Modeling output gaps with structural and financial cycles

Christophe Planas[1], Alessandro Rossi[1] and Rafał Raciborski[2]

[1]Joint Research Centre, European Commission [2]Vistula University

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Motivation (1)

Although macroeconomic analysis often takes measurement of the output gap for granted, its construction is subject to considerable uncertainty. As a practical matter, empirical estimates of the output gap for any given method may not be particularly reliable. This may pose an acute difficulty for economic stabilization policy that requires reliable estimates of the output gap in real time when policy decisions are made.

Orphanides and van Norden (2002)

Motivation (2)

[...] from a measurement perspective, there is little doubt that financial developments contain information about the cyclical component of output. If so, ignoring them is bound to provide less accurate estimates of potential output whenever this is captured by the non-cyclical component of business fluctuations.

Borio et al. (2013)

Various facets of the discussion

- Business vs. financial cycle (Borio et al., 2013, 2014)
- "Business cycle = Housing cycle" (Leamer, 2007)
- Reliability of output gap estimates in real time (Orphanides and van Norden, 2002; Hallett et al., 2012)
- EU/EA context (link between output gap estimates, cyclically-adjusted government balances and the Stability and Growth Pact)

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"Finance-neutral" cycle

Since the outburst of the financial crisis several authors postulated estimating output gaps using financial, not structural variables. Most notable ***Borio et al., (2013, 2014)***. Their main claims:

- Ignoring financial variables (credit, house prices etc.) leads to substantial underestimation of the amplitude of the cycle...
- ...while including these variables improves the real-time properties of the estimators (the ***"finance-neutral" cycle***)
- Using some of the conventional structural variables may actually be harmful (exemplified by inflation)

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Structural vs. financial cycles

- Most of the authors (including Borio et al. 2013, 2014) all but ignore the existence of the conventional "structural" cycle; only one, "financial", cycle
- Questionable from the policy-making perspective (very different policy implications)
- Nevertheless the financial cycle probably (surely!) can't be ignored
- Critique of the use of some structural indicators is controversial but needs to be taken seriously
- Need of a framework for identifying and examining both types of cycles

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- Need of a framework for identifying and examining both types of cycles

What we do

- Build a model that explicitly accounts for 2 cycles ("structural" and "financial") driving the output gap
- Use both, structural and financial variables
- Adopt a statistical approach (exploiting Ruenstler, 2004, and Ruenstler and Vlekke, 2015)
- Study the resulting business cycle properties
- Relate the estimated cycles to conventional structural indicators and additional macro aggregates
- *Attempt to cast some light on the economic interpretation of the cycles (very preliminary)*

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Model

- The econometric model uses a framework developed by Ruenstler (2004) and Ruenstler and Vlekke (2015)
- Similar to the statistical model used in Planas et al. (2009) but more flexible (allows for modeling phase shifts)
- 2 cyclical components assumed to drive the cycles of all observed variables
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Model (observation equations)

Assume we observe J variables y_{jt}.
An observed series j can be decomposed into a trend, p_{jt}, and $K \leq J$ cyclical components, c_{jkt}, according to the formula:

$$y_{jt} = p_{jt} + r_{jk} \sum_{k=1}^{K} c_{jkt} + v_{jt}^{y}$$

with r_{jk} is a loading on cycle (j,k). v_{jt}^{y} is AR(1) with autoregressive coefficient γ_j:

$$v_{jt}^{y} = \gamma_j v_{jt-1}^{y} + \varepsilon_{jt}^{y}$$

where ε_{jt}^{y} is normally and independently distributed (NID) across time and variables.

Model (trends)

Trends are modeled in a flexible manner encompassing ARIMA(1,1,0) and I(2) processes:

$$p_{jt} = p_{jt-1} + \eta_{jt-1}$$

$$\eta_{jt} = (1 - \phi_j)\,\mu_j + \phi_{jt}\,\eta_{jt-1} + \varepsilon_{jt}^{\eta}$$

where μ_j is a drift term, $0 \leq \phi_j \leq 1$, and ε_{jt}^{η} is NID across time and variables.
We find $\phi_j < 1$ for all the series we use.

Model (cycles)

Each cycle c_{kt} is modeled using two auxiliary stochastic cyclical components (SCCs) $(\psi_{kt}, \psi^*_{kt})^T$:

$$(1-\phi_k L)\left(I_2 - \rho_k \begin{pmatrix} \cos\lambda_k & \sin\lambda_k \\ -\sin\lambda_k & \cos\lambda_k \end{pmatrix} L\right)\begin{pmatrix} \psi_{kt} \\ \psi^*_{kt} \end{pmatrix} = \begin{pmatrix} \varepsilon^c_{kt} \\ \varepsilon^{*c}_{kt} \end{pmatrix}$$

where L stands for the lag operator and I_2 is a 2×2 identity matrix.
$0 < \rho_k < 1$ is a decay parameter and $0 \leq \phi_k \leq 1$ is an additional autoregressive root.
Cyclical innovations $(\varepsilon^c_{kt}, \varepsilon^{*c}_{kt})^T$ are NID across time, cycles and from each other.

Model (cycles cont'd)

Given the pair of auxiliary SCCs $(\psi_{kt}, \psi^*_{kt})^T$, the k-th cycle of variable j, c_{jkt}, is defined as:

$$c_{jkt} = \cos\left(\lambda_k \theta_{jk}\right) \times \psi_{kt} + \sin\left(\lambda_k \theta_{jk}\right) \times \psi^*_{kt}$$

Cycle c_{jkt} has frequency λ_k, with $\tau_k = \frac{2\pi}{\lambda_k}$ the period of the cycle. Further, for two variables i, j, the correlation of their k-th cycles:

$$corr\left(c_{ikt}, c_{jkt}\right) = \cos\left(\lambda_k \left(\theta_{jk} - \theta_{ik}\right)\right)$$

where $\left(\theta_{jk} - \theta_{ik}\right)$ is the relative phase shift between the two cycles.
$\left(\theta_{jk} - \theta_{ik}\right) > (<) 0$ indicates that c_{jkt} leads (lags) c_{ikt}.
Note that $corr\left(c_{ilt}, c_{jkt}\right) = 0$ for all i, j and $l \neq k$.

Data and model specification

- Quarterly US data
- 5 variables: $j = gdp, hh, nf, pp, cu$ (output, credit to hh, credit to nf, property prices and capacity utilization in manufacturing/industry)
- 2 cycles: $k = s, f$ (structural and financial)
- Number of other variables used to test the explanatory power of the estimated cycles

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Estimation

- Model estimated with Bayesian methods
- Estimated in state-space form by Kalman filter
- Software used: DMM, see Planas et al. (2016)
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Identifying cyclical components

- Bayesian priors used for identification of cyclical components
- Agnostic cycles identification: $\tau_s \in (12, 32)$, $\tau_f \in (40, 128)$
- ***Idea***: Financial cyclical components tend to be characterized by larger amplitude and ***longer period*** (in line with, e.g., Ruenstler and Vlekke, 2015); but let the data decide which variables' cycles mainly explained by which cyclical component

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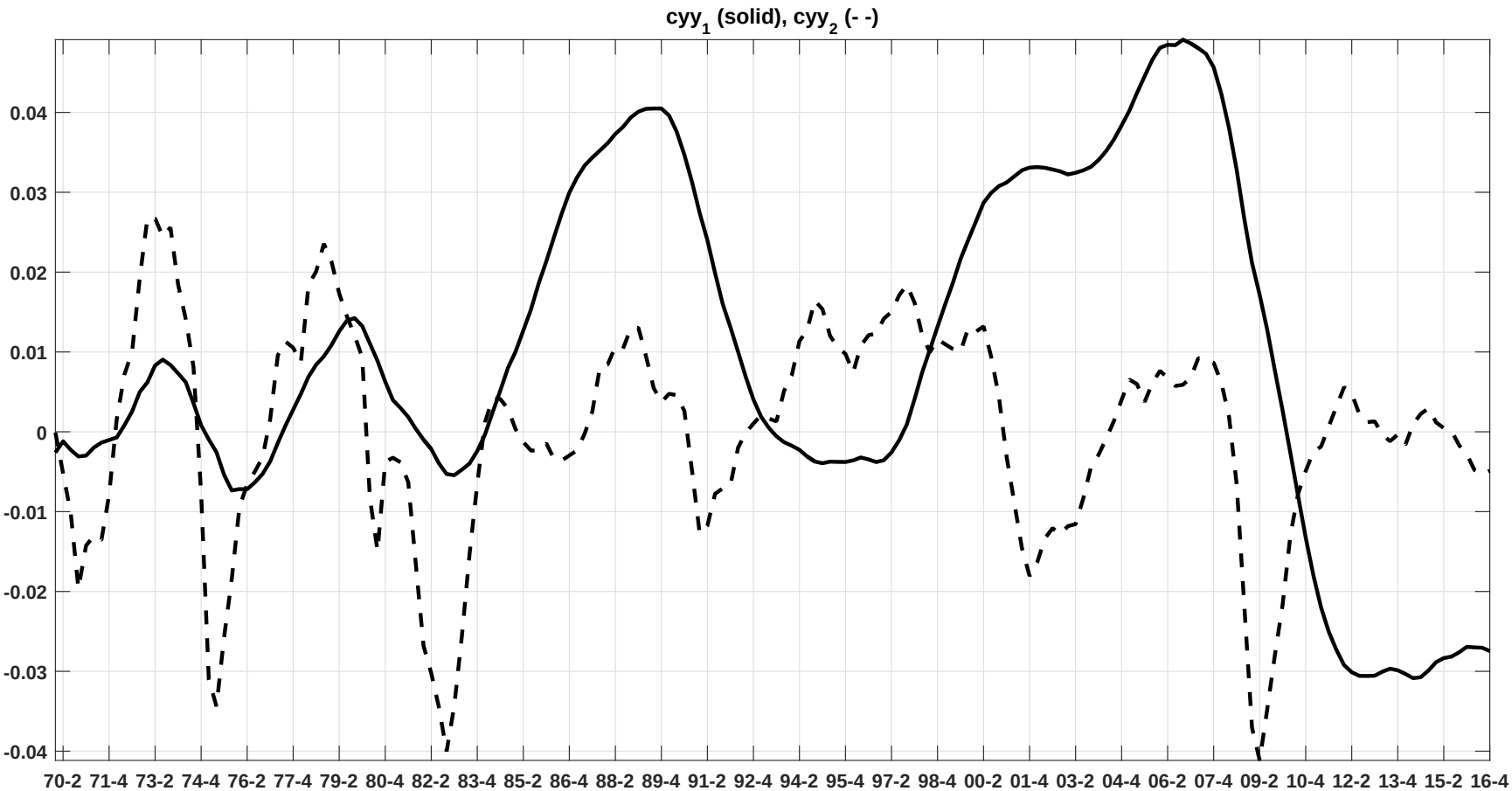
Estimated cycles (GDP)



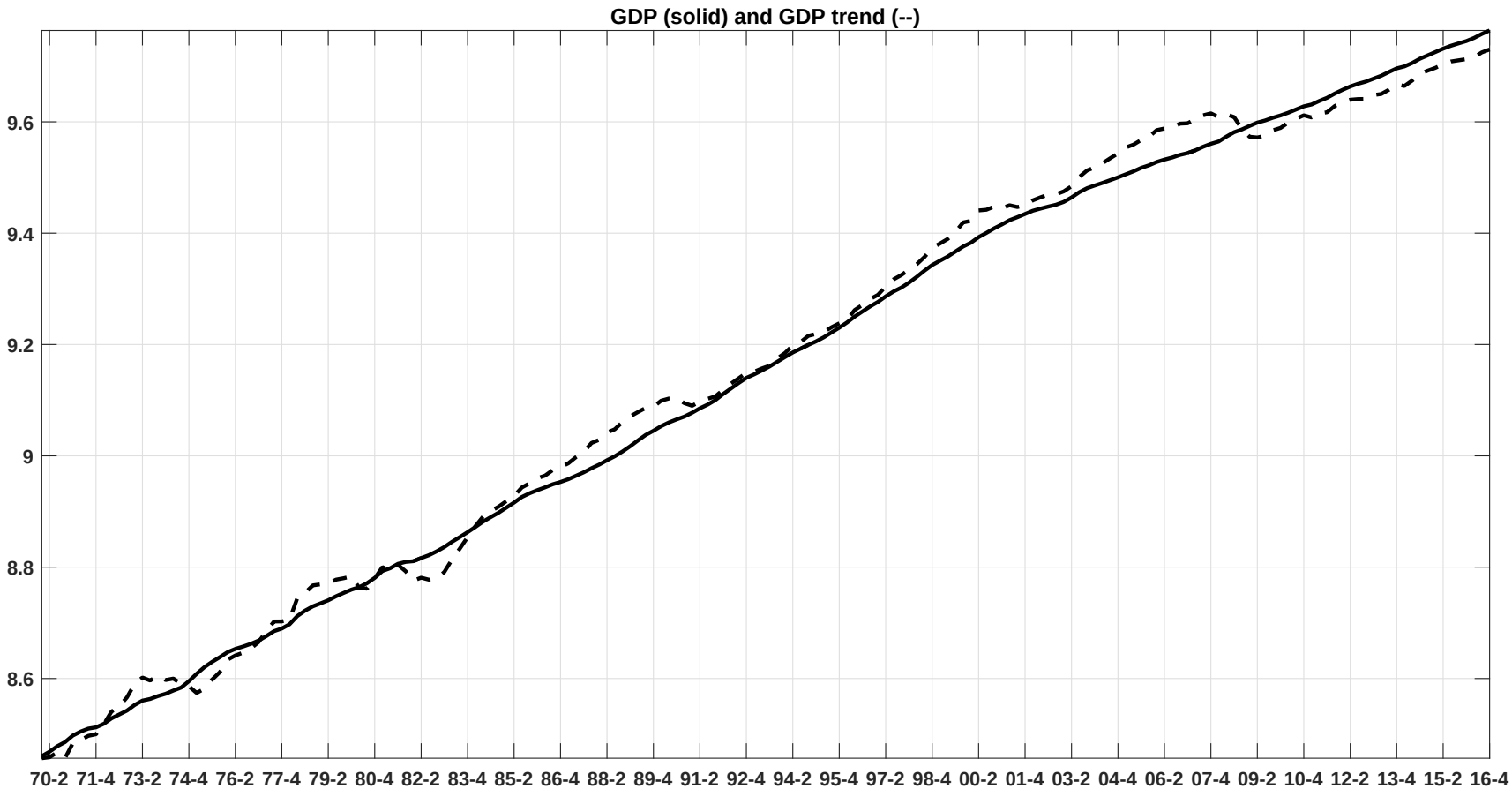
- Larger amplitude and longer period of the financial cycle
- Variance of the financial cycle increasing over time

Cyclical properties of the cycles

Phase shift of	GDP	Credit to HH	Credit to NFC	Property prices	Capacity utilization
Fin. cycle (cf)	0.0	-0.6	-7.3	12.1	5.3
Str. cycle(cs)	0.0	-0.3	-3.8	0.2	-0.5
Period (cf)	86.5	Period (cs)	20.4		

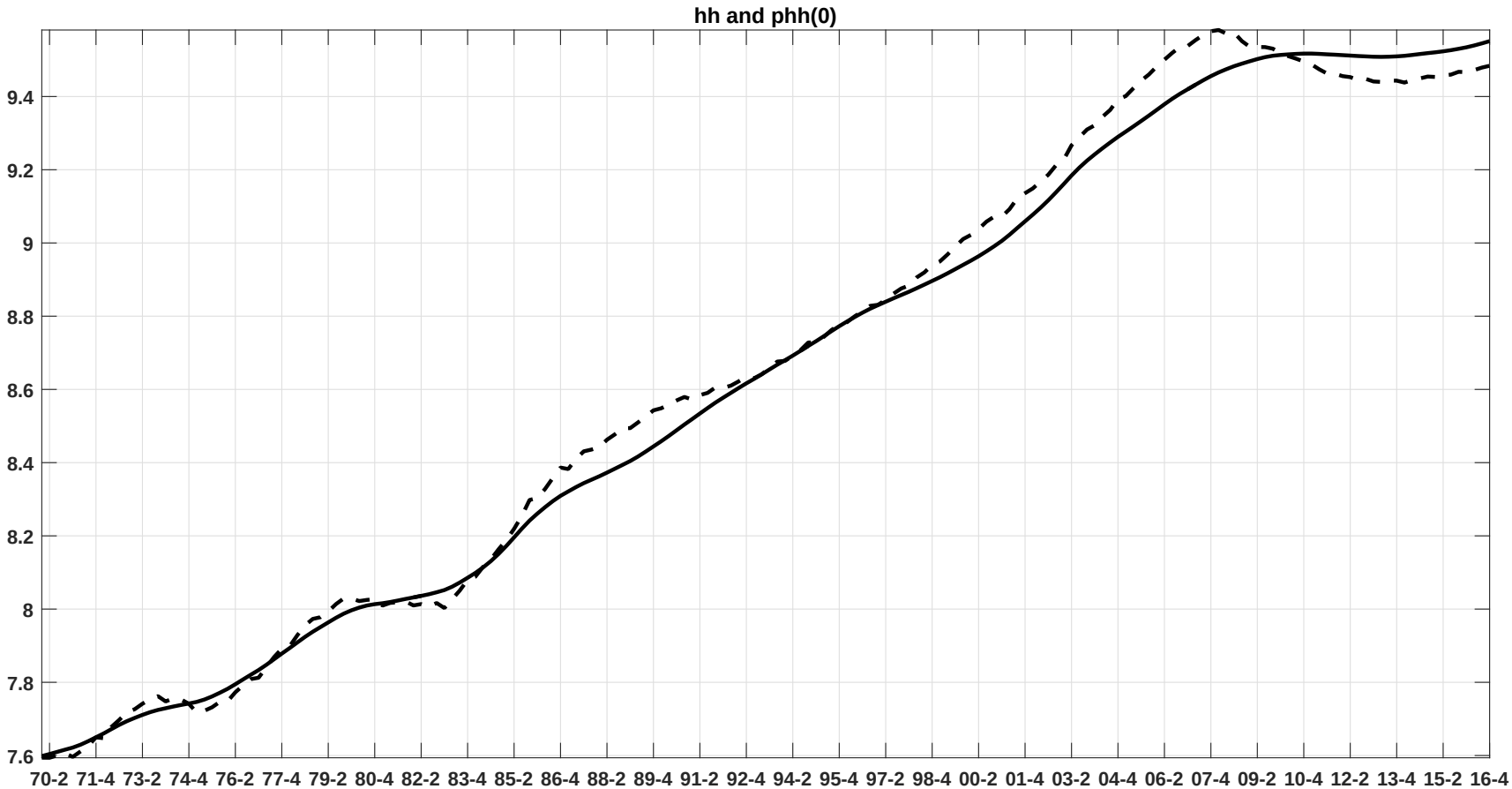
The first two rows of the table show the phase shifts of the two cycles associated with credit to HH, credit to NFC, property prices and capacity utilization relative to the respective cycle associated with GDP; the last row shows the estimated periods (in quarters) of the two cycles.

GDP trend

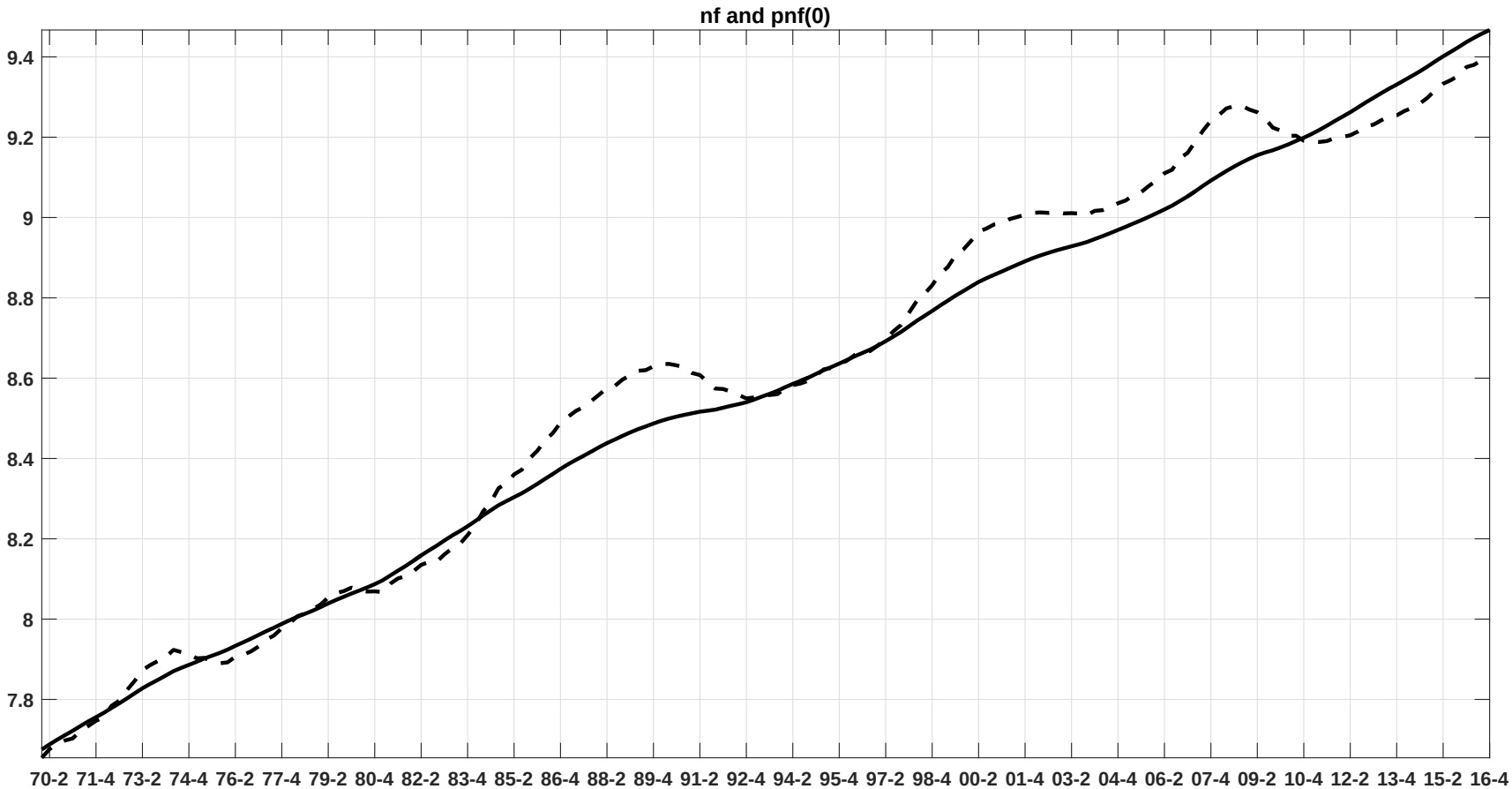


- Clear inflection point in GDP trend around the dot-com bust. Is Gordon (2012, 2014) right about potential output in the US (and the world)?

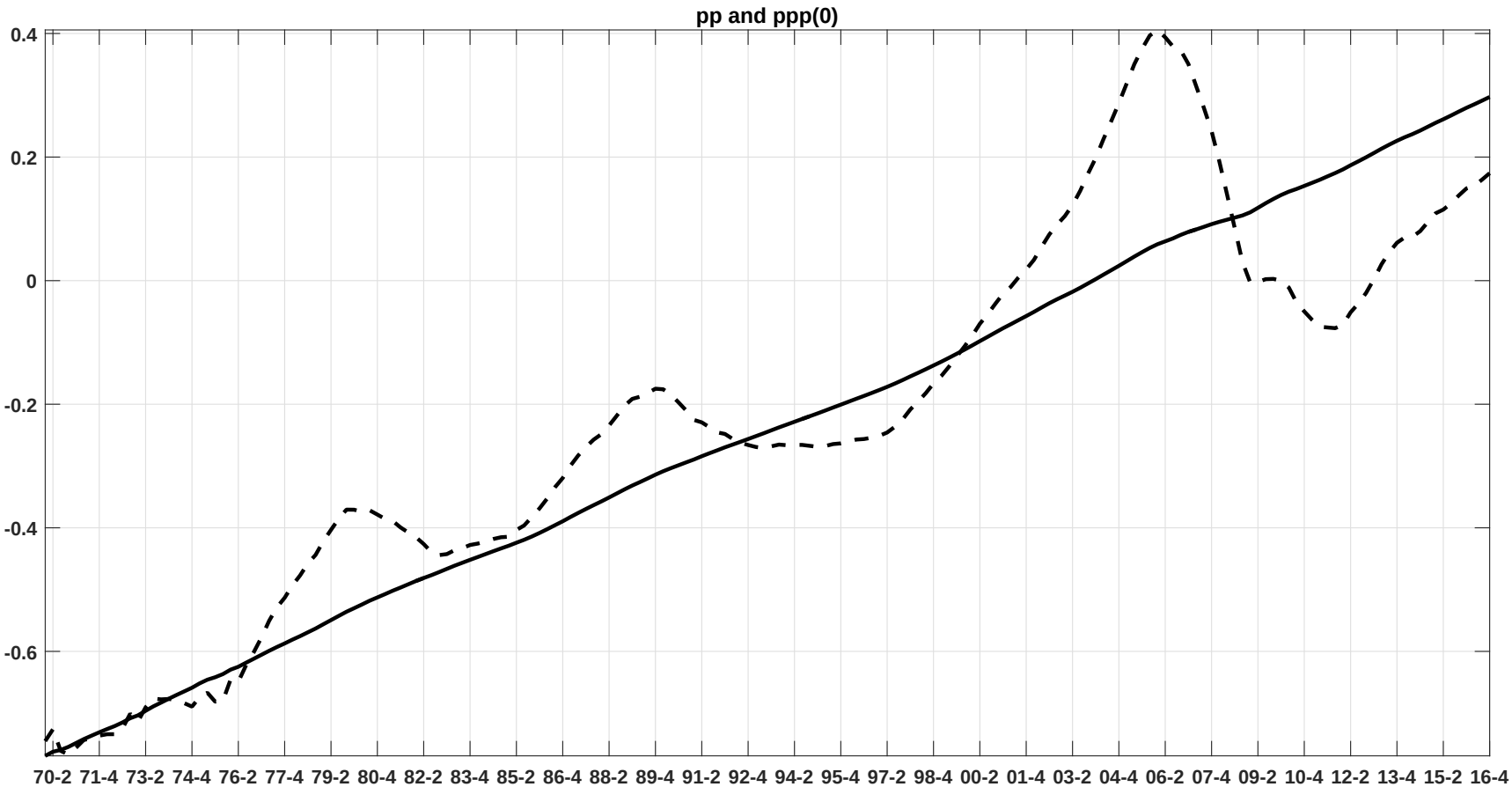
Credit to households



Credit to non-financial corporations



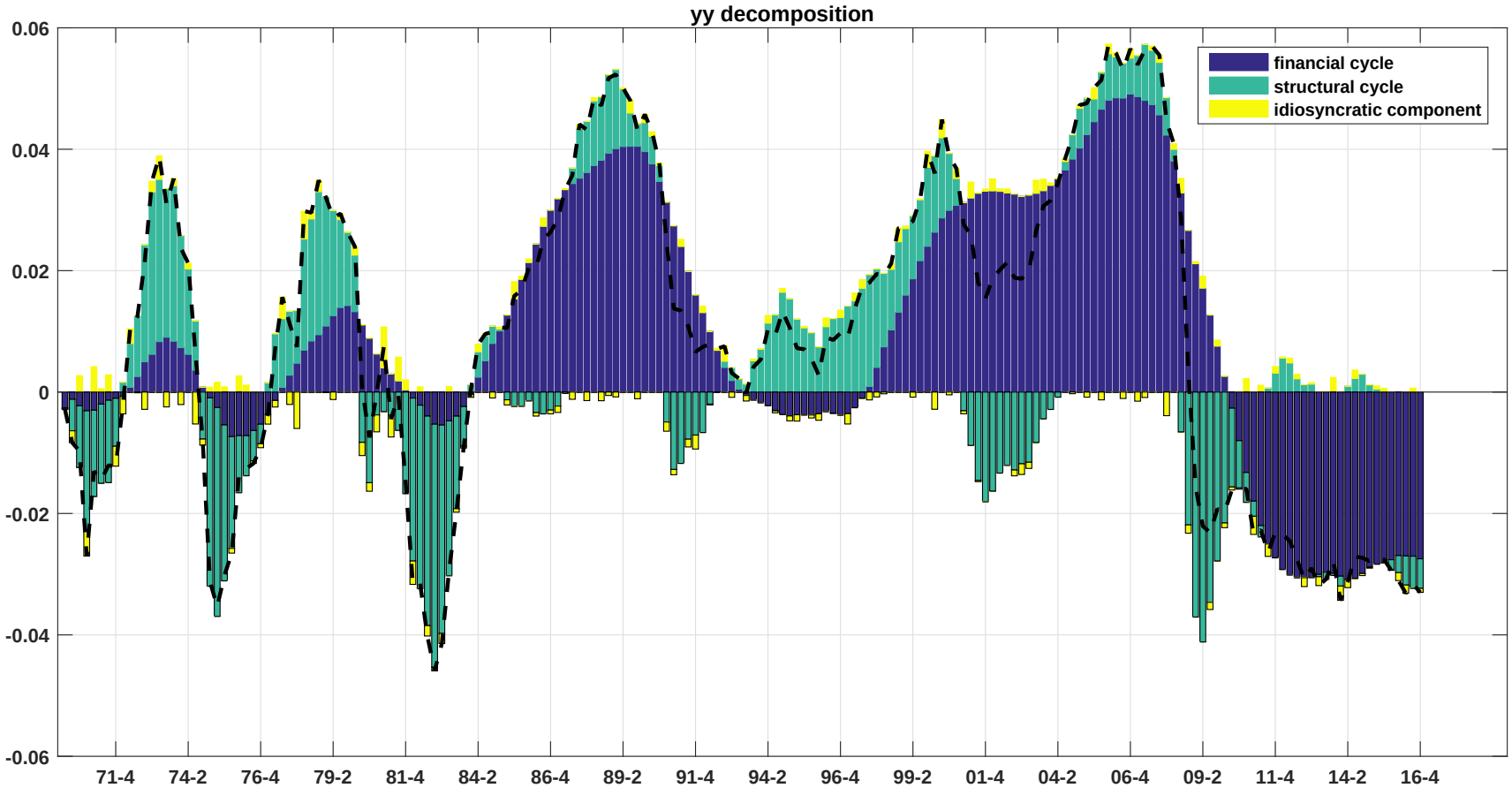
Property prices



Capacity utilization

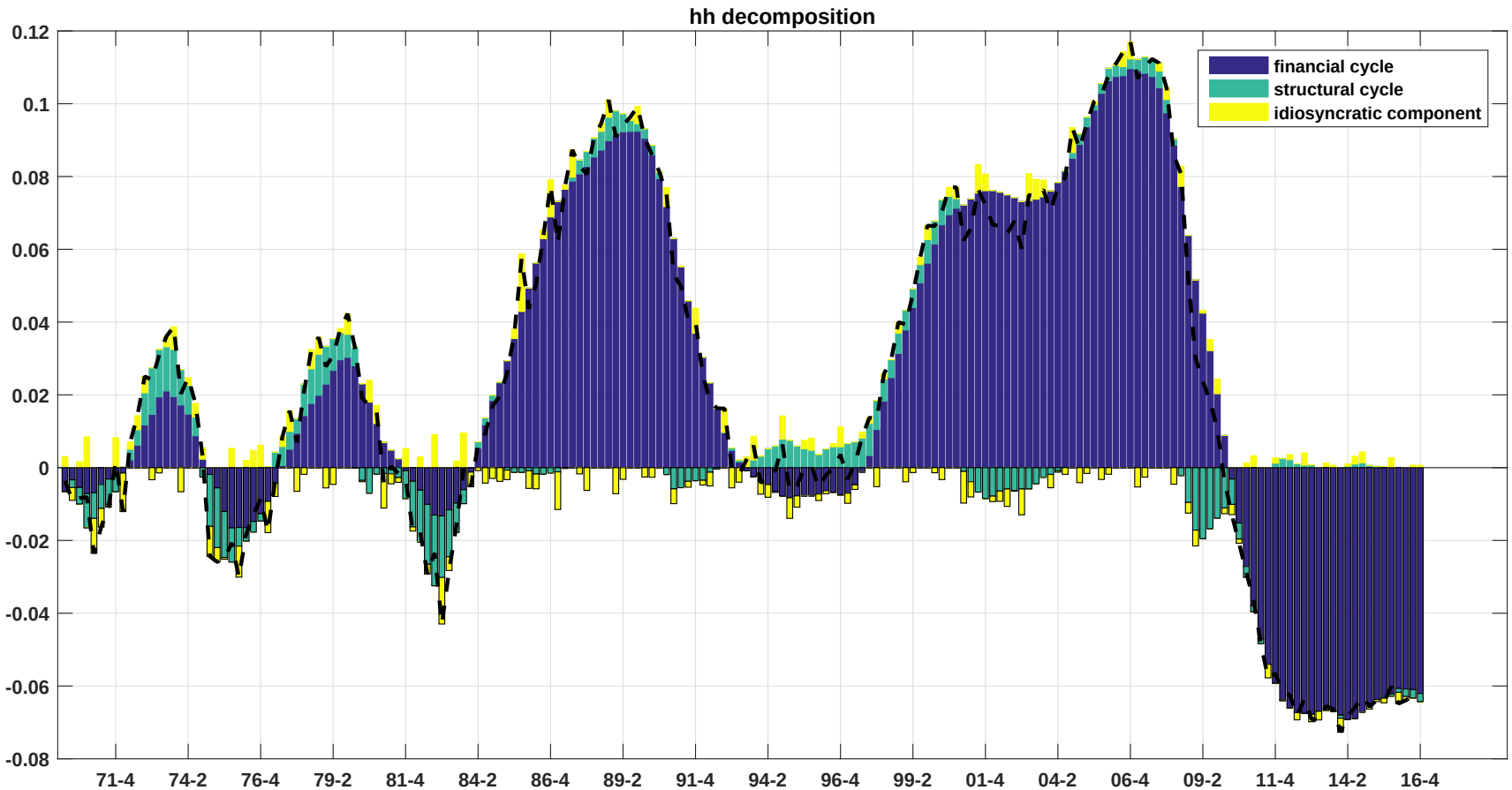
- Treating CU as trendless (in line with theory) may not be correct

Contributions to output cycle



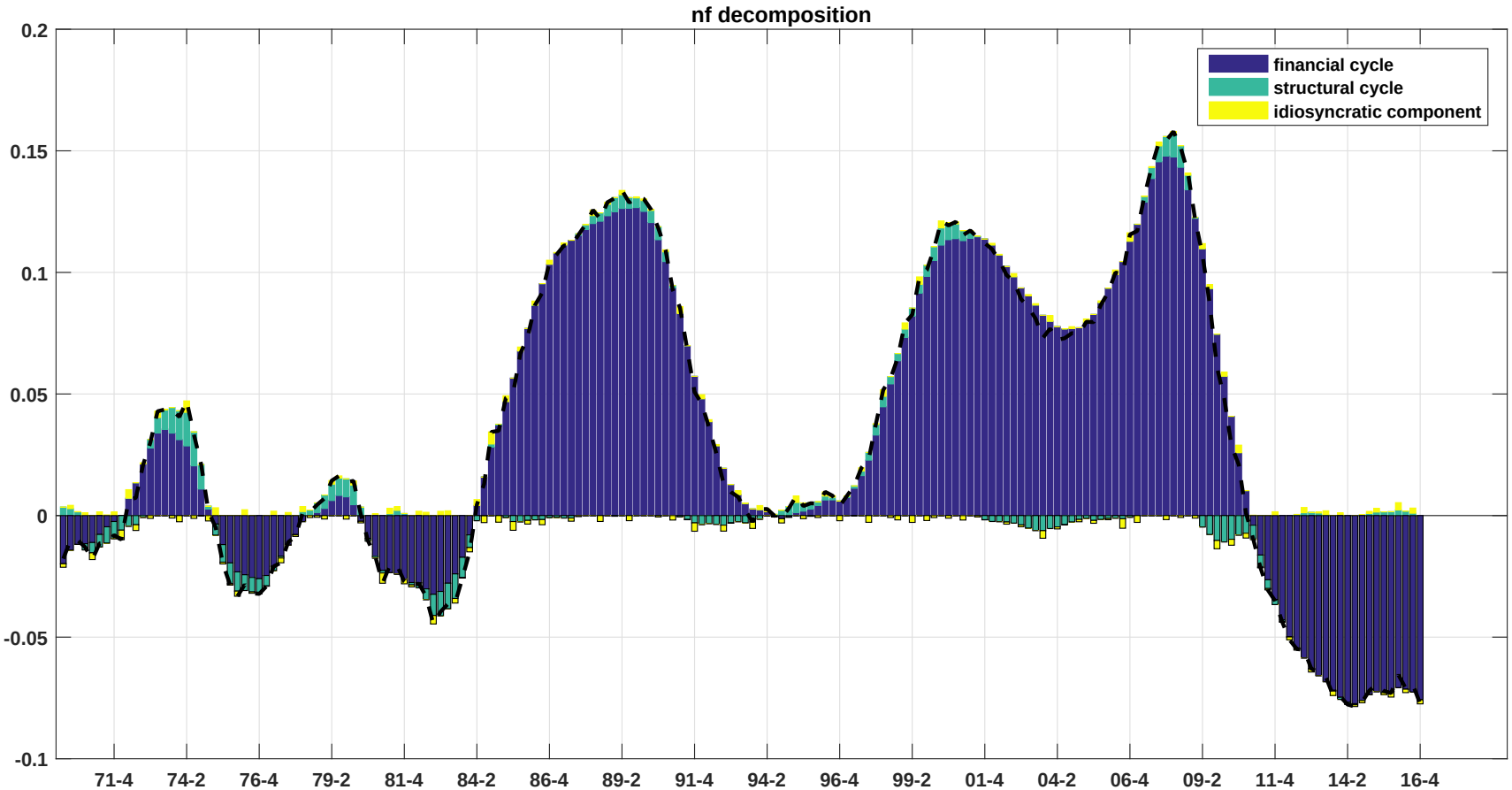
- In recent years the financial cycle contribution dwarfs that of the structural cycle (in line with Borio et al.'s findings); but first phase of the 2008 crisis well explained by movements of the structural cycle (***don't overinterpret!***)
- Still depressed financial conditions may contribute to slow economic recovery in the US

Contributions to credit to hh cycle



- Credit to hh mostly characterized by relatively low frequency cycles

Contributions to credit to nfc cycle



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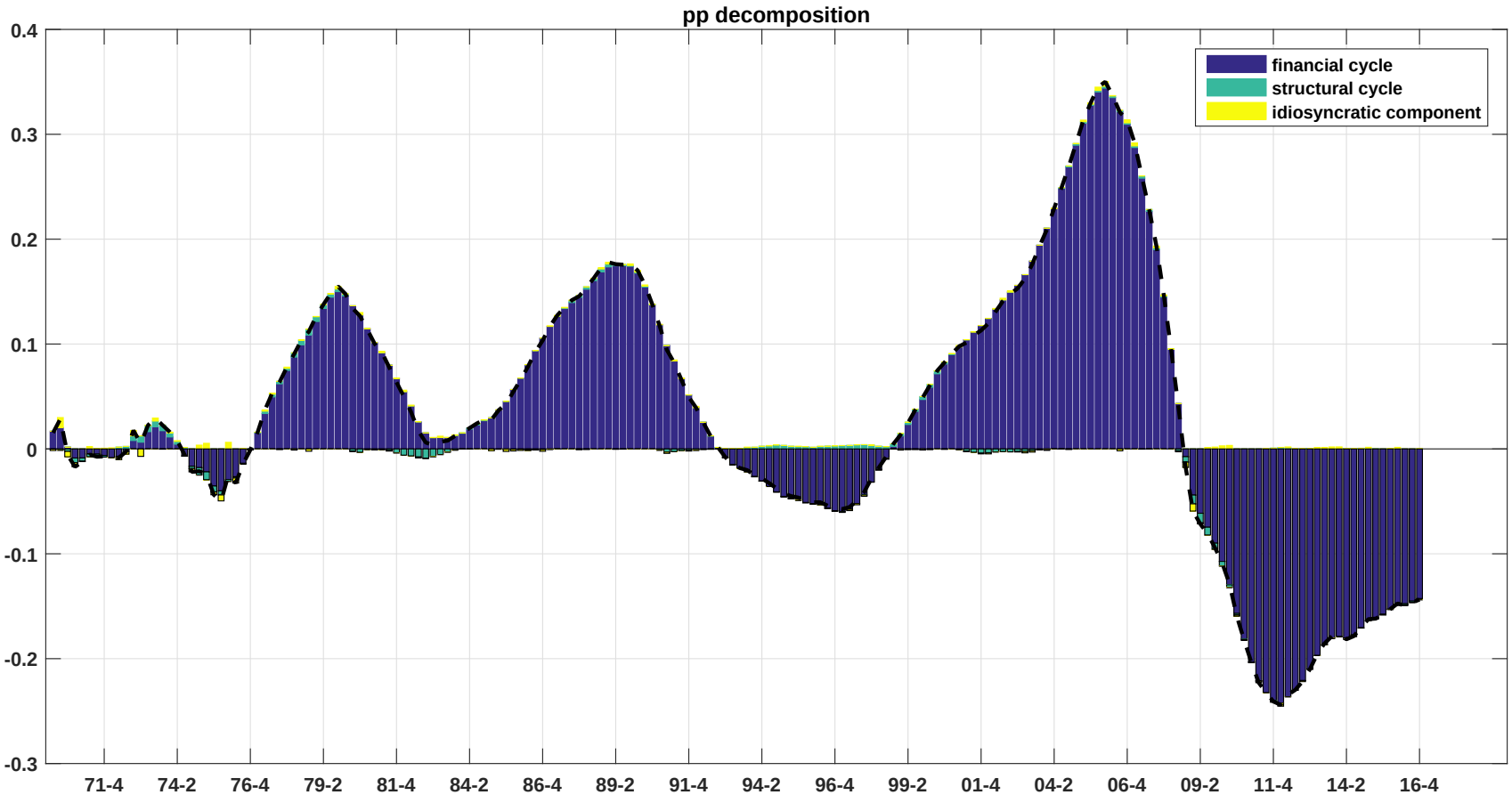
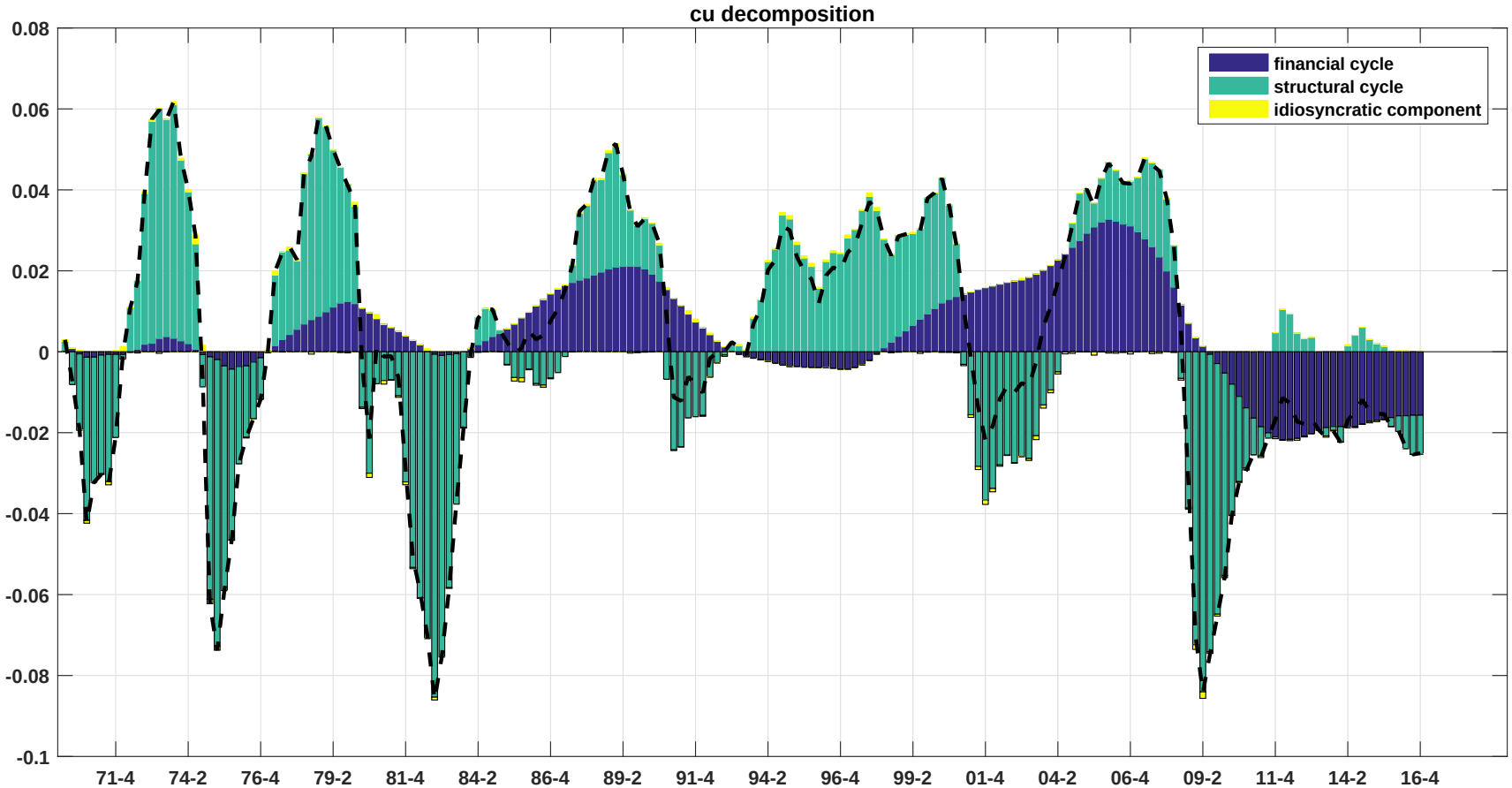
Contributions to property price cycle



- Property prices fully characterized by relatively low frequency cycles

Contributions to CU cycle



- Capacity utilization cycle is too a much greater degree characterized by the conventional "business cycles" frequency

Relation with other macro-variables

- Relation to other conventional structural indicators (price and wage inflation, short-term unemployment etc.)
- Question: What information on the estimated cyclical components can be extracted from these indicators?
- Relation to other macro aggregates (consumption, investment, employment etc.)
- Question: Do the estimated cyclical components explain a chunk the cycles of other macroeconomic variables?

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Model (observation equations and trend)

- Assume we observe variable y_t.
- y_t can be decomposed into a trend, p_t, and a cyclical component, c_t:

$$y_t = p_t + c_t + v_t^y$$

where v_t^y is AR(1) with autoregressive coefficient γ:

$$v_t^y = \gamma v_{t-1}^y + \varepsilon_t^y$$

where ε_t^y is NID across time.

- Trend p_t is modeled as previously, as an ARI(1,1) process.

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Model (cycle)

- Cycle c_t consists of a sum of
  - the endogenously estimated idiosyncratic cyclical component ψ_t and
  - a sum of the structural and financial cyclical components estimated in the 5-variable model, treated as exogenous variables

$$c_t = \psi_t + \sum_{k=f,s} r_k c_{kt}$$

with r_k the loadings on the exogenous cycle $k = f, s$ and $(\psi_t, \psi_t^*)^T$ modeled as previously.

- Essentially, it's a regression of c_t on the previously estimated cycles, with the exception that c_t is not observed

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Cyclical properties of structural indicators

Phase Shift	Sentiment Ind	Unempl Rate (-)	Short-term UR	GDP defl inflation	Cons defl infl	Interest Rate	Wage inflation	W inf in Constr
cf	#N/A	#N/A	3.5	#N/A	#N/A	#N/A	#N/A	#N/A
cs	3.5	-0.6	-2.4	-2.2	-1.4	0.9	-0.2	-3.5
Own	No	No	No	Yes	Yes	Yes	Yes	Yes
Period	#N/A	#N/A	#N/A	7.3	6.9	8.3	7.3	7.6

The first two rows of the table show the phase shifts of the two cycles associated with various structural indicators relative to the respective cycle associated with GDP; the last row shows the estimated period (in quarters) of the two cycles if there is any.

Cyclical properties of macro aggregates

Phase Shift	Total Cons	Durable Cons	Nondur Cons	Total Inv	Nonres Inv	Resid Inv	Total Empl	Empl in Constr
cf	-3.8	-0.1	-4.4	#N/A	#N/A	3.8	#N/A	0.5
cs	2.3	1.9	2.1	-0.4	-2.0	2.3	-2.2	-1.7
Own	No	No	No	Yes	No	Yes	No	No
Period	#N/A	#N/A	#N/A	7.5	#N/A	23.7	#N/A	#N/A

The first two rows of the table show the phase shifts of the two cycles associated with various macroeconomic aggregates relative to the respective cycle associated with GDP; the last row shows the estimated period (in quarters) of the two cycles if there is any.

Take away

- Most conventional cyclical indicators do not carry ***enough*** information on the long (financial) cycle, but are strongly related to the short (structural) cycle
- Hints at the reasons of the failure of the standard structural methods used for calculating output gaps
- Short-term unemployment is a promising cyclical indicator
- Consumption's cycle overall well explained by the estimated cyclical components as is employment in construction
- Residential investment turns out to be a leading indicator for both cycles (in line with Leamer's, 2007,views) but it has an independent cyclical component

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- Cholesky decomposition with the cycles placed in the first 2 rows (??)
- Very preliminary
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- In recent years their negative contribution coincides with relatively slow economic recovery in these countries
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Further work

- More on the economic interpretation of the cyclical components
- Are the cyclical components related to uncertainty indicators like EPU indicator (Baker et al., 2016)?

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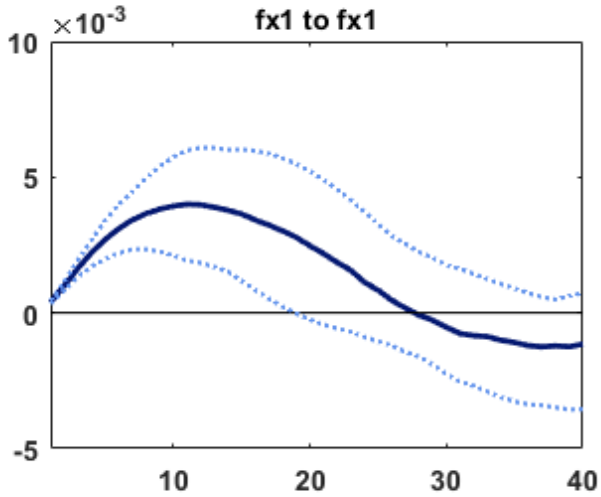
Teaser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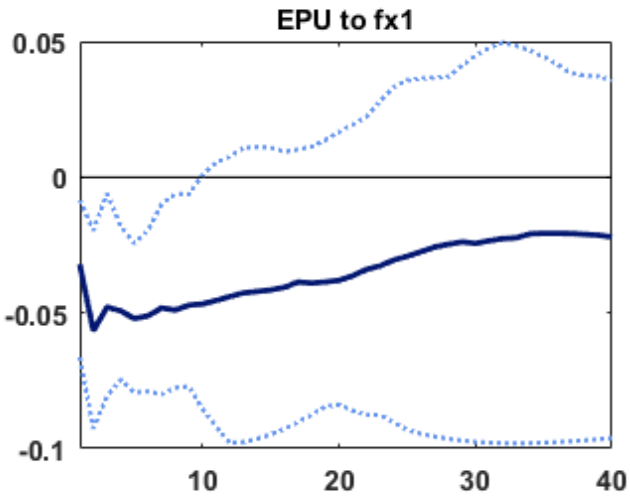
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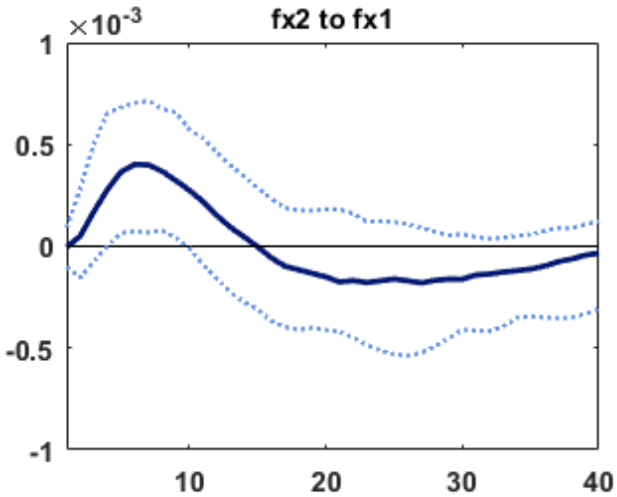
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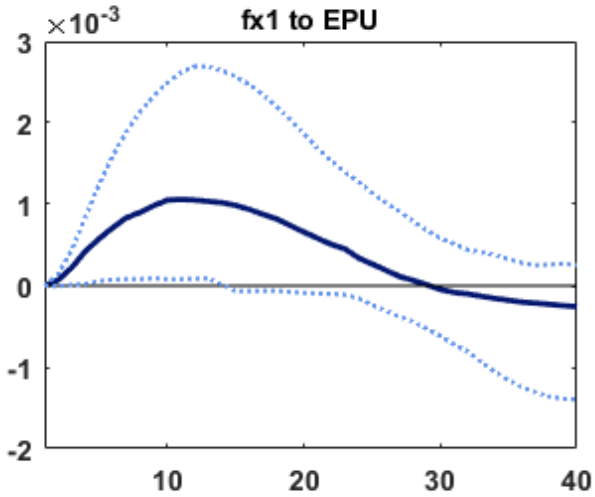
Teaser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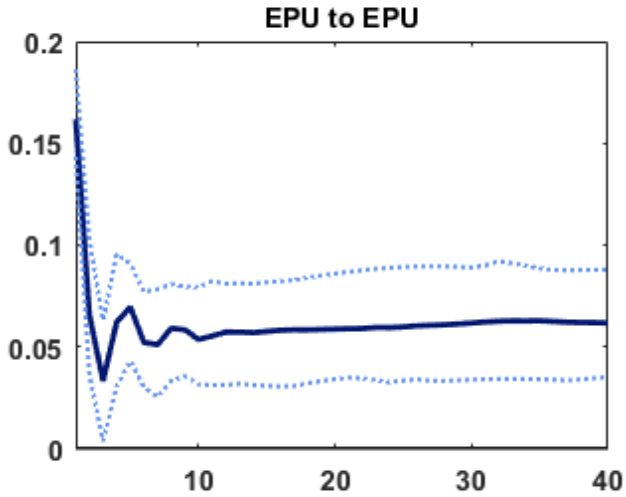
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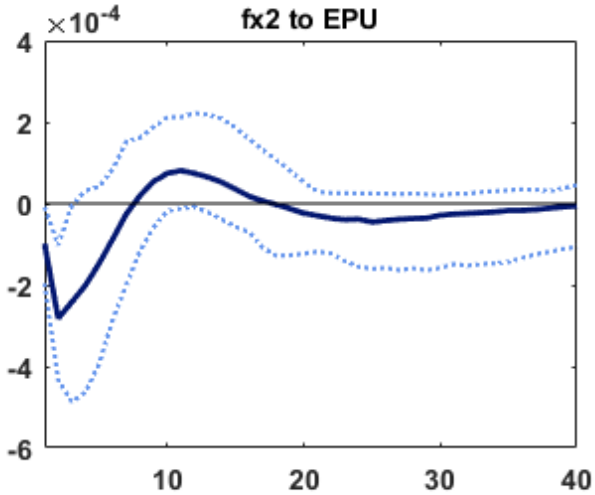
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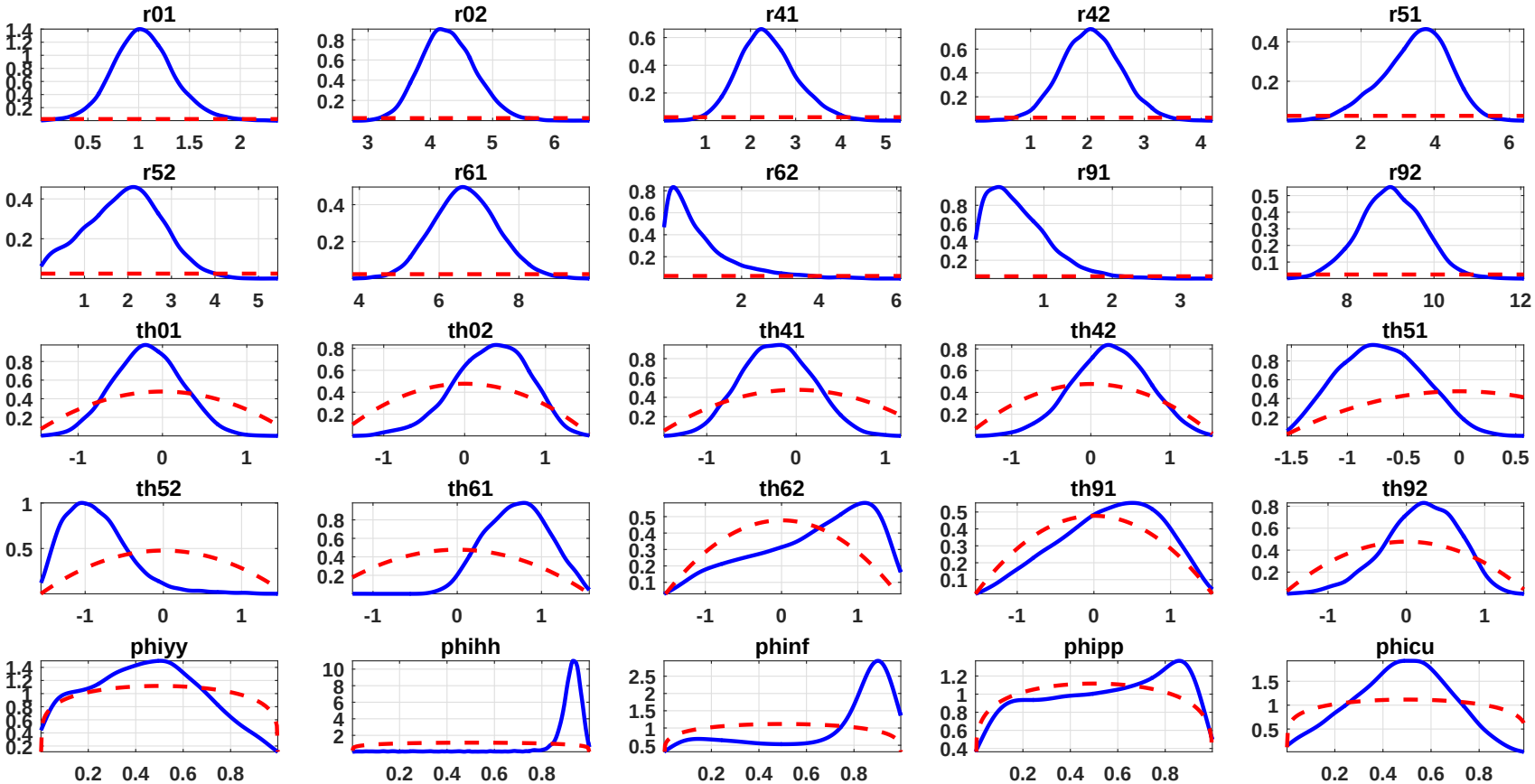
40

Thank you!

Priors and posteriors (1)



Priors and posteriors (2)