PhD Course: Structural VAR models

Ia. Motivation

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Lecture note Ia: Motivation

Content

1. *Introduction*
2. *The Identification problem in econometrics*
3. *Structural VARs and simultaneous equations models (SEM's)*
4. *Econometric of SVARs*

1. Introduction, or, what do SVARs do?

- Structural vector autoregressions can be used to address the following type of question:
    - How does the economy respond to different economic shocks?
    - What is the contribution of the different shocks to the business cycle?

- The answers to these type of questions are key in business cycle analysis, where the purpose is to study impulses and propagations.

- More recently, the answers provided have been very useful in the construction of dynamic, general stochastic equilibrium (DSGE) models

- However, to be useful in practice, need to have good sampling properties. Evaluation.

- Where do we find SVARs?

Examples

- Sources of business cycles (different countries, different periods).

- Detrending (permanent versus temporary shocks)

- Economic fundamental components - historical decompositions
  - Output gap
  - Core inflation

- Discriminate between economic theories
  - Does RBC fit the facts?
  - Contributions of demand versus supply shocks?
  - Response of hour to technology shocks?

- Monetary and fiscal policy
  - Closed economy
  - Open economy (exchange rate)
  - Financial markets (stock prices, house prices etc.)

- Parameterization of economic models
  - Minimize distance between a function of parameters in the theoretical model and a function of the data

2. The identification problem in econometrics

Suppose prices in a market are set by supply and demand. We would like to know the equations for the demand function and the supply function using price (*P*) and quantity (*Q*) data. Clearly, the specification $Q = a + bP$ is not sufficient to identify the supply and the demand parameters separately. The traditional approach has been to include more variables, so that the two equations can be separately expressed and identified. Assume that the quantity supplied also depends on the cost of firms in terms of wages (*W*), while the quantity demanded depends on disposable income (*D*). The system can now be defined as:

Supply: $Q = a_s + b_s P + cW$

Demand: $Q = a_D + b_D P + dD$

P and *Q* are the endogenous variables and W and D are the exogenous variables. In general, for each additional equation to be identified in the system, having at least an additional exogenous variable was necessary.

Another way is to assume there are time dependent relationships in which current values of endogenous variables depend upon past values of endogenous variables as well as exogenous variables. The combination of exogenous and past endogenous variables can be called predetermined variables.

This way of identification usually refers to as the practice of the “Cowles commission”. The idea is to quantify the effect of an exogenous variable on the endogenous variables in the system. Typically variables controlled by the monetary policy maker (the instruments) are taken as exogenous while macroeconomic variable (the final goal of the policy maker) are taken as endogenous.

The practice of the Cowles commission was attacked on several grounds in the 1970s, (did not represent theory, ineffective in policy analysis, etc), and was eventually abolished. Two major critiques are Lucas and Sims.

Lucas argued that expectations are not taken into account explicitly, so identified parameters are a mixture of deep parameters (preference and technology) and expectational parameters that are not stable across policy regimes, i.e. parameter invariance. Hence, models not useful for policy simulations.

Sims introduced the vector autoregressive (VAR) methodology in 1980. He raised several objections to the traditional way of identifying macroeconometric models.

- Exclusion restrictions were routinely imposed and the decision whether a variable should be regarded as exogenous with respect to the system was made rather arbitrarily.

- Identification was often achieved without solid economic or econometric arguments.

- In particular, no variable can be deemed as exogenous in a world of rational forward looking agents.

Sims' basic idea was to treat all variables as endogenous and first estimate an unrestricted model in a reduced form.

No prior knowledge is used except to decide which variables should enter the system.

After estimation by OLS (which we will see is consistent and, under normality of the error terms, efficient), structural shocks are identified.

Sims original idea was to assume recursive contemporaneous interactions among variables, i.e. by imposing a certain structural ordering of the variables. In terms of the moving average (MA) representation, the structural shocks do not affect preceding variables simultaneously.

Later on, restrictions have come in a variety of forms, general short run restrictions, (zero or linear depend relationship), long run restrictions, sign restrictions etc.

3. The VAR'S and simultaneous equations models (SEM'S)

The simultaneous equations models (SEM's) approach interprets the failure of the traditional Cowles approach as a result of specification strategy leading to misspecified models.

LSE approach: Specification should be general-to-specific of a reduced form VAR. Focus on specification (lags, misspecification tests).

Identify and impose long run (cointegration) structure to re-specify the VAR as a VeqCM. Focus is not on the potential of macroeconometric modeling for simulation and policy evaluation.

Both the SVAR and the SEM models can be thought of as versions of the general linear stochastic difference equation model

$$C(L)y_t = \beta + \varepsilon_t \tag{1}$$

where C(L) is a matrix polynomial of the lag operator L and C_0 is full rank. Most structural VAR models require that the elements of the ε_t vector be independent (in the Gaussian case that $\mathrm{var}(\varepsilon_t) = \Omega$ be diagonal). It is also often assumed that if we multiply (1) with C_0^{-1}, (1) can be written as a function of its lags only:

$$C_0^{-1}C(L)y_t = D(L)y_t = C_0^{-1}\beta + C_0^{-1}\varepsilon_t = \gamma + v_t$$

Assume y can be parted into x and m, where x is a vector of macroeconomic (non-policy) variables such as output and prices, and m is a vector of variables controlled by the monetary policy maker (e.g. interest rates).

In the traditional Cowles commission (and SEM), the monetary policy variables are considered exogenous on the grounds that these are the instruments controlled by the policy-maker. Identification in these models is obtained without assuming the orthogonality of structural disturbances (which as we shall see later is at the heart of SVARs).

Dynamic multipliers are used to describe the impact of monetary policy variables on macroeconomic variables. When computing these multipliers, the response of macroeconomic quantities to monetary policy is usually obtained without decomposing monetary policy into its endogenous and exogenous components.

The SEM framework has two standard forms. In one, the system can be described with a Granger causal ordering, i.e. rewrite (1) as

$$\begin{bmatrix} C_{11}(L) & C_{12}(L) \\ 0 & C_{22}(L) \end{bmatrix} \begin{bmatrix} x_t \\ m_t \end{bmatrix} = \begin{bmatrix} \varepsilon_{xt} \\ \varepsilon_{xt} \end{bmatrix},$$

with Ω block diagonal. In this case the m's are **exogenous**, but there is no requirement that ε_{xt} should be an innovation. What is required is only that the full sample's $\{m_t\}$ vector be independent of the full sample's $\{\varepsilon_{xt}\}$ vector.

In the other standard form, only $C_{11,0}$ is block triangular, Ω is block diagonal as before, and the ε_t vector is assumed to be the innovation vector. In this case $\{m_s | s \leq t\}$ are **predetermined**.

For both SEM and SVAR, the usual claim for a structural interpretation is that an equation or block of equations can be altered or replaced to represent a particular intervention, for example a change in policy behavior.

The most important difference between SEM and SVAR is that SVAR usually assert diagonality of Ω, while SEM's do not.

Hence, SEMs leave an ambiguity as to how to interpret "changing a structural equation". Identification in SEM, simultaneous versus sequential causality; data-model correspondence versus model-reality correspondence

In the example above, the assumed exogeneity of the monetary variables makes the model invalid for policy analysis if monetary policy reacts endogenously to macroeconomic variables, (ie. rule out Taylor rules).

The SEM approach also recognize the problem of the invalid exogeneity assumption for monetary policy, and could instead proceed to identify an alternative larger model. However, the new model would still be used for simulation and econometric policy evaluation, whenever the appropriate concept of exogeneity were satisfied by the adopted specification.

In a standard SVAR, it is natural to suppose that this intervention leaves the joint distribution of the non-policy disturbances in the system unaffected. But in a standard SEM, the model implies that in the past disturbances to policy were correlated with disturbances elsewhere in the system.

How should we "hold constant" the distribution of the non-policy disturbances when we fix a time path for the monetary policy variable (interest rate)? We could simply hold the joint distribution of non-policy disturbances constant. This would imply that we interpret the historical correlation of disturbances as reflecting causal influence of non-policy shocks on policy behavior.

However, this approach is not satisfying. If we think that historical correlations of policy with non-policy disturbances reflect influences of private sector behavior on policy, then these influences ought to be accounted for in our policy behavior equations, and vice versa if we think causality has run the other way.

So long as disturbances are correlated, the model does not provide a complete description of how to model a policy change. This is an important difference between the actual practice of most SEM modelers and SVAR modelers.

In VAR models, it becomes crucial to identify monetary policy actions using restrictions independent of the model under investigation, and taking into account potential endogeneity of policy instruments.

VAR is also different in the typical questions being asked. Like quantitative DSGE Models, SVAR asks “How should the Central Bank respond to shocks in macroeconomic variables?” (rather than previously: What is the optimal response in MP to movements in macroeconomic variables for achieving a given target).

One way to describe the Lucas critique of econometric policy advice is to say that he pointed out that parameters characterizing monetary policy behavior are likely to appear, via expectations, in many equations of the model, not just in the “policy equations”. Thus an attempt to predict the effects of a policy change by changing only the policy equation, holding other equations in the model fixed, will fail, because the other equations will in fact change when the policy changes.

4. Econometrics of SVAR

In this course, we will learn how to

1. Starting from a general VAR, choice of variables etc., (Granger causality)
2. Simplifying the VAR: lag length and significance
3. Inverting the VAR – MA representation (Properties of VAR, stability etc.)
4. Structural identification
5. Policy or theory evaluation via impulse response analysis and forecast error decompositions.

Structural VAR → Reduced VAR → MA → Identification → Structural interpretations

Research program for parameterization of economic models

1. Monetary policy shocks are identified in actual data

2. Response for relevant economic variables to monetary policy shocks are described

3. The same experiment is performed in the model economy (DSGE) to compare actual and model based responses as an evaluation tool and a selection criteria for theoretical models.