Are Policy Counterfactuals Based on Structural VARs Reliable?

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This paper:

Issue: ***'Are SVAR-based policy counterfactuals reliable?'***

➔ Based on DSGE models, I explore to which extent SVAR-based counterfactuals can reliably capture the impact of changes in the Taylor rule on the properties of the economy

Motivation:

SVAR-based policy counterfactuals are widely used:

➔ Primiceri (*ReStat*, 2005), Sims-Zha (*AER*, 2006), Gambetti, Pappa, Canova (*JMCB*, 2006) etc. etc. …

However:

- **reliability has never been systematically checked conditional on a set of DGPs**
- **only piece of evidence—Benati and Surico (*AER*, 2009)—is negative …**

Motivation (continued):

➔ **Benati and Surico (*AER*, 2009) provide a single example based on estimated DSGE models in which SVARs fail to uncover the truth about the DGP …**

In particular, SVAR-based counterfactual dramatically fails to capture the impact of changes in the Taylor rule …

So, how serious is the problem?

Do Benati and Surico's results crucially depend on their specific DGP, or do they point towards a general problem?

Let's start by considering the key conceptual issue involved …

The problem in a nutshell

- Take a New Keynesian model
- Consider two sets of parameters for the Taylor rule:

$$\text{Taylor}^1 \Rightarrow [\rho^1, \psi_\pi^1, \psi_y^1]$$
$$\text{Taylor}^2 \Rightarrow [\rho^2, \psi_\pi^2, \psi_y^2]$$

Together with other parameters, you have:

$$\text{Taylor}^1 \Rightarrow \text{DSGE}^1 \Rightarrow \text{SVAR}^1 \Rightarrow \text{MonetaryRule}^1$$
$$\text{Taylor}^2 \Rightarrow \text{DSGE}^2 \Rightarrow \text{SVAR}^2 \Rightarrow \text{MonetaryRule}^2$$

where MonetaryRule^i, $i = 1, 2$ is interest rate equation of the structural VAR representation of the DSGE model

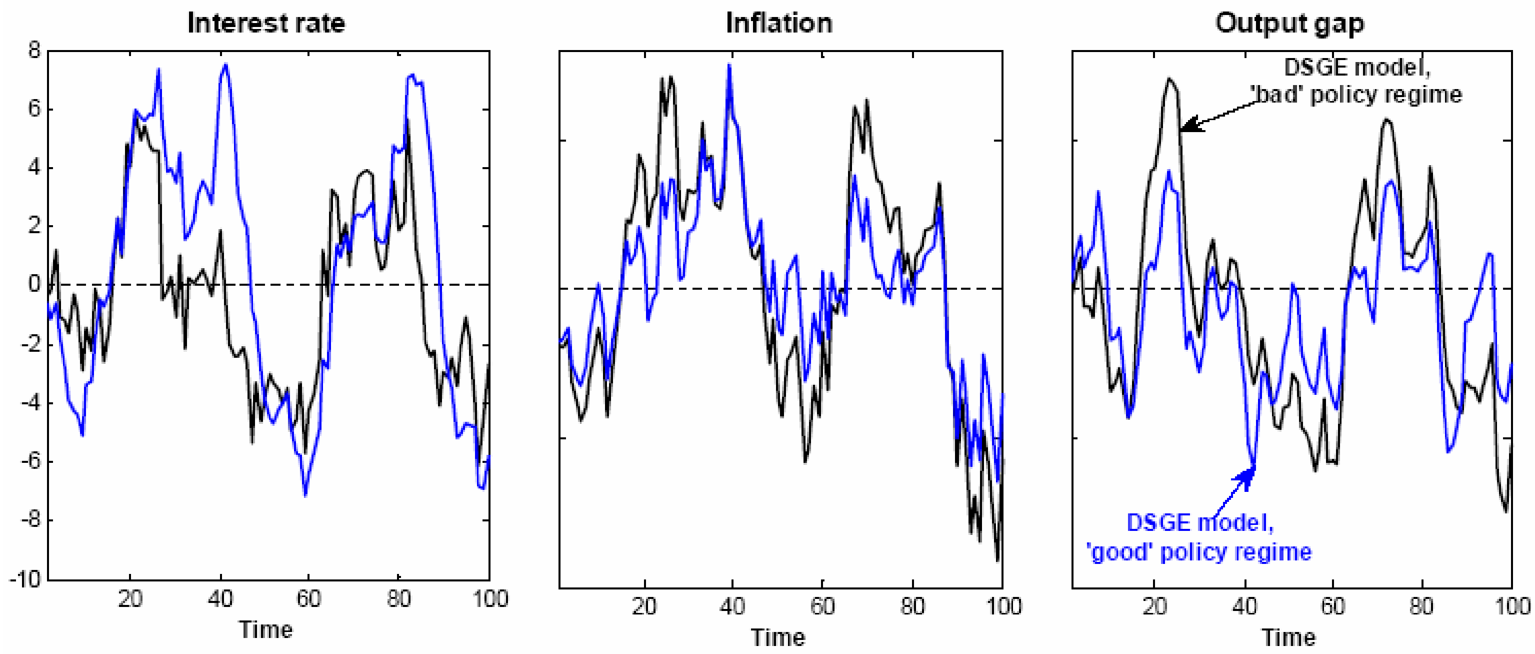
Key issue is: 'Switching MonetaryRule^1 and MonetaryRule^2 is not the same as switching Taylor^1 and Taylor^2'

➔ difference is sometimes large …

A simple illustration:

Feed same set of shocks to New Keynesian 3-equation 'toy' model conditional on two alternative Taylor rules:

- **Taylor^1 ➔ $[\rho^1, \psi_\pi^1, \psi_y^1]$ (call it 'bad' policy)**
- **Taylor^2 ➔ $[\rho^2, \psi_\pi^2, \psi_y^2]$ (call it 'good' policy)**



Switching Taylor^1 and Taylor^2 within the DSGE model causes black lines to become blue, and viceversa …

Two alternative notions of policy counterfactual:

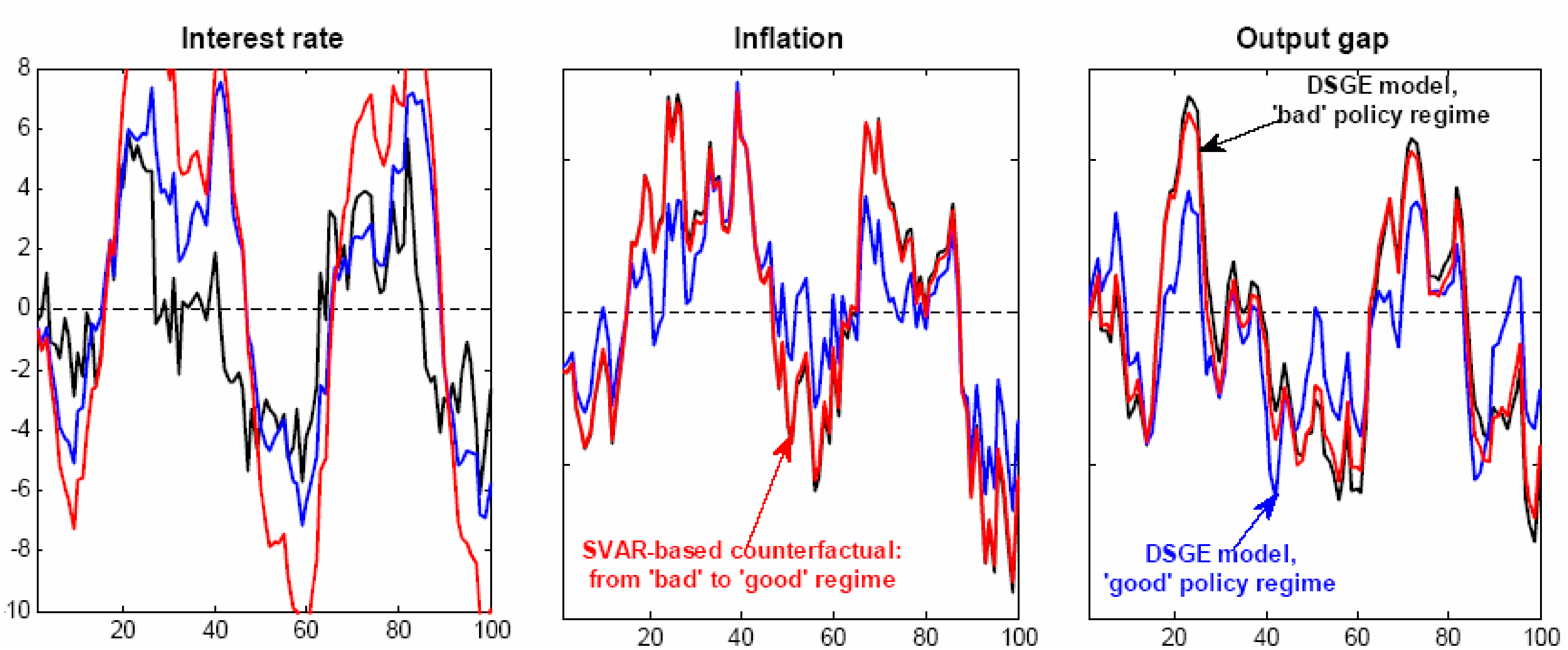
- **Switching Taylor^1 and Taylor^2 within the DSGE model is the authentic policy counterfactual**
- **switching MonetaryRule^1 and MonetaryRule^2 within the SVAR model is the SVAR-based policy counterfactual**

Question: ***'Can I replicate the authentic policy counterfactual by switching the monetary rules of the structural VAR representations of the DSGE models?'***

The answer is NO, and the difference between the outcome of the authentic policy counterfactual and the outcome of the SVAR-based counterfactual is sometimes large …

Let's see in this case how large the error is in going from 'bad' to 'good' ➔ imposing MonetaryRule^2 in SVAR^1

If SVAR-based counterfactual worked, red lines would be identical to the blue lines …but this is clearly not the case …



- **On the contrary, for inflation and output gap you hardly move from the 'bad' regime (➔ red almost identical to black)**
- **SVAR-based counterfactual fails to capture truth**

➔ Let's see results based on numerical methods …

Theoretical properties of SVAR-based policy counterfactuals

- **Model: standard New Keynesian model with backward and forward-looking components**

$$y_t = \gamma y_{t+1|t} + (1-\gamma) y_{t-1} - \sigma^{-1}(R_t - \pi_{t+1|t}) + \epsilon_{y,t}$$

$$\pi_t = \frac{\beta}{1+\alpha\beta}\pi_{t+1|t} + \frac{\alpha}{1+\alpha\beta}\pi_{t-1} + \kappa y_t + \epsilon_{\pi,t}$$

$$R_t = \rho R_{t-1} + (1-\rho)[\phi_\pi \pi_t + \phi_y y_t] + \epsilon_{R,t}$$

- **Country: United States**
- **Sample period: post-1960 period**
- **Bayesian estimates: standard (Random-Walk Metropolis)**

These 'benchmark' estimates imply certain theoretical properties for the economy

➔ trivially recovered from VAR implied by DSGE model …

I will show results from the following exercise:

- **Let $Taylor^{B} \equiv [\rho^{B}, \psi_{\pi}^{B}, \psi_{y}^{B}]$ be the estimated benchmark Taylor rule**
- **Let $Taylor^{A} \equiv [\rho^{A}, \psi_{\pi}^{A}, \psi_{y}^{A}]$ be an alternative Taylor rule, with different values of the key coefficients**

We have

$$Taylor^{B} \Rightarrow DSGE^{B} \Rightarrow SVAR^{B} \Rightarrow MonetaryRule^{B}$$
$$Taylor^{A} \Rightarrow DSGE^{A} \Rightarrow SVAR^{A} \Rightarrow MonetaryRule^{A}$$

which implies two sets of theoretical standard deviations for the series

$$SVAR^{B} \Rightarrow STDs^{B}$$
$$SVAR^{A} \Rightarrow STDs^{A}$$

By definition, Substituting Taylor^{A} with Taylor^{B} implies that STDs^{A} becomes STDs^{B}

Question: ***'What if I try to do that via the SVARs, by imposing MonetaryRule^{B} into SVAR^{A}?'***

Let STDs^{C} (C for counterfactual) be the theoretical standard deviations of the series produced by such SVAR-based policy counterfactual

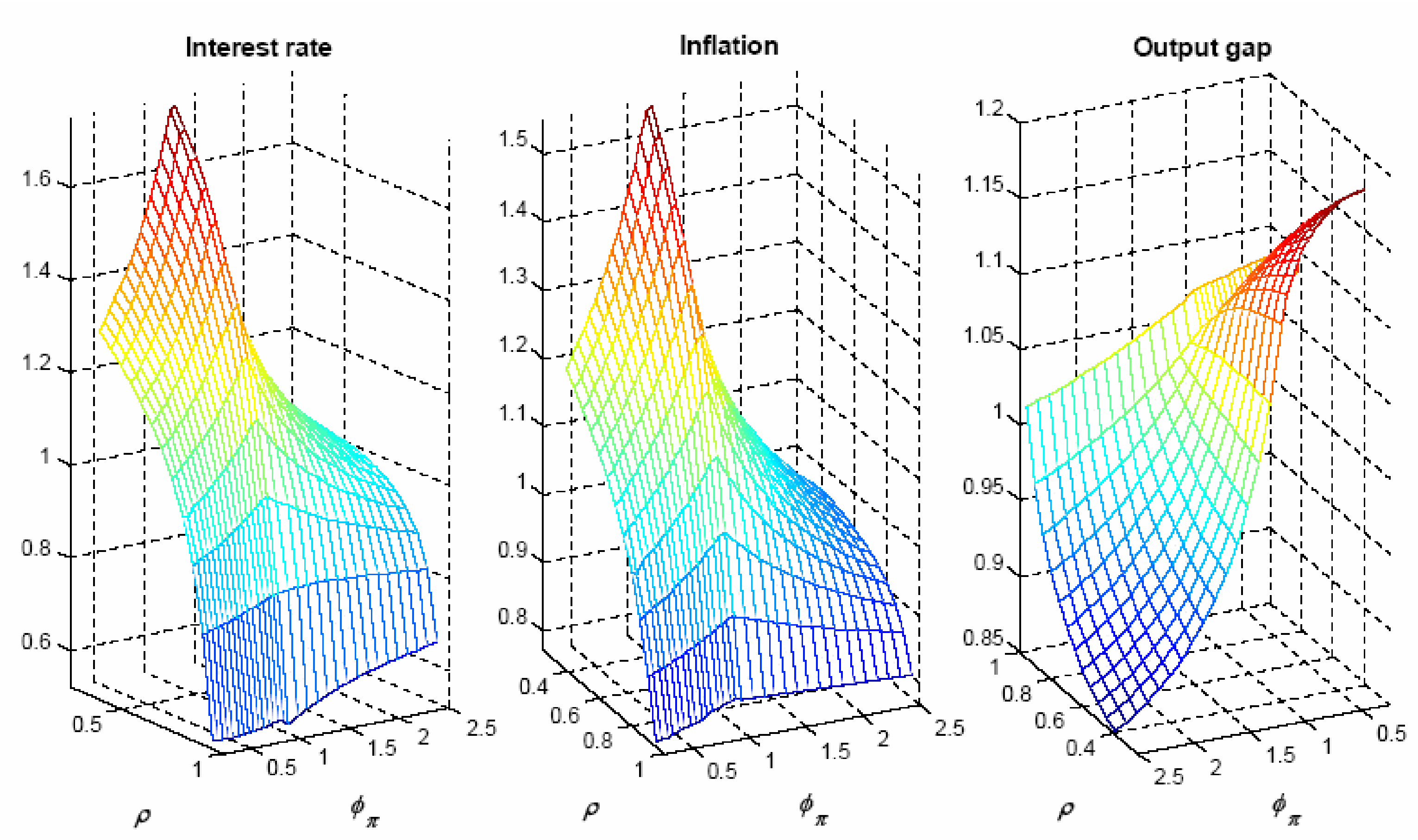
If it worked fine, we would have, for each variable

$$\text{STDs}^{C} = \text{STDs}^{B}$$

So that for each possible alternative Taylor rule (Taylor^{A}), their ratio would be uniformly one …

➔ but that's not the case

The ratio STDs^C/STDs^B for grids of values for ρ^A and ψ_π^A:



Only close to 1 if Taylor^A is close to Taylor^B …

➔ In general, SVAR-based counterfactual fails …

Same results based on two alternative DSGE models:

(*i*) Lubik and Schorfheide (*AER*, 2004)
(*ii*) Andres, Lopes-Salido, and Nelson (St. Louis FED WP, 2008), which I estimate for post-WWII United States

Problem also pertains macroeconomic relationships …

➔ SVAR-based counterfactuals distort macro relationships, as captured by VAR-implied cross-spectral statistics between the series …

Next, key question: 'Where does the problem originate from?'

‘Where does the problem originate from?’

I show it is due to the cross-equations restrictions imposed by rational expectations on the solution of macroeconomic models with forward-looking components …

So it is exactly the problem discussed by Sargent in his critique of VAR methods, and it has to do with the Lucas critique …

Seriousness of the problem, however, has never been checked conditional on a set of models …

Formally, let the SVAR representations of the DSGE model conditional on 2 alternative values of the policy parameters, θ_1 and θ_2, be:

$$\tilde{B}_0(\theta_1)Y_t = \tilde{B}_1(\theta_1)Y_{t-1} + ... + \tilde{B}_p(\theta_1)Y_{t-p} + \epsilon_t$$

$$\tilde{B}_0(\theta_2)Y_t = \tilde{B}_1(\theta_2)Y_{t-1} + ... + \tilde{B}_p(\theta_2)Y_{t-p} + \epsilon_t$$

The SVAR-based counterfactual associated with imposing the SVAR's structural monetary rule for regime 2 onto the SVAR for regime 1 produces the following structure:

$$\begin{bmatrix} \tilde{B}_0^R(\theta_2) \\ \tilde{B}_0^{\tilde{}R}(\theta_1) \end{bmatrix} Y_t = \begin{bmatrix} \tilde{B}_1^R(\theta_2) \\ \tilde{B}_1^{\tilde{}R}(\theta_1) \end{bmatrix} Y_{t-1} + \ldots + \begin{bmatrix} \tilde{B}_p^R(\theta_2) \\ \tilde{B}_p^{\tilde{}R}(\theta_1) \end{bmatrix} Y_{t-p} + \epsilon_t$$

The problem is clear:

- **SVAR-based counterfactual only changes θ in the interest rate equation**
- **it leaves θ unchanged in the other equations**

Therefore, in general, results from SVAR-based counterfactual are different from results of DSGE-based counterfactual …

Paper shows mathematically that problem disappears only in one extreme case: when model solution is vector white noise …

‘How relevant is the problem in practice?’

Only way to answer would be to know the true data generation process …

In what follows I will provide tentative evidence on likely practical relevance of the problem, based on estimated DSGE models for Great Inflation and most recent period

- **Countries: United States, United Kingdom**
- **Models: (*i*) standard New Keynesian backward- and forward-looking, and (*ii*) Andres, Lopes-Salido, and Nelson (*JEDC*, 2009)**
- **Estimation: Bayesian ➔ Random-Walk Metropolis**
- **I allow for one-dimensional indeterminacy, but no sunspot shocks**

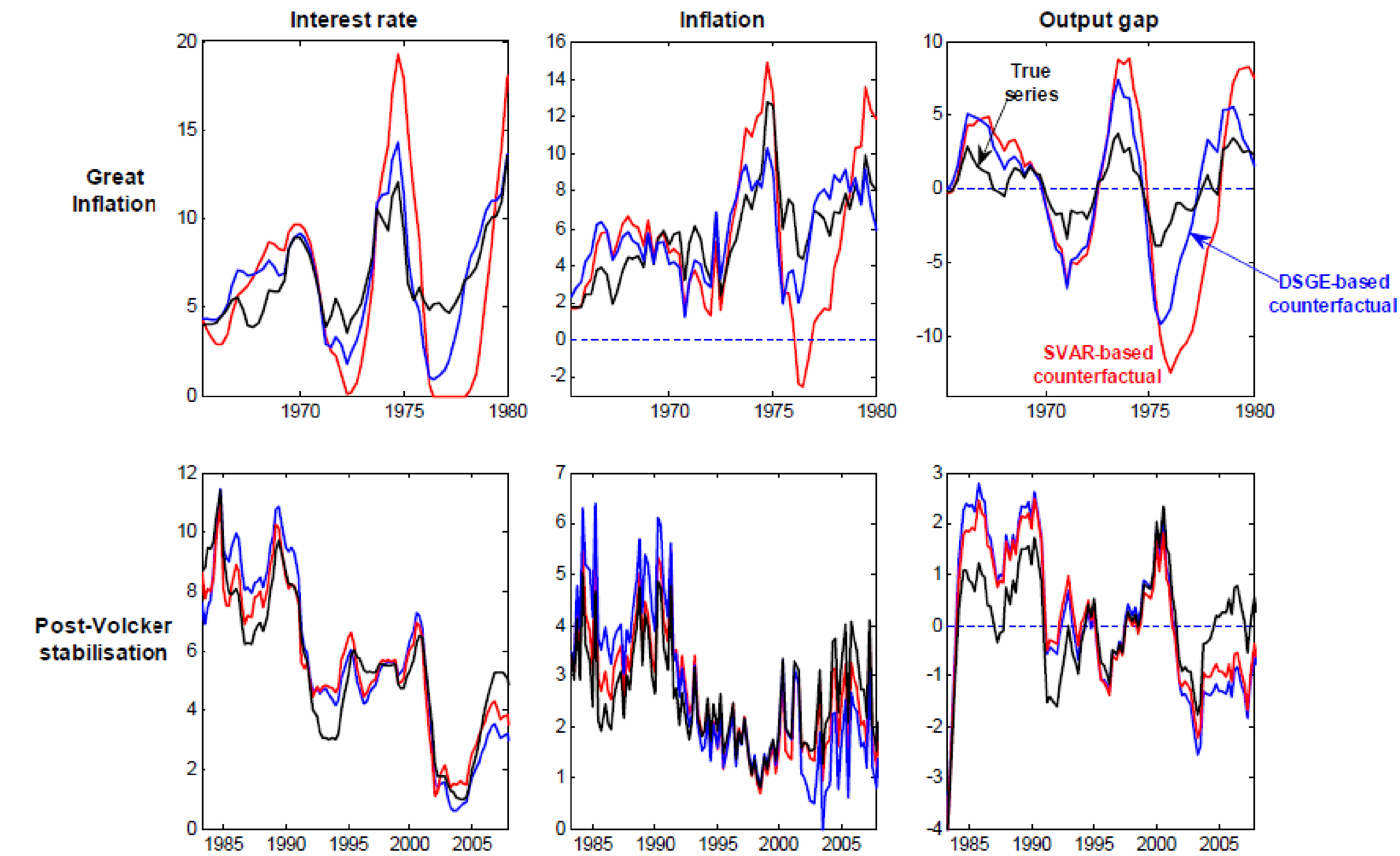
  ➔ with sunspot shocks, identification problem under indeterminacy …

Then, based on estimated models for two periods, I perform policy counterfactuals

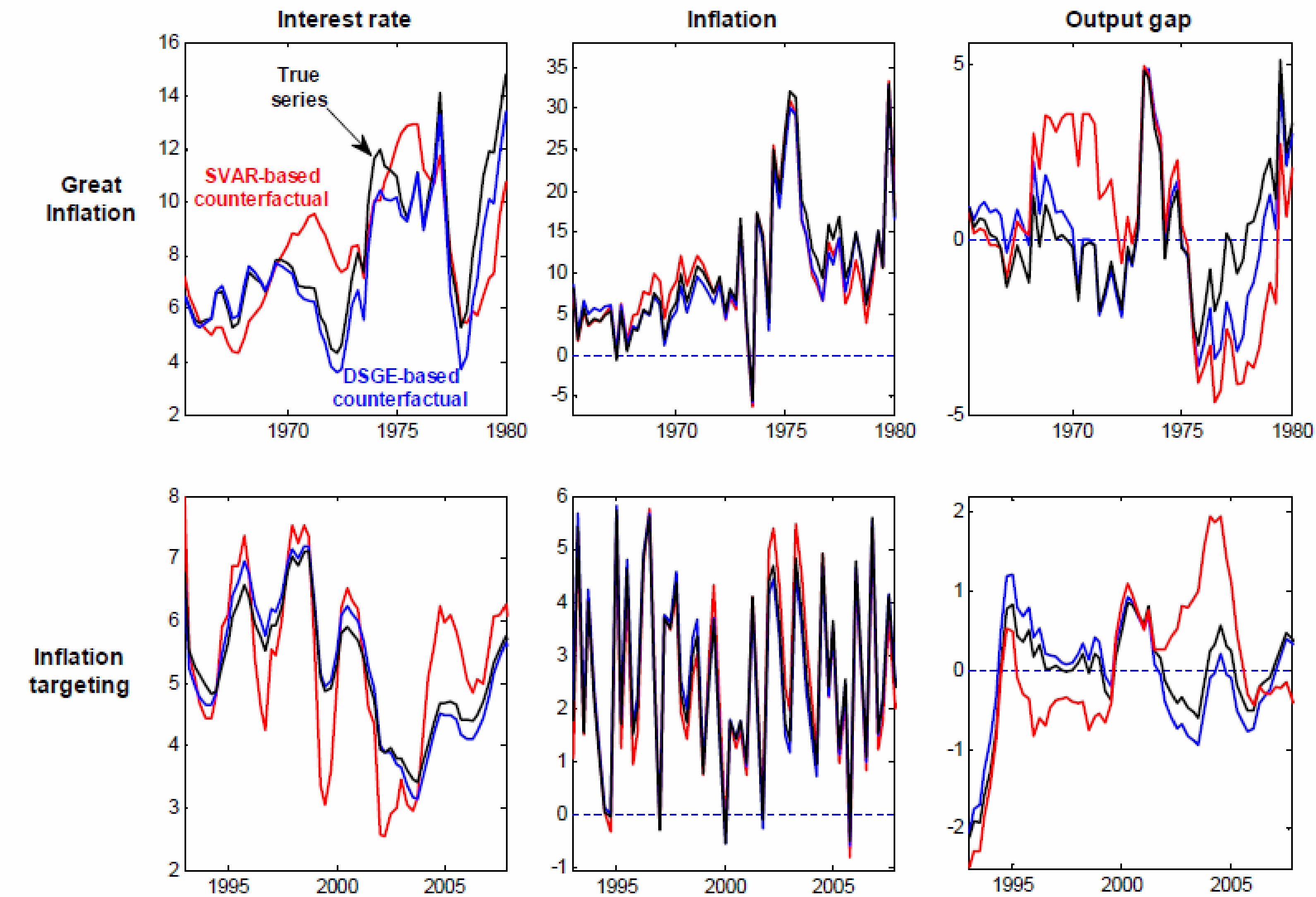
- **both DSGE-based and SVAR-based**
- **for both periods**

Let's see the results …

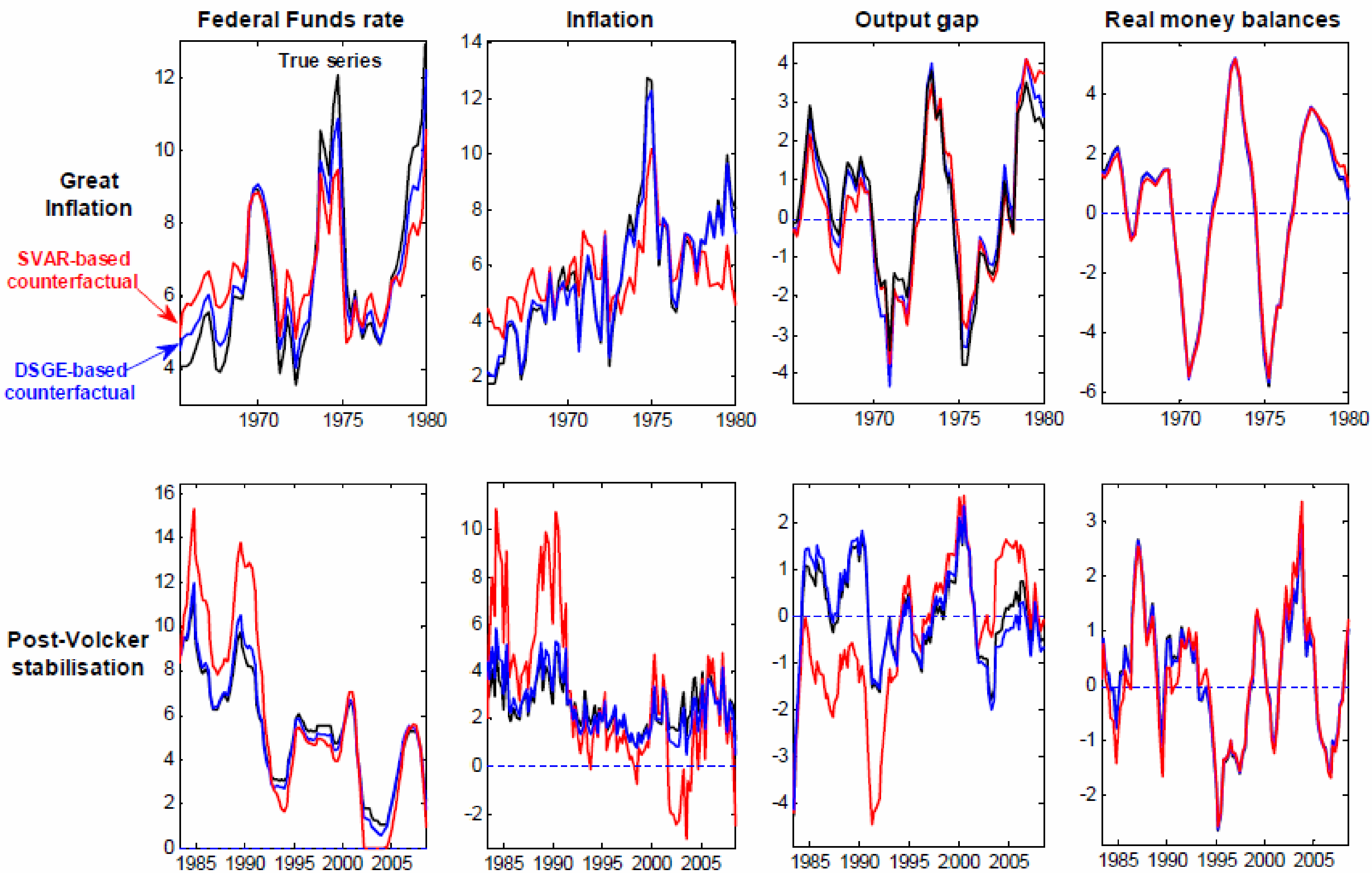
I: U.S., New Keynesian backward- and forward-looking model



II: U.K., New Keynesian backward- and forward-looking model



III: U.S., Andres *et al.* (JEDC, 2009) model



Key points to stress: I

Results are already sufficiently bad without sunspots …

If I allow for sunspots, everything becomes worse, because

- **there's an identification problem under indeterminacy (*N* VAR residuals, *N*+1 shocks)**
  ➔ 'identified' shocks under indeterminacy are not true structural shocks
- **the DSGE-based counterfactual 'kills off' the sunspots, the SVAR-based one cannot …**
  ➔ results are necessarily distorted

Key points to stress: II

SVAR-based counterfactuals suffer from key logical problem

- **reliability crucially depends on unknown structural characteristics of data generation process**
  ➔ extent of forward- as opposed to backward-looking behaviour, etc.
- **you can't just assume it**
- **only way to check for reliability within specific context is to estimate a (DSGE) structural model …**
- **but that's exactly what the SVAR methodology wanted to avoid in the first place!!**

Summing up

SVAR-based counterfactuals perform well only conditional on extreme model features ➔ model solution is vector white noise

Under normal circumstances SVAR-based counterfactuals always suffer from an approximation error which can be quite substantial …

Results from SVAR-based counterfactuals should be taken with caution, precisely because they may suffer from a substantial imprecision …

SVAR-based counterfactuals suffer from crucial logical problem: only way to check for reliability within specific context is to estimate structural model …

Still to be done:

What Sims would say:

- **'All of this pertains to the case of a one-time, unanticipated, permanent change in policy …'**
- **'If policy can change, rational agents will attach probabilities to various regimes'**
- **'This will nullify the impact of switches across regimes'**

➔ Sims' rebuttal of the Lucas critique

So let's see … There are two competing 'technologies', as far as fitting macro post-WWII data is concerned:

- **the random-walk VAR *cum* reflecting barriers of Cogley and Sargent (*NBER Macro Annuals*, 2001; *RED*, 2005)**
- **the Markov-switching VAR of Sims and Zha (*AER*, 2006)**

They have fundamentally different implications for the issue at hand …

- **in the random-walk VAR of Cogley-Sargent, all shifts are permanent**
  ➔ the results you've seen up until now apply directly
  ➔ SVAR-based policy counterfactuals do have fundamental problems …

- **In the Sims-Zha Markov-switching environment, everything depends on the transition matrix …**

Assume monetary rule switches between 2 regimes, and consider the following transition matrices:

$$T_1 = \begin{bmatrix} 0.5 & 0.5 \\ 0.5 & 0.5 \end{bmatrix} \quad T_2 = \begin{bmatrix} 1\text{-}\epsilon & \epsilon \\ 0 & 1 \end{bmatrix}$$

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T_1 and T_2 encode two extreme, polar cases …

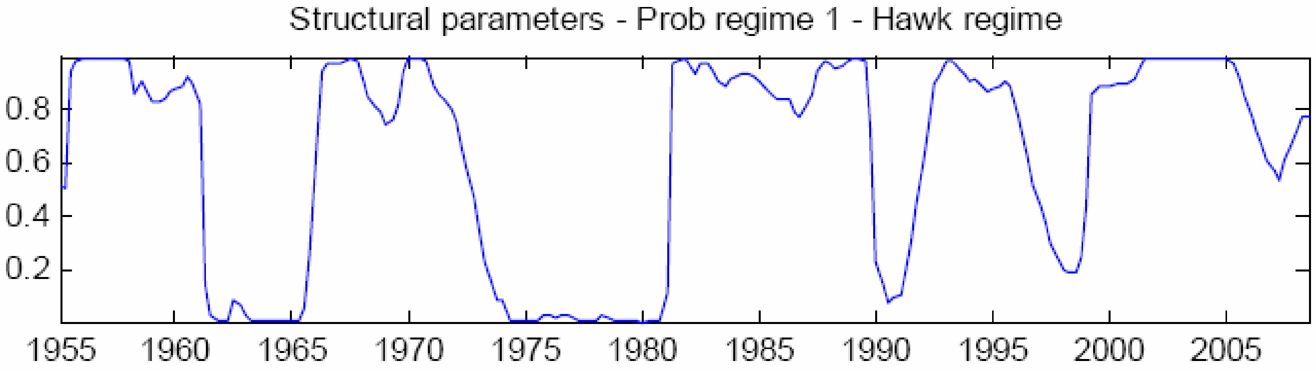
- **Under T_1, the expectation of the future is independent of the current state of the economy …**
  ➔ impact of change in policy is minimised, because it only affects period *t*, whereas it has no impact on expectations …
  ➔ this is an extreme example of what Sims has in mind …

- **T_2, with ε in a neighbourhood of zero, is very close to notion of unanticipated and permanent change in regime**
  ➔ impact of change in policy is maximised
  ➔ this is essentially the case I have analysed up until now

Question: 'Which of 2 cases is closer to reality?' Let's see ...

I: Results from estimated Markov-switching DSGE models

Bianchi (2009) estimates 2-state Markov-switching DSGE model. This is estimated probability of the Hawk regime:



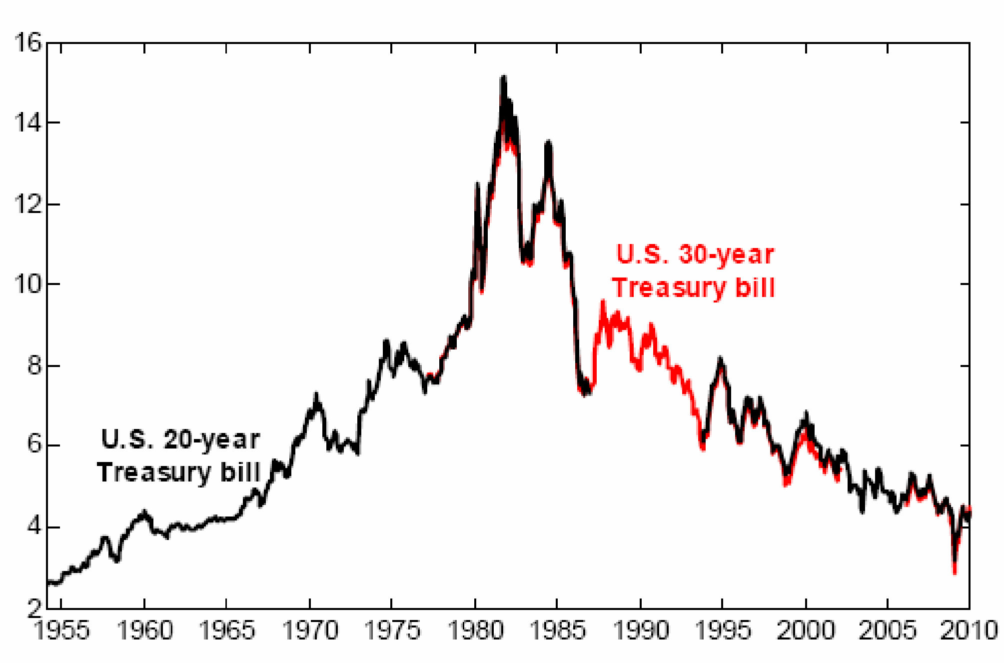
It is obviously quite far away from T_1: indeed, diagonal elements of transition matrix are 0.92 and 0.92 …

So, first thing I'll do next is estimate Markov-switching DSGE model conceptually in line with Bianchi (2009), and, based on estimated model, check whether SVAR-based counterfactuals capture the impact of a switch in the Taylor rule …

II: Implications for long-term interest rates

A necessary implication of T_1, is that long-term interest rates should be approximately constant

- if reality is T_1, only impact of regime switch is on current period
- this will have almost no impact on interest rates at the 20-30 year maturity



If I find a lot of movement in long-term rates, this implies that, no matter what other features of reality are, we are pretty far away from T1 …

Indeed …

Bottom line:

Two technologies for fitting macro series:

- **Cogley-Sargent: SVAR-based policy counterfactuals have problems**
- **Sims-Zha: SVAR-based counterfactuals do not have problems if and only if we are close to T_1 …**

  ➔ … but this does not seem to be empirically the case …