Proxy SVARs - The Example of Gertler and Karadi (2015)

Barcelona GSE. Empirical Time Series Methods for Macroeconomic Analysis.
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1 Introduction

This set of lecture notes introduces an example of the usage of Proxy SVARs in understanding the effects of monetary policy shocks on the macroeconomy. First, we will cover, step by step, the econometric methodology. Second, we will replicate Gertler and Karadi (2015).

2 Econometric Methodology

The approach proposed by Gertler and Karadi (2015) uses high frequency data among FOMC meetings (in a 30 minutes window of the announcement) as an external instrument to identify monetary policy shocks. This methodology is a variation of the ones developed by Stock and Watson (2012) and Mertens and Ravn (2013).
Consider the following reduced form Vector Autoregressive (henceforth, VAR) model with p lags:

$$Y_t = C + A_1 Y_{t-1} + A_2 Y_{t-2} + ... + A_p Y_{t-p} + u_t \tag{1}$$

where Y_t is a vector containing the monetary policy variable ordered first and then a set of macroeconomic and financial variables, and let $u_t = S\epsilon_t$. Let $\mathbf{s}$ denote the column in matrix S corresponding to the impact, on each variable of the vector of reduced form residuals u_t, of the structural monetary policy shock ϵ_t^p. Therefore, to compute the impulse responses to a monetary policy shock, (1) reduces to:

$$Y_t = C + \sum_{j=1}^{p} A_j Y_{t-p} + \mathbf{s}\epsilon_t^p \tag{2}$$

How do we estimate $\mathbf{s}$? We can make use of external instruments as an identification strategy. Let Z_t be a vector of instrumental variables and let ϵ_t^q be a vector of structural shocks **other** than the monetary policy one. For these instrumental variables to be valid instruments, we need two conditions:
a) Z_t must be correlated with the monetary policy shock ϵ_t^p:

$$E(Z_t \epsilon_t^{p'}) = \Phi \tag{3}$$

b) Z_t must be orthogonal to the other variables' shocks ϵ_t^q:

$$E(Z_t \epsilon_t^{q'}) = 0 \tag{4}$$

The estimation consists of three main steps:

1) Estimate, by ordinary least squares, the VAR(p) process in (1) and obtain the vector of residuals $\hat{u}_t$.
2) Let $\hat{u}_t^p$ be the estimated residual in (1) for the monetary policy variable and let $\hat{u}_t^q$ be the estimated residual for the remaining variables in the system. The procedure works in 2 stages. The first stage isolates the variation in the reduced form residual for the policy indicator that is due to the structural policy shock only:

$$\hat{u}_t^p = \alpha + \beta Z_t + \xi_t \tag{5}$$

Obtain $\hat{\hat{u}}_t^p$ from (5). Given that the variation in $\hat{\hat{u}}_t^p$ is due only to ϵ_t^p, by (3) and (4), we can estimate consistently $\frac{\mathbf{s}^q}{s^p}$ as follows (second stage):

$$\hat{u}_t^q = \frac{\mathbf{s}^q}{s^p}\hat{\hat{u}}_t^p + \delta_t \tag{6}$$

3) Normalizing s^p to 1, then $\hat{\mathbf{s}} = (1, \hat{\mathbf{s}}^{q'})'$.
What is the intuition behind this methodology? In the first stage regression, the variation in the reduced form residual for the monetary policy variable related to the structural monetary policy shock is isolated. In the second stage, regressing $\hat{\hat{u}}_t^p$ on $\hat{u}_t^q$, we estimate the ratio between the impact of the monetary policy shock on the variables q and the one on the policy variable, as shown by Gertler and Karadi (2015).
Therefore, the impulse responses to the monetary policy shock ϵ_t^p are computed from the $VMA(\infty)$ representation of the process described in (2):

$$\begin{aligned} Y_t &= (I - \sum_{j=1}^{p} A_j L^j)^{-1} C + (I - \sum_{j=1}^{p} A_j L^j)^{-1} \mathbf{s}\epsilon_t^p \\ &= \mu + C(L)\mathbf{s}\epsilon_t^p \\ &= \mu + \sum_{j=0}^{\infty} C_j \mathbf{s}\epsilon_{t-j}^p \end{aligned} \tag{7}$$

where μ and C_j are estimated in the reduced form VAR presented in (1) and $\mathbf{s}$ is estimated through the external instrument methodology presented above.

3 Replication of Gertler and Karadi (2015)

As Gertler and Karadi (2015)'s baseline specification, the macroeconomic and financial variables included in the reduced form VAR analysis are: the logarithm of CPI, the logarithm of industrial production and Gilchrist and Zakrajšek's excess bond premium. Therefore, Y_t includes the policy variable ordered first and then the set of macroeconomic and financial variables just mentioned. The VAR in (2) is estimated with data from 1979:7 to 2012:6 with $p = 12$ lags. The instrumental variable used to estimate $\mathbf{s}$ is the 3 months ahead federal funds future rate, namely FF4. This instrument is chosen as it is the one that performs best, in terms of F test, in the two stages regression described in (5) and (6). As presented above, the estimation is conducted in 3 main steps:

1. Estimate the reduced form VAR in (1) and store the residuals $\hat{u}_t$:

```
%% Estimate a VAR(12) with finaldata:

% First of all, we have to create the T x n matrices of the SUR
% representation, i.e. Y and X:

n=size(finaldata,2); % # of variables
p=12; % 12 lags
c=1; % constant

% First Step - Estimate VAR and store residuals:

[pi_hat,Y,X,Y_initial,Yfit,err]=VAR(finaldata,p,c);
BigA=[pi_hat(2:end,:)'; eye(n*p-n) zeros(n*p-n,n)]; % BigA companion ...
    form, npxnp matrix
```

2. Perform the two stages regression presented above:

```
%% External instrument:

% Second Step - Two stage regression:

eps_p=err(length(finaldata)-p-length(FF4)+1:end,end);
eps_q=err(length(finaldata)-p-length(FF4)+1:end,1:end-1);

Z = FF4;

[ols_instr,stderr_ols,tstat_ols]=OLS(eps_p,Z,1);

u_hat_p=[ones(length(Z),1),Z]*ols_instr;

sq_sp=(u_hat_p'*u_hat_p)\u_hat_p'*eps_q;
```

3. Normalize the response on impact of the policy variable to be equal to one and compute the IRFs:

```
% Step 3 - Normalise s_p=1 and compute IRFs

s=[sq_sp,1];

H=zeros(n,1,50);
for i=1:50
    H(:,:,i)=C(:,:,i)*s'; % IV wold respesentation
end

H_wold=(reshape(permute(H,[3 2 1]),50,n,[]));

c=1;
cc=1;

Z = [NaN(length(finaldata)-p-length(FF4),1);FF4];

% Bootstrap:

hor=50;
iter=1000;
conf=95;

[HighH,LowH]=bootstrapVARIVnewmonthly(finaldata,hor,c,cc,iter,conf,p,n,Z);
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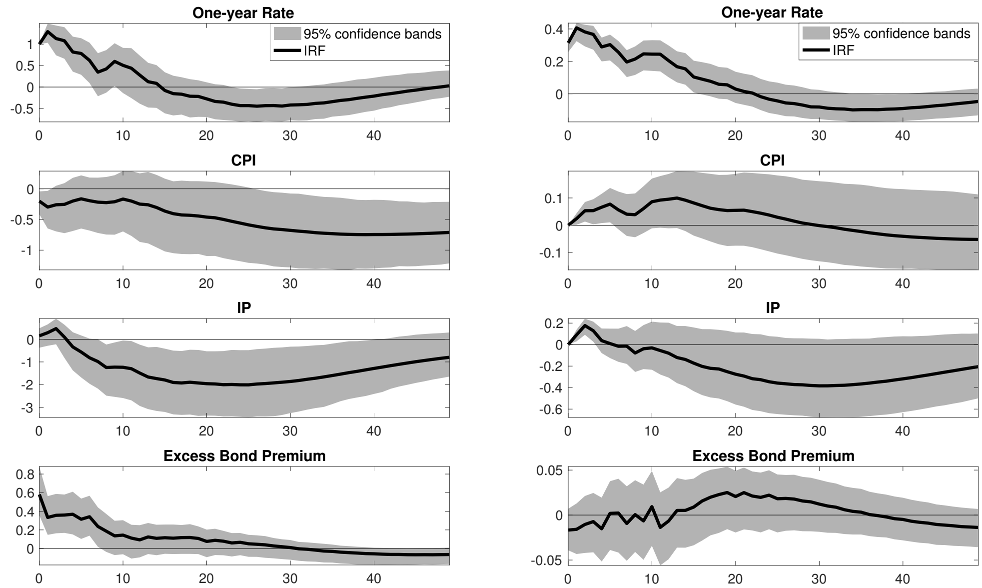

(a) Proxy SVAR

(b) Cholesky

Figure 1: Effects of Monetary Policy Shocks

Figure 1 presents the effects of monetary policy shocks in the Proxy SVAR framework vs. the Cholesky one. Consistently with the existing literature on the effects of monetary policy on the macroeconomy, a contractionary shock decreases significantly and persistently both inflation and output, feature that was not present in the simple recursive specification, in which, for instance, inflation increased (prize puzzle) and output decreased, but not significantly. Furthermore, it increases significantly the excess bond premium on impact and persistently up to 7 months ahead, giving evidence of an increase in credit costs following an unexpected interest rate increase, feature not present in the Cholesky specification.