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# 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

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## 1. New tools and initiatives

[www.macromodelbase.com](http://www.macromodelbase.com)

[Home](#) [About](#) [Download](#) [Contribute](#) [Forum](#)



## 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

## The Macroeconomic Model Comparison Initiative

The MMB is developed by contributors around the world under the auspices of the Macroeconomic Model Comparison Initiative (MMCI), a joint project of the **Hoover Institution at Stanford University** and the **Institute for Monetary and Financial Stability (IMFS) at Goethe University Frankfurt**, which is supported financially by the **Alfred P. Sloan Foundation**. The MMCI aims to facilitate the comparison of macroeconomic models, enable the reproducibility of macroeconomic research and bring together researchers in this area.

[Learn more about project and initiative](#)



respective moeais.

[Learn more about MMB](#)

2nd Research Conference of the CEPR Network on Macroeconomic Modelling and Model Comparison (MMCN)

7 June 2018

[Download MMB](#)

Get started by downloading the latest version of the MMB software.

[Contribute](#)

Guidelines and tools to contribute your model to the MMB.

[Join the Discussion](#)

Any suggestions or ideas? Spread your thoughts in the community.

## Recent related publications and new work

### *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.

**Understanding Science**  
how science *really* works

UNDERSTANDING SCIENCE 101 FOR TEACHERS RESOURCE LIBRARY

[contents](#)

### Copycats in science: The role of replication

*Exactly 352 grams!*

## 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.



## Original Model

Model specific equations

Model specific Policy equations

Model specific  
policy equations



Common  
policy equations  
and variable  
definitions

## Augmented Model

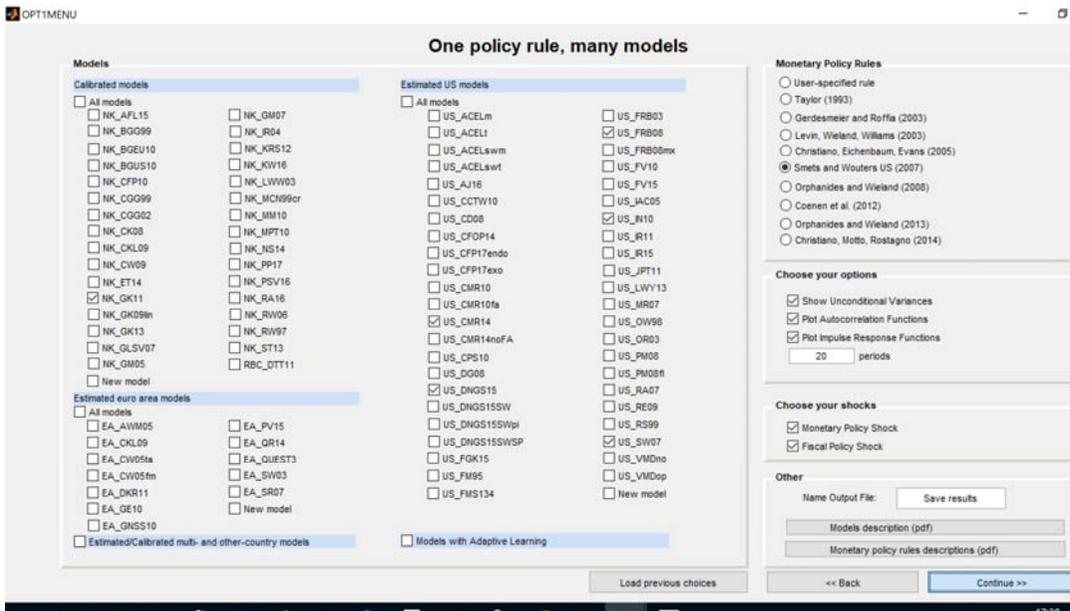
Model specific equations

Common policy equations  
and common variable definitions

MFJ, June 20, 2018

Volker Wieland

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## 2<sup>nd</sup> 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.

MFJ, June 20, 2018

Volker Wieland

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## 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

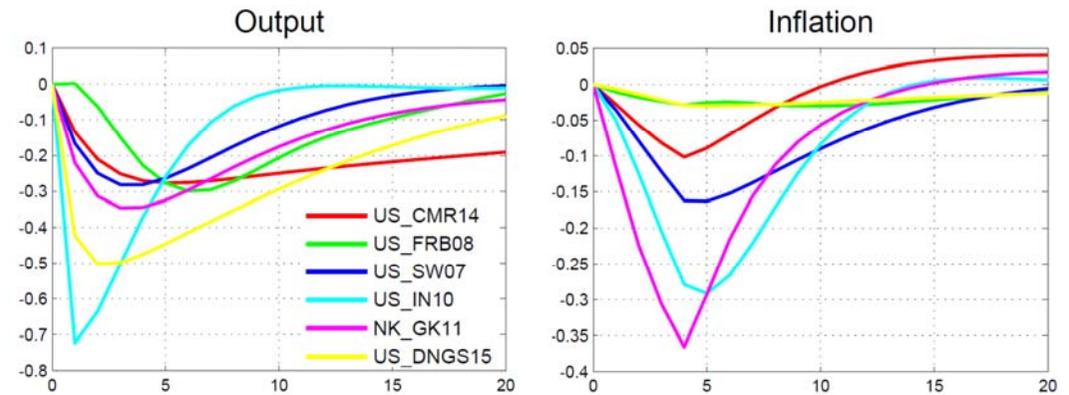
## 2. Examples using MMB 2.3

The screenshot shows the MMB 2.3 GUI with the title "One policy rule, many models". It features several panels for model selection:

- Models:**
  - Calibrated models:** A list of models such as NK\_AF15, NK\_BGG99, NK\_BOEU10, etc.
  - Estimated US models:** A list of models such as US\_ACELM, US\_ACEL1, US\_ACELSwrm, etc.
  - Estimated euro area models:** A list of models such as EA\_AVM05, EA\_CKL09, EA\_CW05a, etc.
- Monetary Policy Rules:** A list of rules including Taylor (1993), Gerdsemeier and Roffla (2003), Levin, Wieland, Williams (2003), etc. The "Smets and Wouters US (2007)" rule is selected.
- Choose your options:** Checkboxes for "Show Unconditional Variances", "Plot Autocorrelation Functions", and "Plot Impulse Response Functions".
- Choose your shocks:** Checkboxes for "Monetary Policy Shock" and "Fiscal Policy Shock".
- Other:** A "Name Output File" field and "Save results" button.

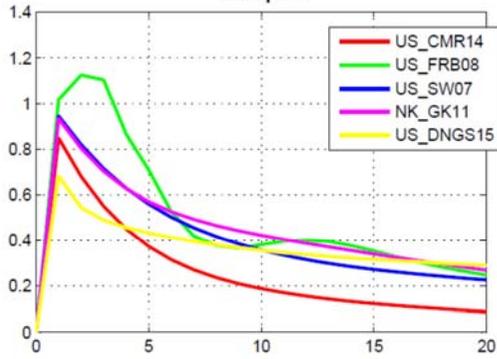
At the bottom, there are buttons for "Models description (pdf)", "Monetary policy rules descriptions (pdf)", and "Continue >>".

### Monetary policy shock with SW rule

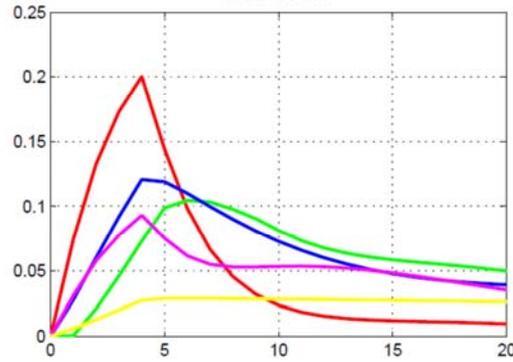


## Government purchases shock with SW rule

Output

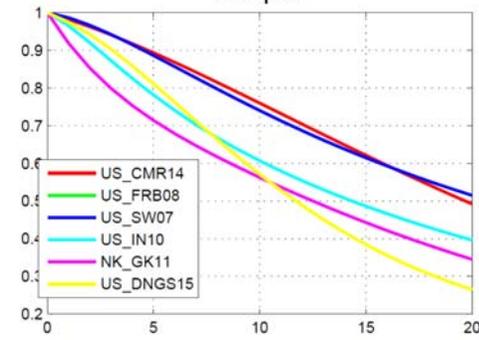


Inflation

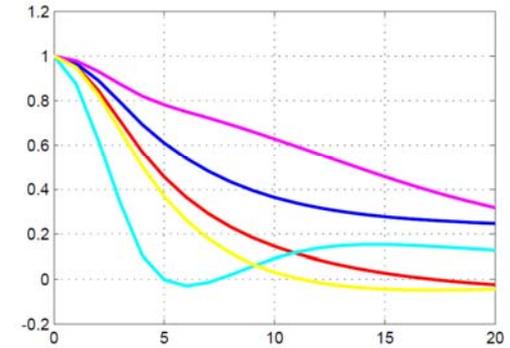


## Autocorrelation functions: All shocks with SW Rule

Output



Inflation



OPT2MENU

### One model, many policy rules

**Calibrated models**

- NK\_AFL15
- NK\_BOG99
- NK\_BGEU10
- NK\_BGU510
- NK\_CFP10
- NK\_COG99
- NK\_COG02
- NK\_CK08
- NK\_CKL09
- NK\_CW09
- NK\_ET14
- NK\_GK11
- NK\_GK09in
- NK\_GK13
- NK\_GLSV07
- NK\_GM05
- New model

**Estimated euro area models**

- EA\_AWM05
- EA\_CKL09
- EA\_CW09a
- EA\_CW09m
- EA\_DKR11
- EA\_OE10
- EA\_QNS10
- EA\_PV15
- EA\_OR14
- EA\_QUEST3
- EA\_SW03
- EA\_PHS5
- EA\_SR07
- New model

**Estimated US models**

- US\_FRB03
- US\_FRB08
- US\_FRB08mk
- US\_FV10
- US\_FV15
- US\_IAC05
- US\_R10
- US\_R11
- US\_R15
- US\_IPT11
- US\_LWY13
- US\_CMR10
- US\_CMR10fa
- US\_CMR14
- US\_CMR14anfA
- US\_CPS10
- US\_DG08
- US\_DNGS15
- US\_DNGS15SW
- US\_DNGS15SWpi
- US\_DNGS15SWSP
- US\_FOK15
- US\_SW03
- US\_VMD0p
- US\_VMD0p
- US\_FMS134
- New model

**Monetary Policy Rules**

- User-specified rule
- Taylor (1993)
- Gerdemeier and Roffa (2003)
- Levin, Wieland, Williams (2003)
- Christiano, Eichenbaum, Evans (2005)
- Smets and Wouters US (2007)
- Orphanides and Wieland (2008)
- Coenen et al. (2012)
- Christiano, Motto, Rostagno (2014)
- Model specific rule
- All available rules

**Choose your options**

- Show Unconditional Variances
- Plot Autocorrelation Functions
- Plot Impulse Response Functions
- 20 periods

**Choose your shocks**

- Monetary Policy Shock
- Model Specific Shocks

**Other**

Name Output File:  Save results

Models description (pdf)

Monetary policy rules descriptions (pdf)

MATLAB R2014a

EDITOR

Current Folder: C:\v\w\projects\MODELBASE\MMB\mmb-gui-matlab-2.3\MODELS\NK\_GK11\NK\_GK11.m

```

NK_GK11.mod
%write
%Monetary Policy parameters
rho_i = 0; %0.8 %Interest rate smoothing parameter
kappa_pi = 1.5; %Inflation coefficient
kappa_y = -0.5/4; %Output gap coefficient
%Shocks
sigma_ksi = 0.05; %size of the capital quality shock
rho_ksi = 0.66; %persistence of the capital quality
sigma_a = 0.01; %size of the TFP shock
rho_a = 0.95; %persistence of the TFP shock
sigma_g = 0.01; %size of the government expenditure
rho_g = 0.95; %persistence of the government expenditure
sigma_le = 0.01; %wealth shock
sigma_i = 0.01; %monetary policy shock
rho_shock_psi = 0.66; %persistence of the CP shock
sigma_psi = 0.072; %size of the CP shock
    
```

Workspace:

Name	Value	Min	Max
AL_Info	1x1 double	69	
AL_Models	1x33 double	-0.972	
common_rule	1x1 double		
currentpath	C:\v\w\projects\M...		
data	3x1 double	NaN	
Est_Cal_Models	1x2 double	42	42
Est_EA_Models	1x2 double	34	34

Command Window:

New to MATLAB? Watch this Video, see Examples, or read Getting Started.

Total computing time: 0h00m00s

Figure 1: MODELSPECIFICMENU

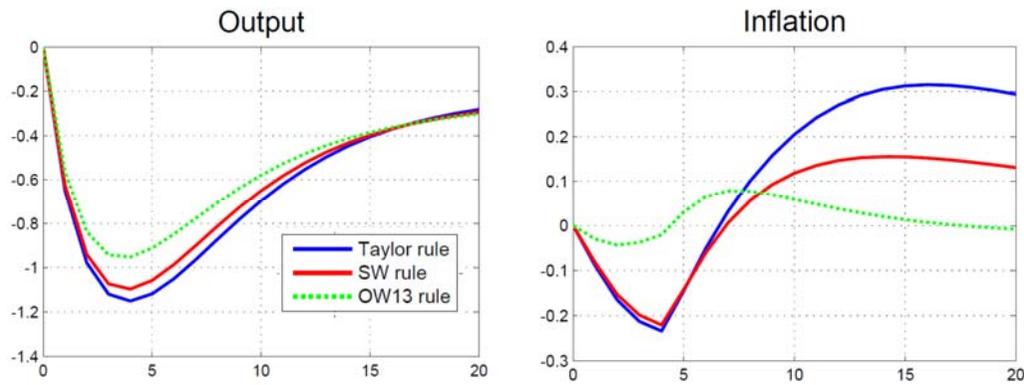
Shocks:

- e\_a
- e\_ksi
- e\_Ne
- interest\_
- fiscal\_

Variables to be plotted:

- Calibrated variables (Output Gap, Inflation, Inter...
- Only non zero RFs, decimal for precision: 5
- All model variables

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

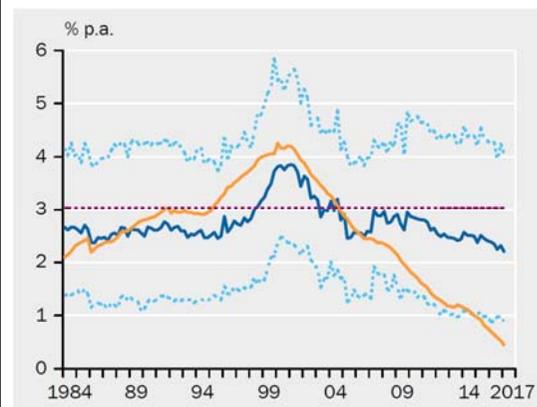


3. Research applications: Equilibrium real interest rates, macro-prudential policy rules.

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<sup>4</sup>

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](#)

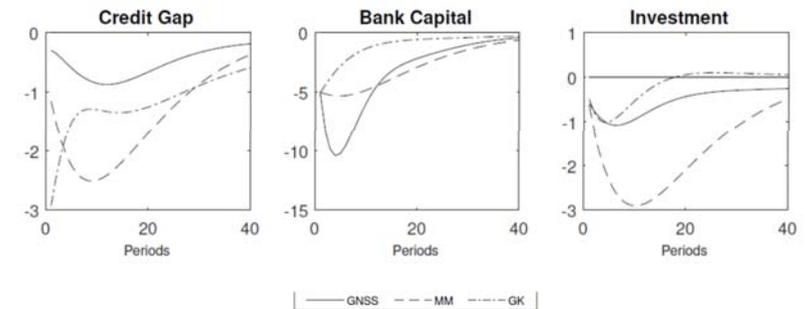
- Monopolistic banks set deposit and lending rates, capital out of retained earnings, quadratic cost if capital-asset ratio moves from (regulatory) target.

## Benchmark monetary policy rule

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

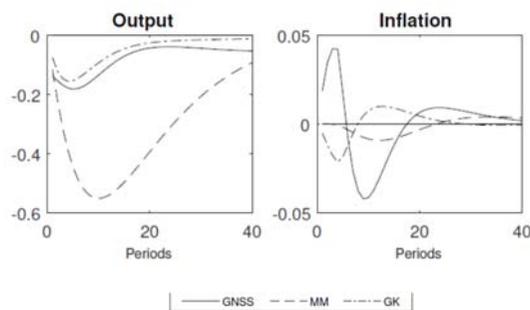
$$i_t = i_{t-1} + 0.5\pi_t + 0.5(x_t - x_{t-4})$$

## 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



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.

## 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

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

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

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

## Leader follower regime

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

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

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

## 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	$\infty$	$\infty$	-

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

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

where  $\rho_m$  is policymaker's prior as to model  $m$ .

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

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

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

## Robustness

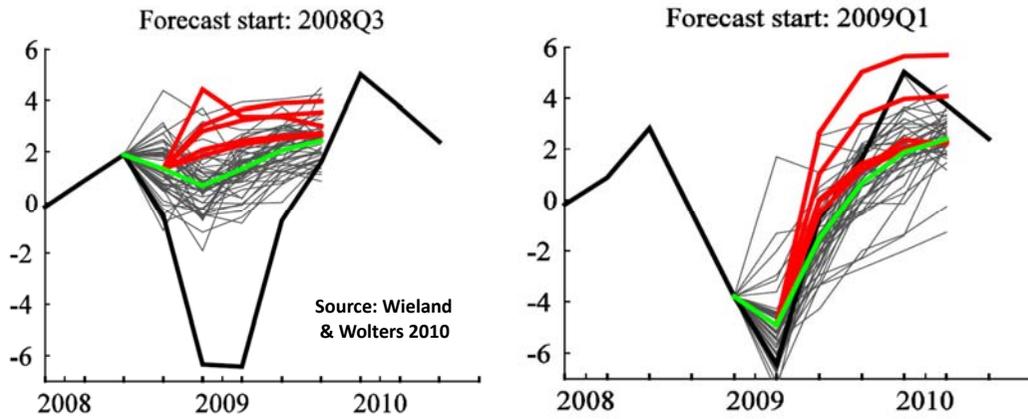
Optimized Model-Averaged Macprudential Rules

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

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

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

## Performance SPF versus model forecasts



Notes: Solid black line shows annualized 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](mailto:wieland@wiwi.uni-frankfurt.de)

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## 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 $x_t^m$ )
$\eta_t^m$	policy shocks in model $m$
$\varepsilon_t^m$	other economic shocks in model $m$
$g_m(\cdot)$	policy rules in model $m$
$f_m(\cdot)$	other model equations in model $m$
$\gamma^m$	policy rule parameters in model $m$
$\beta^m$	other economic parameters in model $m$
$\Sigma^m$	covariance matrix of shocks in model $m$

## A particular model: Policy rules and other equations

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

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

## Innovations/shocks

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

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

## 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 $z_t$ )
$\eta_t$	common policy shocks in all models
$g(\cdot)$	common policy rules
$\gamma$	common policy rule parameters

## Augmented model

$$E_t[g(z_t, z_{t+1}, z_{t-1}, \eta_t, \gamma)] = 0 \quad (5)$$

$$E_t[h_m(z_t, x_t^m, x_{t+1}^m, x_{t-1}^m, \theta^m)] = 0 \quad (6)$$

$$E_t[f_m(x_t^m, x_{t+1}^m, x_{t-1}^m, \varepsilon_t^m, \beta^m)] = 0 \quad (7)$$

$h_m(\cdot, \theta^m)$ : 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  $\eta$ 's, variances and correlations of z's given all shocks, etc.
- Compute metric measuring distance between different models.

## Common variables & policy rules

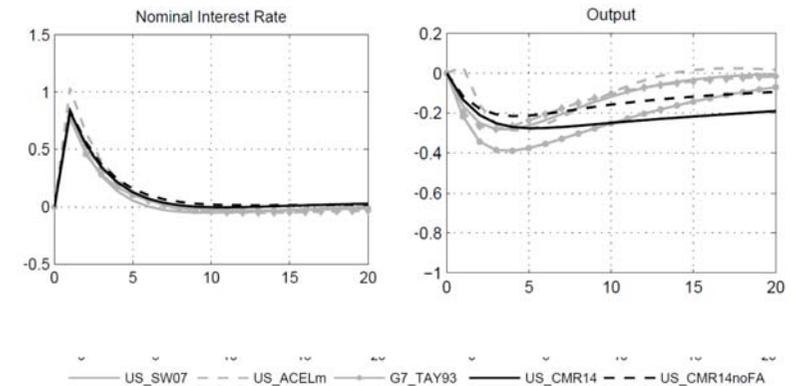
```

//*****
// 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; //**
//*****

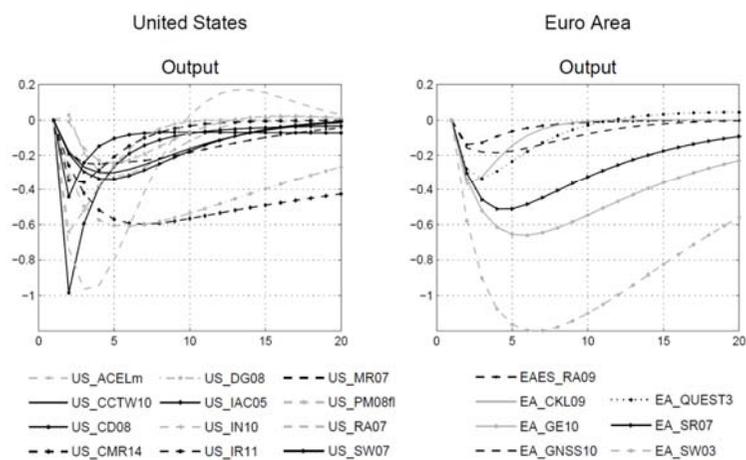
// Policy Rule //**
//**
// Monetary Policy //**
//**
interest = cofintintb1*interest(-1) //**
          + cofintintb2*interest(-2) //**
          + cofintintb3*interest(-3) //**
          + cofintintb4*interest(-4) //**
          + cofintinf0*inflationq //**
          + cofintinfb1*inflationq(-1) //**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