

# Vector Autoregressions

Brunner, ed. (1972). *Problems and Issues in Current Econometric Practice*. (OSU)

- Based on two conferences held to address the issue.
- Many papers were highly critical of large-scale econometric (structural) models.

Christ (1975), *IER*.

- Assessed 11 U.S. Economy models
- "...[the models] disagree so strongly about the effects of important monetary and fiscal policies that they cannot be considered reliable guides to such policy effects..."

McNees (1982), *Journal of Forecasting*.

- Argued that criticisms were unfair unless you could offer a superior, alternative model.

Cooper (1972) in Hickman (ed.); and Nelson (1972), *AER*.

- "The prediction performance of the FRB-MIT-Penn model..." demonstrates the 'good' forecasting performance of time series model relative to large-scale structural econometric models.

H Methods of identification and estimation of simultaneous equation models were being questioned.

Sargent and Sims (1977), *FRB Minneapolis*.

- “Researchers have made the unwarranted assumption of too much *a priori* theory when building their models.”
- Extended in Sims (1980) “Macroeconomics and Reality”.

Lucas and Sargent (1979), *FRB Minneapolis*.

- Argue that rational expectations are not properly represented in the large-scale models.

Consider the Identification Issue (getting from the reduced form equations to the structural equations and parameters):

- We seek reduced-form equations to exploit the assumption that in this form the RHS variables are uncorrelated with the residuals.
- This is more or less equivalent to the exogeneity assumption, which was also called into question. This failing, more general techniques are required.
- Identification amounts to finding linear restrictions (exclusion restrictions) to ensure that the structural parameters can be recaptured.

- Economic Theory is applied to exclude nonsalient variables so as to dictate the specification of each equation in the system. That is to say, identification reduces to specification.
- Prior to Sims (1980), the debates about simultaneous equations systems revolved around problems of over-identification and the selection of included variables. Sims (1980) changes the focus.

Prior to Sims, the focus in modeling was essentially the so-called “Cowles Commission Approach”:

1. A structural system captures jointly determined variables in relationships that represent the principal theories of economic behavior.
2. Broader economic theory defined the restrictions necessary for identification.
3. Decisions regarding endogenous variables and their explanatory variables must be explained by economic theory.
4. The spirit is more one of verification of theory.

There is a presumption about the direction of causality and the nature of the exogeneity.

- Causality is taken as *a priori* and untestable, even though causality testing may examine statistical orderings.
- Exogeneity is a property of a structural model, an assumption based on *a priori* theory.

Robert Lucas, Rational Expectations, and the Lucas Critique.

- “... no reason to believe that the structural parameters remained invariant under a policy intervention.”
- The expectations and the forecasts that result from the model must be consistent.

Sims (1980) is “... uneasy about the *a priori* restrictions on lag lengths employed for the identification of rational expectations models.”

Specifically, he suggests:

- Include all salient variables in all structural equations.
- He denies that *a priori* theory can yield the necessary restrictions for identification.
- The model is not “testable” since the structural form is not estimable.
- Structural identification is not needed for forecasting and policy analysis.

According to Sims, why can't economic theory be relied upon for identification?

- Econometric models abstract from the real world by limiting the number of variables under consideration.
- Thus, there always exist excluded relevant variables, excluded from the models and from individual equations.
- Identification through exclusion restrictions requires that some exogenous variables appear only in some equations and not in others—hence more excluded variables.
- If you don't provide the exclusions restrictions, the system will not be identified.
- In a macroeconomy, virtually all variables are endogenous, so that models are generally underidentified.

"Few variables are truly exogenous, so that endogenous variables are being treated as 'as if' they were exogenous. Therefore, the equations are underidentified."

- Sims suggests an alternative:
  - Replace all *ad hoc* expectations formation with REH.
  - Endogenize all the variables.
  - Forget trying to transform the reduced forms to recover the structural equations.

Sim's Structural Model:

$$B\mathbf{y}_t + \sum_{j=1}^p \Gamma_j \mathbf{y}_{t-j} = \mathbf{u}_t$$

$\mathbf{y}_t = N \times 1$  vector of current variables

- B and  $\Gamma_j$  are  $N \times N$ , full (not sparse) matrices.
- No exogenous variables. Only predetermined variables. No restrictions.
- All variables are endogenous. Use all lags (the same lag lengths) for all variables, although he admits that there must be some “pragmatic limits” to lag lengths.
- He argues that one should include all variables on the RHS of all the equations to capture all forms of possible (linear) interaction.
- Because the model does not rely on any particular economic theory, he refers to the model as “atheoretical”.
- Sims refers to this as a vector autogression or VAR.

H Sims argues that the assumption that sum variables are exogenous is not “innocuous”.

Example: Money-Income Model.

$$\mathbf{y}_t = \sum_{i=1}^p \mathbf{a}_i M_{t-i} + \sum_{j=1}^p \mathbf{b}_j \mathbf{y}_{t-j} + \varepsilon_1$$

$$M_t = \sum_{i=1}^p \mathbf{c}_i M_{t-i} + \sum_{j=1}^p \mathbf{d}_j \mathbf{y}_{t-j} + \varepsilon_2$$

Note that money and income are treated symmetrically. This avoids the theoretical issue of the exogeneity of the money supply.

H Webb (1984), *FRB Richmond Rev.* compares a 5-variable, 6-lag VAR to a structural model containing several hundred variables, and concludes that “the VAR model holds its own....”

Pagan (1987) summarizes the VAR Method:

1. Transform the data so that a VAR can be fitted to it. (Make sure the series are stationary, etc.)
2. Choose as large a lag-length ‘p’ and as large a dimension of  $y_t$  as is possible given the size of the data set. Then fit the VAR.
3. Try to simplify the VAR by reducing ‘p’ or by imposing ‘smoothness’ restrictions on the coefficients.
4. Address questions of interest to the reduced form.

Cooley and LeRoy (1985), *AER*. “Atheoretical macroeconometrics: a critique.” Criticizes the last step (4).

Using the VAR for policy analysis is only possible in the narrow sense of adding a known “innovation shock” to the model.

- Rewrite the model as a moving average model.

- Apply the shock.
- Trace out the effects of the unexpected shocks to the  $i$ th variable on all subsequent values of all the variables.
- This is all done under the unstated assumption that the behavior of the system is not the underlying economic origin of nature of the shock. I.e., all shocks look alike and are unrelated to (independent of) anything in the model.
- The response of the system is then examined by simulating different combinations of shocks.
- An implication of this approach is that a VAR could not be used to evaluate the effect of policy interventions in the form of changes in the feedback rule governing a monetary or fiscal policy variable.