Evaluating the Performance of Macroeconometric Models

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How to think about DSGE models...

Source: BBC, Beijing 2008 Olympic Games, men’s event.
1980s: can DSGE model reproduce key sample correlations, e.g. between output and hours worked or output and inflation? Compare model-implied correlations and sample correlations computed from actual data.

1990s: do impulse responses to, say, unanticipated changes in monetary policy, from a DSGE model look like impulse responses from a vector autoregression (VAR)?

2000’s: can DSGE models track and forecast key macroeconomic time series?

The literature has developed numerous econometric tools to provide formalize the evaluation.
Evaluating DSGE Models

- Performance in some “disciplines” is more difficult to evaluate than in others.

- **Forecasting performance:**

  \[ \text{error} = \text{forecast} - \text{actual} \]

- **policy predictions:**

  \[ \text{policy effect} = \text{counterfactual outcome} - \text{actual outcome} \]

- Forecast performance is easy to assess because forecasts can be computed from reduced form time series models.

- Policy predictions are more difficult to assess because in the absence of controlled trials the calculation of counterfactual outcomes requires elaborate structural macroeconomic models.
How Well Do DSGE Models Forecast Relative to AR(2) Models?

RMSE ratios: DSGE / AR(2).

AR(2): \[ y_t = \phi_0 + \phi_1 y_{t-1} + \phi_2 y_{t-2} + u_t. \]
What Is Important for Good Forecasts?

Getting trends right:

- Easier said than done: should trends be modeled “inside” or “outside” of the structural model?

- Example: inflation has been falling in the U.S. from 1982 to 1990
  - Use monetary policy rule with \textit{time-varying target inflation rate};
  - Use \textit{data on long-run inflation expectations} to measure time-varying target inflation rate.
Inflation expectations measure time-varying inflation target $\pi_{*,t}$;

Model interest rate policy as responding to deviations $\pi_t - \pi_{*,t}$. 

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- **Incorporating real-time information:**
  - GDP etc, used to estimate DSGE models, becomes available only with a delay
  - Either link DSGE model to monthly observations or condition DSGE model forecasts on external nowcasts for the current quarter.
RMSE Forecast Performance With and Without Blue Chip Nowcasts

- DSGE model with inflation expectations: magenta
- DSGE model with inflation expectations and nowcasts: salmon
Consider the following question: **what is a good target inflation rate?**

Imagine a stylized DSGE model with two channels:

- **Friedman channel**: inflation is a tax on transactions involving money as medium of exchange.
- **New Keynesian channel**: prices are costly to adjust and forcing firms to make price adjustments carries a resource cost.
- Of course one can think of other channels as well... ZLB, downward nominal wage rigidity, mis-measured inflation - but we abstract from these channels.
- **Empirical question**: which channel is more important?

**Should we use the parameters that deliver best forecast performance to determine the optimal inflation rate?**
Empirical Analysis

- Suppose we estimate the DSGE model using a likelihood-based approach that optimizes one-step-ahead predictive performance...
Here Are the Welfare Implications
Suppose we estimate a vector autoregression using the same data to estimate the DSGE model.

It turns out the VAR does a slightly better job tracking the data.

We can’t use the VAR for the welfare calculations, but at least we can compare impulse responses to a shock to the target inflation rate.

Some details:
- Use inflation expectations as observation for target inflation in VAR;
- Assume that target inflation does not respond contemporaneously to other shocks.
Large discrepancy in the real-money balance response.
Why Is The Impulse Response Mismatch Problematic?

- Consider a simple money-in-the-utility function model with household preferences:

\[
\mathbb{E}_\tau \left[ \sum_{t=\tau}^{\infty} \beta^{(t-\tau)} \left\{ U(C_t) - AH_t + \frac{\chi_t}{1-\nu} \left( \frac{M_t}{P_t} \right)^{1-\nu} \right\} \right]
\]

- Getting demand for real money balance right is important for welfare calculations.

- It turns out that the estimation of parameter \( \nu \) is very important for welfare analysis.
Likelihood versus Loss-Function Based Estimation

DSGE (blue) versus VAR (red) Responses of Real-Money Balances

\[ \nu = \hat{\nu}_{\text{Bayes}} = 30 \]

\[ \nu = 3 \]

Real Money

F. Schorfheide

DSGE Model Evaluation
Welfare Implications $\nu = 30$ (Green) versus $\nu = 3$ (Red)
Lessons Learned

- Good forecasting performance does not guarantee good policy analysis... nor does bad forecasting performance!

- It's important to evaluate the predictions of your structural models and assess model misspecifications.

- VARs, FA-VARs, and dynamic factor models can play an important role in this regard - formally and informally.

- For policy analysis the measurement of policy trade-offs is very important.
There is now more work on DSGE model with (strong) nonlinearities:

- nonlinearities seem to have been important in recent episodes, e.g., Great Recession;
- we have the computational tools to analyze more complicated models than in the past.

Types of nonlinearities:

- stochastic volatility and risk shocks;
- zero lower bound (ZLB) on nominal interest rates;
- occasionally binding borrowing constraints of firms or households;
  occasionally binding regulatory constraints.
Model Solution:

- solving the model means expressing agents' decision, e.g. consumption and investment, as a function of state variables, e.g. exogenous shocks and capital stock such that equilibrium conditions are satisfied;
- this gets complicated if one allows decision rules to be nonlinear;
- imposes a constraint on the size of the model.
$g$ is an exogenous demand shock and one of the state variables in the model.
Nonlinearities – Challenges

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● **Tracking data with the model:**
  - models are driven by exogenous shocks:
    
    \[
    \text{shocks} \rightarrow \text{fluctuations}
    \]
  - When we fit the model we see the fluctuations and have to infer the shocks. This is called filtering.
  - For linear models we use Kalman filter; for nonlinear models we use simulation-based filters.
We get to observe $y_t = g(s_t; \Psi) + u_t$

We use filters to extract hidden states $s_t = f(s_{t-1}, \epsilon_t; \Phi)$
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- **Evaluating the model:**
  - for linear models we have a VAR as natural benchmark;
  - for nonlinear models no natural benchmark exists (though there are many nonlinear time series models).