Models for Monetary Policy

Central Bank of Iceland

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1 Why Models?

- Everyone uses models—either implicit or explicit

- Explicit models are preferred

- Some reasons for using explicit models
  - help tell consistent stories
  - impose discipline on policy analysis and policy making
  - help communicate to public in consistent and credible manner

- Models complement but *do not* replace judgment and sector expertise

- Multiplicity of models reflects
  - different economic and political prior beliefs
  - different trade-offs between fit and interpretability

- How should we handle multiple models?
  - take model uncertainty seriously

2 Which Model(s)?

- In practice, a trade-off between fit and interpretability
  - but most models have problems with both
- Multiple models for the foreseeable future
- Models now in use at central banks
  1. reduced-form forecasting
  2. traditional simultaneous equations
  3. dynamic stochastic general equilibrium
  4. identified VARs

- Simultaneous equations and DSGE are special cases of identified VARs
  - impose restrictions often avoided by VARs
- Restrictions from theory aid in interpretation often at cost of fit to data
- I will focus on Bayesian identified VARs
- Bayesian priors serve three purposes
  - improve fit and out-of-sample forecast performance
  - incorporate economically meaningful prior information
  - produce complete posterior distribution

3 Identified VARs

- General strategy: impose as few restrictions as necessary to identify objects of interest

- Example: separate economy into behaviorally distinct sectors
  - monetary policy
  - money demand/banking sector
  - goods and labor markets
  - auction-market prices

- VAR:

$$A_0 X_t = A(L) X_{t-1} + \varepsilon_t$$

X_t : vector of endogenous variables like GDP, price level, employment, exchange rate, short-term nominal interest rate, money stock

- Restrictions placed on A_0 such that
  - each type of behavior of interest is identified
  - equivalently, each exogenous shock of interest, ε_t^i, uncorrelated with other shocks of interest
  - no restrictions placed on $A(L)$

- Note: could deviate from spirit of VAR and impose restrictions on $A(L)$
  - might be interested in "simple" relations
  - might wish to impose "small open economy" restrictions—rest of world exogenous

- Monetary policy: one equation in system

$$R_t = f(\Omega_t) + \varepsilon_t^{MP}$$

Ω_t : central bank's information at t

f : linear function ("systematic" policy)

ε_t^{MP} : exogenous shift in policy (policy "shock")

- Disturbances to ε_t^{MP} should produce the dynamic impacts of monetary policy

4 What Identified VARs Can Do

Given *some* identification of exogenous policy

- Basic forecasting
  - out-of-sample forecasts
- Counterfactual questions
  - projections conditional on interventions: exogenous paths for policy or other variables

- Display and evaluate trade-offs
  - joint distributions of forecasts
  - joint probability statements for policy
- Define a *policy intervention* to be a hypothetical path for $\{R_t\}$
  - engineered by a particular path for $\{\varepsilon_t^{MP}\}$, holding all other ε's fixed
- Inflation targeter: what path of $\{R_t\}$ over the next k years will bring inflation to its target value?

- When is this a reasonable exercise?
  - we are holding estimated A's fixed: Lucas critique
  - requires that ε_t^{MP} uncorrelated with other ε's
- Any model is "structural" only for *some* class of interventions (Hurwicz via Cowles)
  - Lucas critique relevant to any modeling technique
- respect Lucas critique: is contemplated intervention "modest"?

Example from Leeper-Zha (*JME* 2003)

A standard identification of policy in small model

Consider an intervention on policy variable (e.g., exogenous part of policy):

$$I_T = \{\tilde{\varepsilon}^{MP}_{T+1}, ..., \tilde{\varepsilon}^{MP}_{PT+K}\}$$

Take draws from distributions for $\left(\hat{A}, \hat{\varepsilon}\right)$ to get distribution for $\{X_t\}$ conditional on I_T

- compute "rivers of blood"

- assess risks to forecast

How likely are the effects of I_T given policy's historical impacts?

- If likely, then I_T is *modest* and projections reliable
  - agents unlikely to infer regime changed, so original decision rules hold
- If unlikely, then I_T is *immodest* and projections unreliable
  - agents may infer regime changed, so they update decision rules and destabilize constant-parameter VAR

Figure 1. Forecasts Conditional on Actual and Tighter Policy

Actual (solid) and out-of-sample forecast (dashed). First column: forecasts conditional on actual path of the federal funds rate from October 1990 to January 1991 (8.11%,7.81%,7.31%,6.91%); second column: forecasts conditional on tighter policy (8.70%,8.95%,8.95%,8.95%). 68% probability bands (dashed). Annual average growth rates or percentage points.

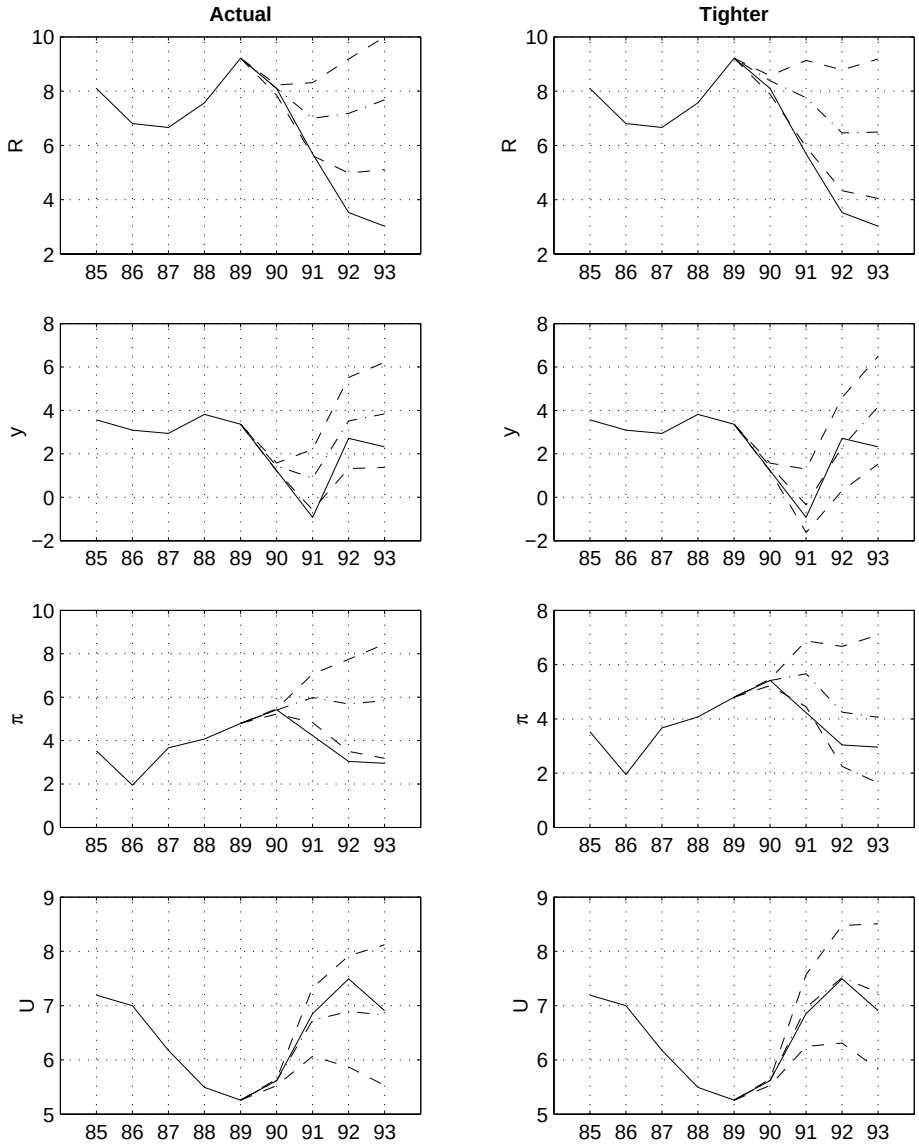

Table 1. Joint and Marginal Probabilities Conditional on Alternative Policies

Outcomes Based on Out-of-Sample Forecasts from September 1990.
"Tighter" policy raises R^f to 8.70% in October and to 8.95% in November 1990-January 1991 and is produced by the sequence of exogenous actions $\tilde{\varepsilon}_P = (2.3,1.7,1.0,0.9)$.
"Actual R^f" sets R^f at 8.11% in October, 7.81% in November, 7.31% in December, 6.91% in January 1991 and is produced by the sequence of exogenous actions $\tilde{\varepsilon}_P = (0.5,0.1,-0.7,-0.7)$.

	Tighter	Actual R^f
P(*low* π *in* 1992)	.67	.47
P(*low* π *in* 1993)	.66	.46
P(*low* π *in* 1992 and 1993)	.57	.36
P(*recession in* 1991)	.53	.27
P(*recession in* 1992)	.12	.05
P(*recession in* 1993)	.05	.06
P(*recession* and *low* π)	.33	.11
P(*recession* and *high* π)	.25	.22
P(*no recession* and *low* π)	.24	.25
P(*no recession* and *high* π)	.18	.42

P(*recession*) is the probability of negative real GDP growth in 1991 or 1992 or 1993.
P(*low* π) is the probability of inflation below 5½ percent in 1992 and 1993.
P(*recession* and *low* π) is the probability of negative real GDP growth in 1991 or 1992 or 1993 *and* inflation below 5½ percent in 1992 and 1993.

- Business-as-usual policy questions
  - 50-bp increase in R over next few months
  - constant R over next few months

* tend to involve modest interventions

* projections from linear models reliable

- Conditioning on constant R over 2-3 years

– tends to need an immodest intervention: effects on $\{X_t\}$ unlikely to arise given historical effects on X of fluctuations in ε

– projections unreliable

Use projection techniques to address

- Counterfactuals about "structural" aspects of economy
  - degree of competitiveness of markets
  - degree of financial market integration
  - degree of forward-looking behavior
- Requires constructing interventions that mimic these aspects
  - still intervening on shocks, rather than parameters
  - a question of perceived persistence of changes

5 What Identified VARs Could Do

1. Extend identification to entire model

   (a) many behavioral relationships

   (b) restrictions on lags

   (c) cross-equation restrictions

– overidentifying restrictions: the economist's friend (but test them)

– freed of "incredible restrictions" stricture

– nothing to lose but your unidentified parameters

2. Priors on economically meaningful objects

   (a) uncovered interest parity

   (b) liquidity effect/Fisher relation

   (c) expectations theory of term structure

   (d) slope & location of Phillips curve

   (e) signs & magnitudes of elasticities

3. Expand size of VAR (Bayesian)

   (a) LSZ estimated 18-variable systems

   (b) break model into sub-systems to disaggregate

   (c) combine weekly/monthly and quarterly data

4. Integrate judgmental analysis

   (a) compute projections conditional on subjective forecasts

   (b) compare model forecasts to subjective forecasts

   (c) use "modesty metric" to gauge how much judgment is moving the forecast or use relative entropy (Robertson-Tallman-Whiteman)

   (d) add subjective forecasts as explanatory variables in VAR

   (e) especially useful around large unusual events

6 Things to Worry About

- Some important concerns
  - identification: try several; check robustness; check fit
  - parameter constancy
  - modeling errors (non-normality)
- Constancy: Sims-Zha
  - change in shock distribution is critical for fit
  - even with a prior concentrated on non-constant parameters, cannot dismiss constant parameter model

Need more theory of behavior under parameter drift

- e.g., on-going regime changes

- decision rules embed probability of change and nature of equilibrium can differ sharply from permanent regime environment

7 Limitations of VARs

- Identification
  - most behavioral relations not identified
    - can be addressed a la Cowles but will violate rational expectations
  - expectations not identified
    - cannot intervene easily (credibly?) on expectations formation

8 What We Would Like to Do

- Central banks have "suites" of models
  - often arose piecemeal
  - historical accidents
  - designed to handle diversity among policy makers
- How can we make sense of the disparate answers offered by these models?
- Take model uncertainty seriously

- If models competitive in terms of fit ... identified VAR and DSGE (Smets-Wouters)
  - Bayesian model averaging (Brock-Durlauf-West)
  - ascribe prior probability to each model (tied to policy makers' priors?)
  - update as new data arrive, recompute probability weight for each model as function of fit
  - over time, some models will emerge as more consistent with data and will receive heavier probability weights

- with similar predictions, DSGE offers detailed economic interpretations

- with different predictions, need to know how much attention to pay to each model (use probability weights)

9 Models and Communication

- Aligning communication and behavior
  - some inflation targeters think communication must be simple to be understood
  - but central bank behavior is *not* simple
    - even inflation targeters care about output
    - central banks recognize and act on trade-offs
  - effective communication must reflect this behavior

- Sveriges Riksbank example
  - "rule of thumb": if inflation forecast two years ahead is above 2%, they will raise the interest rate
  - a simple and easily understood rule
  - 2004:2 Statistics Sweden changed definition of CPI and forecasted inflation after 2 years was 2.2%
  - the Riksbank did not change the interest rate
  - press asked if this was a change in policy
  - the Riksbank had to explain that it doesn't *really* follow the simple rule exactly

  - modified rule to add "in normal circumstances..." (Heikensten 1999)

- Problem stems from not obeying the adage
  - "mean what you say...and
  - say what you mean"
  - because of the Riksbank's credibility, people believe that the Riksbank means what it says
  - because communication and behavior are misaligned, the Riksbank doesn't say what it means

- Morale: talking simply *does not imply* acting simply

- How can models help?

- Use a model to show
  - when you changed the rate in the past, exactly what the inflation and output forecasts were *before and after* the change
  - illustrates the impacts of monetary policy
  - shows what would have happened had the bank not taken the action
  - demonstrates trade-offs policy committee faced
  - accurately portrays policy making process

- Report the entire path of the interest rate *actually conditioned on* in the forecasts
  - most banks claim they condition on a constant rate
  - most models misbehave badly if the rate is actually held fixed over the forecast horizon (i.e., "immodest" intervention)
- Using a model to generate a believable interest rate path
  - increases credibility of the forecast
  - communicates about the bank's future intentions

- RBNZ has been publishing interest rate path for some time now
  - no problems with communication
  - no tendency for people to take the path as a firm commitment
- Optimal control approach advocated by Svensson
  - requires central bank to communicate "the model" clearly
  - combined with inflation forecast, model allows people to form expectations of future policy

  - "the model" should be regularly discussed and scrutinized publicly

- But now return full circle to the appeal of announcing interest rate path