Macromodeling, Model Uncertainty and Policy Advice

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Disclaimer

The views put forth in this paper and presentation are those of the author only, and are not necessarily shared by members of the Board of Governors or its staff.

On Uncertainty....

We must infer what the future situation would be without our interference, and what changes will be wrought by our actions. Fortunately, or unfortunately, none of these processes is infallible, or indeed ever accurate or complete.

–Frank Knight (1921) *Risk, Uncertainty and Profit*, p. 201-2.

An outline

I will advance five arguments, as follows:

1. Despite large advances in recent years, the policy prescriptions of modern models are as fragile as ever, if not more so
2. Modeling model uncertainty is therefore a critical step that policy advisors should embrace
3. Bayesian methods of representing model uncertainty can only go so far
4. More nonparametric methods of representing the model space need to be considered
5. Policymakers and policy advisors need to be humble

Along the way, I'll trot out a few examples

DSGE modeling: advancement with fragility

- Cross-equation restrictions and systems estimation: a mixed blessing
- Absence of criteria for the acceptability of microfoundations
- Inability or unwillingness to discriminate amongst competing models
- Nonlinearities, amplification and propagation
  - the shadow price of occasionally binding constraints

The hegemony of rational expectations

Rational expectations in the sense of Muth still rules

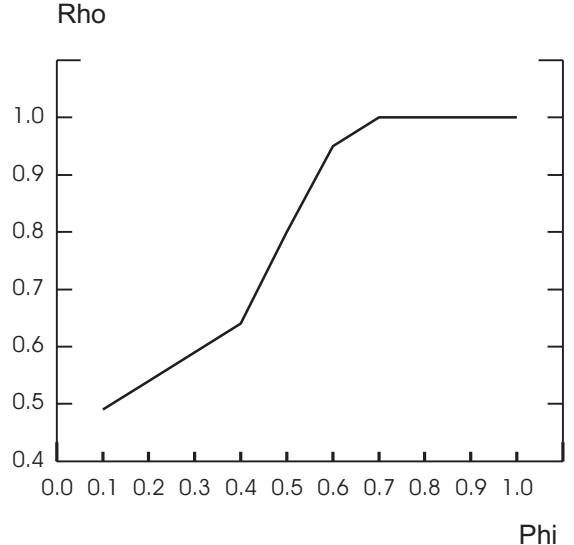
- For positive analysis, this still makes a lot of sense; for normative and policy purposes, arguably less so
- But at least the subject is open for debate:
  - *"Beware of economists bearing free parameters"* – Robert Lucas
  - *"There is a communism in rational expectations"* – Tom Sargent
- The equating of *rational expectations* with *perfect foresight*
  - Forward guidance puzzle (e.g., del Negro & Giannoni, 2015).
- Modeling paradigms and the incidence of risks of misspecification

Expectations and the Optimal Rho

Stylized Model

- $x_t = x_t^e + alpha\ z_t + u_t$
- $x_t^e = (1 - phi) x_{t-1} + phi\ x_{t+1}$
- $del(ff_t) = (1 - phi)(\overline{ff}_t - ff_{t-1})$

Source: Croushore, Sack & Tetlow (2002) *FOMC briefing*



The role of the policy advisor

Linear rational expectations models as Hollywood movies...

- First, there is the set-up of the story (there is a shock)
- A little action ensues (some propagation)
- Then the hero arrives (policy closes the model)
- And there is always a happy ending (REE is unique and stable)

The moral of the story is not that "good triumphs over evil," but...

- *"Beware of policy advisors bearing free lunches"*
- Don't be that advisor!
- *Use* linear rational expectations models, but don't stop there....

Alternatives to consider alongside rational expectations

Expectations that are forward-looking without be rational in the sense of Muth

- *Calculation equilibrium* of Evans & Ramey (1992) where one "forecast the forecasts of others."
- *Eductive Stablity.* Gusnerie (2005)
- *Near-rational expectations*, that is, ambiguity averse. Woodford (2010)

further afield, there is

- *Adaptive learning*. Evans & Honkapohja (2000)

Modeling model uncertainty

Three types of uncertainty

- *Data uncertainty*
- *Parameter uncertainty*
- *Model uncertainty*

Two basic approaches to modeling model uncertainty

- *The Bayesian approach* (parametric by nature)
- *The robust approach* (nonparametric by nature)

...of which *rival models methods* **can be Bayesian or robust**

A very incomplete listing of some literature...

Data uncertainty:

- Sack (1997); Orphanides (1997); Dennis (2002); Croushore (2006).

Parameter uncertainty:

- Brainard (1967); Rudebusch (2002); Soderstrom (2002); Nimark (2005); Kiruma & Kirozumi (2007); lots of others

Model uncertainty – the Bayesian approach:

- Brock, Durlauf & West (2003); del Negro & Schorfheide (2005, 2009), Evans & McGough (2007); Svensson & Williams (2007); others

Model uncertainty – the robust approach:

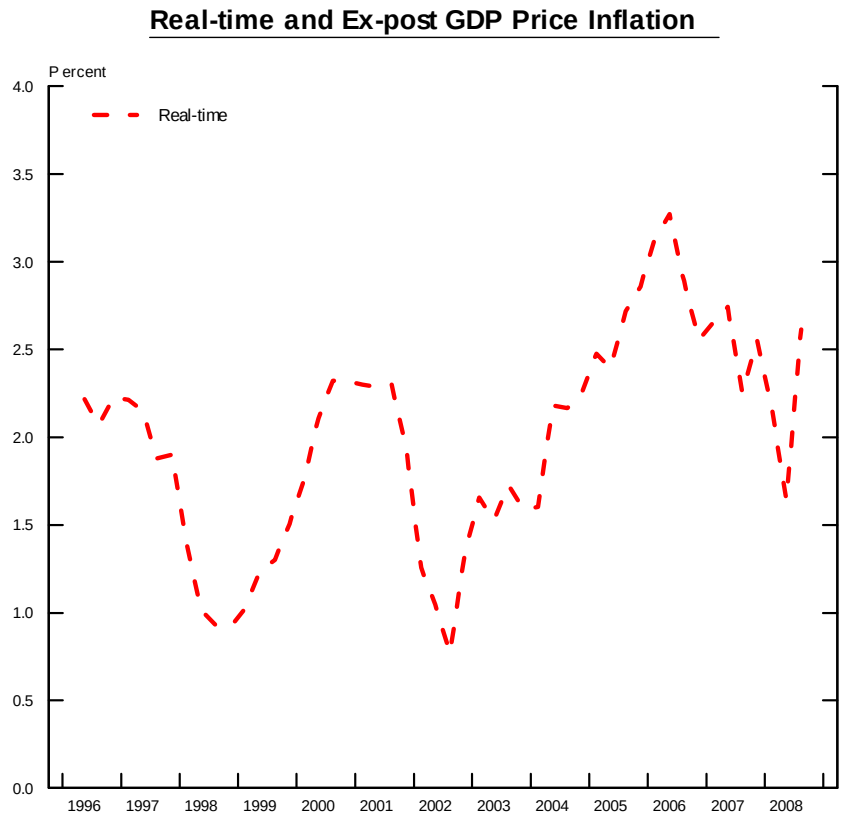
- Hansen and Sargent (2008 book); Onatski & Williams (2002); others

Rival models methods:

- McCallum (1988); Levin, Wieland & Williams (1999, 2003); Levin & Williams (2003); LOWW (2005); Kuester & Wieland (2010);Taylor & Wieland (2012); others

Data uncertainty : the deflation scare of 2002-3

"There is an especially pernicious scenario, albeit remote, in which inflation turns negative...engendering a corrosive deflationary spiral..." – *Alan Greenspan, July 15, 2003*



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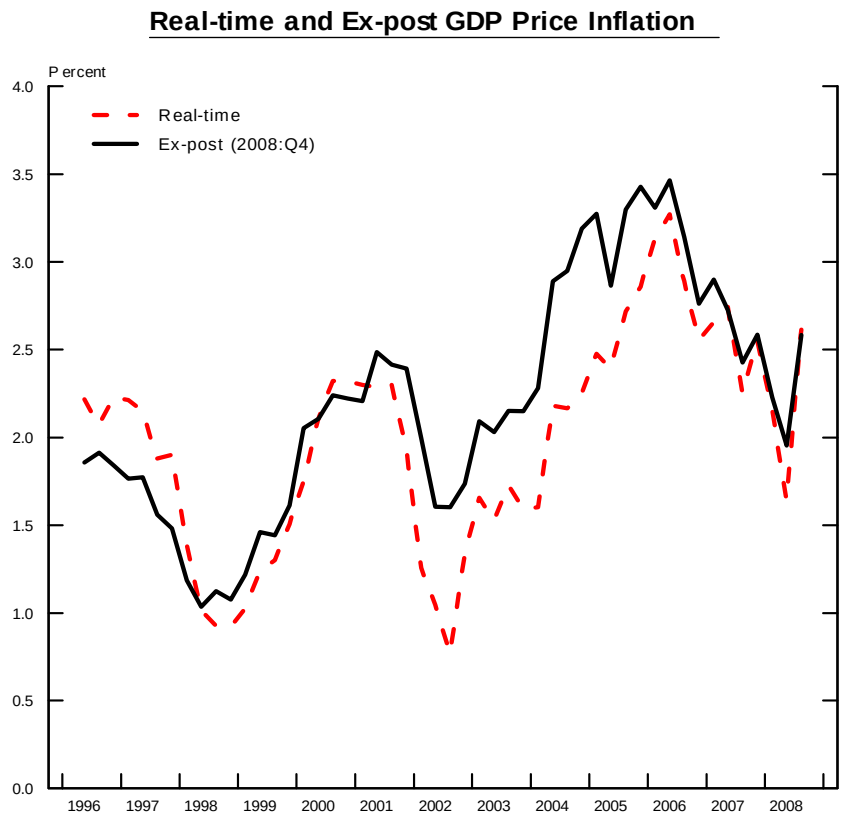


Parameter uncertainty : potential output in the late 1990s

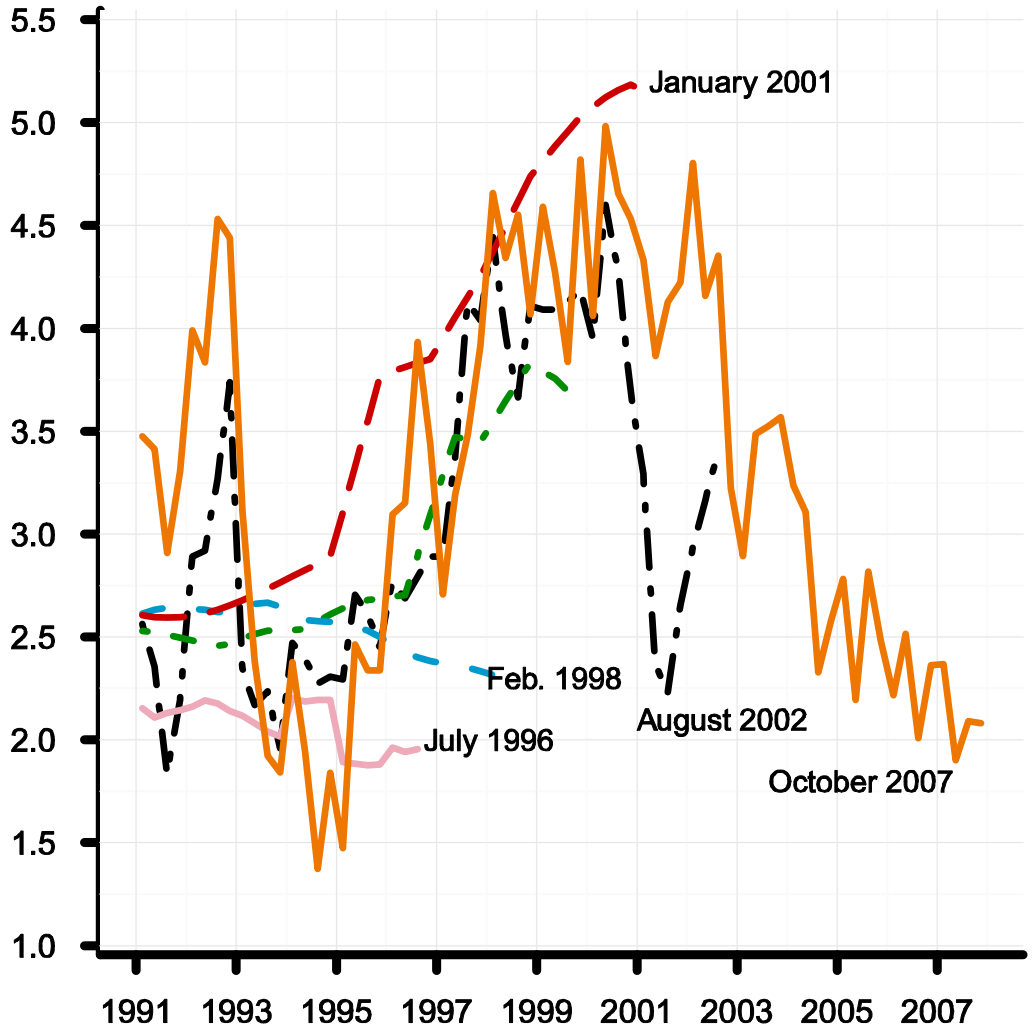
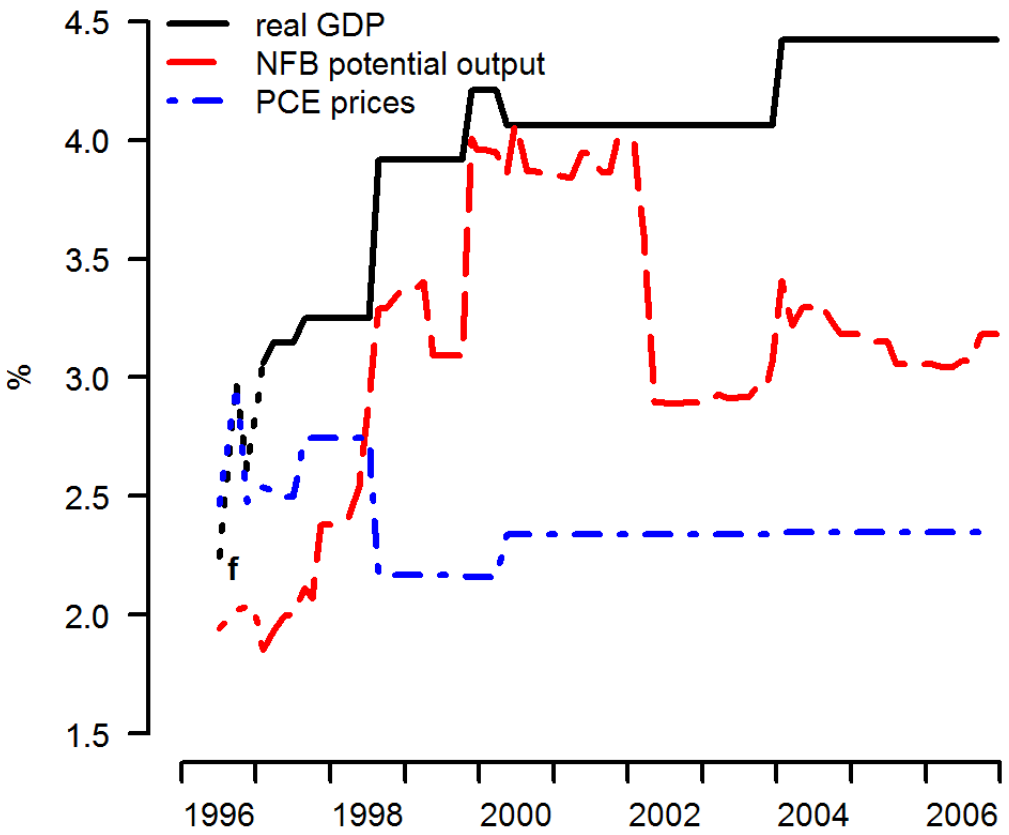


Figure: NFB potential output growth, 4Q, selected vintages

The evolution of the view of 1996



Model Uncertainty

Could be analyzed in either a Bayesian or Robust manner

- Bayesian approach is parametric
  - Whence priors?
  - Priors over priors?
  - Black swans
- Robust approach is nonparametric
  - Policymaker is unable or unwilling to attach probabilities over models...
  - ...so the policymaker just sets out a possibility set of models
  - And chooses the policy that does the best for the "worst-case" model
  - "Worst case" is generally a local concept
  - The problem of choosing the allowable set–the *rival models*

One methodology for doing rival models

Real-time Model Uncertainty

Source: Tetlow and Ironside, *JMCB* (2009); Tetlow, *IJCB* (2015).

- 46 vintages of the Fed's FRB/US model from July 1996 to October 2007.
  - Real-time data and associated latent variables
  - Real-time model multipliers
  - Real-time optimized simple rules
- Performance and robustness
  - How do optimized rules compare when the model is correct?
  - How do optimized rules compare when the model is incorrect?

The FRB/US model

Born: July 1996

- Arguably a large-scale hybrid New Keynesian model
- About 50 behavioral equations, of which perhaps half are microfounded
- Modeling based on concept of polynomial adjustment costs
- Various versions exist with different modes of expectations formation

The version employed here

- VAR-based expectations
- version used for forecasting and policy analysis at the Fed
- materials appear in the Tealbook, FOMC reports and *ad hoc* memos.

Model multipliers

Usually the response after 8 quarters of an endogenous variable to a sustained perturbation. Funds rate held at baseline (with one exception). Each figure shows two lines:

Ex post multiplier (the red dashed line)

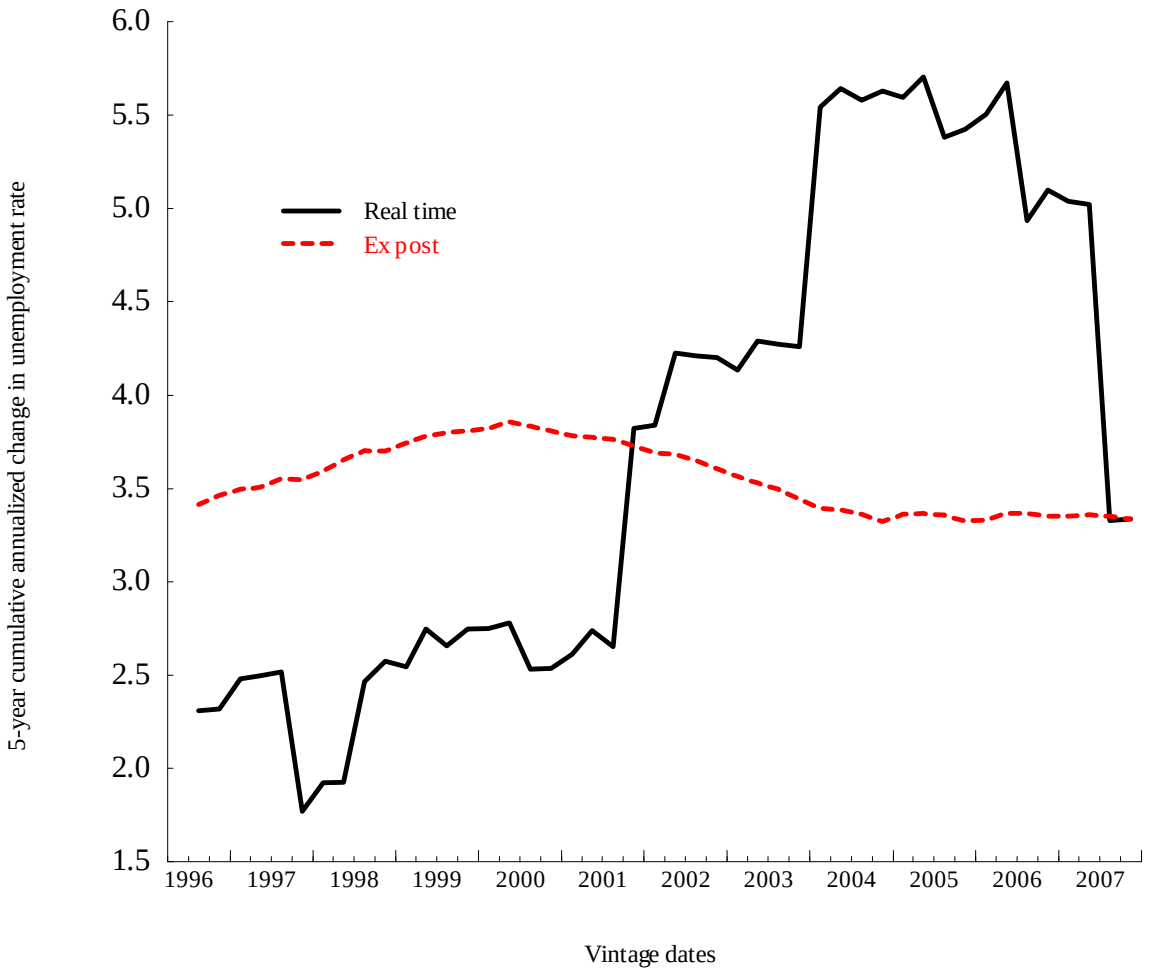
- October 2007 model vintage used over and over
- The simulation date changes to isolate nonlinearities

Real-time multiplier (the black solid line)

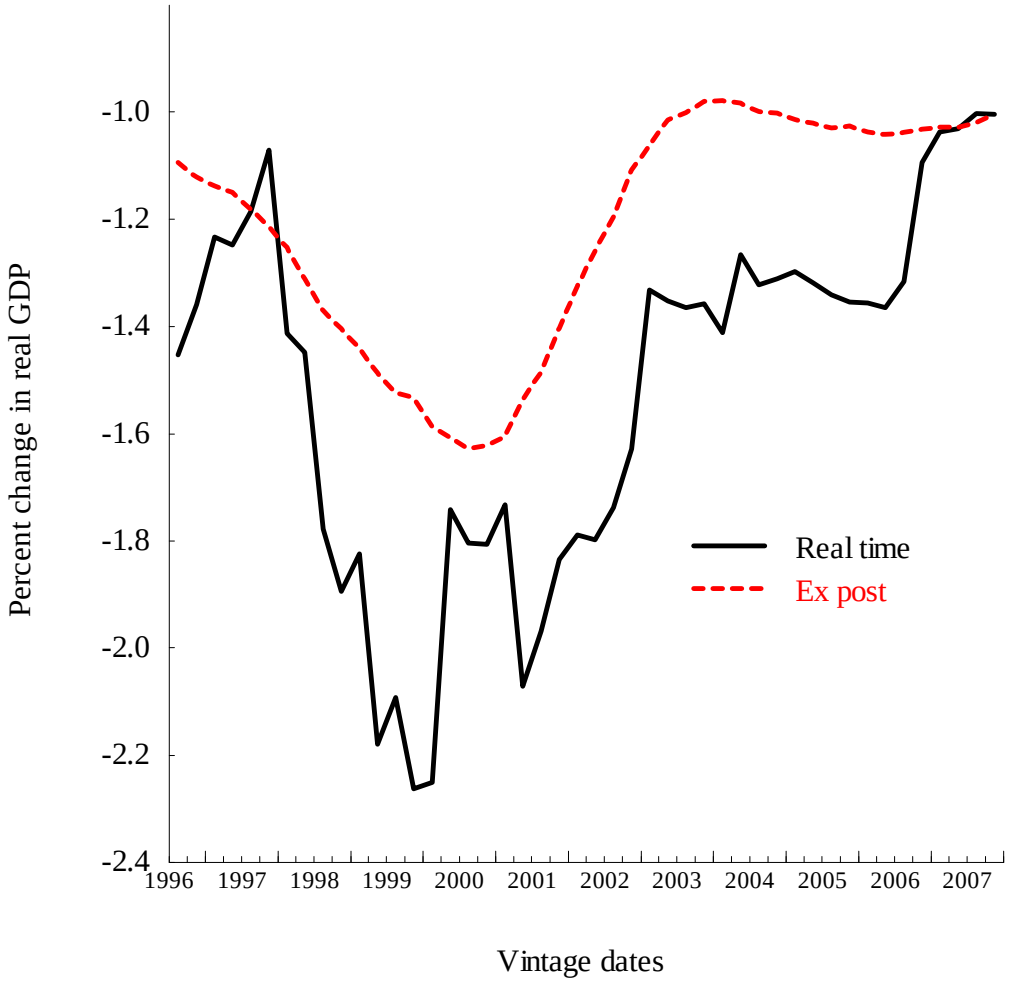
- The model, the baseline and the simulation date all change

By construction, the two lines must meet at the far-right of the chart.

Evolution of the sacrifice ratio



Funds rate multiplier



‘Robust‘ simple policy rules

- Tetlow (2015) considered eight simple rules
- Given time and space constraints, I focus mostly on the Taylor (1993) rule:

The Taylor rule (TR):

$$r_t = rr_t^* + \widetilde{\pi}_t + \alpha_y(y_t - y_t^*) + \alpha_\pi(\widetilde{\pi}_t - \pi^*)$$

- ...with a bit of attention to a rule that avoids feedback on unobservable variables, called the change-in-unemployment rule:

A change-in-unemployment rule (UNR):

$$\Delta r_t = \alpha_\pi(\widetilde{\pi}_t - \pi^*) + \alpha_y \cdot \Delta u_t$$

The policy problem

Define a policy parameter set as follows: $\Phi = \{\alpha_y, \alpha_\pi\}$. Then the objective is:

$$\underset{\langle\Phi\rangle}{MIN} \sum_{i=0}^{T} \beta^i \left[\left(\pi_{t+i} - \pi^*_{t+i}\right)^2 + \lambda_y \left(u_{t+i} - u^*_{t+i}\right)^2 + \lambda_{\Delta r} (\Delta r_{t+i})^2 \right] \tag{2}$$

subject to:

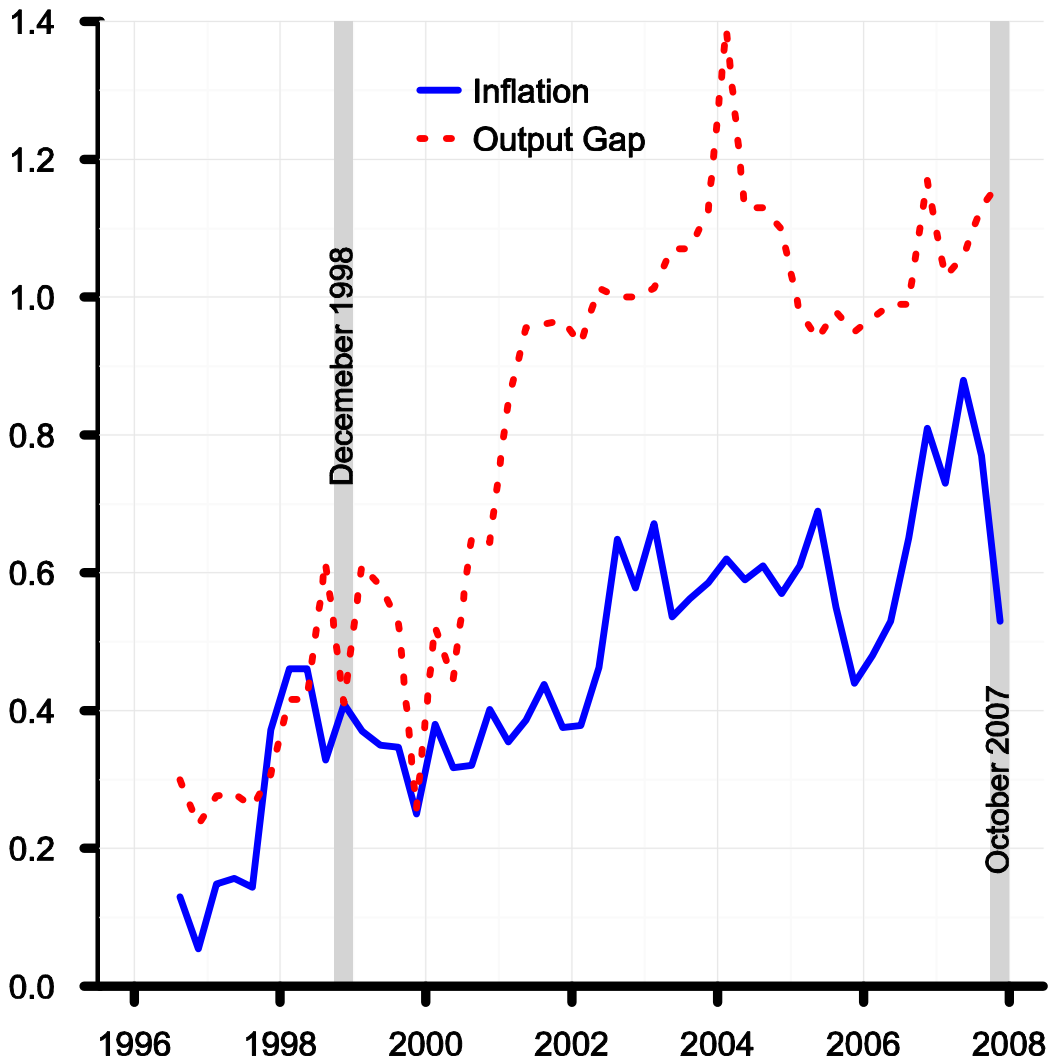
$$x_t = f\left(x_t, \ldots x_{t-j}, z_t, \ldots z_{t-k}, r_t, \ldots r_{t-m}\right) + v_t \qquad j, k, m > 0 \tag{3}$$

plus the form of the policy rule, and

$$\Sigma_v = v'v \tag{5}$$

where x is a vector of endogenous variables, with $\pi, y, r \sqsubset x$, and z is a vector of exogenous variables.

Results : optimized Taylor rule coefficients



Robustness of rules across vintages

Normalized Performance for Selected Simple Optimized Rules

Policy rule	Optimized Vintage	True model December 1998	True model October 2007
Taylor	Dec. 1998	1	1.80
	Oct. 2007	1.66	1
Change-in-unemployment	Dec. 1998	1.19	1.07
	Oct. 2007	1.38	0.88

Conclusions from the rival models exercise

- A whole lot of policy rules that are supposed to be robust turn out not to be
- Noteworthy feedback on output is critical for good and robust performance
- Policies that are robust avoid taking a stand on the equilibrium level of unobservables

Tentative Plans for Modeling Model Uncertainty at the Fed

Risk Sensitive Simple Policy Rules

- Board staff present to the FOMC in the Tealbook some presciptions of simple policy rules, like the Taylor (1993) rule
- These prescriptions from simple ad hoc rules can be augmented with:

1. optimized coefficients based on LQG environment
2. ...then add sensitivity to the prospect of the ZLB
3. ...then generalize to wider sources of uncertainty, such as unmodeled nonlinearities, pessimistic shocks and potential instabilities

- All presented together so that Committee members can see the marginal effects of each

More Plans for Modeling Model Uncertainty at the Fed

Model Misperceptions

- A monetary authority thinks it is controlling one economy, a linearized DSGE model, perhaps...
  - ...but the true economy is different; e.g., nonlinear, or not RE
  - and private agents know the truth and form expectations accordingly
  - Magnitudes of misperception disciplined based on entropy theory
  - Can be augmented with learning

Blue Sky Plans for Modeling Model Uncertainty

Decision theoretic approaches to policy advice

- The Fed maintains an expanding suite of DSGE models which can be exploited as a representation of model uncertainty
- The key decisions are to decide:
  - What models to include
  - How to weight models
  - What uncertainties to protect against
- Two possibilities:
  - Policy prescriptions from Bayesian weighting of models; e.g., Brock, Durlauf and West (2003), Svensson and Williams (2007)
  - Policy prescriptions from Robust weighting of models; e.g., Hansen and Sargent (2010), others

So you want to be a policy advisor....

Best practice on what a policy advisor needs to communicate

- A quantitative central tendency path for policy and target variables
  - Could be based on one model or a pool of models
  - Should feature an "appropriate monetary policy" that could be optimal but need not be
- An candid assessment of the limitations of the baseline model(s)
- one or more scenarios that explicitly consider uncertainty
  - could be a density forecast, preferably based on a range of models
  - could be an explicitly risk-sensitive policy
  - measures of the price of taking out insurance
- A description of how the policy could be communicated to the public

That's it!...

Thanks very much for your attention.