Macroeconomic Model Comparison and Policy Robustness: New Tools & Applications

Macro Financial Modeling Summer Session
Wequassett Resort, Cape Cod, June 17-21, 2018

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IMFS, Goethe University Frankfurt

Outline

1. New tools and initiatives
   – model data base, comparison software, website, recent publications, initiative, network, conferences
2. Examples using MMB 2.3
3. A peek at recent research applications
   – Real equilibrium interest rates
   – Robustness of macroprudential policy rules
4. A proposal for a competition

1. New tools and initiatives

www.macromodelbase.com

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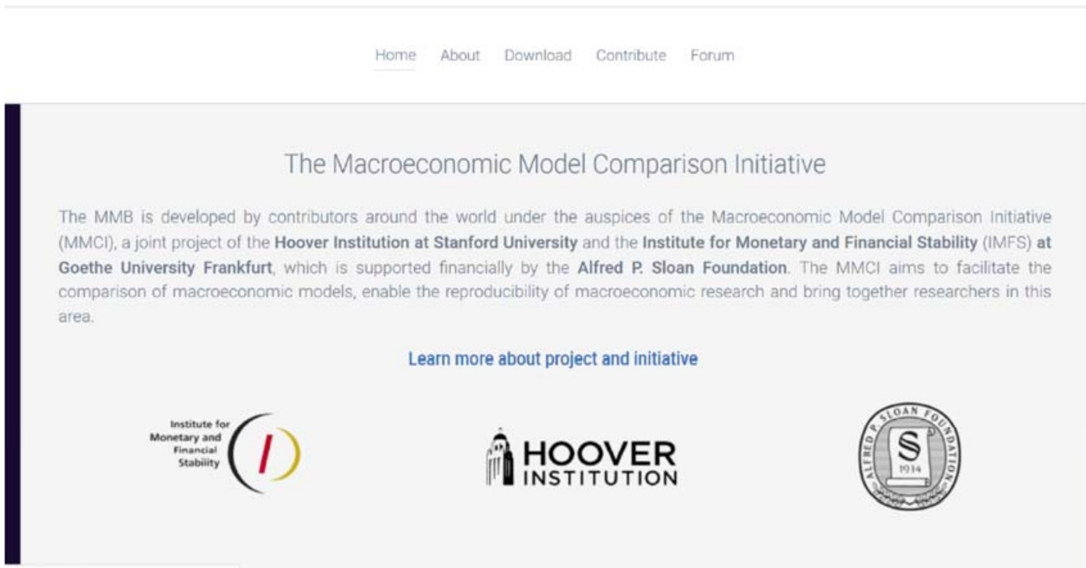
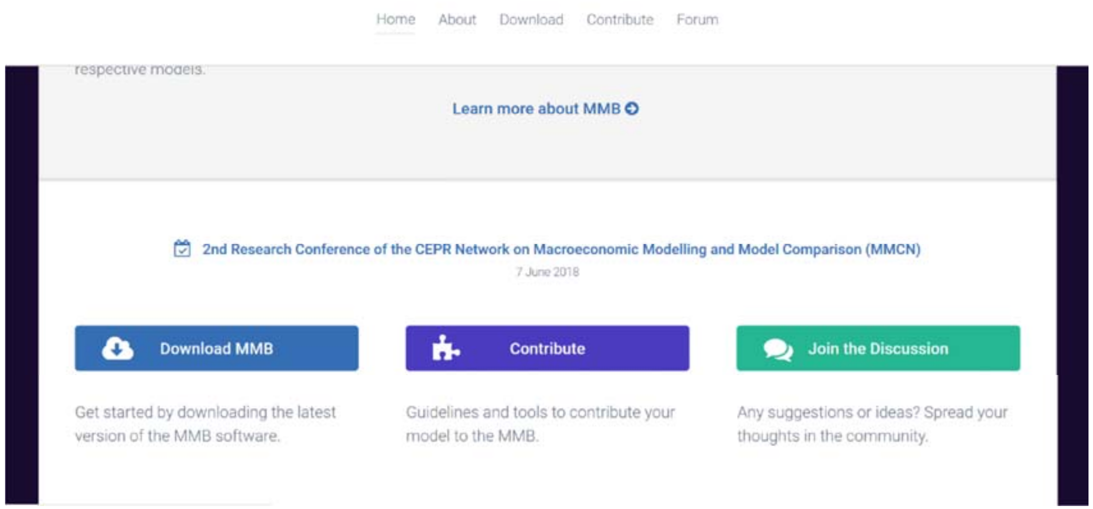
Macroeconomic Model Data Base

The Macroeconomic Model Data Base (MMB) is an archive of macroeconomic models based on a common computational platform for systematic model comparison. The platform features **more than 100 structural macroeconomic models** establishing comparability between them across several dimensions. The user-friendly interface makes the various comparison exercises easily accessible. For each model in the database, replication packages are available that contain codes as well as comments on the replication of the respective models.

Learn more about MMB

MMB 2.3 release from June, 21 new models, total 114





<u>Recent related publications and new work</u>

New Methods for Macro-Financial Model Comparison and Policy Analysis

– Chapter 15, Handbook of Macroeconomics (Vol 2), 2016, editors John B. Taylor and Harald Uhlig.

Model Uncertainty in Macroeconomics: On the Implications of Financial Frictions

– Chapter forthcoming in, Oxford Handbook of Central Banking.

Recent work on equilibrium real rates, fiscal stimulus and financial frictions, macroprudential & monetary policy rules, US tax reform.

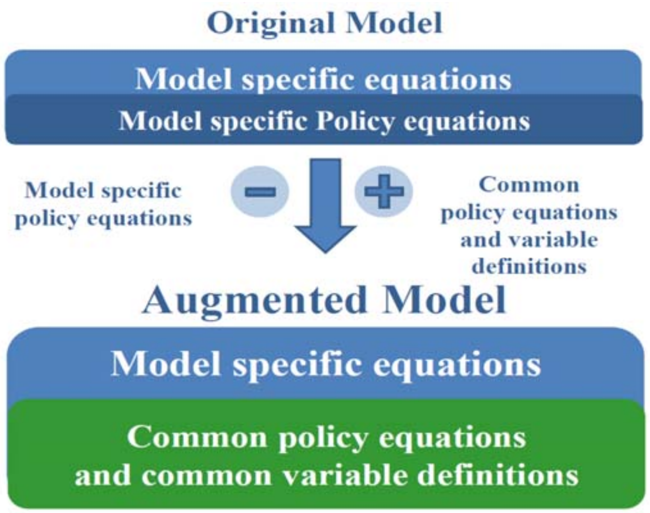
MMCI: Make it easier to evaluate policy across models

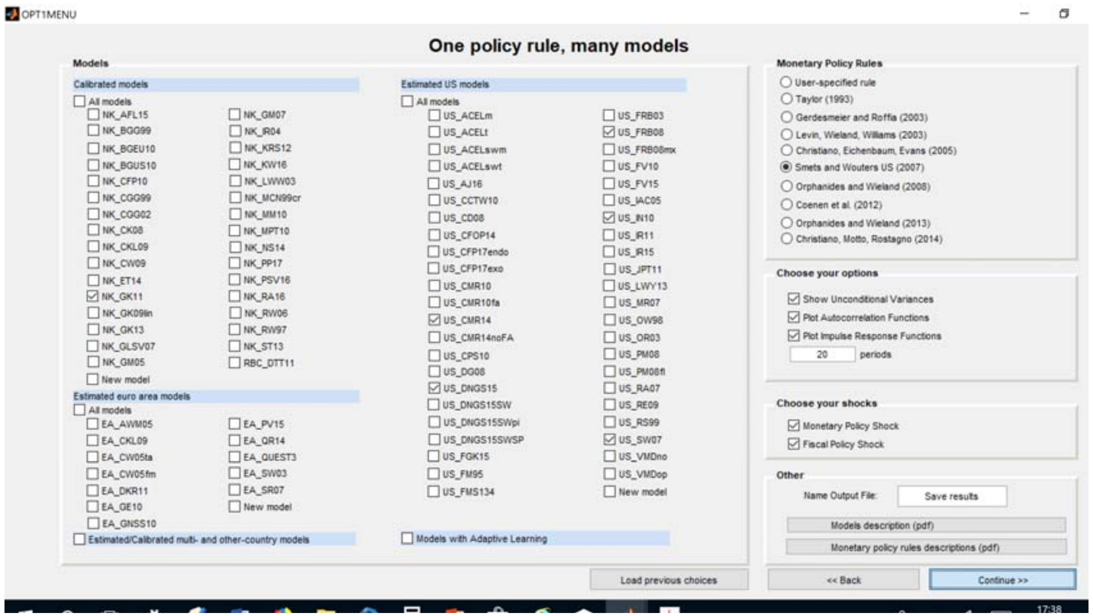
Long tradition in monetary policy: Bryant, Hooper & Mann (Brookings 1993), Taylor (NBER 1999), Levin, Wieland & Williams (AER 2003).

Recently: *Effects of Fiscal Stimulus in Structural Models*

17 authors: Coenen, Erceg, Freedman, Furceri, Kumhof, Lalonde, Laxton, Lindé, Mourougane, Muir, Mursula, Resende, Roberts, Roeger, Snudden, Trabandt, in't Veld, AEJ-Macro, 2012.

9 models: IMF, OECD, ECB, FRB (2), BoC, EU Commission, 2 academic.





2[nd] Research Conference of the Macroeconomic Modelling and Model Comparison Network (MMCN)

June 7-8, 2018

Hoover Institution, Stanford University

Conference organizers:

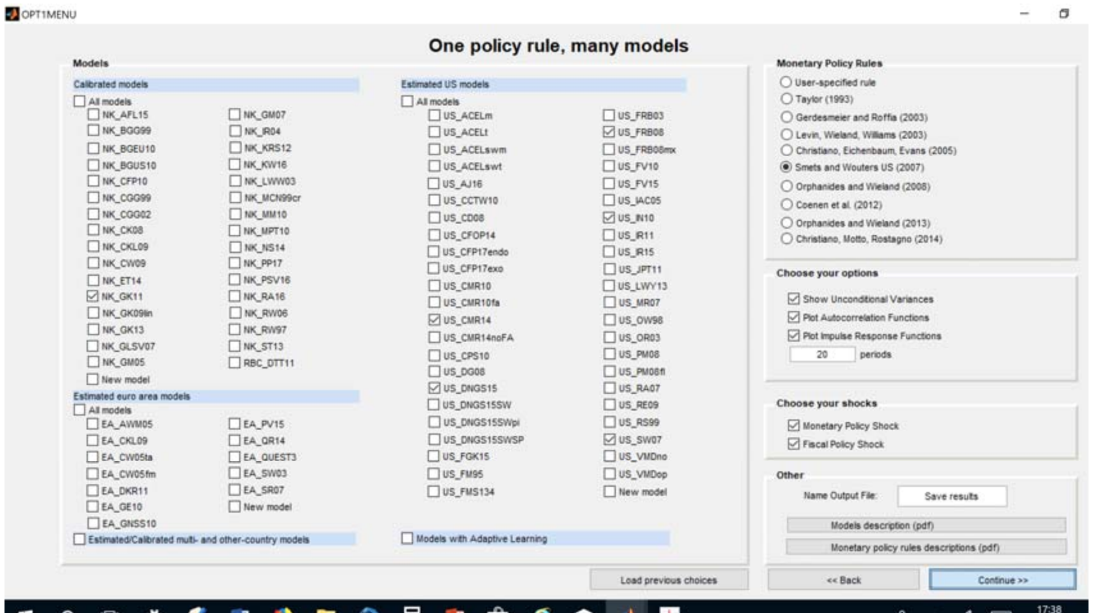
Michael Binder (IMFS, Goethe University Frankfurt)
John B. Taylor (Stanford University and Hoover Institution)
Volker Wieland (IMFS, Goethe University Frankfurt and CEPR)

2 full days,
keynote,
3 plenaries,
6 parallel sessions,
2 poster sessions,
37 papers,
11 posters,
20 discussants.

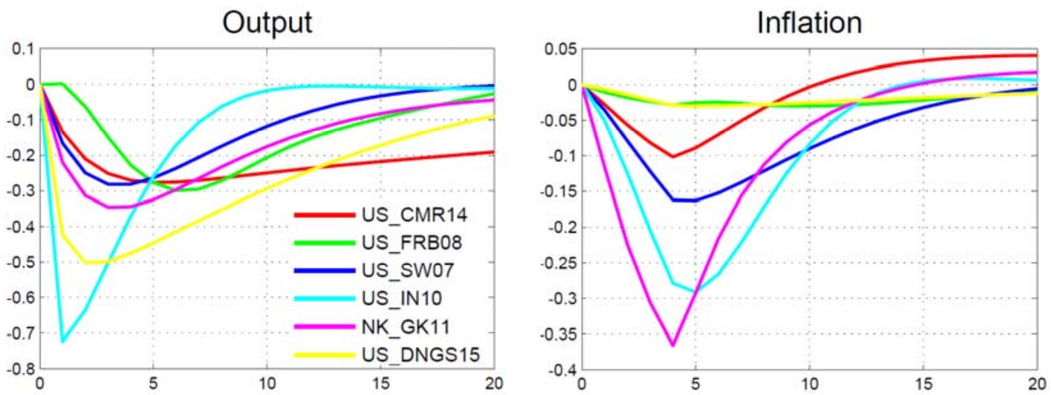
Next steps

- Full open source version of MMB (end of 2018)
  - Browser-based GUI, MMB using Dynare for Octave
- Online comparison database (end of 2018)
  - Browser-based GUI, drawing on simulation archive, possibility to include modeling approaches outside of Dynare
- More than 140 models end of 2019

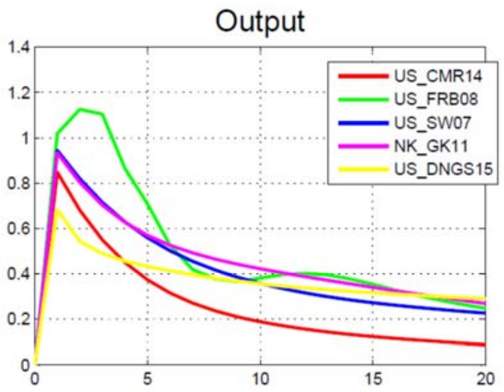
2. Examples using MMB 2.3

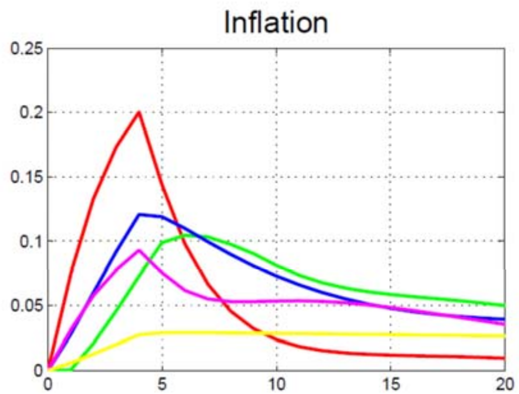


Monetary policy shock with SW rule

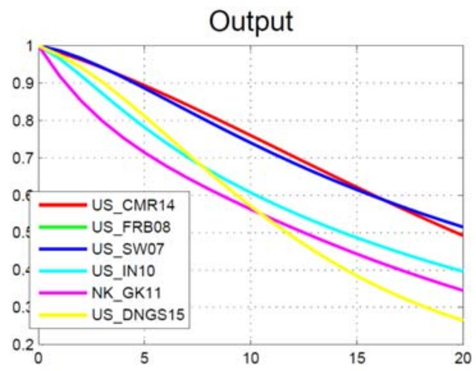


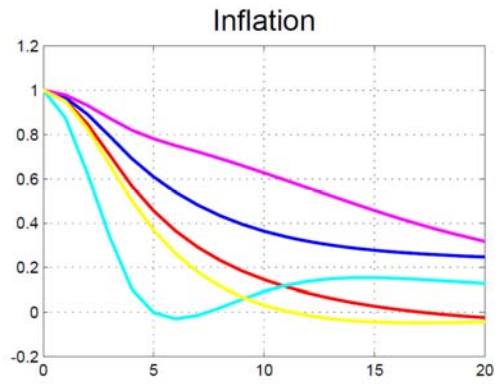
Government purchases shock with SW rule

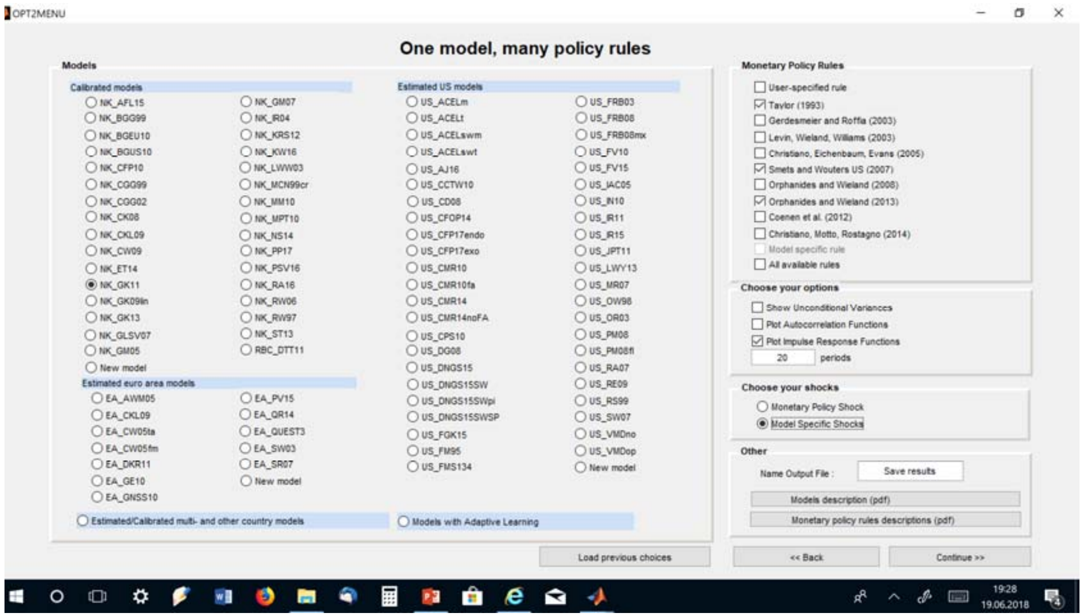


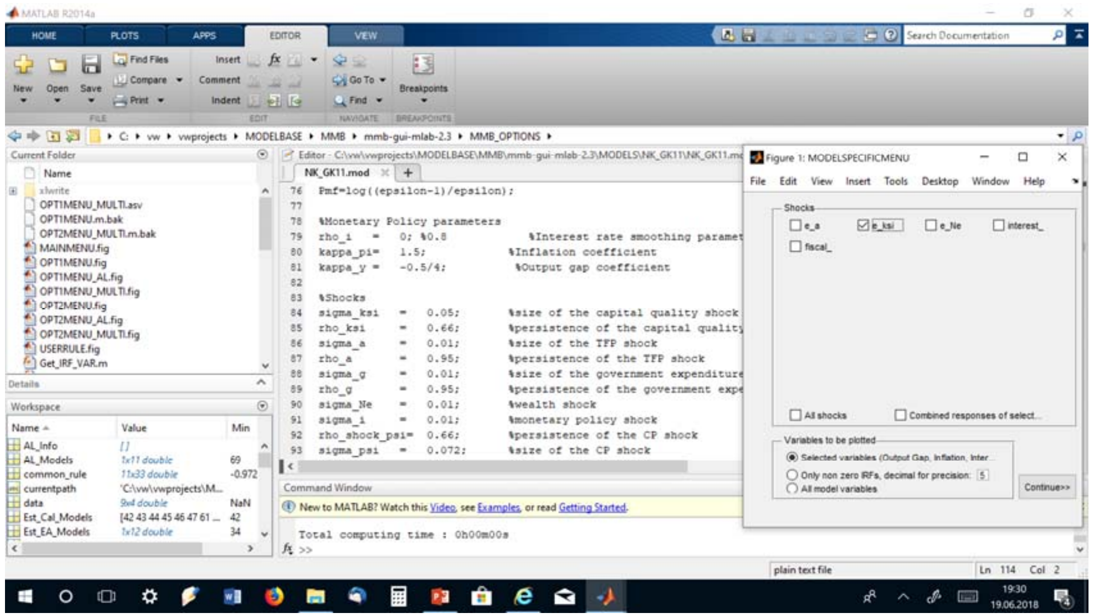


Autocorrelation functions: All shocks with SW Rule

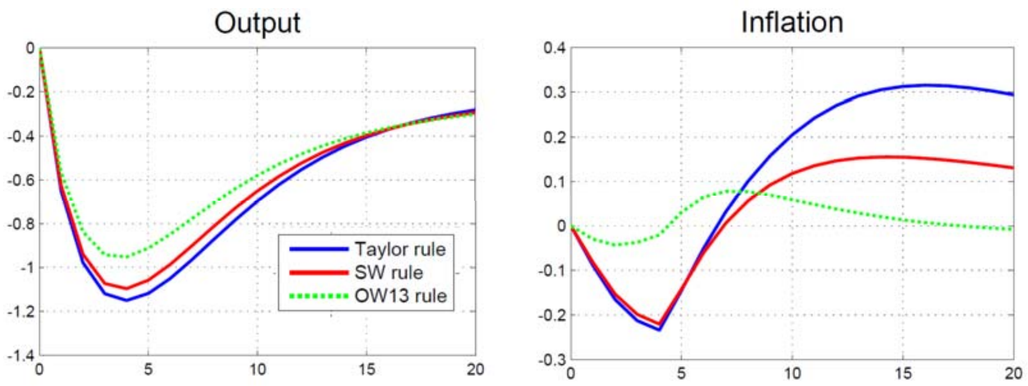








NK-GK11: Gertler-Karadi (2011), Capital quality shock, Taylor rule, SW rule, Orphanides-Wieland 2013 rule



3. Research applications: Equilibrium real interest rates, macro-prudential policy rules.

Real-time estimation and forecasting

- See also Wolters and Wieland (2013), Forecasting and policy making, in Elliott, Granger and Timmermann, Handbook of economic forecasting, vol 2.
- Recent application: Wieland and Wolters, Little decline in model-based estimates of the long-run equilibrium interest rate.

Recursive real-time estimation of long-run equilibrium rate with Smets-Wouters model

SW 2007 r* estimate

Average real rate for 20-year windows

R* for rolling 20-year window's

95% confidence intervals

Contributions to the difference between average real interest rate and long-term r* for the United States[4]

Total difference: –1.75 % = 0.45 % – 2.2 %

Shock	Contribution to difference
Technology	–0,09 %
Risk premiums	–0,48 %
Government expenditure	–0,04 %
Investment-specific	–0,24 %
Monetary policy	–0,83 %
Price markup	0,15 %
Wage markup	–0,01 %

Macro-prudential policy rules

Binder, Lieberknecht, Quintana and Wieland (2017), Robust macroprudential policy rules under model uncertainty, working paper.

Three models with banking sector

1. Gertler-Karadi, JME 2011, NK_GK11
2. Meh-Moran, JEDC 2010, NK_MM10
3. Gerali-Neri-Sessa-Signor., JMCB 2010, EA_GNSS10

Models: banking sector

- Banks play a passive role in financial accelerator and housing finance models.
- By contrast, three models considered treat banks‘ balance sheet and decision processes explicitly, banks‘ financial conditions can affect credit supply.
- Shocks can originate from the banking sector, this sector plays an crucial role in the transmission of standard macroeconomic shocks.

Role for bank capital

Gertler-Karadi (JME 2011), NK_GK11
- Moral hazard problem between banks and depositors, endogenous capital constraint.

Meh-Moran (JEDC 2010), NK_MM10
- Double moral hazard, bank invests net worth with entrepreneur to mitigate moral hazard vs depositor. Bank capital influences ability to attract deposits.

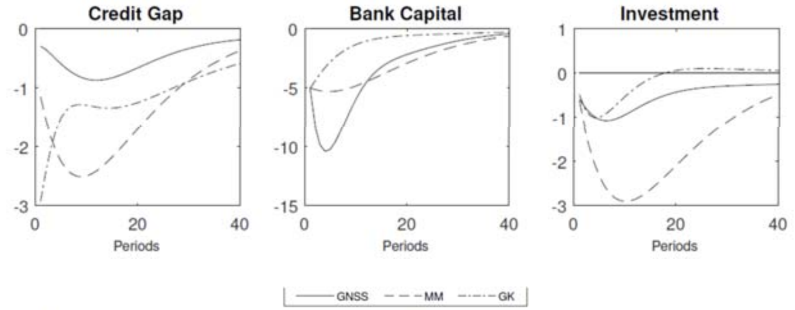
Gerali-Neri-Sessa-Signoretti (JMCB 2010), EA_GNSS10
- Monopolistic banks set deposit and lending rates, capital out of retained earnings, quadratic cost if capital-asset ratio moves from (regulatory) target.

Benchmark monetary policy rule

- Central bank follows first-difference rule as in Orpanides and Wieland (2013)

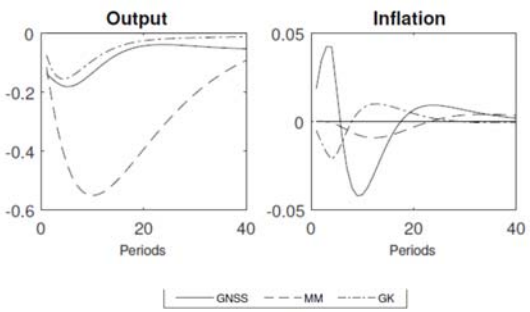
$$i_t \;=\; i_{t-1} + 0.5\pi_t + 0.5\,(x_t - x_{t-4})$$

Bank capital shock



Note: Impulse response functions for a five-percent fall in bank net worth. Monetary policy is modeled according to the rule in Orphanides and Wieland (2013). A period is a quarter and all variables are expressed in percentage deviations from their non-stochastic steady state value.

Bank capital shock



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Macroprudential policy rule

CTA Ratio: Minimum ratio of bank capital to the real value of bank assets

$$\nu_t = \rho_\nu\, \nu_{t-1} + \chi \underbrace{(b_t - y_t)}_{\text{credit gap}}$$

Policy regimes

- Perfect cooperation:
  - monetary policy and macroprudential policy jointly optimize a shared objective.
- Leader-follower:
  - Central bank implements first-difference interest rate rule (as in Orphanides and Wieland 2013),
  - macro-prudential policy authority optimizes conditional on central bank policy.

Perfect coordination regime

$$\min_{\{\rho_i,\phi_\pi,\phi_x,\phi_{dx},\rho_\nu,\chi\}} L = \underbrace{\sigma_\pi^2 + 0.5\sigma_x^2 + 0.5\sigma_{di}^2}_{Central\ Bank\ Objective} + \underbrace{\sigma_{b-y}^2 + 0.5\sigma_x^2 + 0.5\sigma_{d\nu}^2}_{Macro\ Pru\ Objective}$$

$$s.t.\ i_t = \rho_i\, i_{t-1} + \phi_\pi \pi_t + \phi_x x_t + \phi_{dx}(x_t - x_{t-4})$$

$$\nu_t = \rho_\nu\, \nu_{t-1} + \chi(b_t - y_t)$$

Leader follower regime

$$\min_{\{\rho_\nu,\chi\}} L^{mp} = \sigma_{b-y}^2 + 0.5\sigma_x^2 + 0.5\sigma_{d\nu}^2$$

$$s.t.\ \nu_t = \rho_\nu\, \nu_{t-1} + \chi(b_t - y_t)$$

$$i_t = i_{t-1} + 0.5\pi_t + 0.5(x_t - x_{t-4})$$

Perfect coordination lacking robustness under model uncertainty

		Model		
		GNSS	MM	GK
		% [CGP]	% [CGP]	% [CGP]
	GNSS	-	186 [3.66]	191 [7.83]
Rule	MM	1484 [9.69]	-	595 [13.83]
	GK	∞	∞	-

CGP: Credit Gap Premium, the increase in standard deviation of credit gap relative to the outcome under the model-specific optimized rule that is necessary to match the loss under the alternative rule.

Leader-follower regime more robust

		Model		
		GNSS	MM	GK
		% [CGP]	% [CGP]	% [CGP]
	GNSS	-	60 [2.28]	113 [11.62]
Rule	MM	89 [2.54]	-	15 [4.17]
	GK	330 [4.91]	17 [1.23]	-

Bayesian model averaging

- Bayesian perspective on models, with (probability-weighted) loss

$$L = \sum_{m \in M} p_m L_m$$

where p_m is policymaker's prior as to model m.

$$\min_{\{\rho_\nu, \chi\}} \sum_{m \in M} \left[\frac{L_m^{mp} - \min\left(L_m^{mp}\right)}{\min\left(L_m^{mp}\right)} \right]$$

$$\begin{aligned} s.t. \quad \nu_t &= \rho_\nu \nu_{t-1} + \chi\left(b_t - y_t\right) \\ i_t &= i_{t-1} + 0.5\pi_t + 0.5\left(x_t - x_{t-4}\right) \end{aligned}$$

Robustness

Optimized Model-Averaged Macroprudential Rules

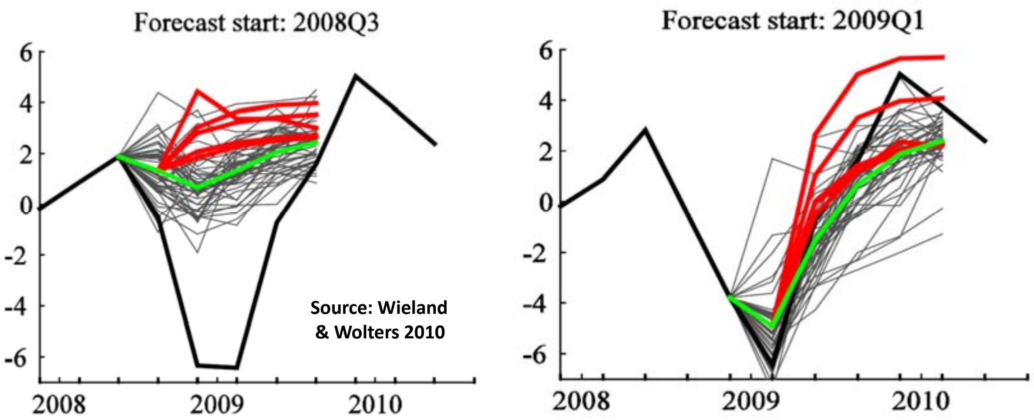
CTA

Instrument	Average Loss		Standard Deviation		
	% Increase	GCP	Inflation	Output Gap	Credit Gap
GNSS	28.23	1.44	1.36	0.80	1.81
MM	8.31	0.85	0.78	1.08	1.86
GK	23.74	5.32	0.41	1.12	7.73
Average	20.10	3.22	0.85	1.00	3.80

$$\nu_t = 0.896\nu_{t-1} + 1.883\left(b_t - y_t\right)$$

4. A proposal for a competition: Explaining and forecasting the Great Recession.

Performance SPF versus model forecasts



Notes: Solid black line shows annulized quarterly output growth (real-time data vintage until forecast starting point and revised data afterwards), grey lines show forecasts from the SPF, green line shows mean forecast from the SPF, red lines show model forecasts conditional on the mean nowcast from the SPF.

What have we learned?
The MMCI forecasting competition

1. Comparing models estimated on U.S. data:
   – What were the main drivers of the decline in GDP growth in 2008/9?
   For example, variance decomposition for GDP growth.

2. Forecasting competition based on real-time, historical data vintages:
   – Provide and share data. Compare forecasts and recession risks.
   – Checks: Public models, forecasts of other recessions and future.

Interested? Contact wieland@wiwi.uni-frankfurt.de

Appendix: A systematic approach to model comparison

Model(-specific) elements

Table 1: Model-Specific Variables, Parameters, Shocks and Equations

Notation	Description
x_t^m	endogenous variables in model m
$x_t^{m,g}$	policy variables in model m (also included in x_t^m)
η_t^m	policy shocks in model m
ε_t^m	other economic shocks in model m
$g_m(.)$	policy rules in model m
$f_m(.)$	other model equations in model m
γ^m	policy rule parameters in model m
β^m	other economic parameters in model m
Σ^m	covariance matrix of shocks in model m

A particular model: Policy rules and other equations

$$(1) \qquad E_t[g_m(x_t^m, x_{t+1}^m, x_{t-1}^m, \eta_t^m, \gamma^m)] = 0$$

$$(2) \qquad E_t[f_m(x_t^m, x_{t+1}^m, x_{t-1}^m, \varepsilon_t^m, \beta^m)] = 0$$

Innovations/shocks

$$(3) \qquad E([\eta_t^m \varepsilon_t^m]') = 0$$

$$(4) \qquad E([\eta_t^{m\prime} \varepsilon_t^{m\prime}]'[\eta_t^{m\prime} \varepsilon_t^{m\prime}]) = \Sigma^m = \begin{pmatrix} \Sigma_\eta^m & \Sigma_{\eta\varepsilon}^m \\ \Sigma_{\eta\varepsilon}^m & \Sigma_\varepsilon^m \end{pmatrix}$$

Introducing common ingredients

Table 2: Comparable Common Variables, Parameters, Shocks and Equations

Notation	Description
z_t	common variables in all models
z_t^g	common policy variables in all models (also included in z_t)
η_t	common policy shocks in all models
$g(.)$	common policy rules
γ	common policy rule parameters

Augmented model

$$E_t[g(z_t, z_{t+1}, z_{t-1}, \eta_t, \gamma)] = 0 \quad (5)$$
$$E_t[h_m(z_t, x_t^m, x_{t+1}^m, x_{t-1}^m, \theta^m)] = 0 \quad (6)$$
$$E_t[f_m(x_t^m, x_{t+1}^m, x_{t-1}^m, \varepsilon_t^m, \beta^m)] = 0 \quad (7)$$

$h_m(.,\theta^m)$: model-specific equations defining common variables in terms of model-specific variables.

Solution

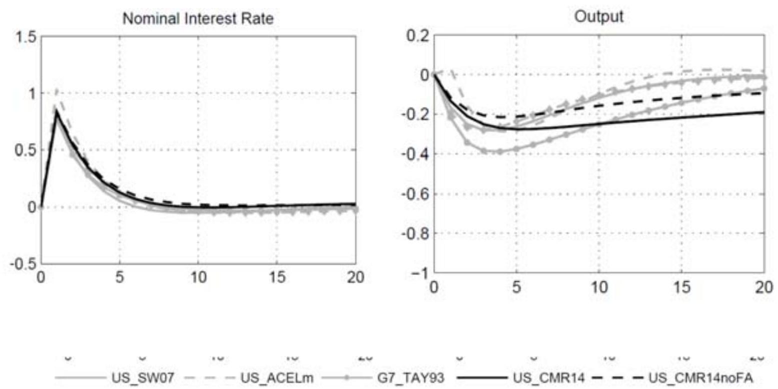
$$z_t = k_z(z_{t-1}, x_{t-1}^m, \eta_t, \varepsilon_t^m, \kappa_z) \quad (8)$$
$$x_t^m = k_x(z_{t-1}, x_{t-1}^m, \eta_t, \varepsilon_t^m, \kappa_x) \quad (9)$$

- Numerical approximation,
- Compute comparable objectives
  - IRF's of z's to η's, variances and correlations of z's given all shocks, etc.
- Compute metric measuring distance between different models.

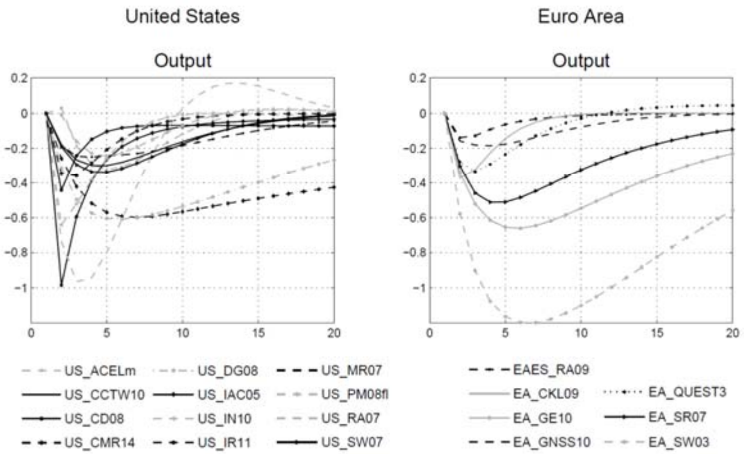
Common variables & policy rules

```
//****************************************************************************
// Definition of Modelbase Variables in Terms of Original Model Variables //*

interest   = r*4;                                                          //*
inflation  = pinf4;                                                        //*
inflationq = 4*pinf;                                                       //*
outputgap  = y-yf;                                                         //*
output     = y;                                                            //*
fispol     = eg;                                                           //*
//****************************************************************************

 //***************************************************************************

 // Policy Rule                                                            //*
                                                                           //*
 // Monetary Policy                                                        //*
                                                                           //*
   interest =    cofintintb1*interest(-1)                                  //*
               + cofintintb2*interest(-2)                                  //*
               + cofintintb3*interest(-3)                                  //*
               + cofintintb4*interest(-4)                                  //*
               + cofintinf0*inflationq                                     //*
               + cofintinfb1*inflationq(-1)                                //*
               + cofintinfb2*inflationq(-2)                                //*
               + cofintinfb3*inflationq(-3)                                //*
```


Monetary policy shocks: model generations (U.S., SW rule)



Monetary policy shocks: Economies



Reproducibility of computational research

A topic in other fields:

- Fomel, Claerbout (2009, Computing in Science and Engineering), Freire, Bonnet, Shasha (2012, SIGMOD), Sandve et al (Computational biology 2013).
- Stanford statistician Donoho (2010, Biostatistics):

  „an article about computation result is advertising, not scholarship. The actual scholarship is the full software, code and data, that produced the result.“