On the Estimation and Application of Structural Decompositions of the South African Business Cycle

Hylton Hollander and Dawie van Lill
Stellenbosch University

MISSPECIFICATION

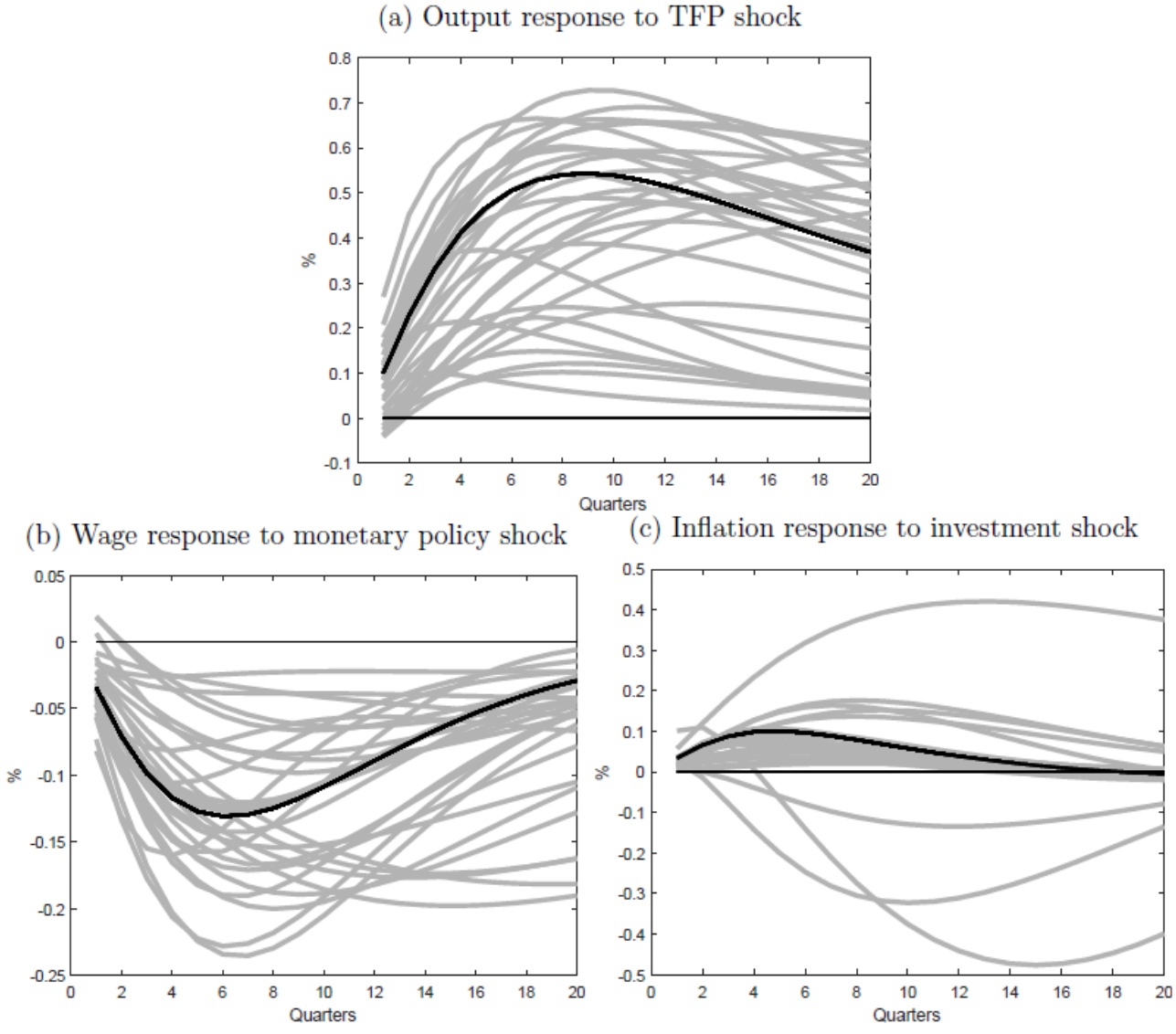

Figure: IRFs to true (black) and misspecified structural disturbances (grey) empirical DSGE models (Den Haan & Dreschel, 2018)

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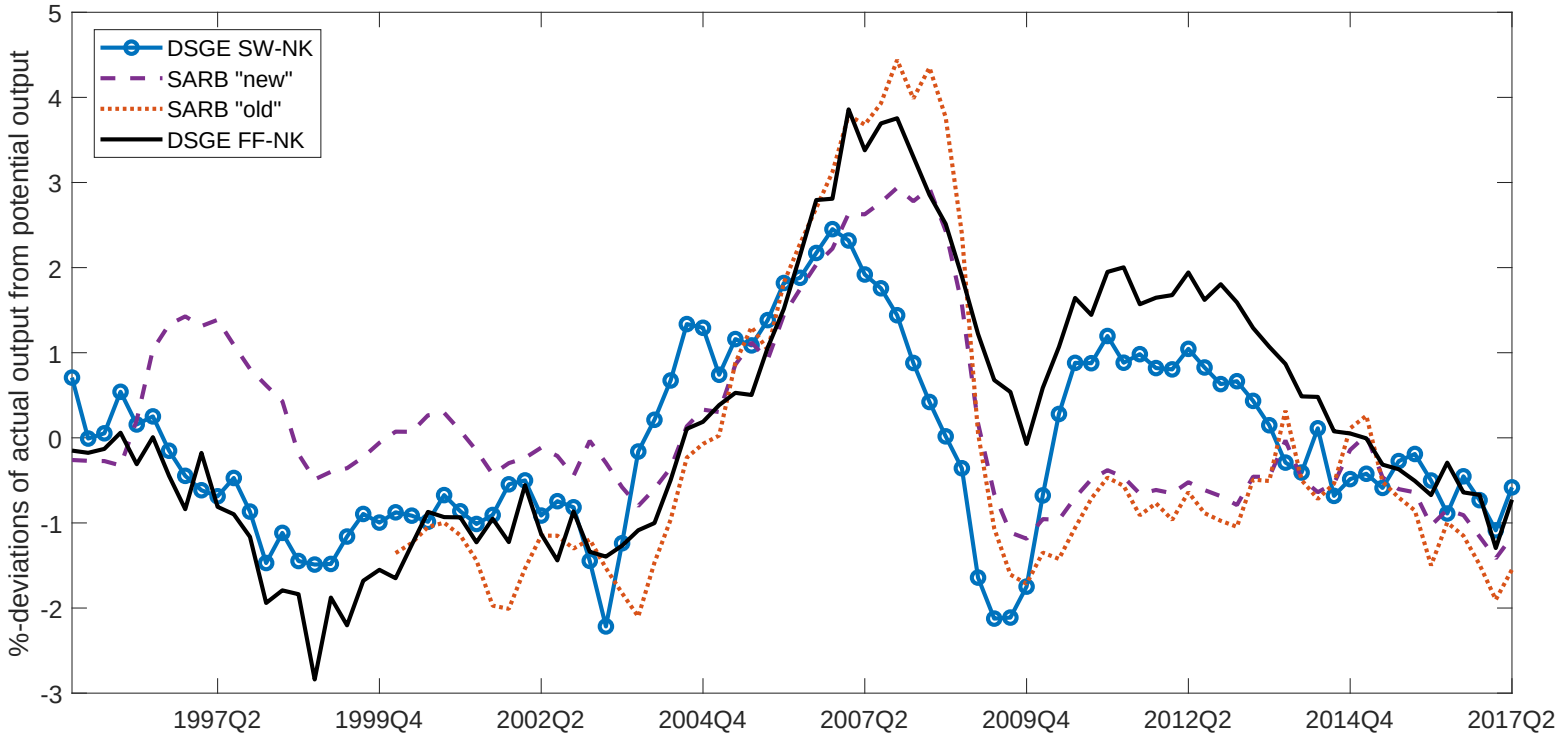


Figure: DSGE model output gap comparisons with SARB output gap estimates. Period: 1995Q1–2017Q2

MISSPECIFICATION - WHAT COULD BE WRONG?

1. **Misspecification due to wrong functional forms**

   Solution is to compare empirical performance of
   (a) a set of several theoretical models (still a fraction of all possible models)
   (b) a reduced-form specification (Lucas critique still holds for policy analysis)

2. **Misspecification due to missing elements**

   Solution (of the econometrician) is to add a regression error term, u_t, to the model

   $$y_t = g(y_{t-1}, \varepsilon_t; \psi) + u_t$$

   the problem is that u_t will be correlated with y_{t-1}, the explanatory variable (i.e., the residual after estimation on a sample)

Den Haan & Dreschel (2018, 2019, 2021)

MISSPECIFICATION - WHAT COULD BE WRONG?

Suppose we have the following system of equations to characterize $y_t = g(y_{t-1}, \varepsilon_t; \psi)$:

$$\begin{aligned} y_t &= y_{1,t} + y_{2,t} \\ y_{1,t} &= A_1(\psi) y_{1,t-1} + B_1(\psi)\varepsilon_{1,t} \ , \\ y_{2,t} &= A_2(\psi) y_{2,t-1} + B_2(\psi)\varepsilon_{2,t} \ , \end{aligned} \tag{1}$$

where $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$ are independent.

The problem is that we only observe y_t, not its two components $y_{1,t}$ and $y_{2,t}$...

Why can't we add a regression residual to capture the missing part?

$$y_t = A_1(\psi) y_{t-1} + B_1(\psi)\varepsilon_{1,t} + u_t$$

MISSPECIFICATION - WHAT COULD BE WRONG?

Using the equations from the true underlying model, we get the following system:

$$
\begin{aligned}
y_t &= y_{1,t} + y_{2,t} \\
&= A_1(\psi) y_{1,t-1} + B_1(\psi)\varepsilon_{1,t} + A_2(\psi) y_{2,t-1} + B_2(\psi)\varepsilon_{2,t} \\
&= A_1(\psi)(y_{1,t-1} + y_{2,t-1}) + B_1(\psi)\varepsilon_{1,t} \\
&\quad +(A_2(\psi) - A_1(\psi)) y_{2,t-1} + B_2(\psi)\varepsilon_{2,t} \\
&= A_1(\psi) y_{t-1} + B_1(\psi)\varepsilon_{1,t} + u_t \\
&\text{with} \\
u_t &= (A_2(\psi) - A_1(\psi)) y_{2,t-1} + B_2(\psi)\varepsilon_{2,t} \ .
\end{aligned}
\tag{2}
$$

MISSPECIFICATION - WHAT COULD BE WRONG?

For u_t to be uncorrelated with the explanatory variables one would need:

- A_1 and A_2 to be identical
- $\varepsilon_{2,t}$ is not serially correlated
- and the two mechanisms are independent from each other

Therefore, unlikely that measurement error is the only reason for the gap between observed data and economic models.

MISSPECIFICATION - DEALING WITH IT

Comprehensive misspecification procedure

$$\begin{aligned} y_t &= y_{1,t} + y_{2,t} \\ y_{1,t} &= A_1(\psi) y_{1,t-1} + B_1(\psi)\varepsilon_{1,t} \ , \\ y_{2,t} &= \mathbf{A_2} y_{2,t-1} + \mathbf{B_2}\varepsilon_{2,t} \ , \end{aligned} \tag{3}$$

where the bold symbols $\{\mathbf{A_2}, \mathbf{B_2}, \varepsilon_{2,t}\}$ indicate reduced-form objects not based on the theory of the structural model.

- the existing approaches in the literature dealing with misspecification in macro models are based on this setup.
- deals with misspecification **#1** due to missing elements, and **#2** of the model itself, since the reduced form block can completely take over the explanatory power

DSGE as Modelling Paradigm

- Has there been a core failure in our modelling paradigm?
  - Fit for purpose
  - No model can be all things to all people (e.g., Blanchard, 2018)
- Few instances of DSGE models developed to look at the underlying structure of the South African business cycle.
  - Not been well-established how alternative specifications affect the estimated structure and dynamics of the business cycle
  - Important implications for policy analysis.
- "Identified moments"
  - estimated responses to identified structural shocks $---$ what micro calls "causal effects" (e.g., Nakamura & Steinsson, 2018)

Main Findings

Parameter estimates and model dynamics are sensitive to model specification:

- Some important model sub-blocks insensitive
- 3-Equation New-Keynesian model and a traditional Small Open Economy model provide qualitatively and quantitatively similar results to the benchmark medium-scale NK model
- Significant differences from financial frictions
- Types of exogenous shocks included in the model are key determinants for the variation of results.

Benchmark Model and Extensions

Our benchmark DSGE model is a New-Keynesian DSGE model which aligns closely with Smets and Wouters (*SW-NK*)*

We compare results from this model to three related variants:

- Three equation New-Keynesian model (*Naive-NK*)
- Small open economy New-Keynesian model (*SOE-NK*)
- New-Keynesian model with a financial sector (*FF-NK*)

We also compare our results with selected DSGE articles with an explicit focus on South Africa

*Source: Macro Model Data Base (MMB) with own standardizations

Posterior Estimates

Comparison with other SA-based DSGE models

Table: Estimated parameter comparisons from alternative South African-based DSGE models

	Posterior Estimates							
	SW-NK	*SMS09*	*SPS14*	*AKW10*†	*AKW10-SMS*	*PG16*	*PG16-NK*	*HGW18*
Data sample	95Q1—17Q4	90Q1—07Q4	00Q1—12Q4	90Q1—07Q4	90Q1—07Q4	71Q1—13Q1	71Q1—13Q1	95Q1—17Q2
Preferences								
ϕ	0.80	0.70*	0.81	0.70*	0.70*	-	-	0.70*
σ_c	1.20	1.03	1*	0.58	0.99	1*	1*	3.92
labor elast. (σ_n)	2.62	3*	5*	3*	3*	1.90	1.45	3*
Firms & Price setting								
capital adj. (κ_v)	6.47	-	10.5	-	-	-	-	0.25*
θ_p	0.81	0.54	0.70	0.46	0.49	0.81	0.79	0.50
γ_p	0.23	0.25*	0.50	0.25*	0.25*	0.43	0.45	0.55
θ_w	0.65	0.50*	0.69*	0.50*	0.50*	0.64	0.65	0.75*
γ_w	0.34	0.70	0.50*	0.70	0.70	0.39	0.46	0.50*
Monetary policy rule								
inflation (κ_π)	1.52	1.39	1.73	1.48	1.37	1.24	1.19	1.41
output (κ_y)	0.50	0.63	0.25	0.48	0.59	1.19***	1.43***	0.73
Obs. var.	7	6	15	7	6	8	8	6
# est. shocks	7	9	12	6	5	10	10	7
# est. param.	24	24	40	17	15	29	27	26

* fixed (calibrated) parameters. ** either risk premium or preference shock. *** output gap, not output growth, used in MP-reaction function.
† posterior mode "similar" to posterior mean (p. 177). List of parameters only include those corresponding to *SW-NK*.

▸ Go to

Posterior Estimates

Comparison of nested DSGE models

	Posterior Distribution Means			
	SW-NK	*Naive-NK*	*SOE-NK*	*FF-NK*
Marginal density	2088.04	1050.22	2939.0	2597.79
Preferences				
ϕ	0.795	0.611	0.792	0.726
σ_c	1.197	-	1.197	1.246
σ_n	2.616	-	2.885	0.501
Firms & Price setting				
κ_v	6.469	-	0.305	9.049
θ_p	0.810	0.586	0.709	0.858
γ_p	0.231	0.376	0.315	0.158
θ_w	0.647	-	0.777	0.748
γ_w	0.342	-	0.203	0.185
Monetary policy rule				
κ_π	1.521	2.101	1.559	1.527
κ_y	0.502	1.856	0.546	0.565

$$i_t = \rho_i i_{t-1} + (1-\rho_i)(\kappa_\pi E_t \pi_{t+1} + \kappa_y y_t)$$

SARB QPM: $\rho_i = 0.79$, $\kappa_\pi = 1.57$, $\kappa_y = 0.54$

Priors and Posteriors

Deep / Structural Parameters

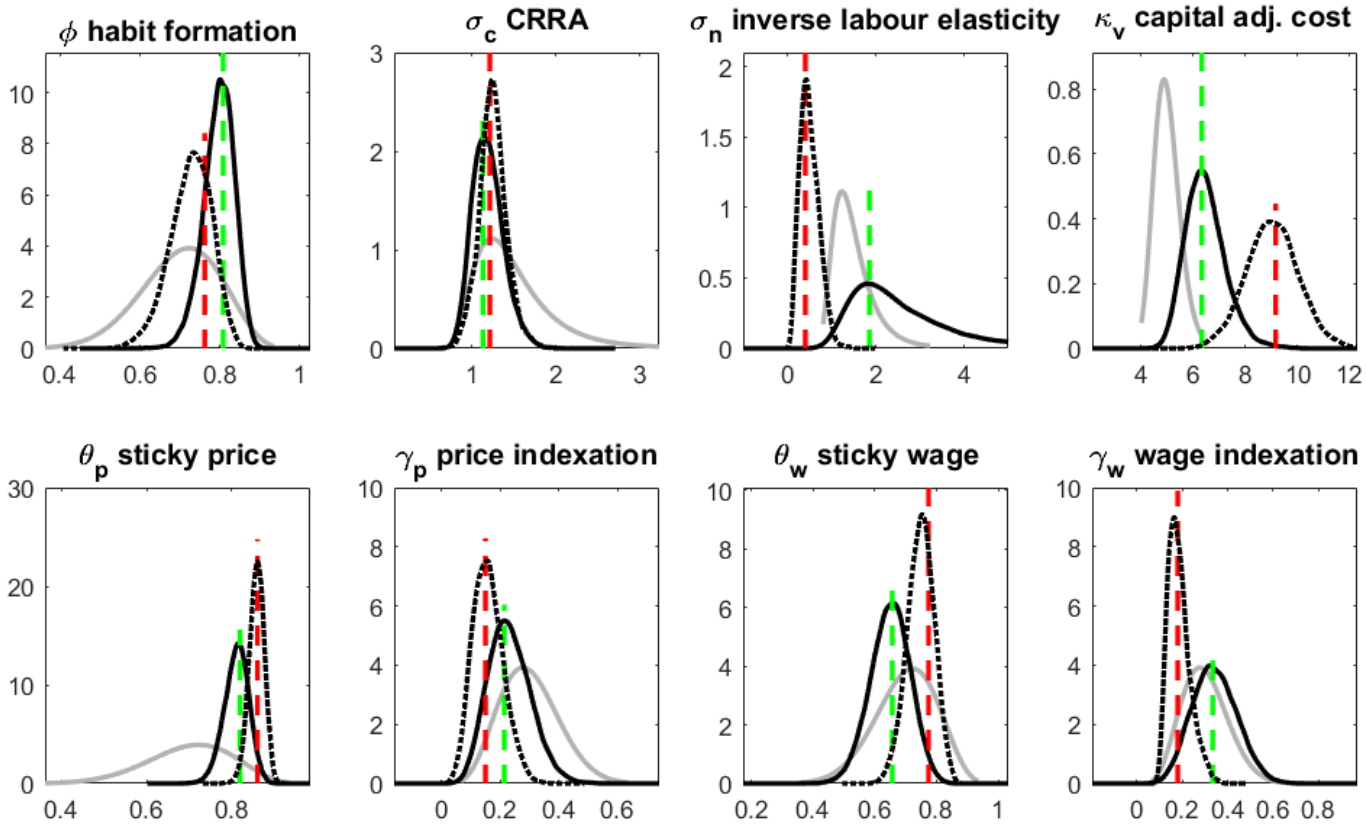


Figure: Prior (grey), *SW-NK* posterior (solid black) and *FF-NK* posterior (dotted black) distribution statistics with posterior modes (dashed green and red vertical lines).

Priors and Posteriors

Monetary Policy Parameters

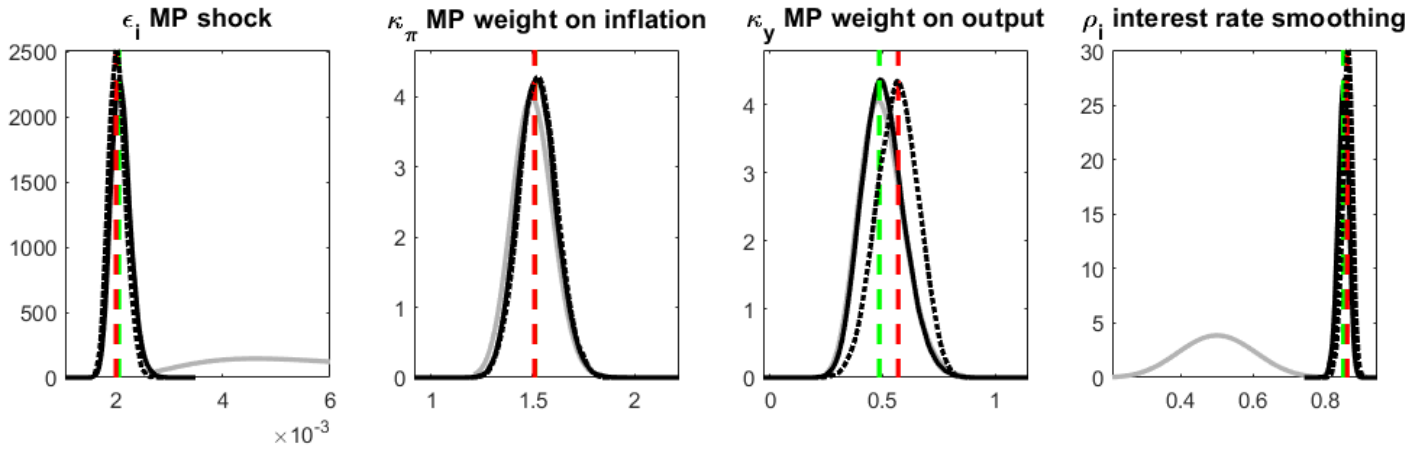


Figure: Prior (grey), *SW-NK* posterior (solid black) and *FF-NK* posterior (dotted black) distribution statistics with posterior modes (dashed green and red vertical lines).

Priors and Posteriors

Shocks

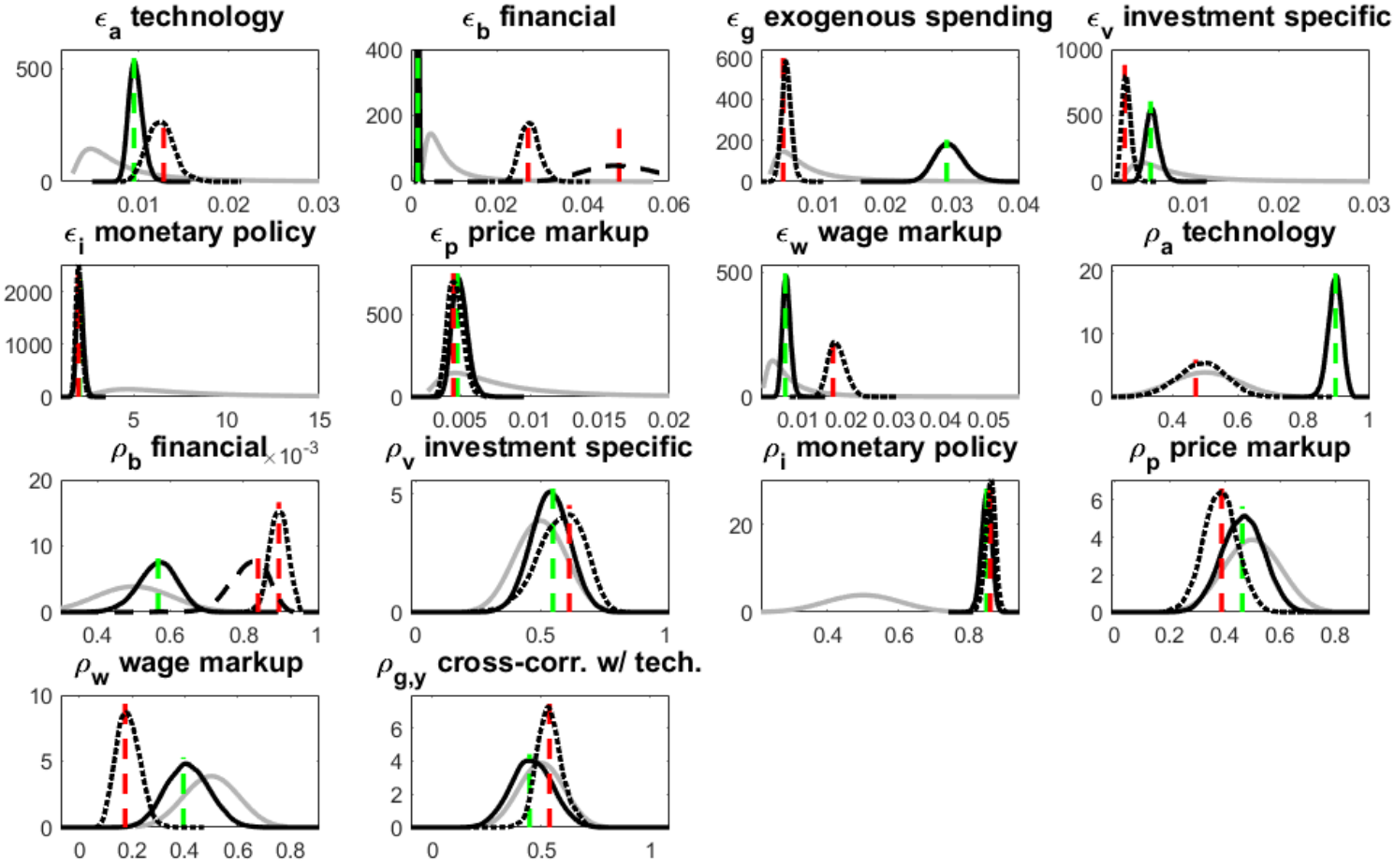


Figure: Prior (grey), *SW-NK* posterior (solid black) and *FF-NK* posterior (dotted black) distribution statistics with posterior modes (dashed green and red vertical lines). Distrubitions for ϵ_b and ρ_b includes equity price ψ (dashed black).

Impulse Response Analysis

Contractionary Monetary Policy Shock (without *FF-NK*)

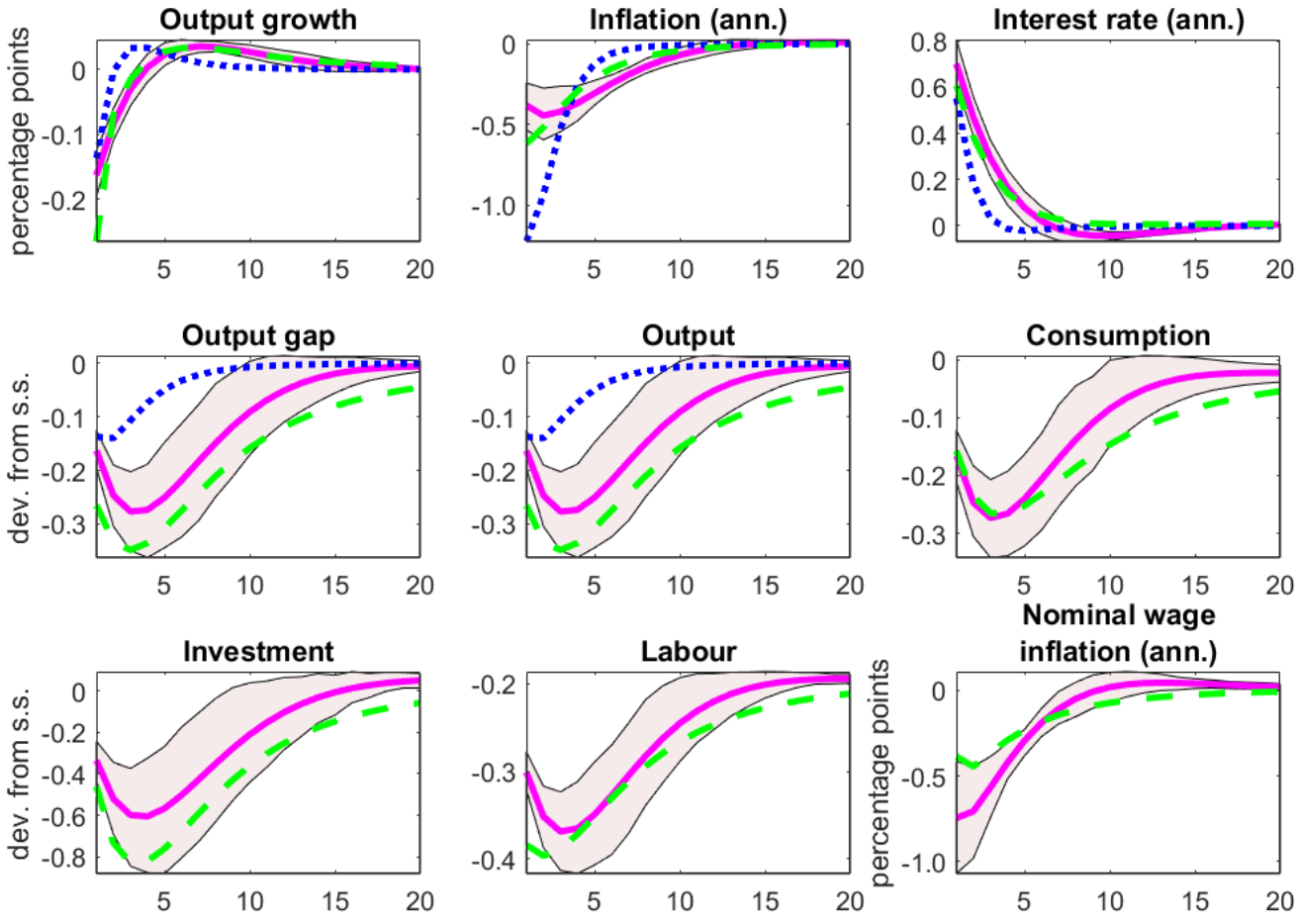


Figure: Solid line: *SW-NK* model. Dotted line: *Naive-NK* model. Dashed line: *SOE-NK* model.

Impulse Response Analysis

Contractionary Monetary Policy Shock (with *FF-NK*)

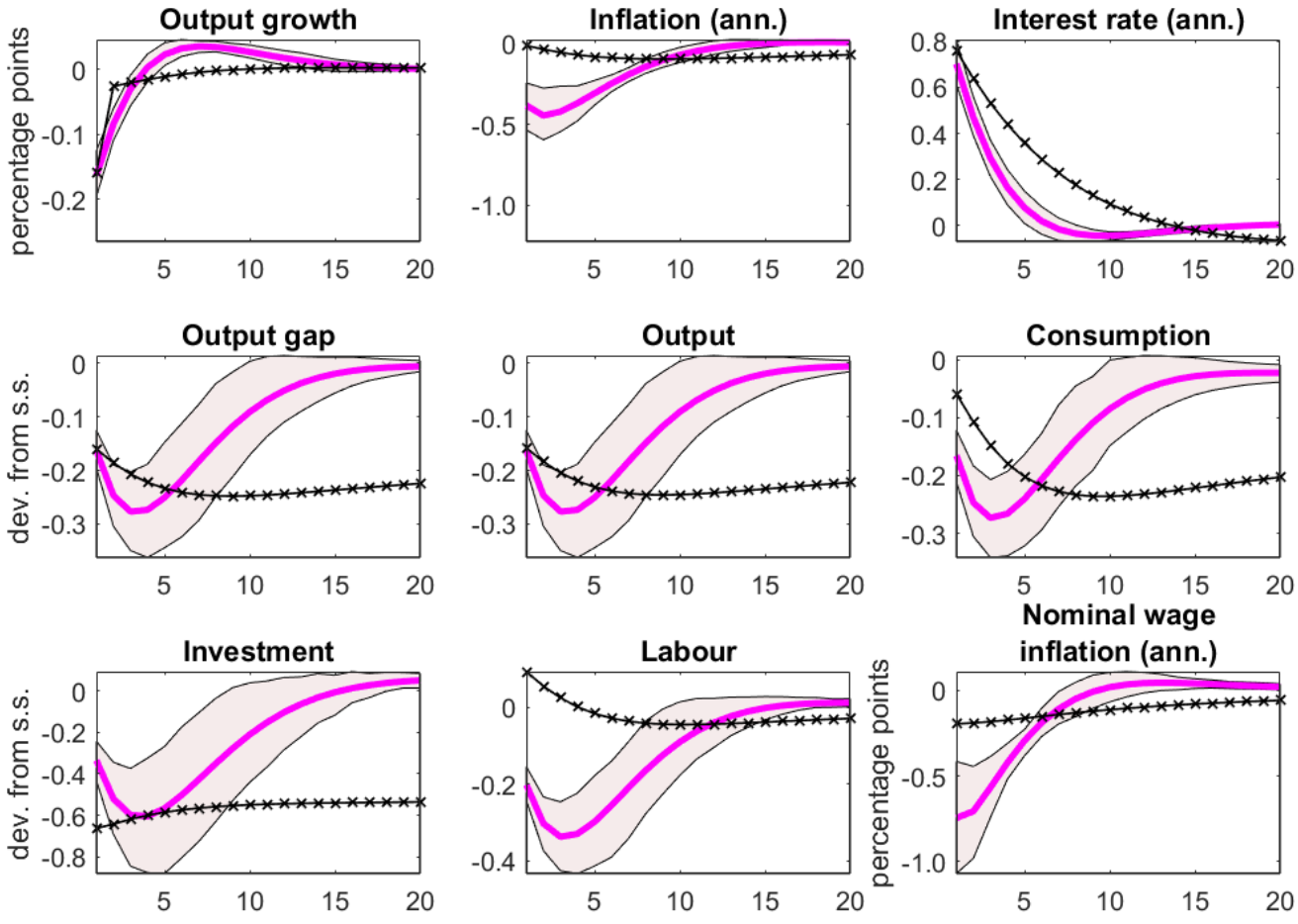


Figure: Solid line: *SW-NK* model. Cross-marker line: *FF-NK* model.

Forecast Error Variance Decomposition

Output Gap

		SW-NK: Time Horizons				*FF-NK*: Time Horizons			
Description	Shocks	1-quarter	1-year	2-years	5-years	1-quarter	1-year	2-years	5-years
Technology	ϵ_a	21	13.74	9.69	8.7	2.95	1.27	0.52	0.21
Risk premium	ϵ_b	53.64	40.66	30.72	26.99	0.48	0.29	0.25	0.27
Exogenous spending	ϵ_g	6.35	4.35	3.26	2.9	0.16	0.09	0.06	0.04
Investment specific	ϵ_v	2.7	4.46	4.59	4.28	0.34	0.15	0.18	0.22
Monetary policy	ϵ_i	5.02	6.45	6.66	6.29	1.63	1.16	1.02	0.94
Price mark-up	ϵ_π	8.3	19.14	22.45	21.02	10.42	9.72	8.89	7.4
Wage mark-up	ϵ_w	3	11.2	22.64	29.82	4.8	5.37	3.75	2.29
Credit supply	ϵ_τ; $\epsilon_{h,e}$	-	-	-	-	9.86	10.52	8.07	5.99
Credit demand	ϵ_{ν_h,ν_e}	-	-	-	-	17.89	25.06	26.33	24.26
Equity	ϵ_ψ	-	-	-	-	51.46	46.38	50.93	58.37

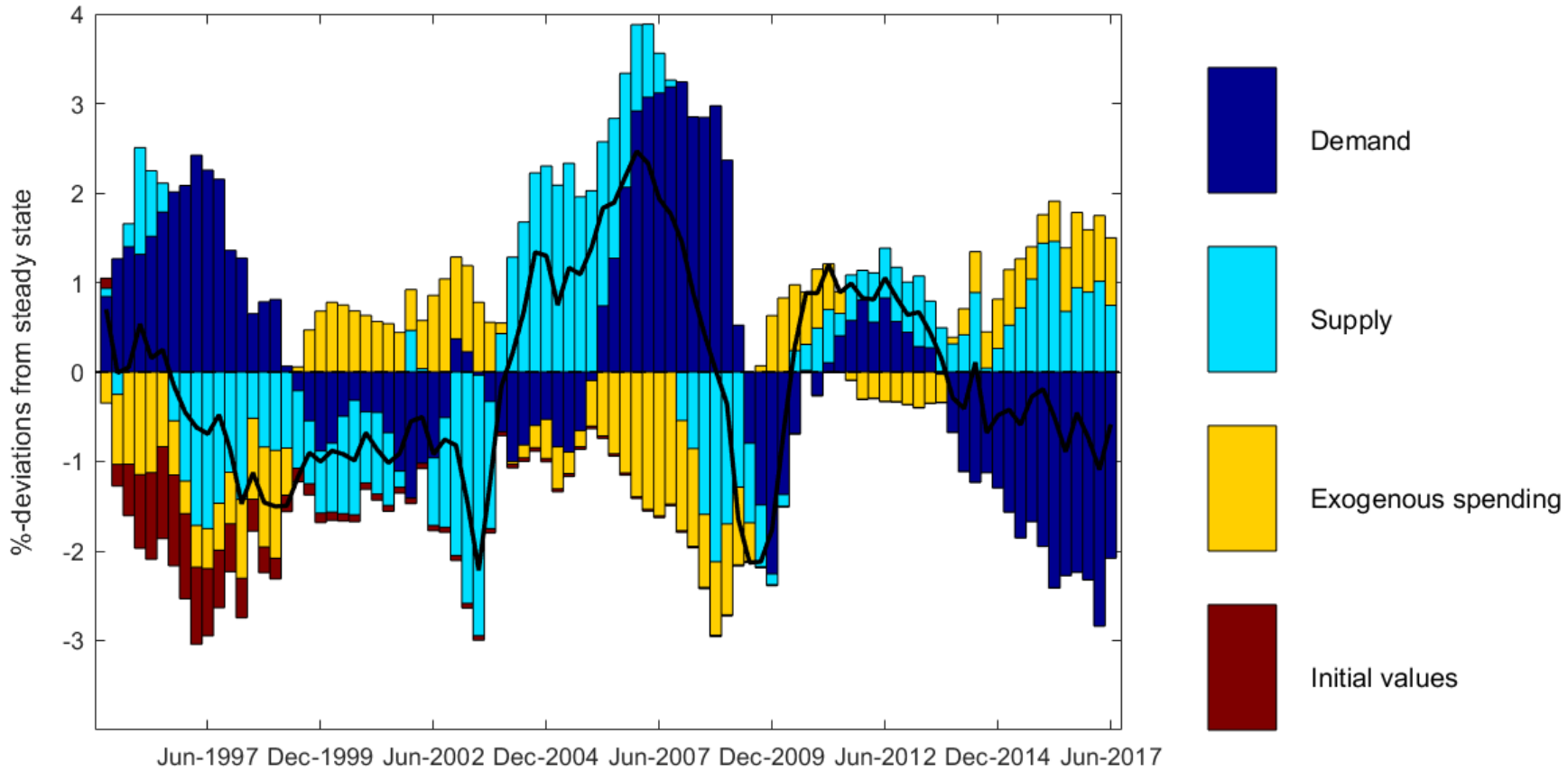
Forecast Error Variance Decomposition

Nominal Interest Rate

		SW-NK: Time Horizons				*FF-NK*: Time Horizons			
Description	Shocks	1-quarter	1-year	2-years	5-years	1-quarter	1-year	2-years	5-years
Technology	ϵ_a	0.94	4.16	5.93	6.1	3.31	0.58	0.23	0.12
Risk premium	ϵ_b	7.84	16.92	21.84	22.3	0.28	0.6	0.93	1.79
Exogenous spending	ϵ_g	4.32	3.09	3.1	3.08	1.88	0.33	0.13	0.06
Investment specific	ϵ_v	2.23	4.98	6.75	7.08	0.37	0.13	0.08	0.05
Monetary policy	ϵ_i	45.55	19.69	15.71	15.22	46.24	18.54	8.3	3.57
Price mark-up	ϵ_π	35.65	40.11	33.44	33.14	19.1	14.59	5.95	3.38
Wage mark-up	ϵ_w	3.46	11.04	13.21	13.1	6.7	14.63	13.12	8.53
Credit supply	ϵ_τ; $\epsilon_{h,e}$	-	-	-	-	2.83	10.79	11.5	7.66
Credit demand	ϵ_{ν_h,ν_e}	-	-	-	-	2.24	4.08	4.55	5.07
Equity	ϵ_ψ	-	-	-	-	17.06	35.73	55.21	69.78

Historical Decomposition

Output Gap (SW-NK), 1995Q1–2017Q2



Concluding remarks

Weak identification not a big issue

- ...if important sub-blocks insensitive
- "Identified moments" $\rightarrow$ micro can inform macro
  (Nakamura & Steinsson, 2018)

Specification matters

- ...more for financial factors
- ...likely for models with trade frictions too
  (Obstfeld & Rogoff, 2001; Eaton, Kortum & Neiman, 2016)
- ...selection of exogenous shocks

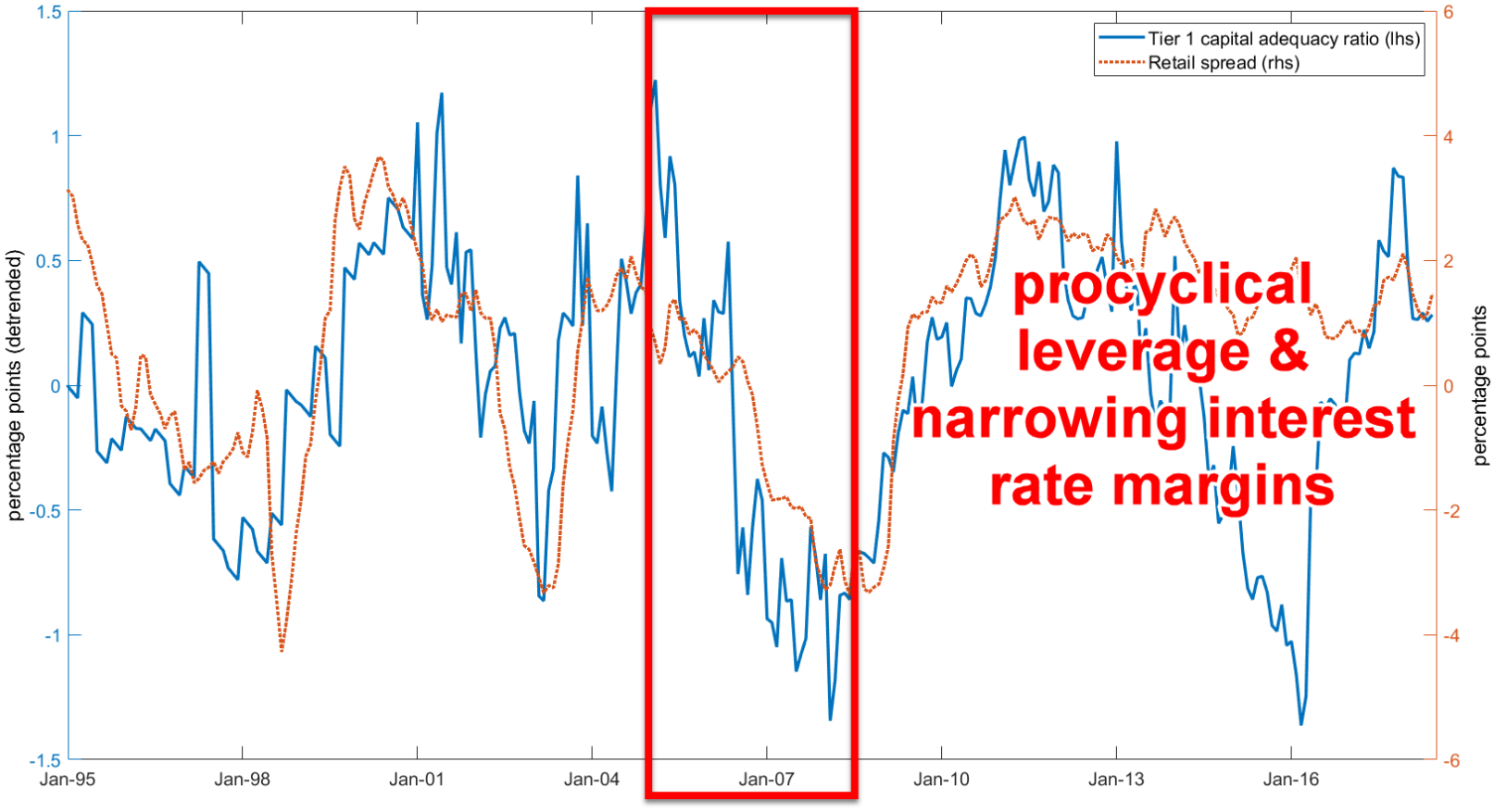
Inference for policy analysis?

- endogeneity of expectations (information effects/forward guidance)
- reduced form specification
- distinguishing between models
  - learn about deep structural parameters; "sufficient statistic"

Thank You

Spreads and Leverage (1)

Justification for financial frictions model (*FF-NK*)



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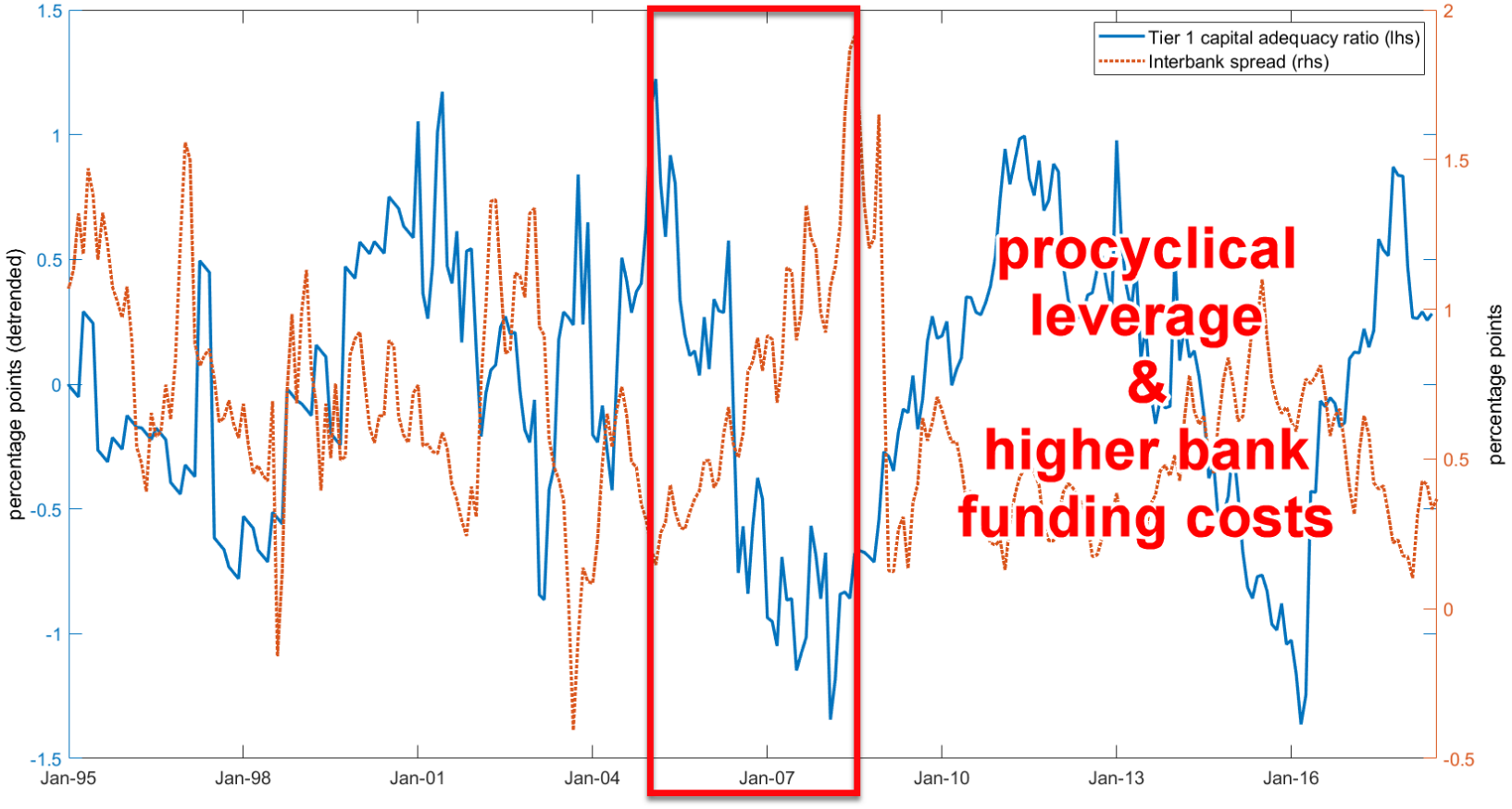
Spreads and Leverage (2)

Justification for financial frictions model (*FF-NK*)



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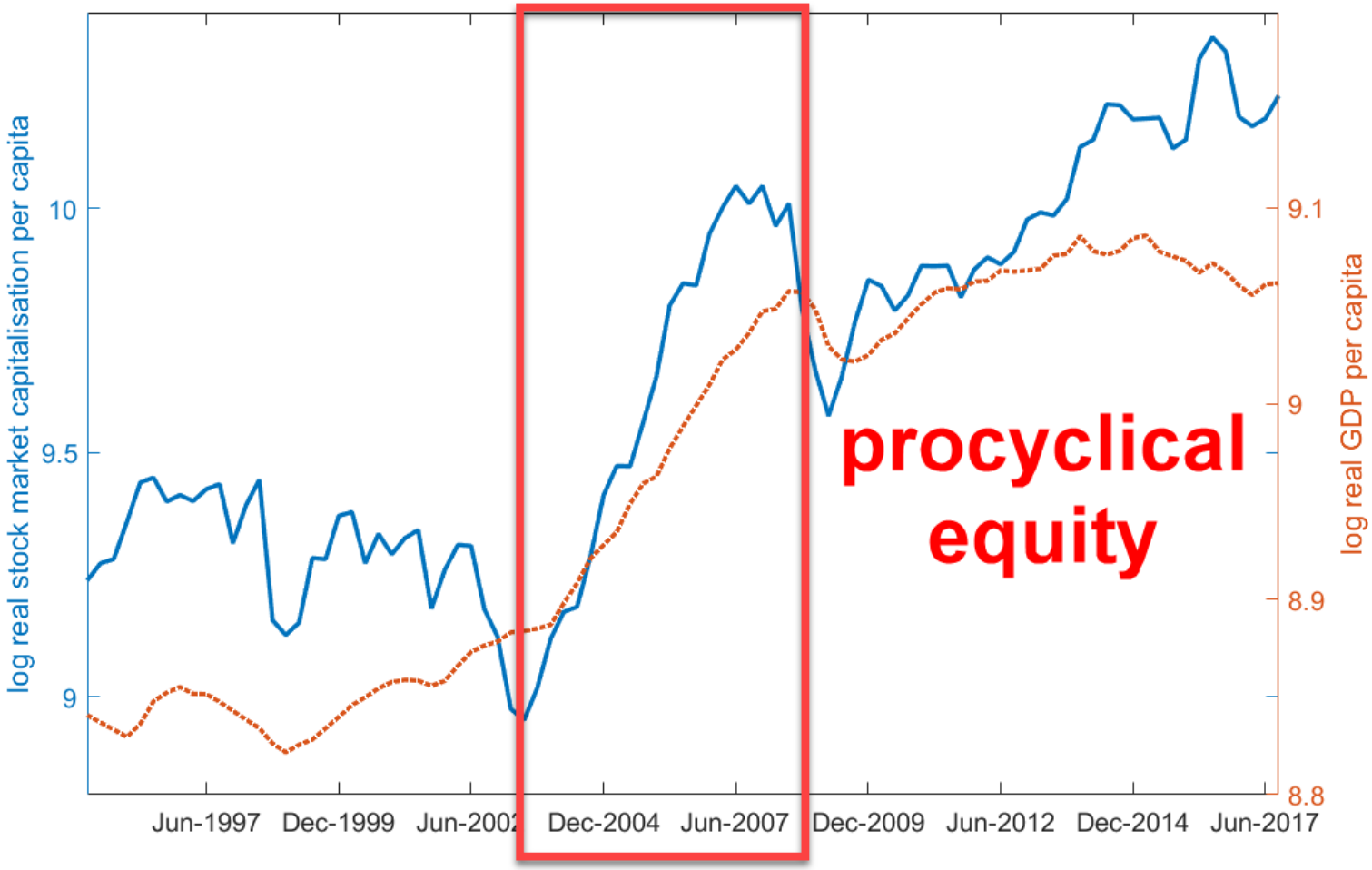
Equity and the real economy

Justification for financial frictions model (*FF-NK*)



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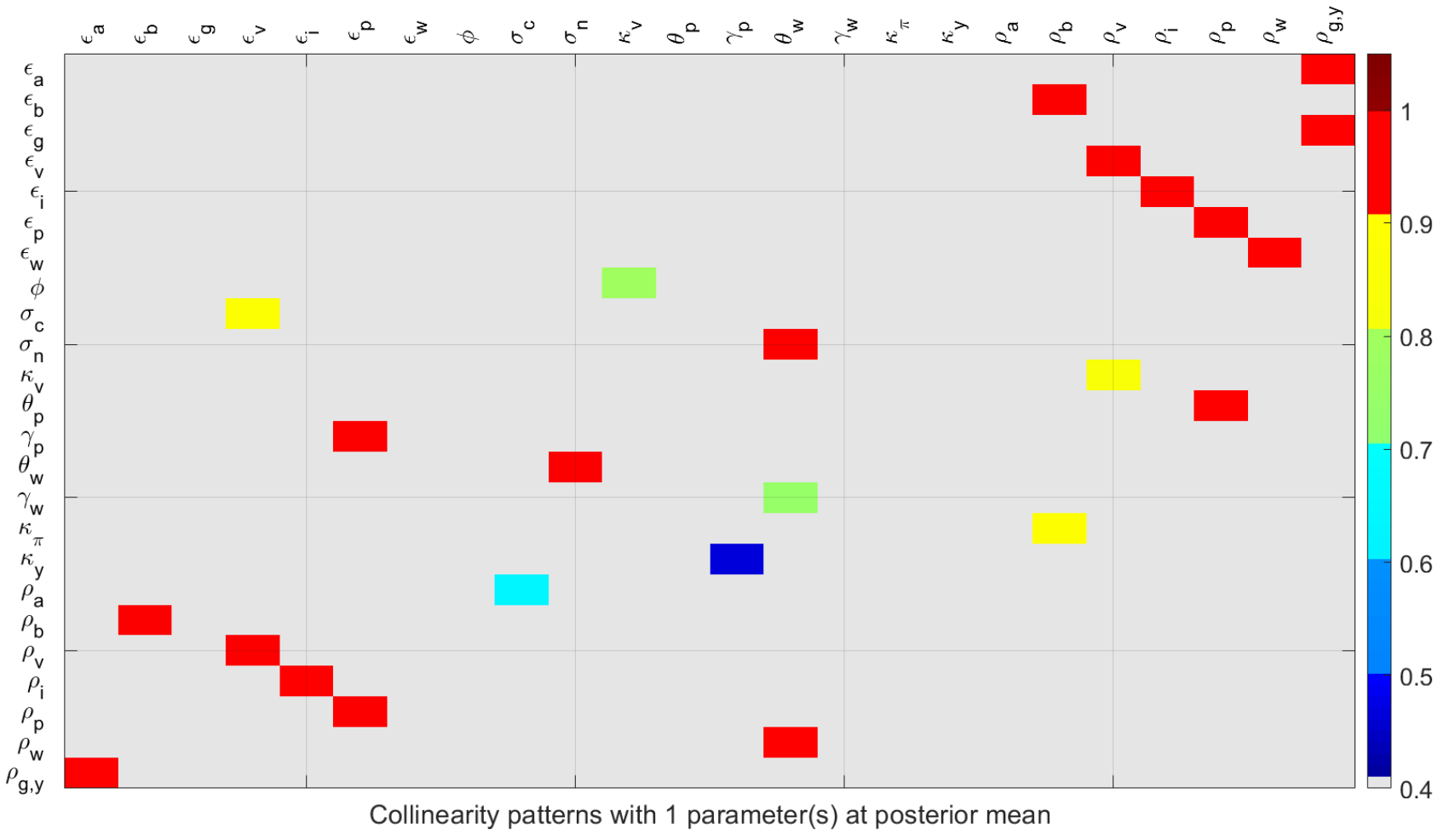
Collinearity (Posterior Mean)



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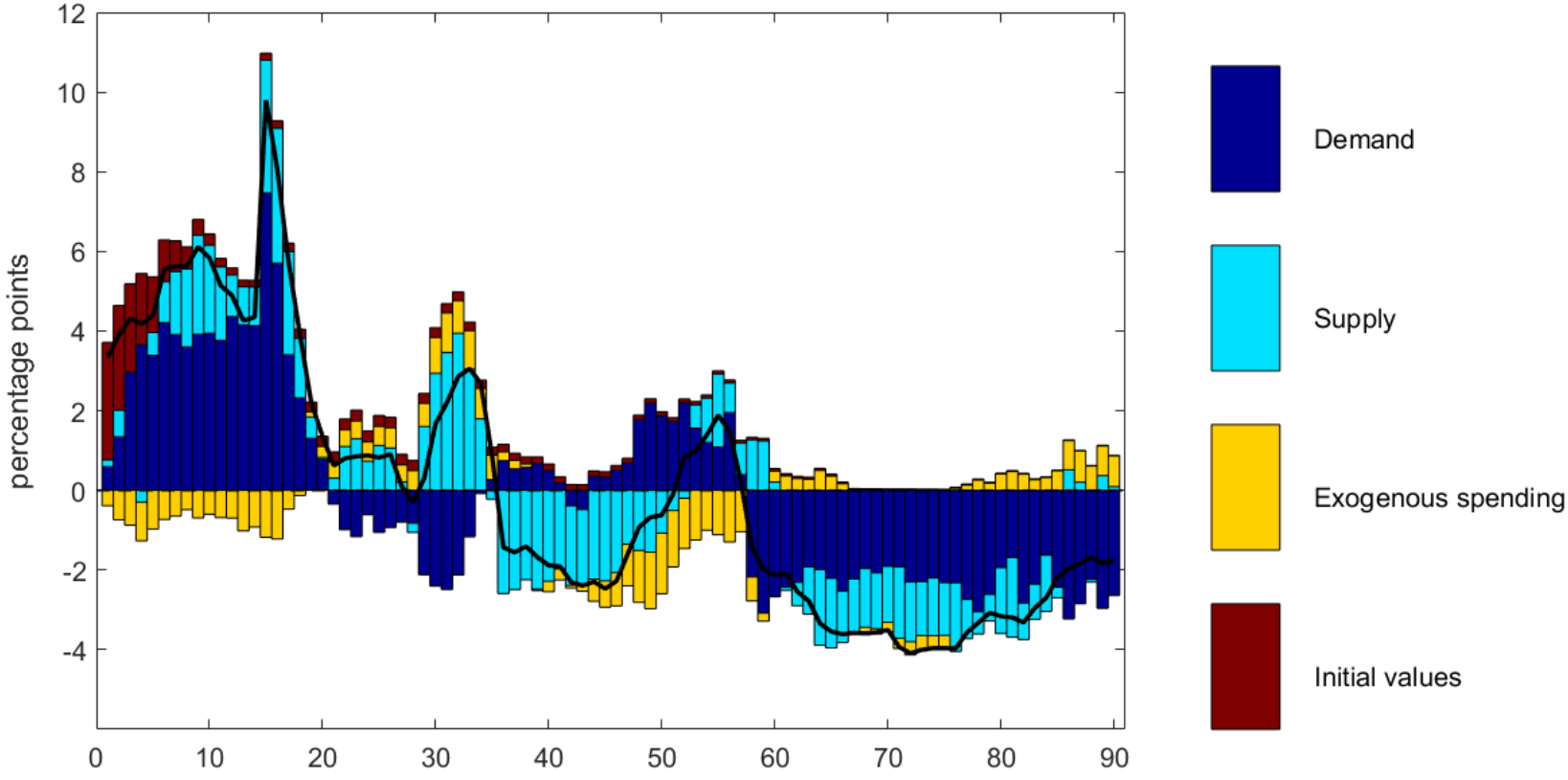
Historical Decomposition

Nominal Interest Rate (annualized) (SW-NK), 1995Q1–2017Q2



Historical Decomposition

Headline Inflation (ann.) & Output Growth (q-on-q) (SW-NK)