Macroeconometrics

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1 Introduction and Motivation

1.1 Macroeconometrics

- Macroeconometrics encompasses large variety of probability models for macroeconomic time series as well as estimation and inference procedures (frequentist and Bayesian)
- Goal: study the determinants of economic growth, to examine the sources of business cycle fluctuations to understand the propagation of shocks, generate forecasts, and to predict the effects of economic policy changes.
- term 'macroeconometrics' is often narrowly associated with large-scale system-of-equations models in the Cowles Commission tradition that were developed from the 1950s to the 1970s.
- models came under attack in mid 1970s:
  - Lucas (1976) argued that the models are unreliable tools for policy analysis because they are unable to predict the effects of policy regime changes on the expectation formation of economic agents in a coherent manner.
  - Sims (1980) criticized that many of the restrictions that are used to identify behavioral equations in these models are inconsistent with dynamic macroeconomic theories and proposed the use of vector autoregressions (VAR) as an alternative
- modern view of macroeconometrics that is closely tied to modern dynamic macroeconomic theory
- focus on challenges that arise in the econometric analysis of dynamic stochastic general equilibrium (DSGE) models and vector autoregressions (VAR).

1.2 VAR and SVAR models

- The vector autoregressive (VAR) model is a widely used model for multivariate time series analysis.
- consists of a system of regression equations.
- VAR models are estimated by regressing each model variable on lags of its own as well as lags of the other model variables up to some pre-specified maximum lag order
- Similar to dynamic simultaneous equations models such a model is known as a reduced form, defined as a model that expresses the current values of the data as a linear function only of its own lagged values and lagged values of the other model variables.
- This model has proved useful for summarizing the properties of the data, for forecasting, for testing for the existence of equilibrium relationships tying together two or more economic variables, and for quantifying the speed with which the model variables revert back to the equilibrium following a disturbance.
- Structural analysis requires premise that reduced-form VAR model as representing data generated from the structural VAR model
- structural vector autoregressions have evolved into one of the most widely used models in empirical research using time series data. They are used in macroeconomics and in empirical finance, but also in many other fields including agricultural economics and energy economics.
- Structural in the sense that shocks are postulated to be mutually uncorrelated with each element of reduced-form errors, i.e. having a distinct economic interpretation
- Thus we can interpret movements in the data caused by any one element of the structural shock as being caused by that shock.
- Structural shocks in general are not directly observable, but under suitable conditions may be recovered from the reduced-form representation
- The problem of finding suitable economically credible restrictions is known as the identification problem in structural VAR analysis.
- We will cover alternative strategies for achieving identification.
- The existence of a structural VAR model allows us to quantify causal relationships in the data that are obscured in reduced-form VAR analysis.
- Example: Suppose that the structural shock of interest involves changes in monetary policy not in response to macroeconomic conditions. After expressing the estimate of the VAR model in a suitable form, one may answer a range of questions about the causal effects of this shock:

- How much will an unexpected monetary policy tightening in the current quarter reduce output growth over the next two years, when that policy change occurs all else equal and is not followed by any further monetary policy shocks after the current quarter. The response of output growth to this shock over time can be quantified in the form of an impulse response function.
- How much of the variability of output growth on average is accounted for by shocks to monetary policy as opposed to other structural shocks. This question can be answered by a forecast error variance decomposition.
- How much of the recession of 1982, for example, is explained by the cumulative effects of earlier monetary policy shocks. This question can be answered by constructing a historical decomposition.
- How much the recession of 1982 would have deepened, had monetary policy makers not responded to output growth at all. This question, under suitable conditions, may be answered by a policy counter-factual.

- Chief advantage of the structural VAR model: tends to fit the data well and only involves minimal identifying restrictions (no cross-equation restrictions or exclusion restrictions on the reduced form)

1.3 DSGE models

- broad class of dynamic macroeconomic models that spans the standard neoclassical growth model discussed in King, Plosser, and Rebelo (1988) as well as the monetary model with numerous real and nominal frictions developed by Christiano, Eichenbaum, and Evans (2005)
- common feature: decision rules of economic agents are derived from assumptions about preferences and technologies by solving intertemporal optimization problems
- agents potentially face uncertainty with respect to, for instance, total factor productivity or the nominal interest rate set by a central bank.
- uncertainty is generated by exogenous stochastic processes or shocks that shift technology or generate unanticipated deviations from a central bank's interest-rate feedback rule.
- Conditional on distributional assumptions for the exogenous shocks, the DSGE model generates a joint probability distribution for the endogenous model variables such as output, consumption, investment, and inflation.

2 What are goals?

- Business cycle analysts are interested in identifying sources of fluctuations: how important are monetary piolicy shocks for movements in aggregate output?

- understand the propagation of shocks, e.g., what happens to aggregate hours worked in response to a technology shock?
- questions about structural changes in the economy:
  - has monetary policy changed in the early 1980s?
  - Why did the volatility of many macroeconomic time series drop in the mid 1980s?
- forecasting the future:
  - how will inflation and output growth rates evolve over the next eight quarters?
- predict the effect of policy changes:
  - how will output and inflation respond to an unanticipated change in the nominal interest rate?
  - Is it desirable to adopt an inflation targeting regime?

3 What are the challenges?

- Principle: specify a DSGE model that is sufficiently rich to address the substantive economic question of interest; derive its likelihood function and fit the model to historical data; answer the questions based on the estimated DSGE model.
- easier said than done
- trade-off: between theoretical coherence and empirical fit
- Misspecification: calibration as in Kydland and Prescott (1996) vs recent Bayesian and non-Bayesian formal econometric tools
- Presence of misspecification might suggest: ignore the cross-coefficient restrictions implied by dynamic economic theories in the empirical work and try to answer the questions posed above directly by VARs.
- Unfortunately, there is no free lunch
- VARs have many free parameters and without restrictions on their coefficients can lead to poor forecasts.
- VARs do not provide a tight economic interpretation of economic dynamics in terms of the behavior of rational, optimizing agents.
- Difficult to predict the effects of rare policy regime changes on the expectation formation and the behavior of economic agents since these are not explicitly modelled
- DSGE vs SVARs: trade-off between theoretical coherence and empirical fit remains.

- Challenge: identification. The parameters of a model are identifiable if no two parameterizations of that model generate the same probability distribution for the observables.
- In VARs the mapping between the one-step-ahead forecast errors of the endogenous variables and the underlying structural shocks is not unique, and additional restrictions are necessary to identify, say, a monetary policy or a technology shock.
- DSGE models can be locally approximated by linear rational expectations (LRE) models. While tightly parameterized compared to VARs, LRE models can generate delicate identification problems.
- in many cases difficult to detect identification problems in DSGE models, since the mapping from the structural parameters into the autoregressive law of motion for the observables is highly nonlinear and typically can only be evaluated numerically.
- Many regularities of macroeconomic time series are indicative of nonlinearities (rise and fall of inflation in the 1970s and early 1980s, time-varying volatility of many macroeconomic time series)
- In VARs nonlinear dynamics are typically generated with time-varying coefficients, whereas most DSGE models are nonlinear and only for convenience approximated by linear rational expectations models. Conceptually the analysis of nonlinear models is very similar to the analysis of linear models, but the implementation of the computationsis often more cumbersome and poses a third challenge.
- VARs typically have many more parameters than DSGE models and the role of prior distributions is mainly to reduce the effective dimensionality of this parameter space to avoid over-fitting.
- More interestingly, if one interprets the DSGE model as a set of restrictions on the VAR then the DSGE model induces a degenerate prior for the VAR coefficients.