate VAR with industrial production and CPI, ordering the sum of their shocks last, for the sample 1988m12 – 2008m6. I instead consider the effects using a proxy SVAR in the Coibion VAR and using the Jordà IV for the sample 1988m1 – 2007m12. The results are shown in Figure 3.4A and Figure 3.4B.

The proxy SVAR results shown in Figure 3.4A are somewhat consistent with the results obtained by Barakchian and Crowe using a more standard SVAR (Figure 6 of their paper). Industrial production falls more quickly in the proxy SVAR and the magnitude is only half as large. Normalizing the shocks so that both result in a 100 basis point increase in the funds rate at its peak, their VAR implies a trough of 5 percent of industrial production whereas the proxy

SVAR applied to the Coibion system implies a trough of around 2.3 percent. This estimate is similar to Coibion's estimates using robust methods with the Romer-Romer shock.

To explore the robustness of the results, I then use Barakchian and Crowe's shocks as instruments in the Jordà local projection IV framework. Again, I include two lags of all variables as control variables. Figure 3.4B shows the results. The responses are more erratic and less precisely estimated, but they are broadly consistent with those from the proxy SVAR. After a shock that raises the federal funds rate, industrial production falls soon after and unemployment rises. The effects seem to be more persistent when we use the Jordà method. As with the proxy SVAR, there is a pronounced price puzzle; prices rise for over three years.

I now consider the Gertler-Karadi high frequency shock. Figure 3.5A replicates the results from Gertler and Karadi's baseline proxy SVAR for Figure 1 of their paper.[21] This system uses the three-month ahead fed funds futures (ff4_tc) as the shock and the one-year government bond rate as the policy instrument. The other variables included are log of industrial production, log CPI, and the Gilchrist-Zakrajsek (2012) excess bond premium spread. Note that Gertler and Karadi estimate their reduced form model from 1979:6 through 2012:6, but then use the instruments when they are available starting in the 1990s. The results show that a shock raises the one-year rate, significantly lowers industrial production, does little to the CPI for the first year, and raises the excess bond premium. In order to put the results on the same basis as other results, I also estimated the effect of their shock on the funds rate. The results imply that a shock that raises the federal funds rate to a peak of 100 basis points lowers industrial production by about -2 percent.

To explore the robustness of the results, I then use Gertler and Karadi's shocks as instruments in the Jordà local projection IV framework. Figure 3.5B shows the results. We see

[21] The only difference is that I used 90% confidence intervals to be consistent with my other graphs.

the same pattern we saw with the later sample Romer results using this method. The only statistically significant response is the interest rate response, and again, the effects are much more persistent than in the proxy SVAR framework. Output does little for a year and then rises, though not significantly. None of the other responses is statistically significant (at least pointwise).

In order to compare to my other proxy SVARs, I also investigate using Gertler and Karadi's shock as an external instrument applying the proxy SVAR method to the Coibion variable system, for the period 1990m1 – 2007m12. Figure 3.5C shows those results. In this system, a shock that raises the federal funds rate leads industrial production to *rise* and unemployment to fall significantly for the first year after the shock. There is also a price puzzle, though it is not statistically significant. Thus, using their shock and their method, but with slightly different variables in the VAR, and in which everything is run on the same sample, significantly changes the responses.

I then conducted some further investigations of the Gertler-Karadi shock. Several features emerge. First, the shock is not zero mean. The mean is -0.013 and is statistically different from zero. Second, it is serially correlated; if I regress it on its lagged value the coefficient is 0.31 with a robust standard error of 0.11. This is not a good feature since it is supposed to capture only unanticipated movements in interest rates. I discovered that the serial correlation is induced by the method that Gertler and Karadi use to convert the announcement day shocks to a monthly series.[22] Third, if I regress the announcement date series on all of the Greenbook variables that the Romers used to create their shock, I can reject that the coefficients are jointly zero with a p-value of 0.027.[23] Furthermore, the R-squared of the regression is 0.21.

[22] See footnote 11 of Gertler and Karadi (2015) for details.
[23] I am indebted to Peter Karadi for sharing with me the announcement date series.

Thus, the Gertler-Karadi variable is predicted by Greenbook projections. Gertler and Karadi also worried about this issue, but they performed a robustness check based only on the *difference* between private forecasts and Greenbook forecasts. They found a much lower R-squared (see their Table 4). When they use their purged measure, they find greater falls in industrial production. I explored the effect of using a version of their measure that was (i) orthogonal to the Romer Greenbook variables; and (ii) converted to a monthly basis the same way that the Romers converted their data. The results were broadly similar to those using their version in the Jordà IV. Thus, neither the predictability of the series with Greenbook variables nor the method that Gertler and Karadi use to convert to monthly is important for the results.

The fewer restrictions imposed by the Jordà method result in imprecise estimates. Thus, an obvious next step is to use the Romer shocks, the Barakchian-Crowe, and Gertler and Karadi shocks as instruments. I first set out to see how they were related in the sample in which all were available, 1990:1 – 2007:12.[24] The correlation between the two HFI shocks is 0.43. The correlation of the HFI shocks with the Romer shock ranges from 0.2 (BC) to 0.25 (GK). This suggests that each instrument might contain information not contained by the other, though noise in all instruments is another possibility. I then re-estimated the Jordà specification using all three shocks as instruments. I used the variables from Coibion's system (federal funds rate, industrial production, unemployment, CPI, and commodity prices). Two lags of each variable (including the instruments) were included as control variables. The joint instrumentation passed two key diagnostics. First, the first-stage F-statistics were very high, indicating instrument relevance.[25]

[24] I use my new version of the Romer shocks estimated from 1983 through 2007. Barakchian and Crowe (2013) also conduct many useful comparisons to the Romer shocks and the CEE (1999) shocks.
[25] Olea and Pflueger (2013) show that the thresholds are higher when the errors are serially correlated, as is the case with the Jordà method. However, even with their higher thresholds, the tests indicate high levels of instrument relevance.

Second, the Hansen J-statistic test for identifying restrictions was low in most cases, with high p-values, suggesting that one cannot reject the overidentifying restrictions.

Figure 3.6 shows the resulting impulse response estimates. The estimates indicate that the federal funds rate stays above normal for almost two years. In response, the unemployment rate *falls* significantly and industrial production *rises* during the first year, falls slightly in the second year, and then rises again afterward. The price puzzle is pronounced. Moreover, some simple changes to the specification, such as adding more lags or including a quadratic trend did not noticeably change these results. The results are quite perplexing from the standpoint of many researchers' priors.

3.5 Summary

The literature exploring the effects of monetary shocks has made substantial progress in the last 15 years. Researchers now take instrument identification and relevance much more seriously when estimating monetary policy shocks. New methods, such as FAVARs and Greenbook forecasts, have improved the conditioning set for estimating monetary policy shocks. Structural VARS, sign restrictions and regime switching models have provided alternatives to the usual Cholesky decomposition. Moreover, new measures of monetary shocks have been developed using rich external data, such as narrative data, Greenbook projections, and high frequency information from financial markets. Recently published work using shocks estimated with external data results in similar conclusions. In particular, Coibion's (2012) reconciliation of the Romer results with the VAR results suggests that a 100 basis point rise in federal funds rate lowers industrial production by about -2 percent at 18 months. Those results are based on data from 1969 through 1996. Gertler and Karadi's (2015) research uses high frequency identification from fed funds futures and Mertens and Ravn's (2013) proxy SVAR method to find very similar results – a fall in industrial production of about -2 percent at 18 months – for the period 1990 through 2012. Barakchian and Crowe's (2013) high frequency identification shock suggests similar patterns, though larger effects on output.

This rosy reconciliation picture disappears, however, when the specifications are subjected to some robustness tests. In particular, my new results suggest that the Coibion reconciliation results are dependent on the imposition of the typical Cholesky zero restriction. When I instead use the Romer shocks as external instruments in a proxy SVAR, the results imply a significant price puzzle and expansionary effects of monetary contractions. When I use Romer and Romer's shock and/or the HFI shock in a Jordà local projection framework, I again often find expansionary effects of contractionary monetary policy.

As a result, I end this section on the same pessimistic note that Cochrane (1994) ended his explorations. There is still a lot of uncertainty about the effects of monetary policy shocks.

References

Alexopoulos, Michelle. "Read all about it!! What happens following a technology shock?." *The American Economic Review* 101.4 (2011): 1144-1179.

Angrist, Joshua D. and Jorn-Steffen Pischke, "The Credibility Revolution in Empirical Economics: How Better Research Design is Taking the Con out of Econometrics," *Journal of Economic Perspectives*, 24 (Spring 2010): 3-30.

Alesina, Alberto, and Silvia Ardagna, 1998, "Tales of Fiscal Adjustment," *Economic Policy,* Vol. 13, No. 27, pp. 487–545.

Alesina, Alberto, and Silvia Ardagna, 2010, "Large Changes in Fiscal Policy: Taxes versus Spending," *Tax Policy and the Economy*, Vol. 24, ed. by Jeffrey R. Brown (Cambridge, Massachusetts: National Bureau of Economic Research).

Alesina, Alberto, and Roberto Perotti, 1995, "Fiscal Expansions and Fiscal Adjustments in OECD Countries," *Economic Policy*, Vol. 10, No. 21, pp. 205–248.

Alesina, Alberto, and Roberto Perotti, 1997, "Fiscal Adjustments in OECD Countries: Composition and Macroeconomic Effects," *IMF Staff Papers*, Vol. 44 (June), pp. 210–48.

Angrist, Joshua D. and Jorn-Steffen Pischke, "The Credibility Revolution in Empirical Economics: How Better Research Design is Taking the Con out of Econometrics," *Journal of Economic Perspectives*, 24 (Spring 2010): 3-30.

Angrist, Joshua D., Òscar Jordà, and Guido Kuersteiner (2013), "Semiparametric Estimates of Monetary Policy Effects: String Theory Revisited," NBER working paper 19355.

Arias, Jonas E., Juan F. Rubio-Ramirez, and Daniel F. Waggoner, "Inference Based on SVARs Identified with Sign and Zero Restrictions: Theory and Applications," Board of Governors of the Federal Reserve System International Finance Discussion Papers Number 1100, April 2014.

Auerbach, Alan and Yuriy Gorodnichenko. 2012. "Measuring the Output Responses to Fiscal Policy." *American Economic Journal: Economic Policy* 4 (2): 1-27.

Auerbach, Alan and Yuriy Gorodnichenko. 2013. "Fiscal Multipliers in Recession and Expansion" *Fiscal Policy After the Financial Crisis*, eds. Alberto Alesina and Francesco Giavazzi, University of Chicago Press.

Bagliano, Fabio C., and Carlo A. Favero. 1999. “Information from Financial Markets and VAR Measures of Monetary Policy.” *European Economic Review* 43 (4–6): 825–37.

Barakchian, S. Mahdi and Christopher Crowe, “Monetary Policy Matters: Evidence from New Shocks,” *Journal of Monetary Economics*, Volume 60, Issue 8, November 2013, Pages 950–966

Barro, Robert J., “Unanticipated Money Growth and Unemployment in the United States.” *The American Economic Review* Vol. 67, No. 2 (Mar., 1977), pp. 101-115.

Barro, Robert J., “Unanticipated Money, Output, and the Price Level in the United States.” *Journal of Political Economy* Vol. 86, No. 4 (Aug., 1978), pp. 549-580.

Barro, Robert J., and Charles J. Redlick. 2011. “Macroeconomic Effects from Government Purchases and Taxes.” *Quarterly Journal of Economics* 126 (1): 51-102.

Barsky, R. B., and E. R. Sims (2011): “News shocks and business cycles," *Journal of Monetary Economics*, 58(3), 273-289.

Barsky, Robert. B. and Eric Sims, “Information, Animal Spirits, and the Meaning of Innovations in Consumer Confidence," *American Economic Review*, 102(4), 2012.

Basu, Susanto, and Miles S. Kimball. *Cyclical productivity with unobserved input variation*. No. w5915. National Bureau of Economic Research, 1997.

Basu, Susanto, John G. Fernald, and Miles S. Kimball. "Are Technology Improvements Contractionary?." *The American Economic Review* (2006): 1418-1448.

Baumeister, Christiane and James D. Hamilton, “Sign Restrictions, Structural Vector Autoregressions, and Useful Prior Information,” *Econometrica* 83 (September 2015): 1963-1999.

Beaudry, Paul and Frank Portier, “Stock Prices, News, and Economic Fluctuations," *American Economic Review*, 2006, 96(4), 1293-1307.

Beaudry, Paul and Frank Portier, ”News Driven Business Cycles: Insights and Challenges,” *Journal of Economic Literature* 2014, 52(4), 993–1074.

Ben Zeev, Nadav and Evi Pappa, “Chronicle of a War Foretold: The Macroeconomic Effects of Anticipated Defense Spending Shocks,” forthcoming *Economic Journal*.

Bernanke, Ben S. “Alternative explanations of the money-income correlation” Carnegie-Rochester Conference Series on Public Policy, Volume 25, Autumn 1986, Pages 49–99

Bernanke, Ben S. and Alan S. Blinder, “The Federal Funds Rate and the Channels of Monetary Transmission,” *The American Economic Review* Vol. 82, No. 4 (Sep., 1992), pp. 901-921.

Bernanke, Ben S. and Ilian Mihov, “Measuring Monetary Policy,” *The Quarterly Journal of Economics* Vol. 113, No. 3 (Aug., 1998), pp. 869-902.

Bernanke, Ben S., Jean Boivin and Piotr Eliasz, “Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) Approach,” *Quarterly Journal of Economics*, Volume 120, Issue 1, 2002, Pp. 387-422.

Blanchard, Olivier and Mark W. Watson, “Are All Business Cycles Alike?” in *The American Business Cycle: Continuity and Change*, ed. Robert J. Gordon, NBER 1986.

Blanchard, Olivier and Danny Quah, “The Dynamic Effects of Aggregate Demand and Supply Disturbances,” *American Economic Review,* 79 (4): September 1989, 655-673.

Blanchard, Olivier, and Roberto Perotti, “An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output,” *Quarterly Journal of Economics*, 117 (2002), 1329-1368.

Blanchard, Olivier J., and Daniel Leigh. 2013. "Growth Forecast Errors and Fiscal Multipliers." *American Economic Review*, 103(3): 117-20.

Blanchard, Olivier J., Jean-Paul L'Huillier, Guido Lorenzoni, 2013. "News, Noise, and Fluctuations: An Empirical Exploration," *American Economic Review*, vol. 103(7), pages 3045-70, December.

Boivin, Jean. 2006. “Has U.S. Monetary Policy Changed? Evidence from Drifting Coef"cients and Real-Time Data.” *Journal of Money, Credit, and Banking* 38 (5): 1149–73.

Boivin, Jean, Michael T. Kiley, and Frederick S. Mishkin, “How Has the Monetary Transmission Mechanism Evolved Over Time?” *Handbook of Monetary Economics*. 2010.

Boschen, John F. and Leonard O. Mills (1995). “The Relation between Narrative and Money Market Indicators of Monetary Policy,” *Economic Inquiry,* Volume 33, Issue 1, pages 24–44.

Brückner, Markus, and Evi Pappa. "Fiscal Expansions, Unemployment, and Labor Force Participation: Theory and Evidence,” *International Economic Review* 53.4 (2012): 1205-1228.

Burnside, Craig, Martin Eichenbaum, and Sergio Rebelo. "Capital utilization and returns to scale." In *NBER Macroeconomics Annual 1995, Volume 10*, pp. 67-124. MIT Press, 1995.

Burnside, Craig, Martin Eichenbaum, and Jonas Fisher, “Fiscal Shocks and their Consequences,” *Journal of Economic Theory*, 115 (2004), 89-117.

Caldara, Dario and Christophe Kamps, “The Analytics of SVARs: A Unified Framework to Measure Fiscal Multipliers,” Finance and Economics Discussion Series Divisions of Research & Statistics and Monetary Affairs Federal Reserve Board, Washington, D.C., 2012-20.

Canova, Fabio and Luca Sala, “Back to Square One: Identification Issues in DSGE Models,” *Journal of Monetary Economics* 56 (May 2009): 431-449.

Chang, Pao-Li, and Shinichi Sakata. "Estimation of impulse response functions using long autoregression." *The Econometrics Journal* 10.2 (2007): 453-469.

Chari, VV, Patrick J. Kehoe, and Ellen R. McGrattan, “Are structural VARs with long-run restrictions useful in developing business cycle theory?” *Journal of Monetary Economics*, 2008.

Christiano, Lawrence J, Martin Eichenbaum, Charles L. Evans, “What Have We Learned and To What End?” in *Handbook of Macroeconomics*, ed. Michael Woodford and John D. Taylor, 1999.

Christiano, Lawrence J, Martin Eichenbaum, Charles L. Evans, “Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy,” *Journal of Political Econom*y, Vol. 113, No. 1, February 2005.

Christiano, Lawrence J., Martin Eichenbaum, and Robert Vigfusson. 2003. "What Happens after a Technology Shock?" NBER Working Paper Series 9819. Cambridge, MA: National Bureau of Economic Research.

Cloyne, James, “Discretionary Tax Changes and the Macroeconomy: New Narrative Evidence from the United Kingdom,” The American Economic Review, Volume 103, Number 4, June 2013, pp. 1507-1528(22)

Cochrane, John, “Shocks,” *Carnegie-Rochester Conference Series on Public Policy,* 41 (December 1994): 295-364.

Cochrane, John, “Comments on ‘A new measure of monetary shocks: Derivation and implications’ By Christina Romer and David Romer.” July 17 2004, presented at NBER EFG meeting

http://faculty.chicagobooth.edu/john.cochrane/research/papers/talk_notes_new_measure_2.pdf

Cochrane, John and Monika Piazzesi, 2002. "The Fed and Interest Rates - A High-Frequency Identification." *American Economic Review*, 92(2): 90-95.

Coibion, Olivier, and Yuriy Gorodnichenko. 2011. "Monetary Policy, Trend Inflation, and the Great Moderation: An Alternative Interpretation." *American Economic Review* 101 (1): 341–70.

Coibion, Olivier, "Are the Effects of Monetary Policy Shocks Big or Small?" *American Economic Journal: Macroeconomics*, Volume 4, Number 2, April 2012, pp. 1-32(32)

Cook, Timothy., (1989). "Deterrminants of the Federal Funds Rate: 1979-1982," *Federal Reserve Bank of Richmond Economic Review, 75:* 3-19.

Cook, Timothy. and T.Hahn (1989). "The Effect of Changes in the Federal FundsRate Target on Market Interest Rates in the 1970s, *Journal of Monetary Economics, 24: 331-351.*

Cover, James Peery, "Asymmetric Effects of Positive and Negative Money-Supply Shocks," *The Quarterly Journal of Economics* Vol. 107, No. 4 (Nov., 1992), pp. 1261-1282 .

Crafts, Nicholas and Terence C. Mills. 2012. "Rearmament to the Rescue? New Estimates of the Impact of 'Keynesian' Policies in 1930s' Britain." October Working Paper.

Crouzet, Nicolas and Oh, Hyunseung, "What Do Inventories tell us about News-Driven Business Cycles?" Columbia University, November 2013.

Eichenbaum, Martin S. (1992) "Comment on Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy," *European Economic Review* 36(5): 1001-1011.

Elliott, Graham. "On the robustness of cointegration methods when regressors almost have unit roots." *Econometrica* (1998): 149-158.

Erceg, Christopher J., Luca Guerrieri, and Christopher Gust, "Can Long-Run Restrictions Identify Technology Shocks?" *Journal of the European Economic Association*, Volume 3, Issue 6, pages 1237–1278, December 2005.

Evans, Charles L. and David A. Marshall, "Fundamental Economic Shocks and the Macroeconomy," *Journal of Money, Credit and Banking,* Vol. 41, No. 8 (December 2009).

Farhi,, Emmanuel and Iván Werning, "Fiscal Multipliers: Liquidity Traps and Currency Unions," NBER Working Paper No. 18381, September 2012.

Faust, Jon and Eric M. Leeper, "When Do Long-Run Identifying Restrictions Give Reliable Results?" *Journal of Business & Economic Statistics* Volume 15, Issue 3, 1997

Faust, Jon. (1998). "The Robustness of Identified VAR Conclusions about Money. *Carnegie-Rochester Conference Series on Public Policy* 49:207-244.

Faust, Jon, Eric T. Swanson, and Jonathan H. Wright (2004), “Identifying VARS based on high frequency futures data,” *Journal of Monetary Economics*, Volume 51, Issue 6, September 2004, Pages 1107–113.

Favero,Carlo,Giavazzi,Francesco,2012.”Measuring Tax Multipliers: The Narrative Method in Fiscal VARs,” *American Economic Journal: Economic Polic*y 4(2), 69–94.

Fernald, John G. "Trend breaks, long-run restrictions, and contractionary technology improvements." *Journal of Monetary Economics* 54.8 (2007): 2467-2485.

Fisher, Jonas D.M., and Ryan Peters, “Using Stock Returns to Identify Government Spending Shocks,” *The Economic Journal*, 120 (May 2010): 414-436.

Francis, Neville, and Valerie A. Ramey. "Is the technology-driven real business cycle hypothesis dead? Shocks and aggregate fluctuations revisited." *Journal of Monetary Economics* 52.8 (2005): 1379-1399.

Francis, Neville, and Valerie A. Ramey. "Measures of per Capita Hours and Their Implications for the Technology-Hours Debate." *Journal of Money, credit and Banking* 41.6 (2009): 1071-1097.

Francis, Neville, Michael T. Owyang, Jennifer E. Rousch, and Ricardo DeCiccio, “A Flexible Finite-Horizon Alternative to Long-Run Restrictions with an Application to Technology Shocks,” *The Review of Economics and Statistics,* October 2014, 96(4): 638–647.

Friedman, Milton and Anna Schwartz, *A Monetary History of the United States: 1867-1960,* National Bureau of Economic Research, 1963.

Friedman, Milton, “The Role of Monetary Policy, ”*American Economic Review*, 58(1): (March 1968).

Frisch, Ragnar, “Propagation Problems and Impulse Problems in Dynamic Economics,” *Economic essays in honor of Gustav Cassel* (1933), pp. 171–205 (London).

Galí, J., 1999. Technology, employment, and the business cycle: Do technology shocks explain aggregate fluctuations, American Economic Review 89, 249-271.

Gechert, Sebastian, “What Fiscal Policy is Most Effective? A Meta Regression Analysis,” forthcoming *Oxford Economic Papers.*

Gertler, Mark and Peter Karadi, “Monetary Policy Surprises, Credit Costs, and Economic Activity,” *American Economic Journal: Macroeconomics*, 7(1) (January 2015) 44–76.

Giavazzi, Francesco, and Marco Pagano, 1990, “Can Severe Fiscal Consolidations Be Expansionary? Tales of Two Small European Countries,” *NBER Macroeconomics Annual*, Vol. 5 (Cambridge, Massachusetts: National Bureau of Economic Research).

Giavazzi, Francesco, and Marco Pagano, 1996, “Non-Keynesian Effects of Fiscal Policy Changes: International Evidence and the Swedish Experience,” *Swedish Economic Policy Review*, Vol. 3, No. 1, pp. 67–103.

Gilchrist, Simon, and Egon Zakrajšek. 2012. “Credit spreads and business cycle fluctuations.” *American Economic Review* 102 (4): 1692–1720.

Goodfriend, Marvin, “Interest Rates and the Conduct of Monetary Policy,” *Carnegie-Rochester Conference Series on Public Policy 34 (1991) 7-30.*

Gospodinov, Nikolay, Ana María Herrera, and Elena Pesavento. "Unit Roots, Cointegration, and Pretesting in Var Models." *VAR Models in Macroeconomics–New Developments and Applications: Essays in Honor of Christopher A. Sims*. Emerald Group Publishing Limited, 2013. 81-115.

Gordon, Robert J. and Robert Krenn. 2010. “The End of the Great Depression: VAR Insight on the Roles of Monetary and Fiscal Policy,” NBER Working Paper 16380, September.

Granger, C.W.J., “Investigating Causal Relations by Econometric Models and Cross-spectral Methods,” *Econometrica* Vol. 37, No. 3 (Aug., 1969), pp. 424-438 .

Gürkaynak, Refet S., Brian Sack and Eric Swanson, “The Sensitivity of Long-Term Interest Rates to Economic News: Evidence and Implications for Macroeconomic Models,” *American Economic Review,* Vol. 95, No. 1 (Mar., 2005), pp. 425-436.

Hall, Robert E., “The Relation between Price and Marginal Cost in U.S. Industry,” *JPE*, October 1988, 96(5), 921-947.

Hall, Robert E., “Invariance Properties of Solow’s Productivity Residual,” in Peter Diamond (ed.), *Growth/ Productivity/Unemployment: Essays to Celebrate Bob Solow’s Birthday*, MIT Press, 71-112, 1990.

Hall, Robert E. 2009. “By How Much Does GDP Rise If the Government Buys More Output?” *Brookings Papers on Economic Activity,* 2 (2009): 183-231.

Hamilton, James D., "Oil and the Macroeconomy Since World War II," *Journal of Political Economy*, April 1983, pp. 228-248.

Hamilton, James D., "Historical Causes of Postwar Oil Shocks and Recessions," *Energy Journal*, January 1985, pp. 97-116.

Hamilton, James D. “What Is an Oil Shock?” *Journal of Econometrics*, April 2003, vol. 113, pp. 363-398.

Hamilton, James D. “Macroeconomics and ARCH.” In *Volatility and Time Series Econometrics: Essays in Honor of Robert Engle*, edited by Tim Bollerslev, Jeffrey Russell, and Mark Watson, 79-96, Oxford: Oxford University Press.

Hansen, Lars Peter and Thomas J. Sargent, “Two Difficulties in Interpreting Vector Autoregressions,” in *Rational Expectations Econometrics*, ed. Lars Peter Hansen and Thomas J. Sargent. Boulder, CO: Westview Press, 77-119.

Hoover, Kevin D. and Stephen J. Perez, “Post hoc ergo propter once more an evaluation of ‘does monetary policy matter?’ in the spirit of James Tobin,” *Journal of Monetary Economics,* Volume 34, Issue 1, August 1994, Pages 47–74

House, Christopher L., and Matthew D. Shapiro. 2006. "Phased-In Tax Cuts and Economic Activity." *American Economic Review*, 96(5): 1835-1849.

Ilzetski, Ethan, Enrique G. Mendoza, Carlos A. Végh, "How Big (Small?) are Fiscal Multipliers?" 2013. "How big (small?) are fiscal multipliers?," Journal of Monetary Economics, Elsevier, vol. 60(2), pages 239-254.

Jaimovich, Nir and Sergio Rebelo, “Can News about the Future Drive the Business Cycle?" *American Economic Review*, 99(4) 2009, 1097-1118.

Jordà, Òscar. 2005. “Estimation and Inference of Impulse Responses by Local Projections.” *American Economic Review* 95 (1): 161-82.

Justiniano, Alejandro, Giorgio E. Primiceri, and Andrea Tambalotti, “Investment shocks and business cycles*,” Journal of Monetary Economics*, Volume 57, Issue 2, March 2010, Pages 132–145.

Justiniano, Alejandro, Giorgio E. Primiceri, and Andrea Tambalotti, “Investment shocks and the relative price of investment,” *Review of Economic Dynamics*, Volume 14, Issue 1, January 2011, Pages 102–121

King, Robert, Charles Plosser, James Stock and Mark W. Watson (1991), “Stochastic Trends and Economic Fluctuations,” *American Economic Review,* 81 (4) September 1991, 819-840.

Kliem, Martin, and Alexander Kriwoluzky. "Reconciling narrative monetary policy disturbances with structural VAR model shocks?" *Economics Letters* 121.2 (2013): 247-251.

Komunjer, Ivana and Serena Ng, “Dynamic Identification of DSGE Models,”*Econometrica*, Vol. 79, No. 6 (November, 2011), 1995-2032.

Koop, Gary, M. Hashem Pesaran, and Simon M. Potter. "Impulse response analysis in nonlinear multivariate models." *Journal of econometrics* 74.1 (1996): 119-147.

Kurmann, André and Elmar Mertens, "Stock Prices, News, and Economic Fluctuations: Comment," *American Economic Review* " 104.4 (2014): 1439-1445.

Kuttner, Kenneth N., "Monetary policy surprises and interest rates: Evidence from the Fed funds futures market," *Journal of Monetary Economics* Volume 47, Issue 3, June 2001, Pages 523–544.

Kydland, Finn E. and Edward C. Prescott, "Time to Build and Aggregate Fluctuations," *Econometrica* Vol. 50, No. 6 (Nov., 1982), pp. 1345-1370.

Lakdawala, Aeimit, "Changes in Federal Reserve Preferences," Michigan State University working paper, April 2015.

Leeper, Eric M., "Narrative and VAR Approaches to Monetary Policy: Common Identification Problems," *Journal of Monetary Economics* 40 (1997): 641-657.

Leeper, Eric M., Alexander Richter, and Shu-Chun Susan Yang, "Quantitative Effects of Fiscal Foresight," *American Economic Journal: Economic Policy* 4 (2): 1-27.

Leeper, Eric M., Todd B. Walker, Shu-Chun Susan Yang, "Fiscal Foresight and Information Flows," *Econometrica* 81 (3) May 2013: 1115-1145. (Also, unpublished supplement at: https://www.econometricsociety.org/sites/default/files/8337_extensions_0.pdf

Leigh, Daniel, P.Devries, C.Freedman, Jaime.Guajardo, D.Laxton, Andrea.Pescatori "Will It Hurt? Macroeconomic Effects of Fiscal Consolidation" Chapter 3, World Economic Outlook, IMF, October 2010.

Litterman, Robert B. and Laurence Weiss, "Money, Real Interest Rates, and Output: A Reinterpretation of Post-War Data," *Econometrica,* Vol. 53, No. 1 (Jan., 1985), pp. 129-156.

Marcellino, Massimo, James H. Stock, and Mark W. Watson, "A comparison of direct and iterated multistep AR methods for forecasting macroeconomic time series," *Journal of Econometrics*, 2006

McCallum, Bennett T., "A Reconsideration of Sims' Evidence Concerning Monetarism," Economics Letters, 1983, 13 (2-3), 167-71.

Mertens, Karel, and Morten O. Ravn, 2011a "Technology-Hours Redux: Tax Changes and the Measurement of Technology Shocks," *NBER International Seminar on Macroeconomics* 2010.

Mertens, Karel, and Morten O. Ravn, 2011b, "Understanding the Aggregate Effects of Anticipated and Unanticipated Tax Policy Shocks," *Review of Economic Dynamics*, Volume 14:1, January 2011.

Mertens, Karel, and Morten O. Ravn. 2012. "Empirical Evidence on the Aggregate Effects of Anticipated and Unanticipated US Tax Policy Shocks." *American Economic Journal: Economic Policy*, 4(2): 145-81.

Mertens, Karel, and Morten O. Ravn. 2013. "The Dynamic Effects of Personal and Corporate Income Tax Changes in the United States." *American Economic Review*, 103(4): 1212-47.

Mertens, Karel, and Morten O. Ravn., "A Reconciliation of SVAR and Narrative Estimates of Tax Multipliers," *Journal of Monetary Economics* 68 (2014): S1-S19.

Miyamoto, Wataru and Nguyen, Thuy Lan, "News Shocks and Business Cycles: Evidence from Forecast Data," Columbia University, Nov. 2013.

Mountford, Andrew and Harald Uhlig, "What are the Effects of Fiscal Policy Shocks? *Journal of Applied Econometrics* 24 (September/October 2009): 960-992.

Nakamura, Emi, and Steinsson, Jon. (2014). Fiscal Stimulus in a Monetary Union: Evidence from US Regions. *The American Economic Review*, *104*(3), 753-792.

Newey, Whitney K. and Kenneth D. West, "A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix," *Econometrica,* 1987, vol. 55, 3, pp. 703-708.

Olea, Jose Luis Montiel and Carolin Pflueger, 2013. "A Robust Test for Weak Instruments." *Journal of Business & Economic Statistics* 31(3): 358–369.

Owyang, Michael and Garey Ramey, **"**Regime switching and monetary policy measurement," *Journal of Monetary Economics,* Volume 51, Issue 8, November 2004, Pages 1577–1597.

Pappa, Evi. "The Effects of Fiscal Shocks on Employment and the Real Wage," *International Economic Review* 50.1 (2009): 217-244.

Perotti, Roberto, "Expectations and Fiscal Policy: An Empirical Investigation," 2011 Bocconi working paper.

Perron, Pierre. "The great crash, the oil price shock, and the unit root hypothesis." *Econometrica: Journal of the Econometric Society* (1989): 1361-1401.

Piazzesi, Monika and Eric T. Swanson (2008), "Futures prices as risk-adjusted forecasts of monetary policy," *Journal of Monetary Economics*, Volume 55, Issue 4, May 2008, Pages 677–691.

Prescott, Edward C., "Theory Ahead of Business-Cycle Measurement," *Carnegie-Rochester Conference Series on Public Policy*, Volume 25, Autumn 1986, Pages 11–44.

Primiceri, Giorgio, "Time Varying Structural Vector Autoregressions and Monetary Policy," *Review of Economic Studies* (2005) 72 (3): 821-852.

Ramey, Valerie A. and Matthew Shapiro, "Costly Capital Reallocation and the Effects of Government Spending," *Carnegie Rochester Conference on Public Policy* (1998).

Ramey, Valerie A., "Defense News Shocks, 1939-2008: An Analysis Based on News Sources," UCSD manuscript, 2009a. http://econ.ucsd.edu/~vramey/research/Defense_News_Narrative.pdf .

Ramey, Valerie A., "Identifying Government Spending Shocks: It's All in the Timing," NBER Working Paper No. 15464, October 2009. 2009b

Ramey, Valerie A., "Identifying Government Spending Shocks: It's All in the Timing," *Quarterly Journal of Economics*, 126 (February 2011): 1-50.

Ramey, Valerie A. Government Spending and Private Activity, *Fiscal Policy After the Financial Crisis* eds. Alberto Alesina and Francesco Giavazzi, University of Chicago Press. 2013a,

Ramey, Valerie A., "Discussion of 'Roads to Prosperity or Bridges to Nowhere? Theory and Evidence on the Impact of Public Infrastructure Investment'" by Sylvain Leduc and Daniel Wilson *2012 NBER Macroeconomics Annual Conference*, 2013b

Ramey, Valerie A. and Sarah Zubairy, "Government Spending Multipliers in Good Times and in Bad: Evidence from 20th Century Historical Data," November 2014 working paper.

Romer, Christina D. and David H. Romer, "Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwartz," NBER Macroeconomic Annual 1989.

Romer, Christina D., and David H. Romer, "Federal Reserve Information and the Behavior of Interest Rates." *American Economic Review,* June 2000, *90*(3), pp. 429–57.

Romer, Christina D., and David H. Romer, "A New Measure of Monetary Policy Shocks: Derivation and Implications," *American Economic Review*, 94(4) (September 2004): 1055-84 .

Romer, Christina D., and David H. Romer, “The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks,” *American Economic Review*, 100 (June 2010): 763-801 .

Rotemberg, Julio, and Woodford, Michael, “Oligopolistic Pricing and the Effects of Aggregate Demand on Economic Activity,” *Journal of Political Economy*, **100** (1992), 1153–1297.

Rudebusch, Glenn, “Do Measures of Monetary Policy in a VAR Make Sense?” *International Economic Review* , Vol. 39, No. 4, Symposium on Forecasting and Empirical Methods in Macroeconomics and Finance (Nov., 1998), pp. 907-931

Schmitt-Grohe**,** Stephanie and Martin Uribe (2012), “What’s News in Business Cycles?” *Econometrica***,** Volume 80, Issue 6, pages 2733–2764, November 2012

Shapiro, Matthew D. and Mark W. Watson (1988), “The Sources of Business Cycle Fluctuations,” *NBER Macroeconomics Annual 1988.*

Shapiro, Matthew D. "Cyclical productivity and the workweek of capital." *The American Economic Review* (1993): 229-233.

Shapiro, Matthew D., “Federal Reserve Policy: Cause and Effect,” in *Monetary Policy* ed. N. Gregory Mankiw, National Bureau of Economic Research, 1994.

Sims, Christopher A. “Money, Income, and Causality,” *American Economic Review*, Vol. 62, No. 4 (Sep., 1972), pp. 540-552

Sims, Christopher A. 1980a. “Macroeconomics and Reality,” *Econometrica*. 48, pp. 1-48.

Sims, Christopher A. 1980b. “Comparison of Interwar and Postwar Business Cycles: Monetarism Reconsidered,” *The American Economic Review* Vol. 70, No. 2, (May, 1980), pp. 250-257.

Sims, Christopher A., James H. Stock, and Mark W. Watson. "Inference in linear time series models with some unit roots." *Econometrica: Journal of the Econometric Society* (1990): 113-144.

Sims, Christopher A. and Tao Zha, (2006a) “Were there Regime Switches in U.S. Monetary Policy?” *American Economic Review,* Vol. 96, No. 1 (Mar., 2006), pp. 54-81.

Sims, Christopher A. and Tao Zha, (2006b), “Does Monetary Policy Generate Recessions?” *Macroeconomic Dynamics,* 10 (2) April 2006: 231-272.

Slutzky, Eugen, “The Summation of Random Causes as the Source of Cyclic Processes,” *Econometrica,* Vol. 5, No. (2) (April 1937), pp. 105-146.

Smets, Frank and Raf Wouters, "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area," *Journal of the European Economics Association,* Volume 1, Issue 5, pages 1123–1175, September 2003.

Smets, Frank and Raf Wouters, "Shocks and Frictions in U.S. Business Cycles: A Bayesian DSGE Approach," *American Economic Review,* 97(3) June 2007: 586-606.

Solow, Robert M., "Technical Change and the Aggregate Production Function," *The Review of Economics and Statistics* Vol. 39, No. 3 (Aug., 1957), pp. 312-320.

Stock, James H. and Mark W. Watson, "Forecasting Using Principal Components From a Larg Number of Predictors," *Journal of the American Statistical Association* Volume 97, Issue 460, 2002

Stock, James H. "What's New in Econometrics: Time Series," NBER Summer Institute Mini-Course, July 2008.

Stock, James H. and Mark W. Watson, "Disentangling the Channels of the 2007–09 Recession," Brookings Papers on Economic Activity, Spring 2012.

Stock, James H., Jonathan H. Wright, and Motohiro Yogo. 2002. "A survey of weak instruments and weak identification in generalized method of moments." *Journal of Business & Economic Statistics* 20 (4): 518–29.

Strongin, Steven, "The identification of monetary policy disturbances explaining the liquidity puzzle," *Journal of Monetary Economics,* Volume 35, Issue 3, June 1995, Pages 463–497

Tenreyro, Silvana and Gregory Thwaites, Gregory (2013) "Pushing on a string: US monetary policy is less powerful in recessions**,"** CEP Discussion Papers, CEPDP1218. Centre for Economic Performance, London School of Economics and Political Science, London, UK.

Thoma, Mark A., "Subsample instability and asymmetries in money-income causality," *Journal of Econometrics*, Volume 64, Issues 1–2, September–October 1994, Pages 279–306.

Uhlig, Harald. "Do technology shocks lead to a fall in total hours worked?." *Journal of the European Economic Association* (2004): 361-371.

Uhlig, Harald. "What are the effects of monetary policy on output? Results from an agnostic identification procedure." *Journal of Monetary Economics* 52.2 (2005): 381-419.

Uhlig, Harald. "Some fiscal calculus." *The American Economic Review* (2010): 30-34.

Uhlig, Harald, "Economics and Reality," *Journal of Macroeconomics* 34 (March 2012): 29-41.

Weise, Charles L.,"The Asymmetric Effects of Monetary Policy: A Nonlinear Vector Autoregression Approach," *Journal of Money, Credit and Banking,* Vol. 31, No. 1 (Feb., 1999), pp. 85-108.

Wu, Jing Cynthia and Fan Dora Xia, "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound," forthcoming *Journal of Money, Credit, and Banking*.

Tables and Figures

All confidence bands shown on impulse responses are 90% confidence bands.

Table 3.1. Summary of Some Effects of Identified Monetary Shocks

Paper	Method, sample	Impact of 100 basis point increase in funds rate	% of output explained by shock	Price Puzzle?
Christiano, Eichenbaum, Evans (1999) – FFR identification	SVAR, 1965q3 – 1995q3	-0.7% at 8 quarters.	44% at 2 years	Yes, but very small
Faust, Swanson, Wright (2004)	HFI, 1991m2 – 2001m7	-0.6% at 10 months		
Romer and Romer (2004)	Narrative/Greenbook 1970m1 – 1996m12	-4.3% at 24 months	Major part	No, but prices don't change for 22 months
Uhlig (2005)	Sign restrictions, 1965m1 – 1996m12	Positive, but not statistically different from 0	5 – 10% at all horizons.	No (by construction)
Bernanke, Boivin, and Eliasz (2005)	FAVAR, 1959m1 – 2001m7	-0.6% at 18 months	5% at 5 years	Yes
Smets-Wouters (2007)	Estimated DSGE model 1966Q1 – 2004Q4	-1.8 at 4 quarter trough	10% at 1 year (trough)	No
Boivin, Kiley, Mishkin (2010)	FAVAR, 1962m1-79m9, 1984m1-2008m12	-1.6% at 8 months in early period, -0.7% at 24 months in later period		Only in the early period.
Coibion (2012)	"Robust" Romer-Romer methods, 1970m1 – 1996m12	-2 % at 18 months	"Medium" part	Yes, sometimes
Barakchian-Crowe (2013)	HFI, Romer hybrid VAR, 1988m12-2008m6	-5 % at 23 months	50% at 3 years	Yes
Gertler-Karadi (2015)	HFI-Proxy SVAR, 1979m7 – 2012m6 (1991m1-2012m6 for instruments)	-2.2 % at 18 months	?	No

Figure 3.1A. Romer Hybrid Monetary VAR, 1969m1 – 2007m12

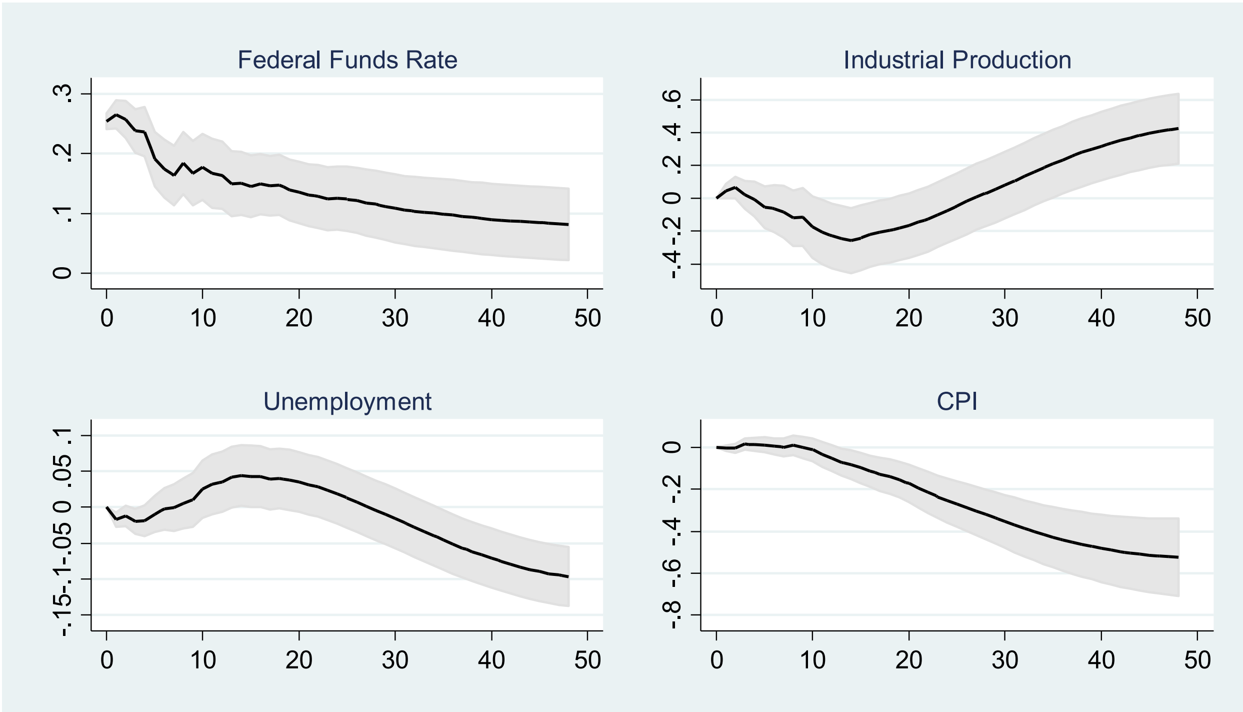

Figure 3.1B. Romer Hybrid Monetary VAR, 1983m1 – 2007m12

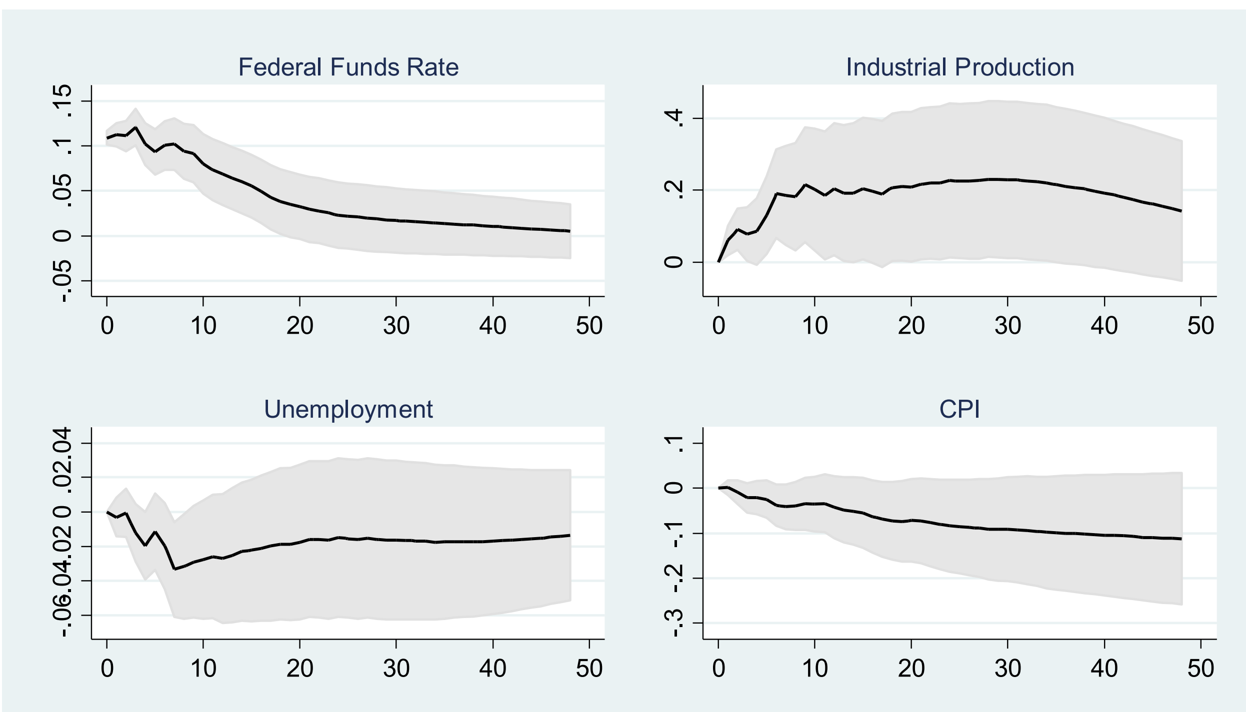

Figure 3.2A. Proxy Monetary SVAR, Romer, 1969m1 – 2007m12

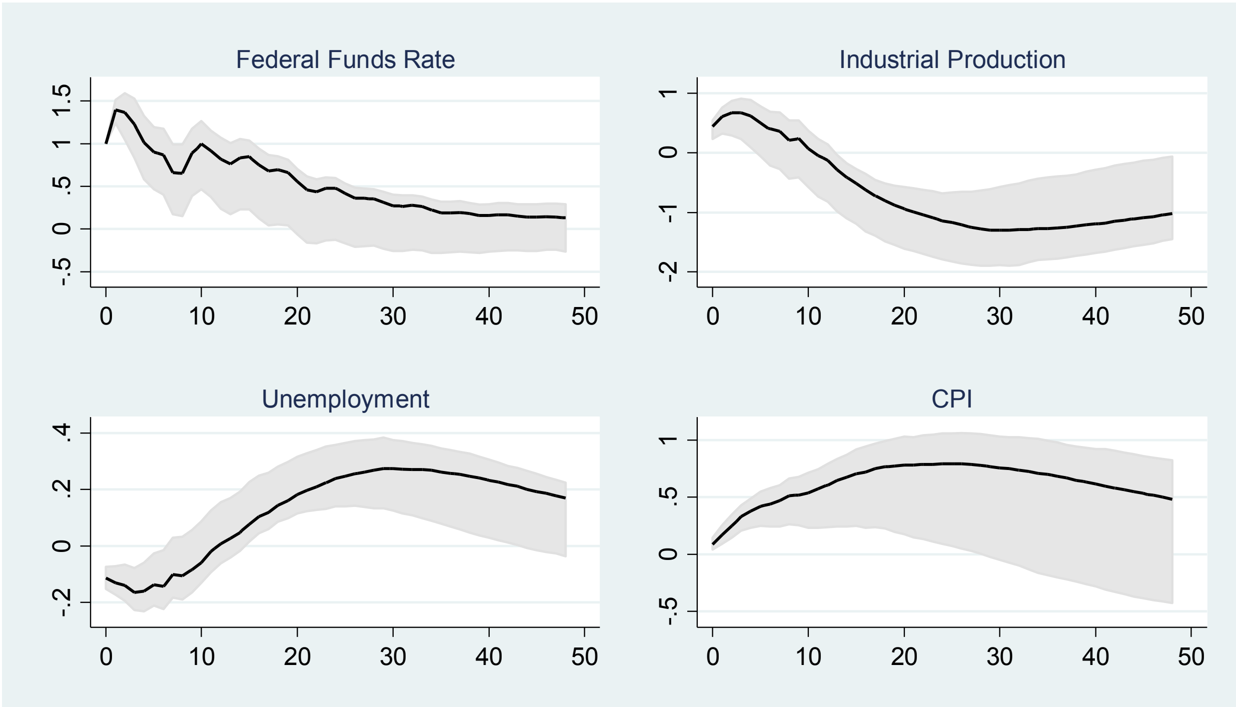

Figure 3.2B Proxy Monetary SVAR, Romer, 1983m1 – 2007m12

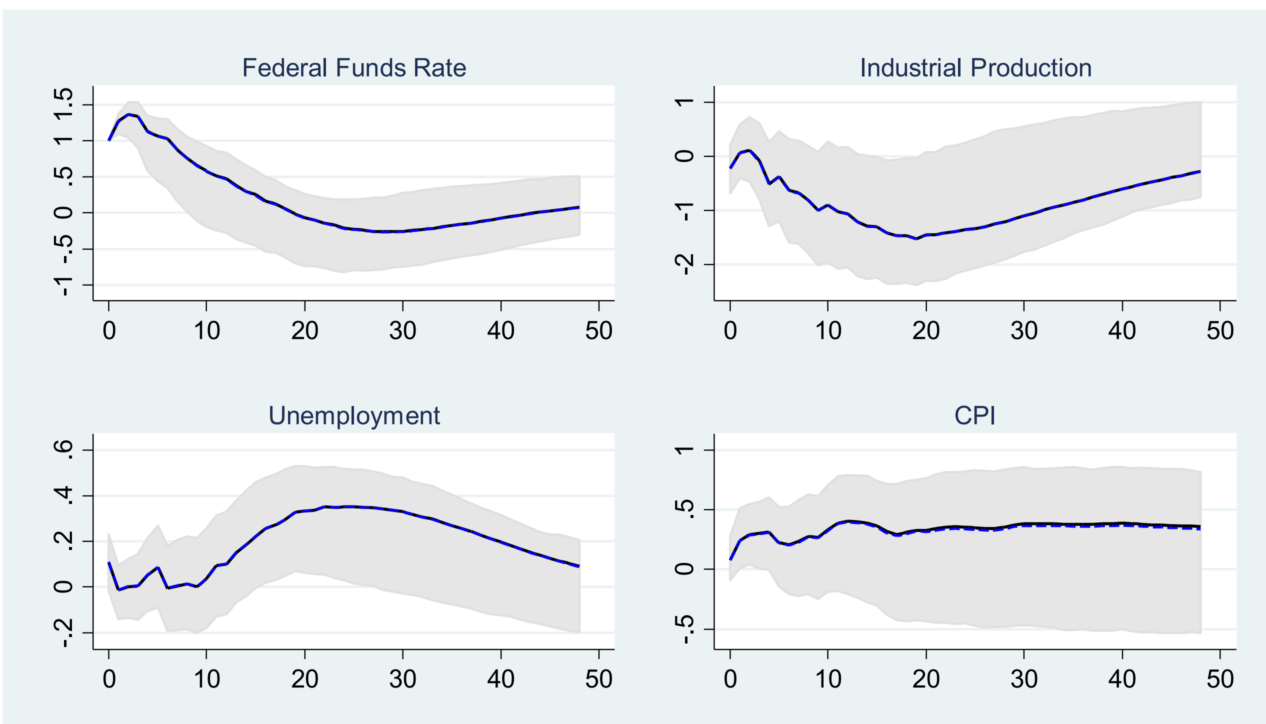

Figure 3.3A. Monetary Jordà IV, Romer, 1969m1 – 2007m12

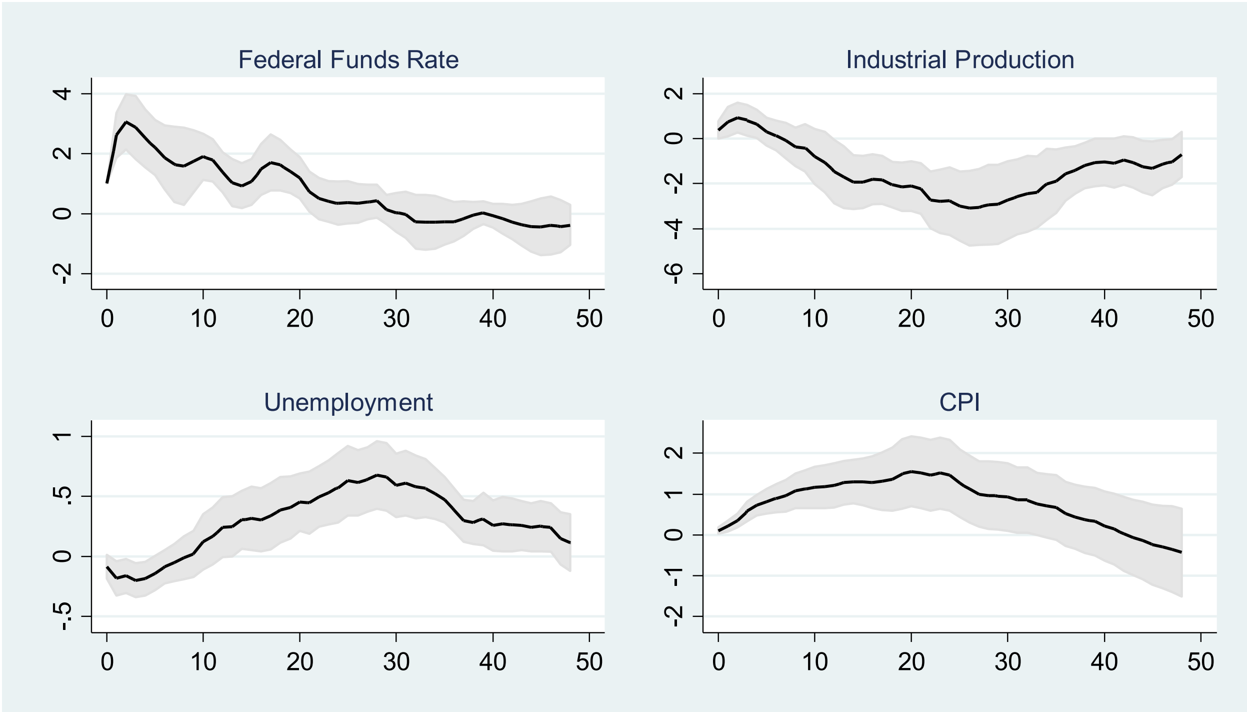

Figure 3.3B. Monetary Jordà IV, Romer, 1983m1 – 2007m12

Figure 3.4A Monetary Proxy SVAR, Barakchian-Crowe, 1988m12 – 2007m12

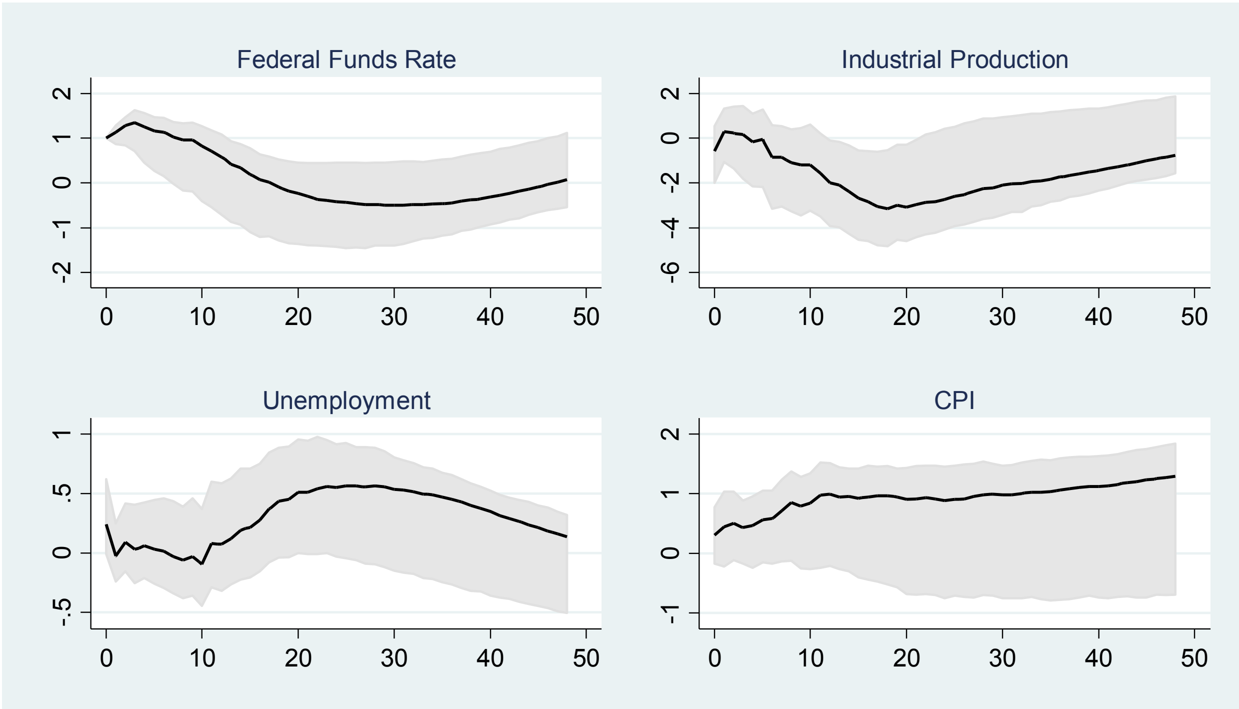

Figure 3.4B Monetary Jordà IV, Barakchian-Crowe, 1988m12 – 2007m12

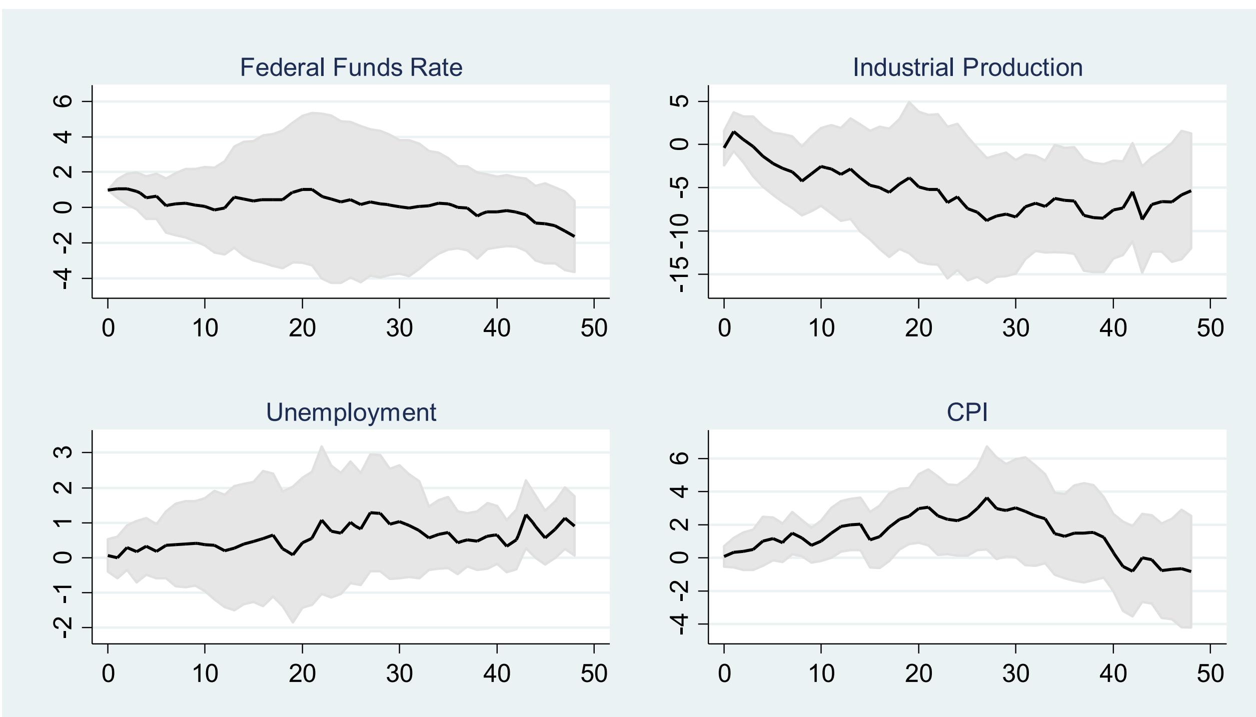

Figure 3.5A Gertler-Karadi's Monetary Proxy SVAR, 1979, 1990m1 – 2012m6

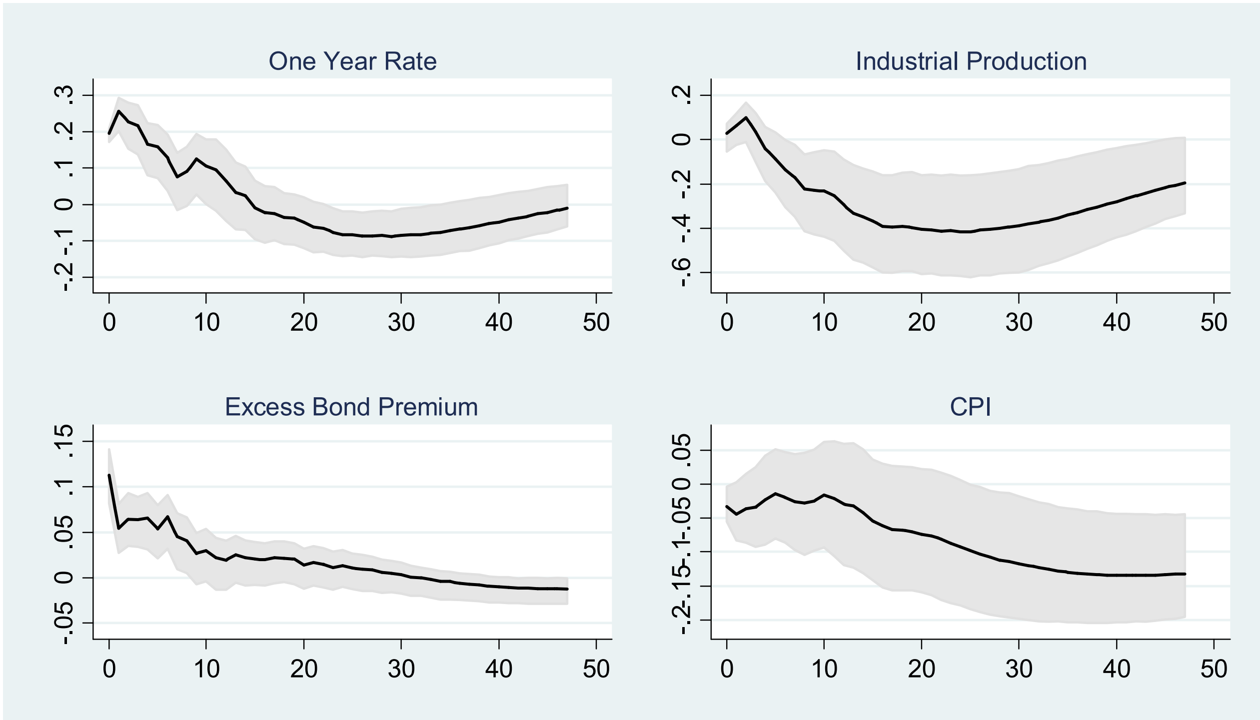

Figure 3.5B Monetary Jordà IV, Gertler-Karadi, 1990m1 – 2012m6

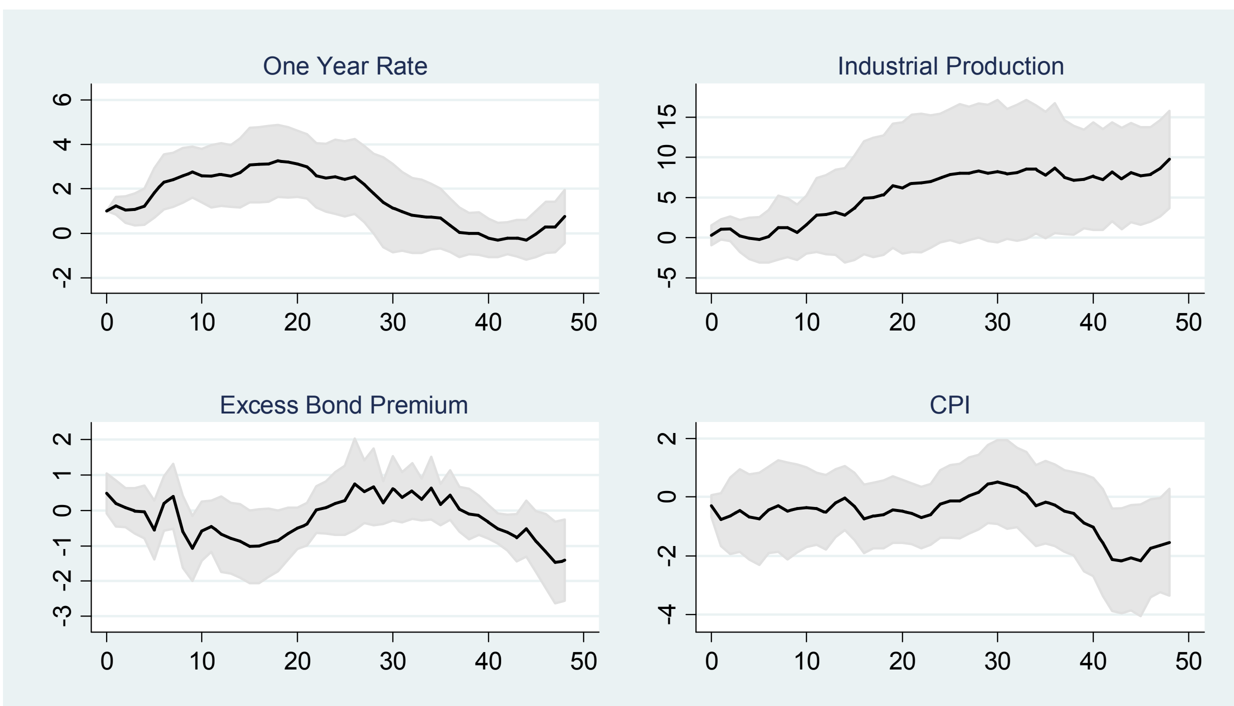

Figure 3.5C Gertler-Karadi's Shock, Monetary Proxy SVAR using Coibion Variables 1990m1 – 2007m12

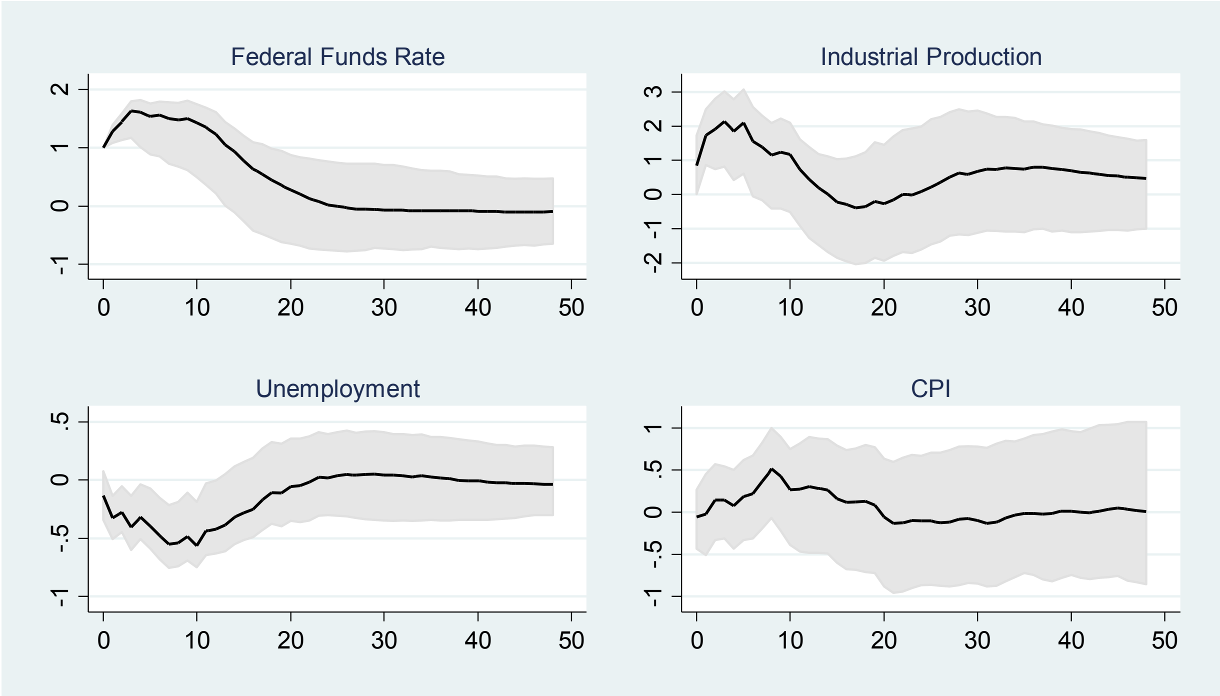

Figure 3.6 Monetary Jordà IV, Romer, Barakchian-Crowe, and Gertler-Karadi Instruments, 1990m1 – 2007m12