Modeling of Economic and Financial Conditions for Nowcasting and Forecasting Recessions: A Unified Approach

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Brief Summary of the Paper

Main research question:

- Do business cycles and financial cycles in emerging markets evolve simultaneously?
- If not do they follow a systematic pattern?
- In other words;
  - Do recessions and expansions of business and financial cycles evolve simultaneously?
  - Do financial cycles lead business cycles when entering recessions or expansions?
  - How many periods for recessions and/or for expansions?

Brief Summary of the Paper

Potential gains:

- If both cycles follow a systematic pattern
  - Increase in identification of the potential recessions and expansions using financial variables as well.
  - This is crucial for emerging markets as we have lack of data for these countries.
- If financial cycle leads business cycles
  - Better predictions of business cycle,
  - Potential early warning indicator.

Brief Summary of the Paper

We use Turkey as our case study.

Potential problems:

- We do not have a measure of business cycle
  - Lack of data,
  - Data with various frequencies covering different time span
  - A 'to be or not to be' question: Which GDP measure should we use, or should we avoid it?
- We do not have a measure of financial cycle to start with
  - Markets are volatile with aberrant observations,
  - There is structural change for many variables around 2001-2004,

Brief Summary of the Paper

- We provide an econometric methodology to answer these questions and to circumvent these problems in the context of dynamic factor models together with (Markov) regime-switching parameters
- Specifically; we develop a regime-switching dynamic factor model that allows for
  - jointly handling of mixed frequency data with different time spans to circumvent the problem of lack of data,
  - imperfect synchronization of recessions and expansions of business and financial cycles due to phase shifts of the business cycle,
  - cycles to enter/exit cyclical regimes with different timing.

Outline

- Motivation
- Econometric framework
  - Model details
  - Estimation strategy
- Statistical Evaluation
- Conclusion

Modeling business cycle

- We denote the 'unobserved' business cycle as, C_t.
- We denote the ith 'observed' coincident variables as, X_t^i.

Consider coincident economic variables driven by the business cycle

$$X_t^i = \gamma_0^i + \gamma_1^i t + \lambda^i C_t + \eta_t^i$$

in terms of the growth rate

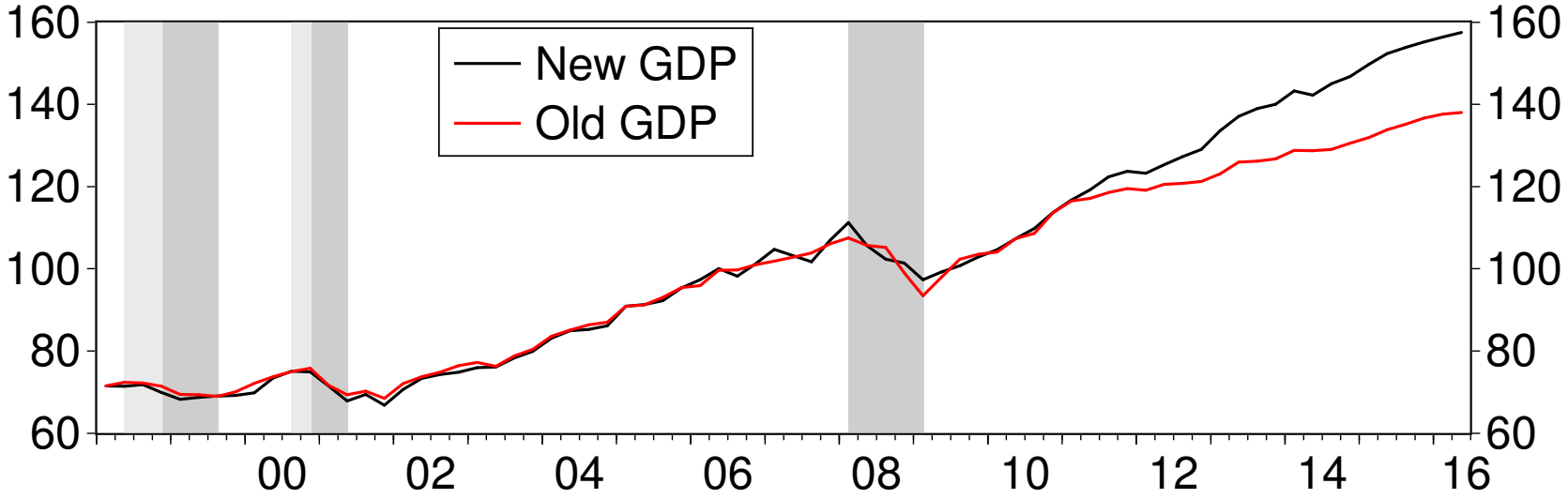
$$\Delta X_t^i = \gamma_1^i + \lambda^i \Delta C_t + \epsilon_t^i$$

in terms of standardized variables

$$x_t^i = \lambda^i f_{1,t} + \varepsilon_t^i$$

Coincident variables - I

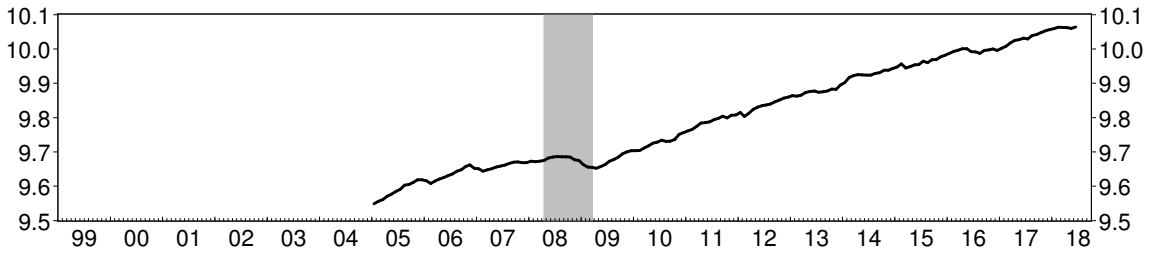
GDP (new and old)



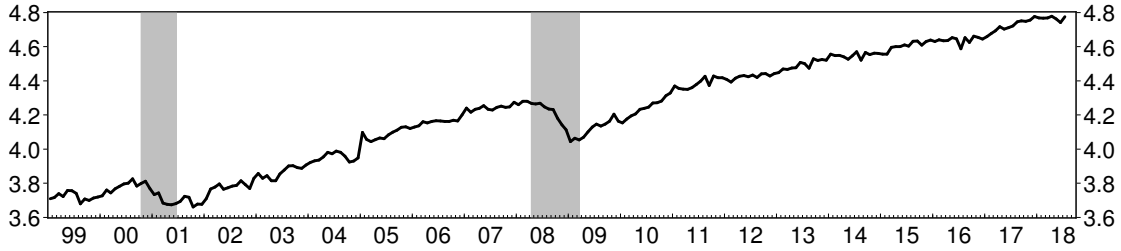
- Prior to 2009 two series seem similar, though there is still a disagreement on the timing of 1998-9 and 2000-2001 recessions.
- There is a large discrepancy between the two series after 2011.
- Therefore, we do NOT use any of the GDP series in inference.

Coincident variables - II

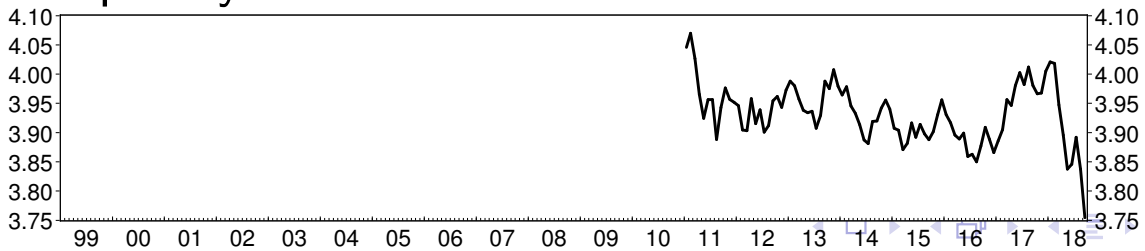
- Employment
  - Employees on non-agricultural payrolls (ENAP)
    Monthly frequency: 2005 Jan - 2018 Aug



- Production
  - Industrial production index (IP)
    Monthly frequency: 1999 Jan - 2018 Sep

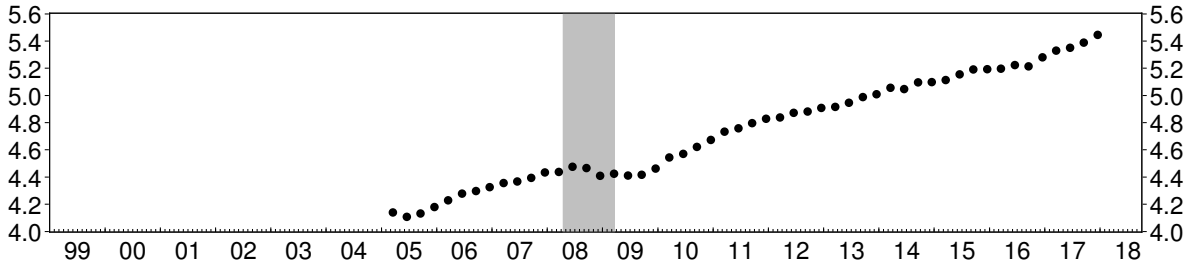


  - Purchasing Manager Index (PMI)
    Monthly frequency: 2011 Jan - 2018 Oct

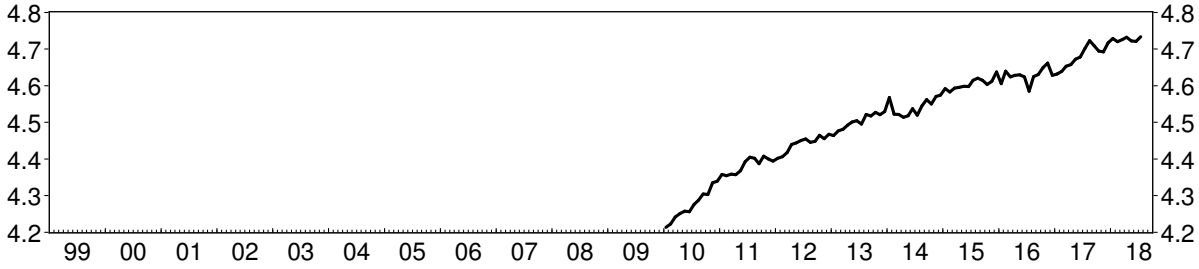


Coincident variables - III

- Trade and Sales:
  - Trade and services turnover index (TST)
    Quarterly frequency: 2005 Q1 - 2017 Q4

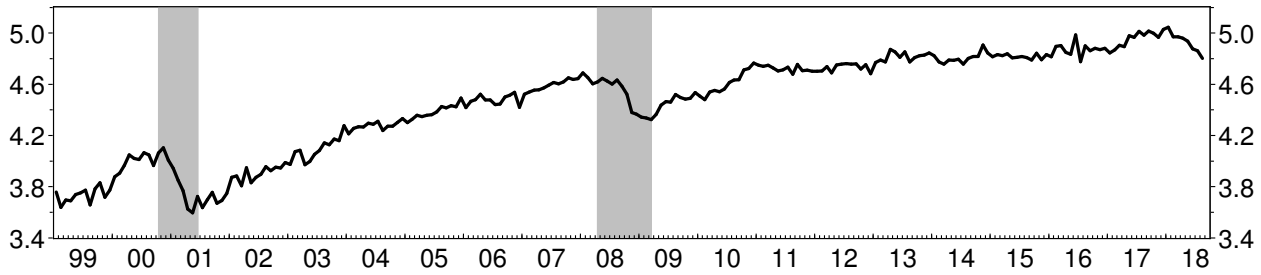


  - Retail sales volume index (RSV)
    Monthly frequency: 2010 Jan - 2018 Sep

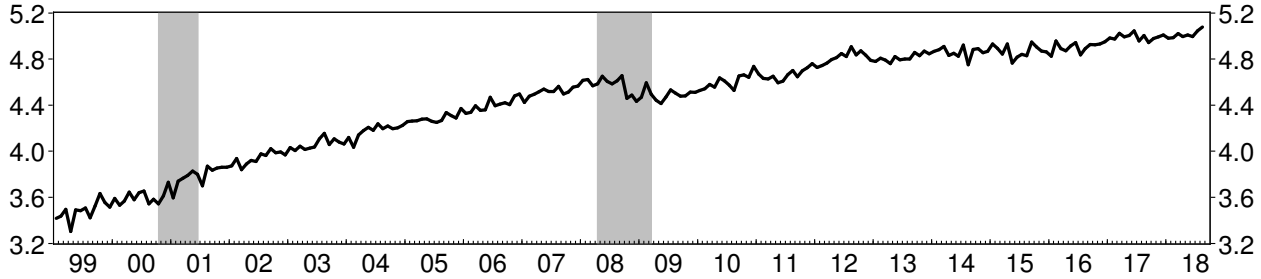


Coincident variables - IV

- Current account
  - Import (quantity index) (MQ)
    Monthly frequency: 1997 Jan - 2018 Sep



  - Export (quantity index) (XQ)
    Monthly frequency: 1998 Jan - 2018 Sep



Modeling financial cycle

- We denote the 'unobserved' financial cycle as, L_t.
- We denote the ith 'observed' financial variables as, Z_t^i.

Consider financial variables driven by the financial cycle as

$$Z_t^i = \alpha_0^i + \alpha_1^i t + \lambda^i L_t + \eta_t^i$$

and in terms of the growth rate

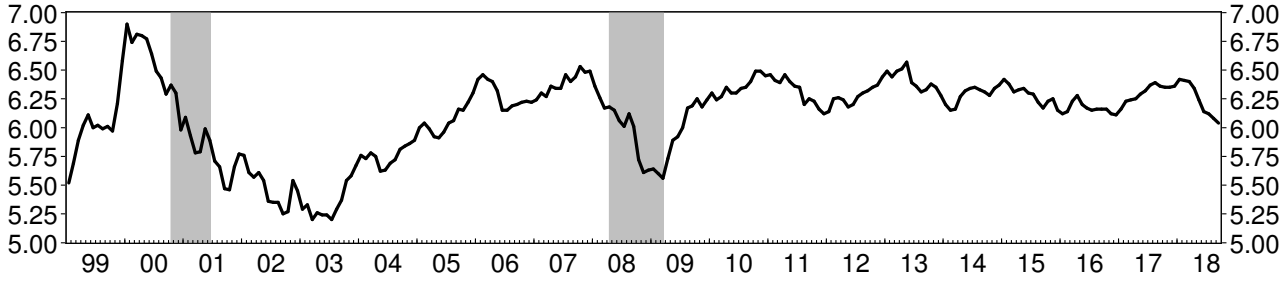
$$\Delta Z_t^i = \alpha_1^i + \lambda^i \Delta L_t + \epsilon_t^i$$

and in terms of standardized variable

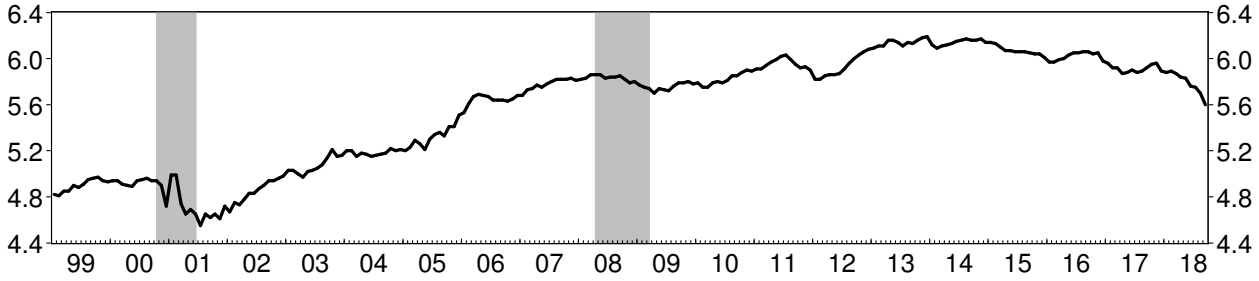
$$z_t^i = \lambda^i f_{2,t} + \varepsilon_t^i$$

Financial variables - I

- Stock market:
  - Real stock price index (RRet) - 1997 Jan - 2018 Oct:



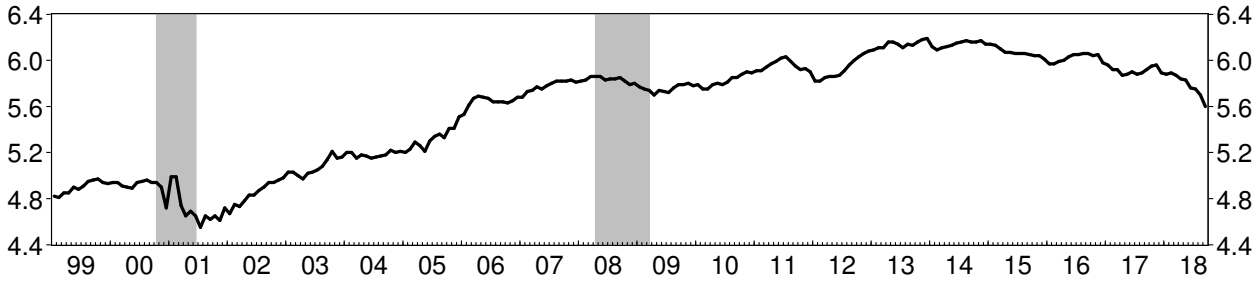
  - Realized volatility of BIST100 - 1997 Jan - 2018 Oct:
  - Price-earnings ratio of BIST100 - 1997 Jan - 2018 Oct:
- Foreign exchange rate
  - Gross foreign reserves (FRes) - 1997 Jan - 2018 Oct:



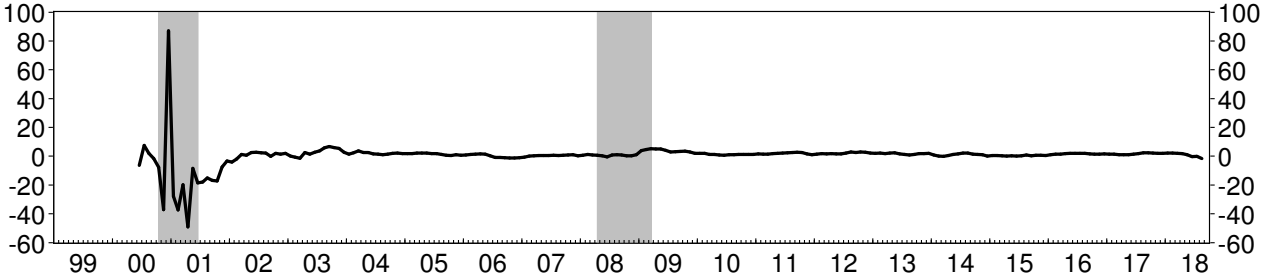
- Credit: Total credits - 2005 Dec - 2018 Oct:

Financial variables - II

- Confidence:
  - Confidence index (RConf) - 1997 Jan - 2018 Oct: Monthly frequency:



- Interest rates and spreads
  - Term spread : 12m - 1m yield (TS) - 2000 Jun - 2018 Oct:



  - 3 month interest rate - 3 months LIBOR
  - Bond price spreads and stock price spreads
  - Treasury auctions rate

Modeling low frequency flow variables

Consider the model using coincident economic variables and business cycle

- Stock variables (snapshot of the instance)

$$x_t^{i,S} = \begin{cases} \lambda^i f_{1,t} + \varepsilon_t^i & \text{if observed} \\ \text{NA} & \text{otherwise} \end{cases}$$

- Flow variables (accumulation over time)

$$x_t^{i,F} = \begin{cases} \lambda^i (f_{1,t} + 2f_{1,t-1} + 3f_{1,t-2} + 2f_{1,t-3} + f_{1,t-4}) & \text{if observed} \\ \quad + \varepsilon_t^i + 2\varepsilon_{t-1}^i + 3\varepsilon_{t-2}^i + 2\varepsilon_{t-3}^i + \varepsilon_{t-4}^i & \\ \text{NA} & \text{otherwise} \end{cases}$$

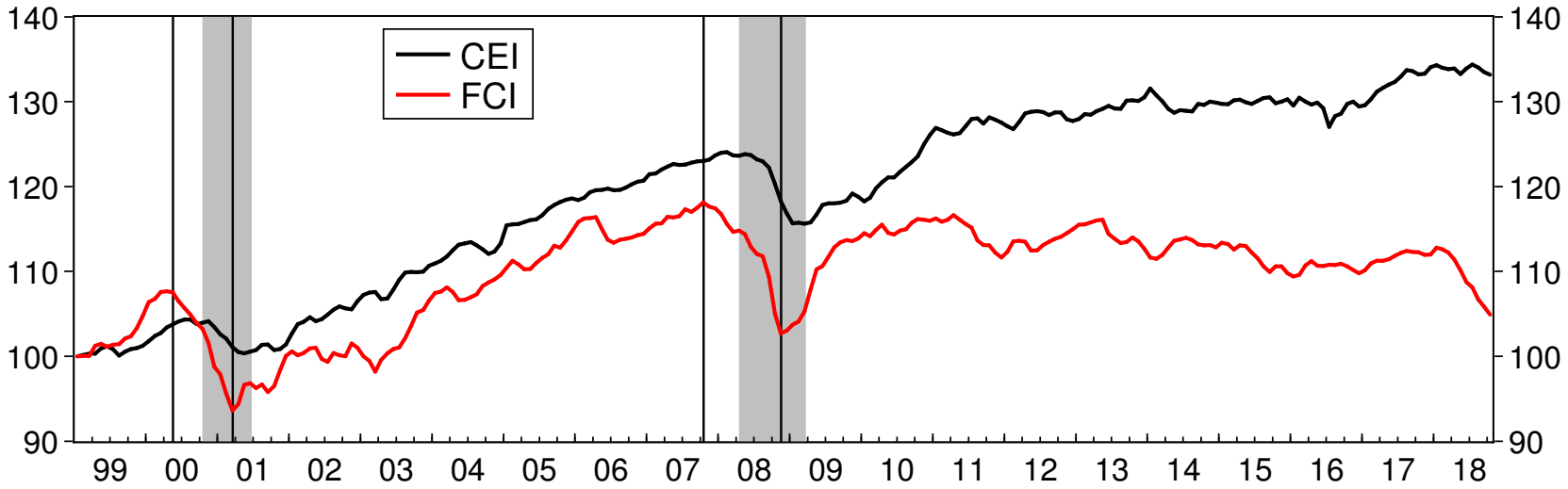
Dynamic factor model

$$
\begin{aligned}
y_t &= \Lambda f_t + \varepsilon_t \\
f_t &= F f_{t-1} + u_{f,t} \\
\varepsilon_t &= \psi \varepsilon_{t-1} + u_{\varepsilon,t}
\end{aligned}
$$

- y_t denotes coincident economic and financial variables.
- $f_t = (f_{1,t}, f_{2,t})'$ denotes economic and financial conditions indexes.
- ε_t denotes idiosyncratic components and that are allowed to follow autoregressive dynamics.

A first set of results

$$
\begin{aligned}
y_t &= \Lambda f_t + \varepsilon_t \\
f_t &= F f_{t-1} + u_{f,t} \\
\varepsilon_t &= \psi \varepsilon_{t-1} + u_{\varepsilon,t}
\end{aligned}
$$



Markov-Switching Vector AutoRegressive (MS-VAR) model

Consider the following MS-VAR model for business cycle ($f_{1,t}$) and financial cycle ($f_{2,t}$).

$$f_{1,t} = \mu_{1,S_{1,t}} + \phi_{1,1} f_{1,t-1} + \phi_{1,2} f_{2,t-1} + u_{f_1,t}$$
$$f_{2,t} = \mu_{2,S_{2,t}} + \phi_{2,1} f_{1,t-1} + \phi_{2,2} f_{2,t-1} + u_{f_2,t}$$

- $S_{1,t}$ ($S_{2,t}$) are latent multinomial variables taking the value j if $y_{1,t}$ ($y_{2,t}$) is in regime j at time t,
- $\mu_{1,S_{1,t}}$ ($\mu_{2,S_{2,t}}$) denotes the intercept of $f_{1,t}$ ($f_{2,t}$) in the regime indicated by $S_{1,t}$ ($S_{2,t}$), respectively.

$$\begin{pmatrix} u_{f_1,t} \\ u_{f_2,t} \end{pmatrix} \backsim IID\left(0, \Sigma_t\right)$$

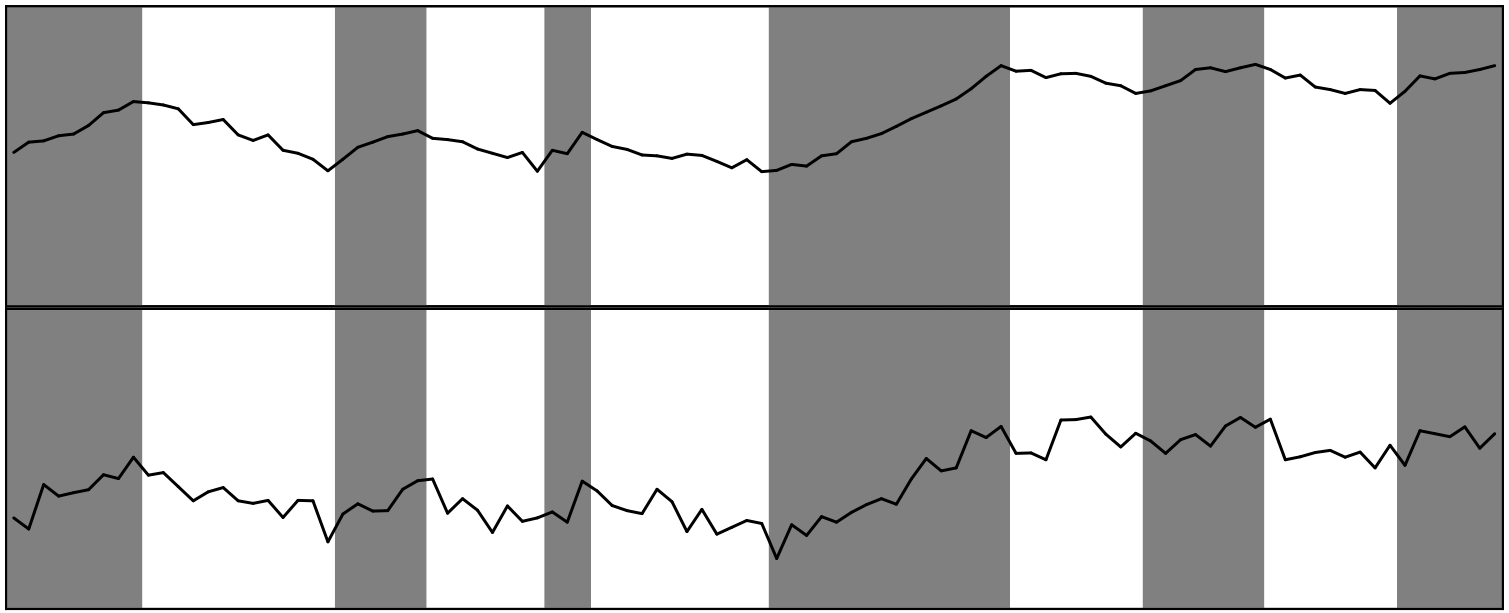
Dynamics of Regime Indicator Functions: Synchronization

- Suppose that the cycle of the business cycle is the reference cycle. We assume $S_{1,t}$ is first-order $J-$state homogeneous Markov processes with transition probabilities $\Pr(S_{1,t} = j | S_{1,t-1} = i) = p_{ij}$
- Two extreme cases
  - $S_{1,t}$ and $S_{2,t}$ are independent: Separate cycle dynamics for each of the series
  - $S_{1,t}$ and $S_{2,t}$ are identical: Perfect Synchronization

Perfect Synchronization (PS)

All regime-shifts (turning points) of business and financial cycles occur simultaneously.

$$S_{2,t} = S_{1,t}$$



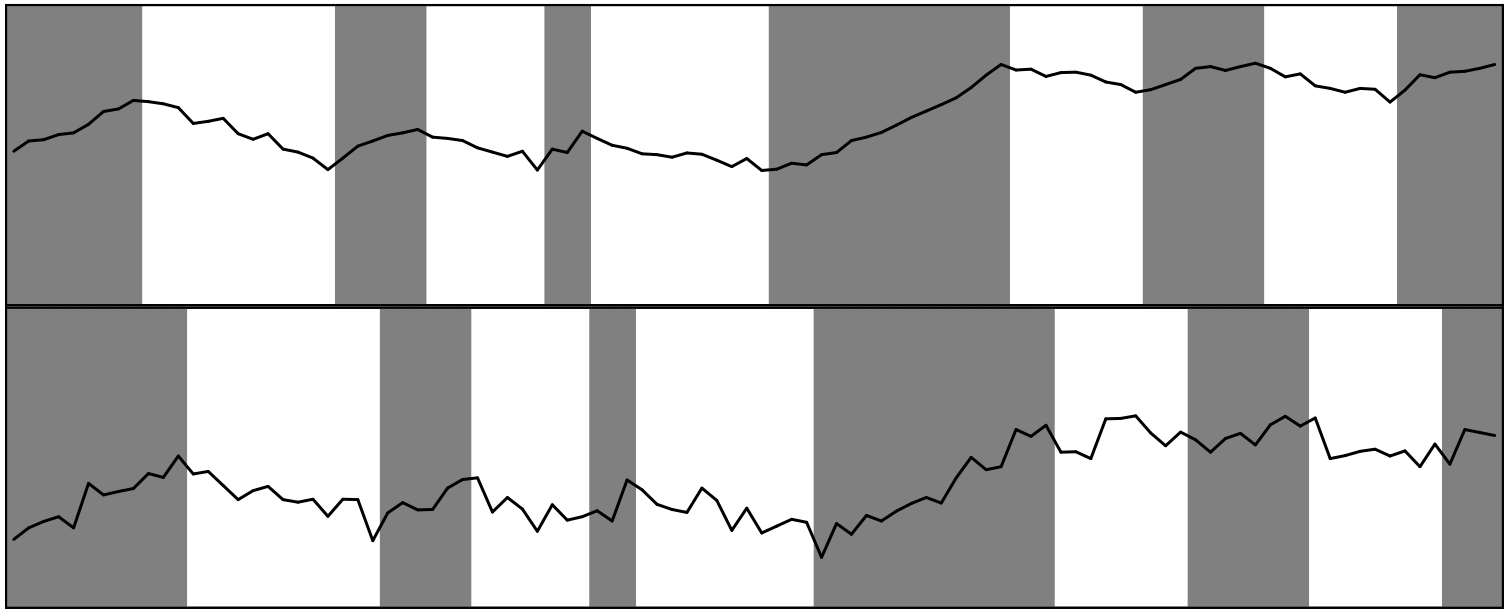
Perfect Synchronization (PS)

- Almost uniformly accepted in regime switching VAR's;
  - Convenient assumption in business cycle analysis with coincident variables: (Krolzig 1997 (all the book), Chauvet (1998 IER) (Regime Switching Factor Models)).
  - Multivariate modeling of size-based portfolios and bond returns: A single cycle governing all portfolios. Timmermann and Guidolin (2006, JAE)
- Tractable way of estimation: Simple extensions over univariate setting of regime-switching models.

Imperfect Synchronization with Symmetric Phase Shifts (IS-SPS)

- Turning points displayed in different series differ by intervals that are roughly constant.
- The phases of business cycle leads/lags the phases of financial cycle by κ periods.

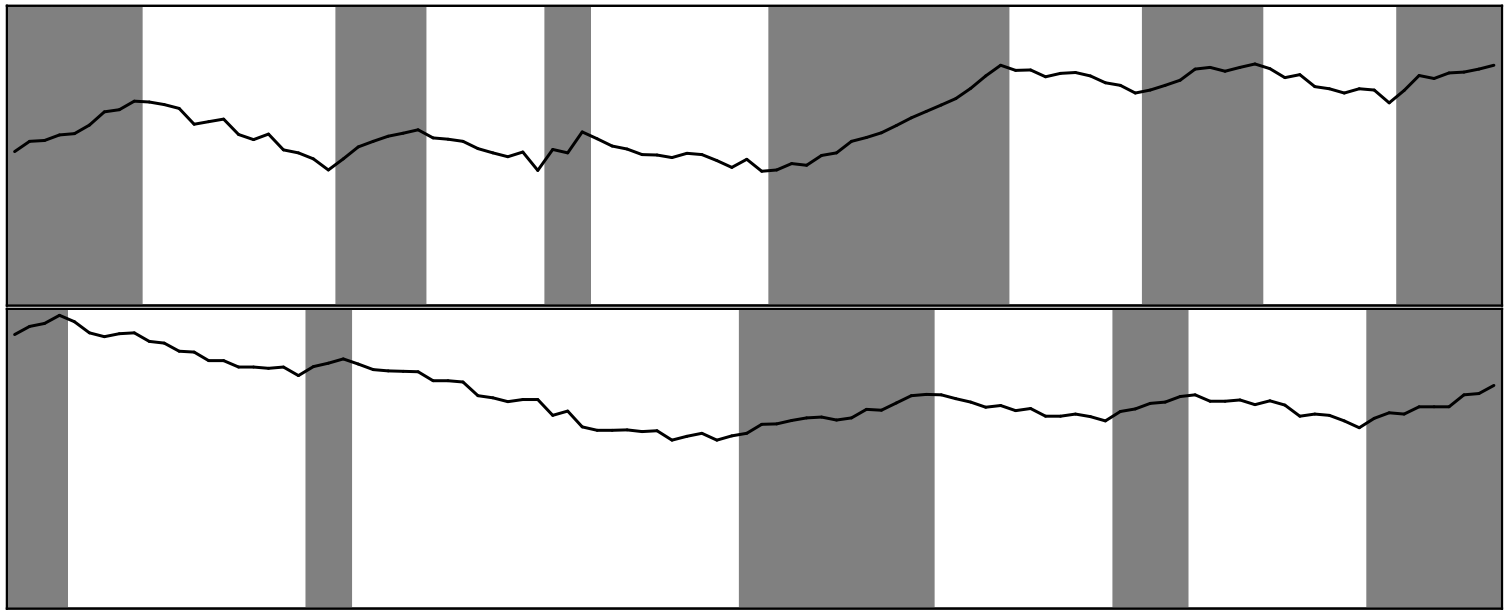
$$S_{2,t-\kappa} = S_{1,t}$$



Imperfect Synchronization with Asymmetric Phase Shifts (IS-APS) I

The regime indicator $S_{1,t}$ itself is shifted but allowing the amount of phase shift to be different across regimes.

$$S_{2,t-\kappa_{s_{1,t}}} = S_{1,t}$$

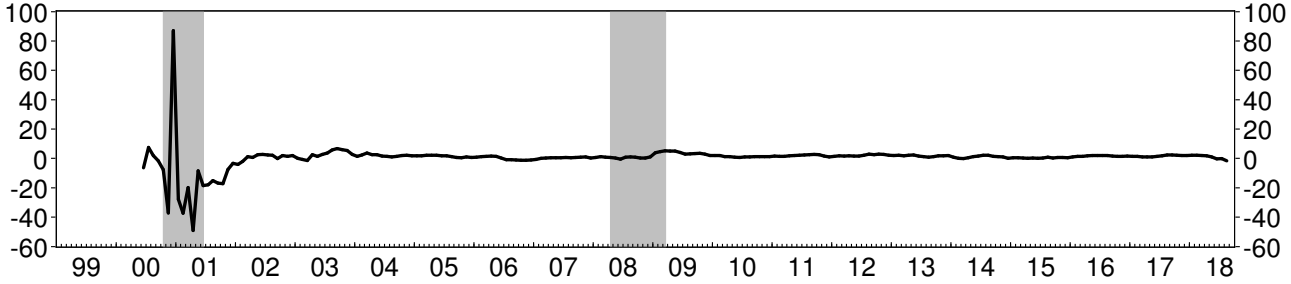


Imperfect Synchronization with Asymmetric Phase Shifts (IS-APS) II

The regime indicator $S_{1,t}$ itself is shifted but allowing the amount of phase shift to be different across regimes.

- i.e. regime indicator is shifted by a possibly different number of time periods for each regime.
- Each regime in the financial cycle starts later or earlier by κ_j periods.
- In case $\kappa_j < \kappa_i$ and a transition from regime i to j takes place, then regime i in financial cycle starts κ_j periods before regime i in business cycle and ends κ_i periods earlier.
- Consequently, regime i in financial cycle are $\kappa_i - \kappa_j$ periods shorter than regime i in business cycle.

Modeling measurement errors



- For some variables we can observe aberrant observations with high values. For capturing these, we assume a t- distribution with d.o.f. of 10 for the distribution of observables.
- Note that t is a scale (gamma) mixture of Normal hence we can write $\varepsilon_{1,t} = \gamma_t^{-1/2}\sigma\epsilon_t$ where $\gamma_t \sim \Gamma(\frac{v}{2}, \frac{v}{2})$. Then we can write

$$\begin{pmatrix} u_{f_1,t} \\ u_{f_2,t} \end{pmatrix} \backsim t\left(0, \Sigma_t, v\right)$$

Covariance Matrix

- For the covariance matrix of the variables, i.e. we allow for a single structural break to capture the structural change at the onset of the 2000's.

$$\Sigma_t = \begin{cases} \Sigma_1 & t \leq \tau \\ \Sigma_2 & t > \tau \end{cases}$$

- τ is estimated along with other model parameters.

Inference

Bayesian estimation strategy

$$p(\theta|y) \propto p(\theta)p(y|\theta)$$

y: Data
θ: Parameters

- Metropolis within Gibbs sampling together with data augmentation: Efficient estimation of posterior surface.

Inference

Prior Distributions' Specifications

$$f(p_{i,j}) = \mathbb{I}[0 < p_{i,j} < 1] \quad \text{for} \quad i,j = 1,\ldots,J$$

$$f(\lambda) \propto 1$$
$$f(\Phi) \propto 1$$
$$f(\psi) \propto 1$$
$$f(\tau) \propto 1$$

$$f(\sigma^2_{l,j}) \propto IG(s,v)$$

$$f(\mu) \propto \begin{cases} N(\mu_0, \Omega_0) & \text{if } \mu_1 \in \{\mu_1 \in \mathbb{R}^J | \mu_{1,1} < \ldots < \mu_{1,J}\} \\ 0 & \text{elsewhere} \end{cases}$$

$$f(\kappa) \propto \begin{cases} 1 & \text{for all } \kappa \in \mathbb{C} \\ 0 & \text{elsewhere} \end{cases}$$

Inference

Likelihood

- Complete data likelihood

$$f(Y^T, \mathcal{S}^T | Y_1, \theta) = \left(\prod_{i=0}^{J} \prod_{j=0}^{J} \left(p_{i,j}^{\mathcal{T}_{i,j}}\right)\right) \prod_{t=k+1}^{T} f(Y_t | Y^{t-1}, \mathcal{S}^t, \theta)$$

where

$$f(Y_t | Y^{t-1}, \mathcal{S}^t, \theta) = \left(\frac{1}{\sqrt{2\Pi}}\right)^2 |\Sigma_t|^{-\frac{1}{2}} \exp\left(-\frac{1}{2}\mathcal{E}_t' \Sigma_t^{-1} \mathcal{E}_t\right)$$

- Likelihood:

$$f(Y_t | Y_1, \theta) = \sum_{S_{1,1}=1}^{J} \sum_{S_{1,2}=1}^{J} \dots \sum_{S_{1,T}=1}^{J} f(Y^T, \mathcal{S}^T | Y_1, \theta)$$

Inference

Posterior Simulation

1. Sample $\{f_{l,t}\}_{t=0}^{T}$ from $f(\{f_{l,t}\}_{t=0}^{T}|Y^T, \mathcal{S}^T, \theta)$ for $l = 1, 2$,
2. Sample μ from $f(\mu|Y^T, \mathcal{S}^T, \theta_{-\mu})$ using MH,
3. Sample Φ from $f(\Phi|Y^T, \mathcal{S}^T, \theta_{-\Phi})$ using MH,
4. Sample κ_j from $f(\kappa_j|Y^T, \mathcal{S}_1^T, \theta_{-\kappa})$ for $j = 1, 2$ using MH,
5. Sample σ_l^2 from $f(\sigma_l^2|Y^T, \mathcal{S}^T, \theta_{-\sigma_l^2})$ for $l = 1, 2$ using MH,
6. Sample p_{ij} from $f(p_{ij}|\mathcal{S}_1^T)$
7. Sample $\mathcal{S}_1^T$ from $f(\mathcal{S}_1^T|\{f_{l,t}\}_{t=0}^{T}, \theta)$
8. Sample λ_l from $f(\lambda|Y^T, \{f_{l,t}\}_{t=0}^{T}, \theta_{-\lambda})$ for $l = 1, 2$,
9. Sample ψ_l from $f(\psi|Y^T, \{f_{l,t}\}_{t=0}^{T}, \theta_{-\psi})$ for $l = 1, 2$,
10. Sample τ from $f(\tau|Y^T, \{f_{l,t}\}_{t=0}^{T}, \theta_{-\tau})$ for $l = 1, 2$.

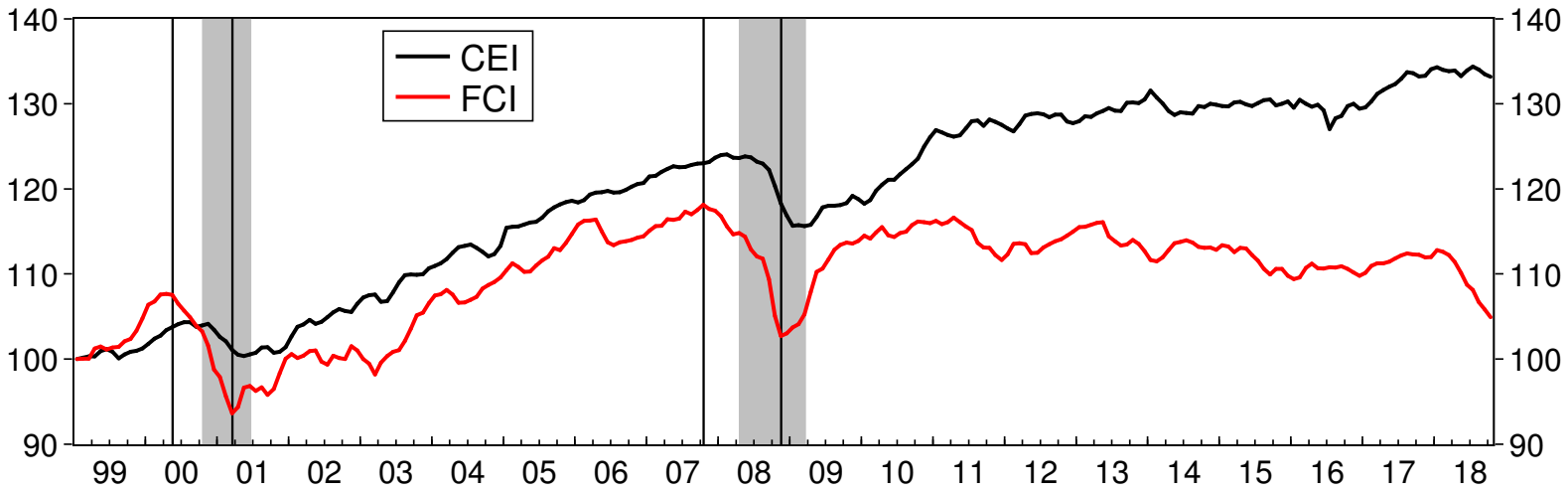
Model details and comparison

- Four competing models based on the degree of synchronization
  1. Perfect synchronization (PS)
  2. Imperfect synchronization with symmetric phase shifts (SPS)
  3. Imperfect synchronization with asymmetric phase shifts (APS)
  4. Independent cycles (Ind)
- Number of lag or lead at most 8 months and differences between phase shifts, $|k_1 - k_2|$ larger than 6 are not allowed.

Marginal likelihood values

Model	PS	SPS	APS	Ind
	-858.57	-814.98	-837.39	-895.89

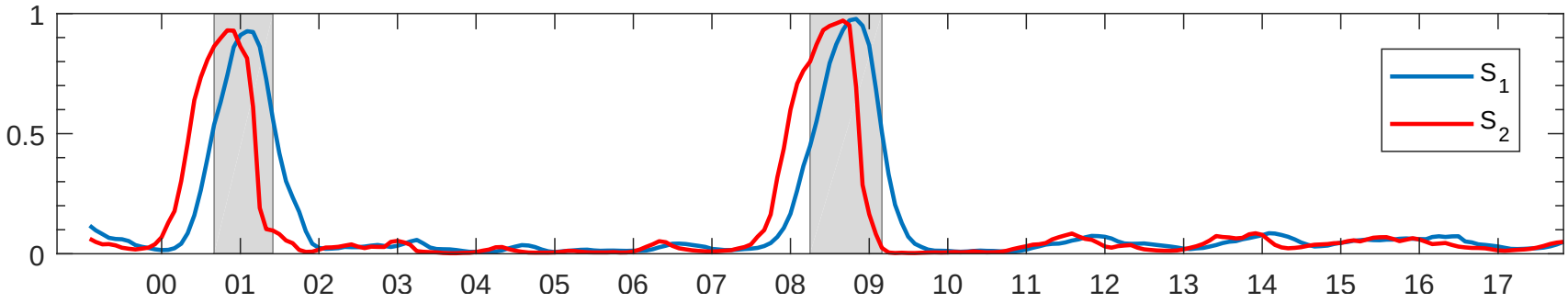
Estimated Indicators and lead/lag parameters



Lead/lag parameters

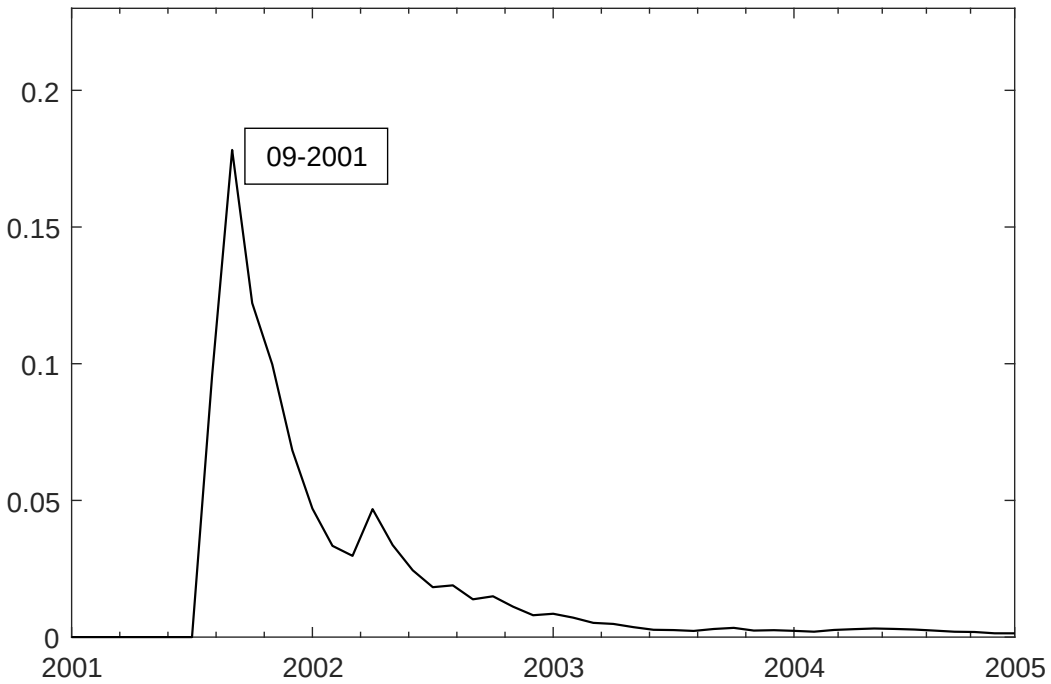
Model	PS	SPS	APS
κ_1	0	3.20 (1.88)	3.48 (2.03)
κ_2	0	3.20 (1.88)	3.44 (2.31)

Model implied recession probabilities



- Model implied recessions nicely fit to stylized facts.
- FCI leads the CEI fairly well at the onset as well at the end of the recessions.

Timing of the structural break, τ



- The mode of the histogram correspond to 2001 September.
- Break is estimated quite precisely.

Parameter estimation results for the CEI variables

	Mean	St. dev.
ϕ	0.34	(0.19)
σ^2	0.85	(0.14)
IP	0.39	(0.10)
MQ	0.28	(0.07)
XQ	0.12	(0.05)
RSV	0.26	(0.15)
PMI	0.16	(0.19)
ENAP	0.20	(0.14)
TST	0.11	(0.50)

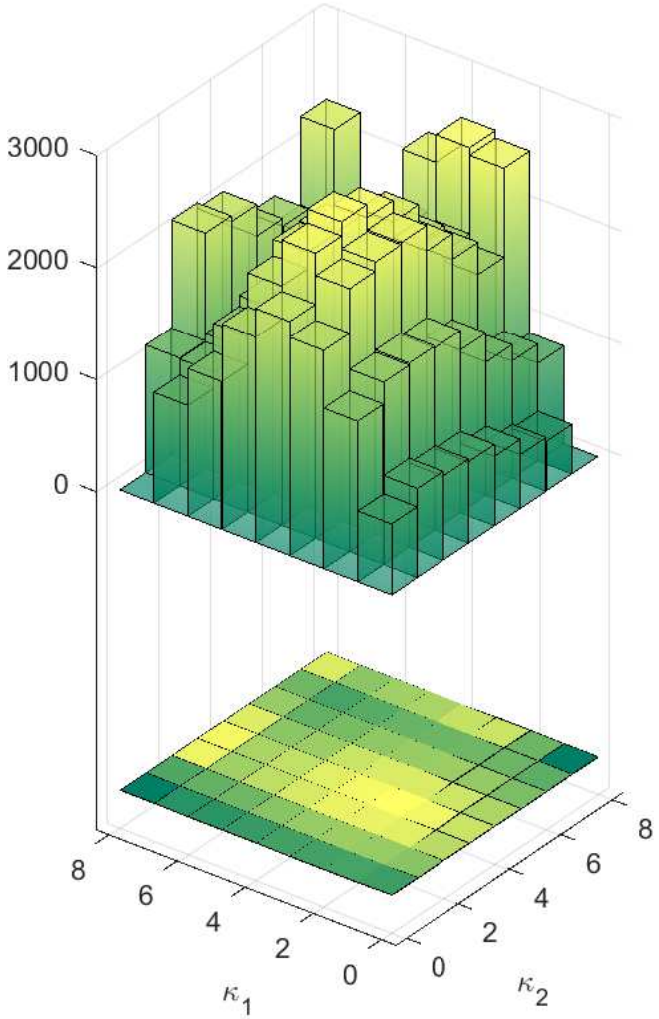
- For all economic variables but IP, the variances reduce to almost one third of the initial variances following a structural break in 2001 September.
- t distribution nicely captures aberrant observations which improves precision.
- Autoregressive process for the idiosyncratic elements are crucial for all variables and especially for ENPA in terms of the higher order lags.

Parameter estimation results for the FCI variables

	Mean	St. dev.
ϕ	0.32	(0.19)
σ^2	0.86	(0.13)
RRet	0.65	(0.06)
FRes	0.18	(0.06)
RConf	0.56	(0.08)
TS	0.01	(0.02)
BistVOL	-0.20	(0.08)
P/E	0.28	(0.12)
TAR	-0.27	(0.08)
TETS	-0.06	(0.04)
TCred	-0.24	(0.10)
MSCI	0.76	(0.09)
Spread-Bond	0.06	(0.03)

- Compared to economic variables, the reduction in variances is much extreme especially for spreads.

Lead-lag parameters, APS case



Lead-lag parameters,SPS case

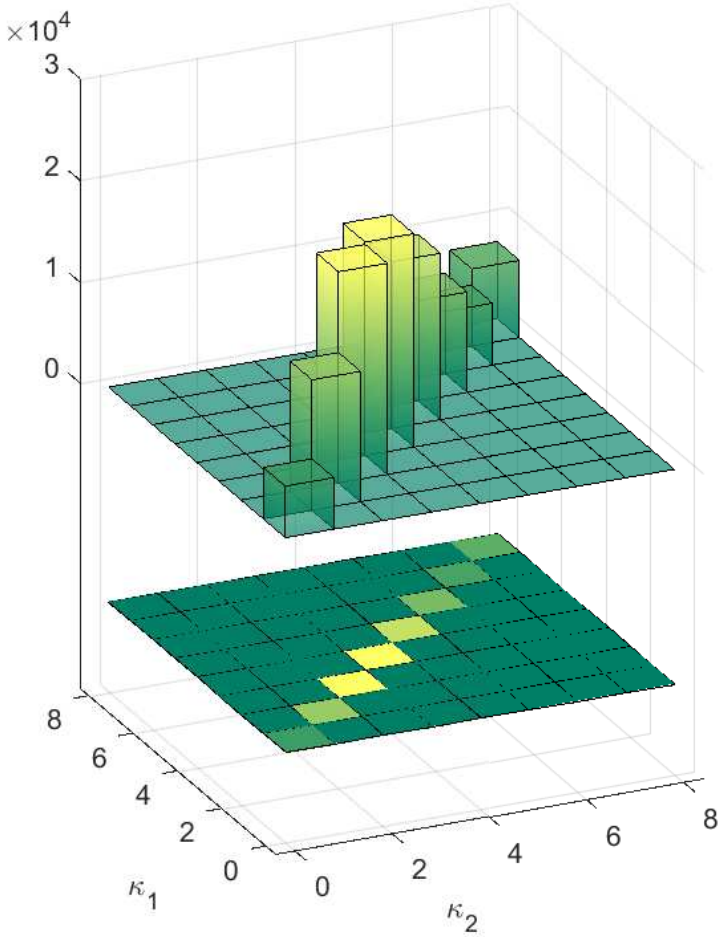
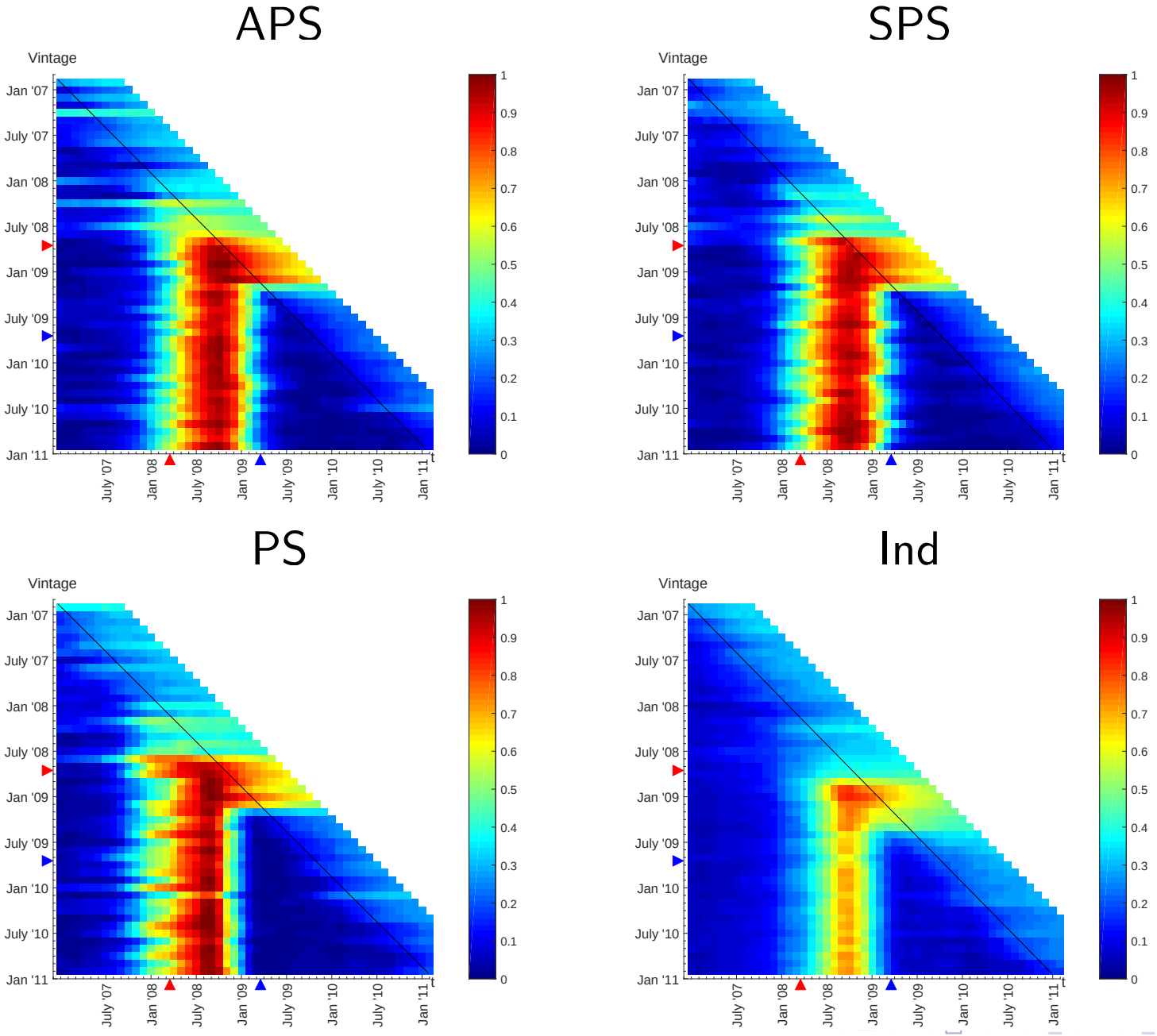


Illustration for the recent recession



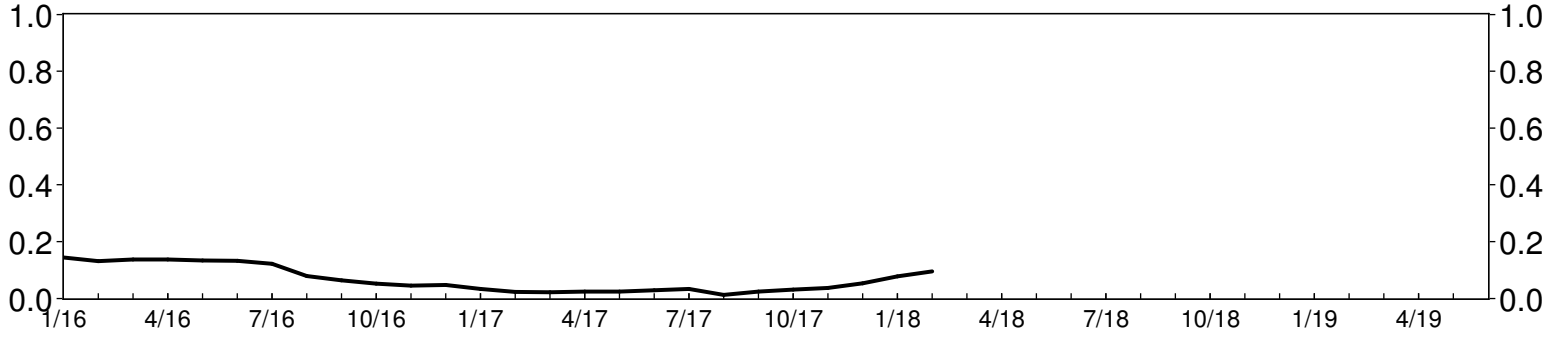
Relative performances

TPFE relative to APS

Horizon	SPS	PS	Ind
1	0.966	1.145**	1.753**
2	0.985	1.106**	1.597**
3	1.001	1.063	1.464**
4	0.992	1.008	1.301***
5	1.004	1.011	1.211***
6	1.013	1.020	1.135
7	1.020	1.031	1.104
8	1.016	1.028	1.082
9	1.025	1.018	1.051

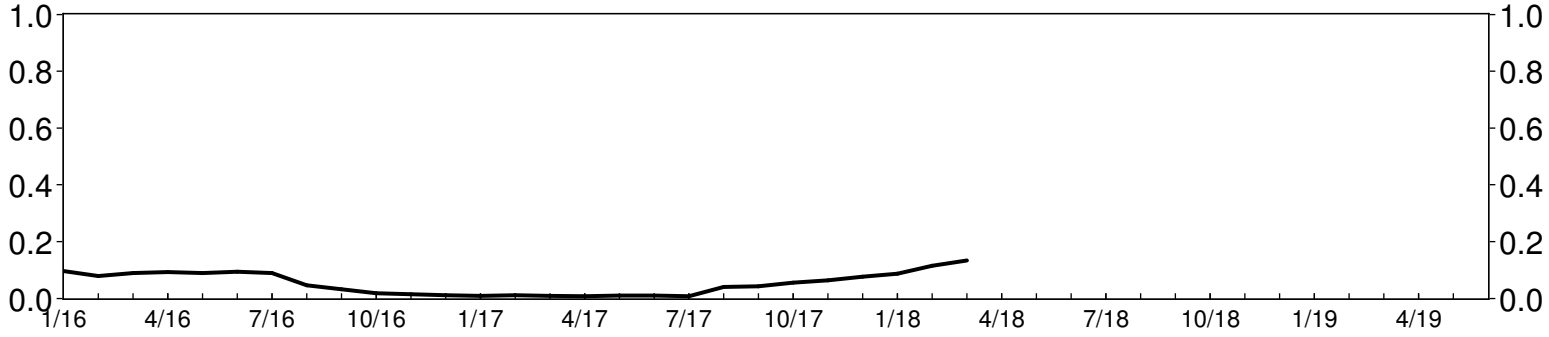
Is Turkish Economy in Recession?

2018 January



Is Turkish Economy in Recession?

2018 February



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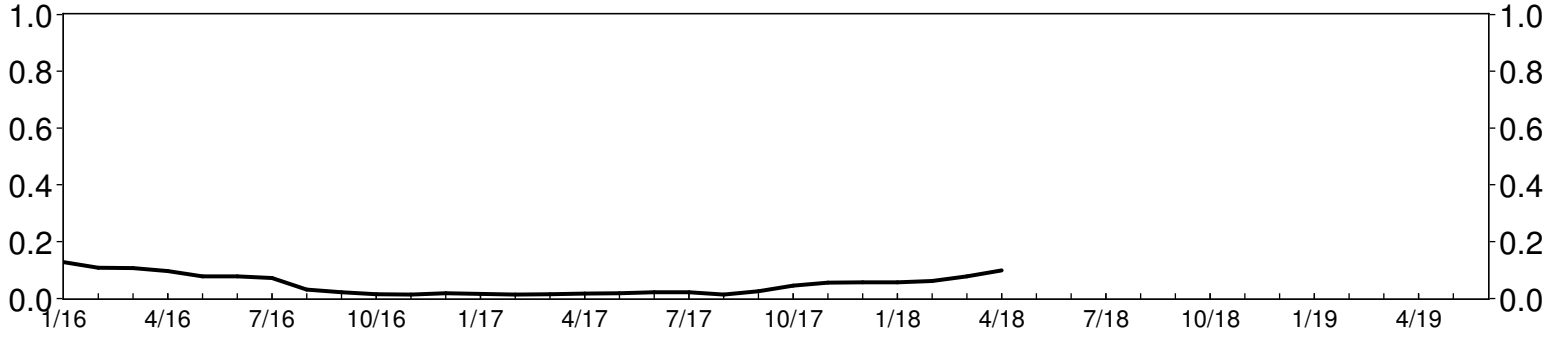
2018 March



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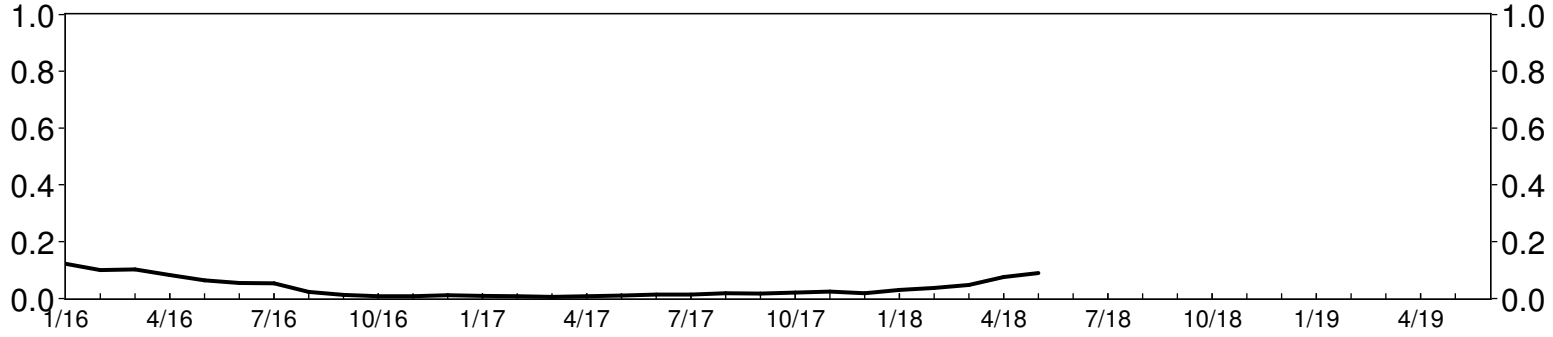
2018 April



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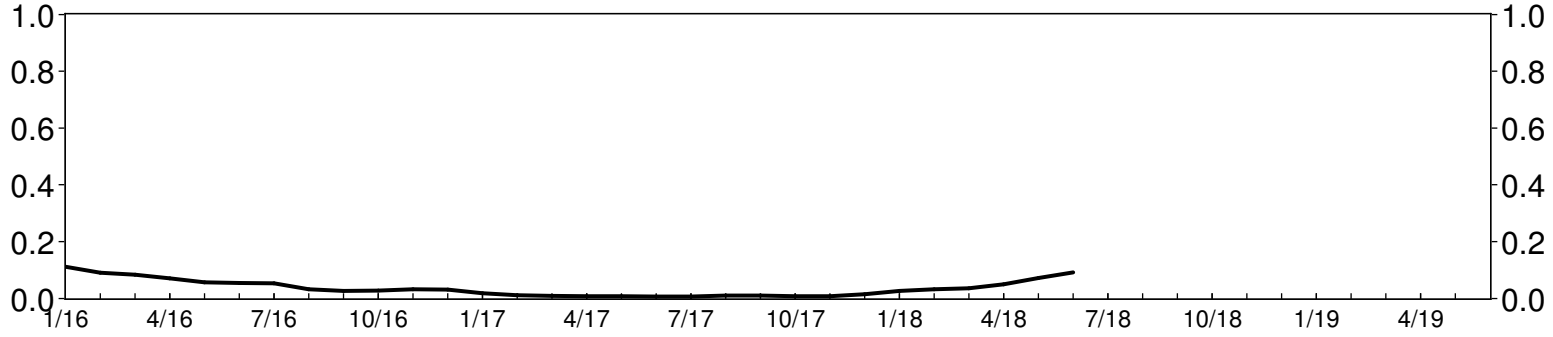
2018 May



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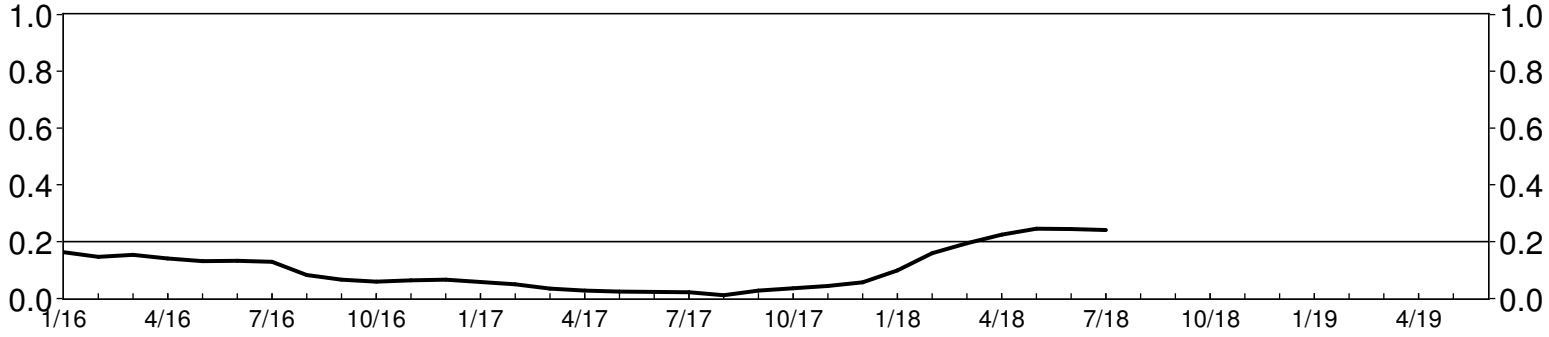
2018 June



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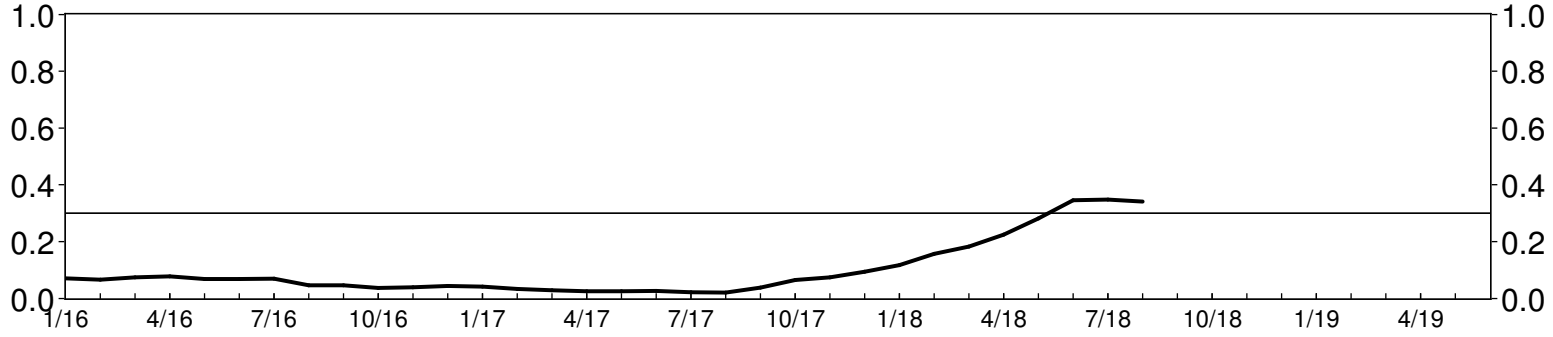
2018 July



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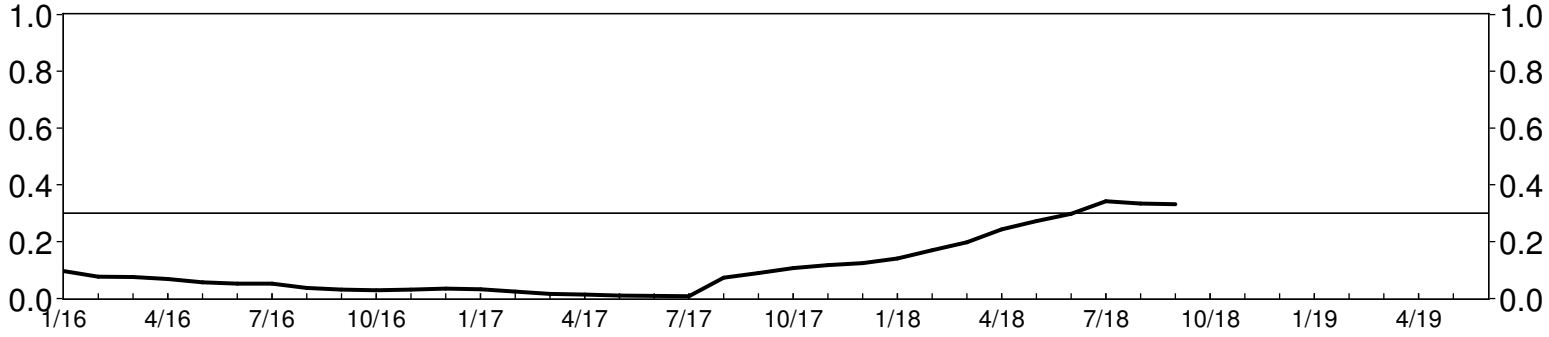
2018 August



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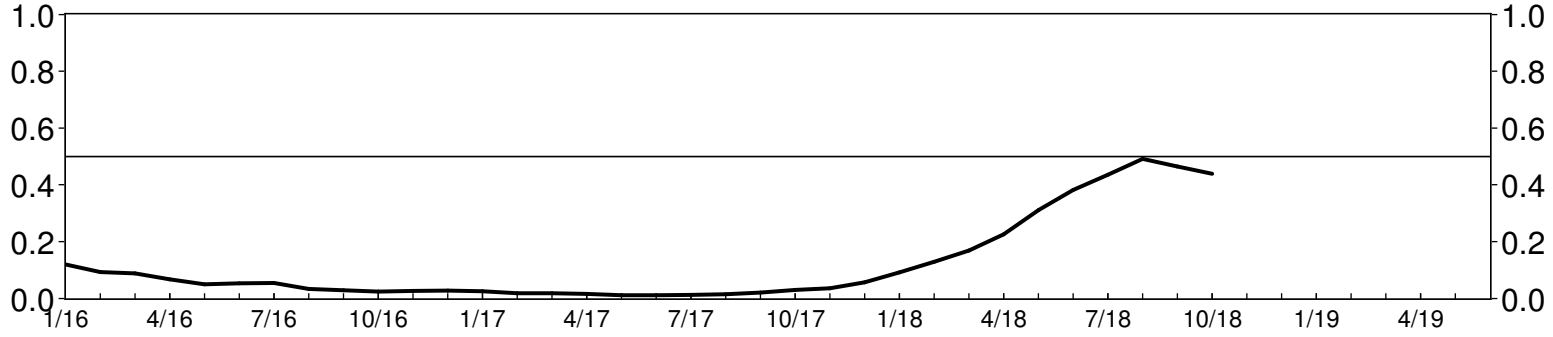
2018 September



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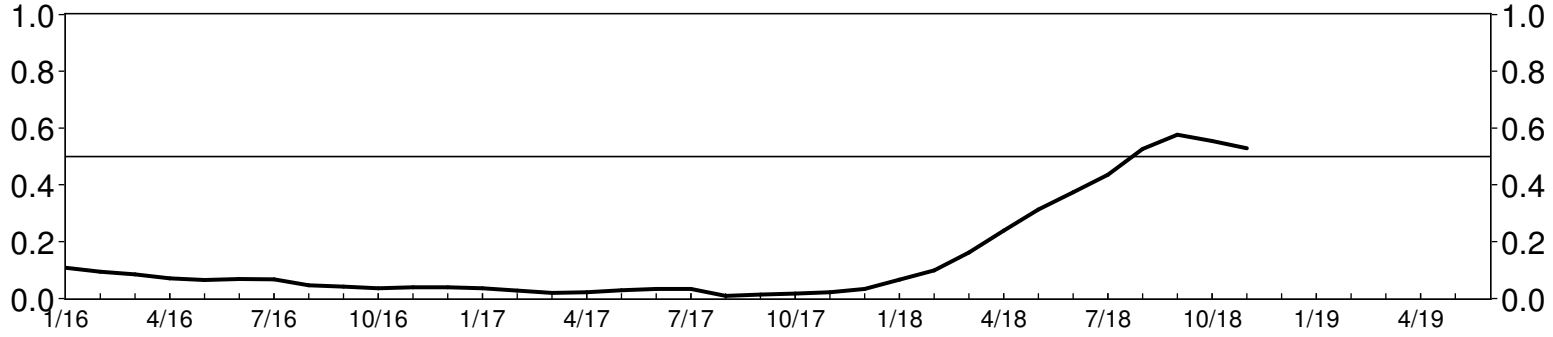
2018 October