SYSTEM PRIORS

Formulating priors about DSGE Models' System Properties

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[1] The views expressed herein are those of the author and should not be attributed to the International Monetary Fund, its Executive Board, or its management.

Outline of the Talk

- **Definition**
- **Motivation for system priors**
  - Unintended consequences of marginal priors
  - Intuitive nature of system priors
- **System priors**
  - Candidates for system priors
  - Implementation
- **Illustrative experiment**

  (inducing parameter priors with one system prior. . .)

System Priors: Definition & Examples

System priors:
Prior views about **system properties** of the model, which are complex function of all underlying parameters

Examples:

- Sacrifice ratio after a permanent disinflation
- What is an upper bound on inflation deviating from the target after a persistent demand shock?
- What is a maximum share of variance of a measurement error for a variable X
- ...

System priors are very explicit, transparent, and can relate to any of model's properties.

Dogmatic 'system prior'?: Blanchard-Kahn stability condition!

System Priors: Motivation (A)

- **Eliciting priors for parameters of the model can be hard**
  - Are the parameters truly ‘structural’? E.g. Calvo parameter versus the slope of the Phillips curve…
  - Can we take on board evidence from micro-studies?
  - It makes hardly any sense to transfer parameter priors from one model to another
- **Independent marginal priors have unintended consequences! Have you checked?**
  - What is the prior distribution of an IRF?
  - What is the prior distribution of the cross-correlation between variables X and Y?
  - Can the response of X to Y be negative a priori at all?

System Priors: Motivation (B)

- **Top Down vs. Bottom Up Specification...**
  - Calibrated models used top down specification
  - Top down **priors** on system behavior of the model
  - Top down approach allows to implement **priors that make sense**, even if data are uninformative

- **System priors induce cross-dependence among parameters**
  - A prior on a model feature is consistent with a set of parameterizations (iso-parametric path)
  - Just one system prior may induce a joint distribution prior across multiple structural parameters

Problems with ‘standard DSGE’ priors (A)

- Assumption of independent marginal priors is **unrealistic**
- Reporting marginal parameter prior and posterior distribution is **not informative enough**
- Independent priors induce **unintended consequences** for the prior distribution of model features (IRFs, moments, conditional moments, etc.)
- Independent marginal priors are **not transparent.** Looking at them gives one no clue about a priori model behavior
- No or very **little economics** of adjustment-costs, etc. priors

Problems with 'standard DSGE' priors (B)

Prior-predictive analysis needed to reveal the effects of priors on key hypothesis

- What is the priori distribution of your monetary policy IRF?
- Could the response of labor to a TFP be positive in your model at all? Do priors tilt it that way?

Marginal independent priors give little control over priors!

- Too **diffuse** marginals imply loose control on a system feature of the model…
- Too **tight** marginals give little chance for data to speak…
- Marginal priors are **too blunt** for economics priors

Candidate System Priors

System priors:
Anything useful feature of the model: **“smell tests”**

Candidate system priors:

- Steady-state values of model variables
- Conditional or unconditional moments of the model
- Prominent policy scenarios
  (disinflation, delayed policy response, . . .)
- Characteristics of IRFs (peaks, cummulatives, . . .)
- Frequency response function and spectral characteristics
- . . .

With system priors, it is fine to have informative, economic priors!

Relationship to the Literature

- Faust (2009) and Gupta and Faust (2011) point at unintended consequences of ‘standard’ marginal independent priors using **prior-predictive analysis.**
- Geweke (2010) discusses prior-predictive analysis at lengths.
- Canova and Sala (2010) point out identification problems of DSGE models
- Fernandez-Villaverde and Rubio-Ramirez (2008): How Structural are Structural Parameters?
- Work of E.T. Jaynes on priors and max-ent priors, ’moment approach’ to prior selection in J.O. Berger (1985)

System Priors: Implementation

Posterior distribution: priors get updated using likelihood

Composite prior $\tilde{p}(\theta|\ldots)$ includes:

(i) marginal independent priors $p_m(\theta|\mathcal{M})$

(ii) system priors $p_S(\theta|\mathcal{M})$

Bayesian updating:

$$\begin{aligned} p(\theta|Y^o, Z^o, \mathcal{M}) &\propto L(Y^o|\theta, \mathcal{M}) \times p_S(Z^o|\theta, \mathcal{M}) \times p_m(\theta|\mathcal{M}) \\ &\propto L(Y^o|\theta, \mathcal{M}) \times \tilde{p}(\theta|Z^o, h, \mathcal{M}). \end{aligned}$$

General principle: estimation with side constraints...

(e.g. Bayesian Simulated Method of Moments with System Priors, Andrle (IMF,2012))

System Priors: Computation

Loss function with three components:

(i) likelihood function (or other criterion function) $L(Y^O|\theta, \mathcal{M})$

(ii) marginal independent priors $p_m(\theta|\mathcal{M})$

(iii) system priors $p_S(\theta|\mathcal{M})$

Posterior sampling:

- Simple extension of standard MCMC, e.g. RW-Metropolis
- To sample composite prior, just switch-off the likelihood!
- To sample just the composite prior, adaptive importance sampling is feasible (massively parallel)

System Priors: Example (A)

Simple New-Keynesian "gap" model used for illustration:

$$\hat{y}_t = \beta_1 y_{t+1|t} + \beta_2 y_{t-1} + \beta_3 (rr_t - \overline{rr}_t) + \varepsilon_t^y \quad (1)$$

$$\pi_t^c = \lambda_1 \pi_{t+1|t}^c + (1-\lambda_1)\pi_{t-1}^c + \lambda_2 \hat{y}_t + \varepsilon_t^\pi \quad (2)$$

$$i_t = \gamma_1 i_{t-1} + (1-\gamma_1) \times \left[(\overline{rr}_t + \overline{\pi}_t) + \gamma_2 (\pi_{t+3|t}^{y/y} - \overline{\pi}_{t+3}) + \gamma_3 y_t \right] + \varepsilon_t^i \quad (3)$$

$$rr_t = i_t - \pi_{t+1|t} \quad (4)$$

$$\overline{\pi}_t = \overline{\pi}_{t-1} + \varepsilon_t^{\overline{\pi}} \quad (5)$$

Sacrifice ratio:
Cumulative loss of output after a permanent disinflation by 1 ppt.

System Priors: Example (B)

Experiment:
If the sacrifice ratio is assumed to be distributed as N(0.8,0.05), how do parameter priors change?

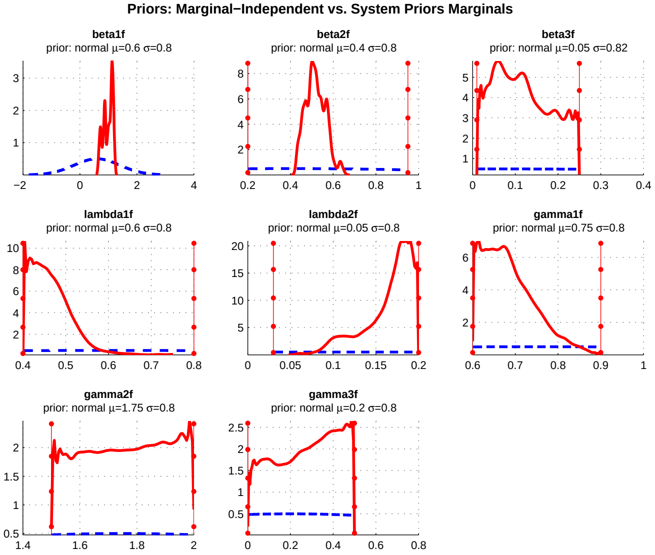
Specifically:

- System prior induces individual parameters priors joint distribution
- What parameters get affected?
- How does the *iso-parametric path* look like?

Note:

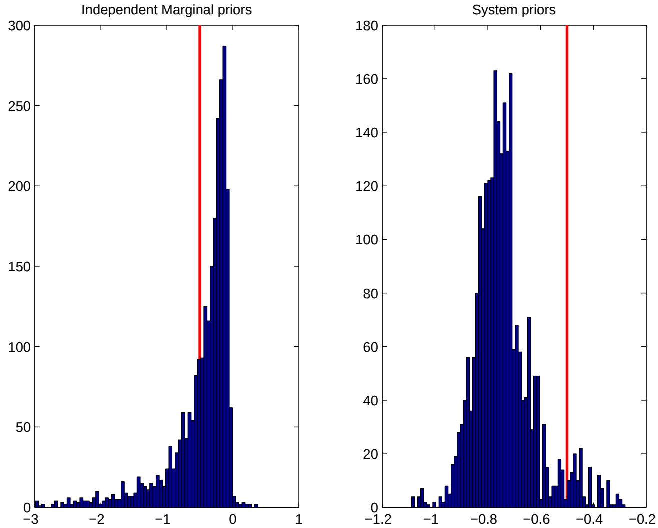
- Sacrifice-ratio prior does not breach the likelihood principle
- Likelihood is usually not informative about permanent disinflation response
- Cross-country evidence on disinflation available...

System Priors: Example (C-1: diffuse priors)



System Priors: Example (prior and posterior)

Sacrifice ratio: prior and system prior



System Priors: Usage & Toolbox

System priors are easy to implement:

- Just one more function to evaluate...
- IRIS Toolbox (`www.iris-toolbox.com`) features a subset of system priors

Implementation tips:

- Use objects and function handles to build the interface
- Employ switches for components of the loss function (loglik, sprior, mprior)
- Pass a solved model to a system prior routine

Conclusions

- System priors are the economic way of using priors
- System priors solve many problems of marginal independent priors
- System priors induce individual parameter priors
- System priors encompass ‘standard’ way of doing things

Thank you for your patience!