Estimating the Fed's Unconventional Policy Shocks

Marek Jarociński

European Central Bank

9th NBP Summer Workshop, June 28, 2021

Question

- What are the effects of Fed's policies?
- Instrumental variables: high-frequency responses of financial markets to FOMC announcements (Kuttner, 2001)
- Challenge: FOMC announcements are multi-dimensional
  - news about current policy decisions (interest rates, asset purchases...)
  - future policies
  - comments on the economy, projections

  How to disentangle their effects?

What I do

- Observation: financial market responses to FOMC announcements are very leptokurtic (often small, occasionally very large).
- I exploit this feature to **estimate** the underlying independent shocks.
- I track the effects of these shocks on the economy with local projections

Findings

- Data contain identifying information about the Fed shocks, previously ignored
- The estimated shocks can be naturally labeled ex-post as:
  1) Standard Monetary Policy 2) Odyssean Forward Guidance
  3) Asset Purchases 4) Delphic Forward Guidance
- Odyssean forward guidance - the most prominent
- Asset purchases have persistent effects on long term rates.
- Delphic forward guidance has significant, expansionary effects.

Related literature

- Identification through non-Gaussianity
  - Independent Components Analysis (ICA) - Common (1994), Hyvarinen et al. (2001). Used in signal processing, telecommunications, medical imaging.
  - ICA for identifying factor loadings - Bonhomme and Robin (2009)
  - Lanne, Meitz, Saikkonen (2017 JoE) Structural VAR identification with Student-t shocks. Gourieroux, Montfort, Renne (2017 JoE) SVAR identification with pseudo maximum likelihood. GMR (2020 REStud) show that SVARMA is identified.
- Analogies to identification through heteroskedasticity, Rigobon (2003), Brunnermeier et al. (forth. AER), Lewis (2019,2020): statistical identification exploiting that shocks arrive "irregularly".
- Deconstructing monetary policy surprises: Gürkaynak, Sack and Swanson (2005), Campbell et al. (2012), Cieslak and Schrimpf (2019), Swanson (2021), Jarociński and Karadi (2020), Miranda-Agrippino, Ricco (2021)
- Effects of unconventional policies: Woodford (2012), ...; Fed information effects: Romer and Romer (2000), Nakamura and Steinsson (2018)

Comparison to three related papers

Most papers **construct the shocks** with the desired features:

- Gürkaynak, Sack and Swanson (2005): target+path factor; **zero restriction** on short term rates response to the path factor.
- Swanson (2021): 3 shocks; GSS(2005) above + asset purchases shocks are **minimized** pre-ZLB
- Jarociński and Karadi (2020): 2 shocks; **sign restrictions**.

This paper: **estimate the shocks** using the likelihood function. Do not impose their restrictions. Still find fairly similar shocks!

Plan

- Data
- Identification: intuition
- Econometric model
- Empirical results

Data

- Gürkaynak, Sack and Swanson (2005) dataset, 1990-2019 (240 obs.)

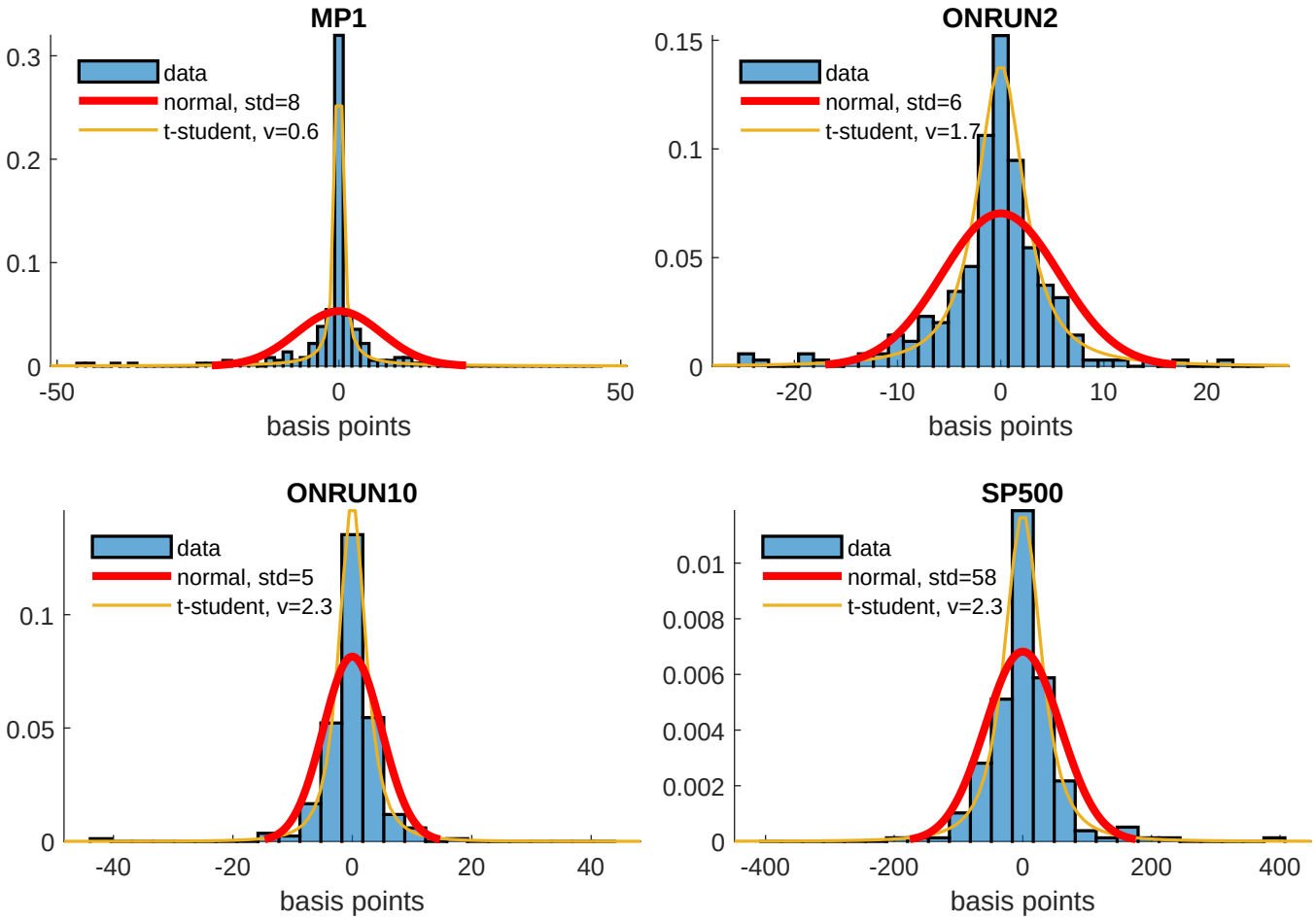
- Δ financial variables in 30-min window around FOMC announcements

MP1	future, fed funds rate after the meeting
ONRUN2	2-year Treasury yield
ONRUN10	10-year Treasury yield
SP500	stock index

- MP1, ONRUN2, ONRUN10 approximately span Swanson's (2021) **target**, **path** and **LSAP** factors

- I add SP500 to capture the effects beyond the yield curve

Responses to FOMC announcements are very non-Gaussian: leptokurtic

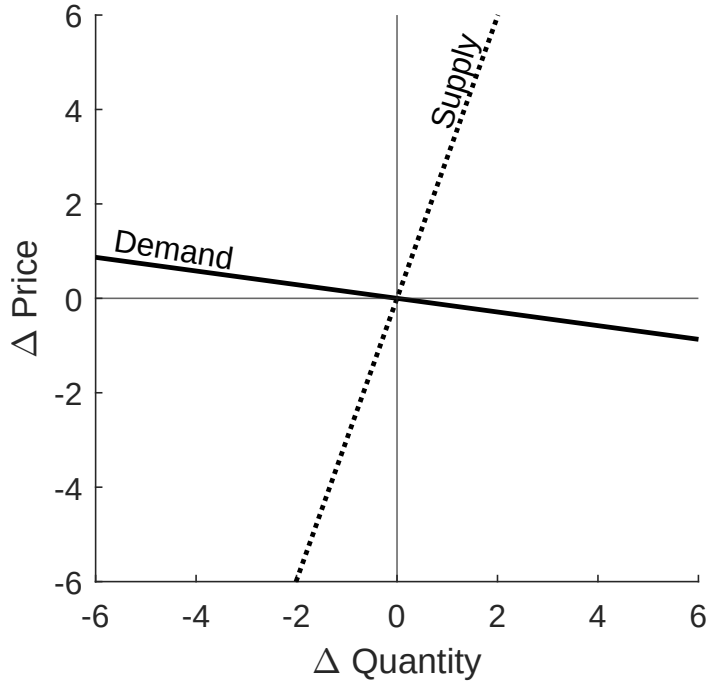


How kurtosis helps pin down structural shocks: stylized example

Market for good A: prices and quantities, demand and supply.

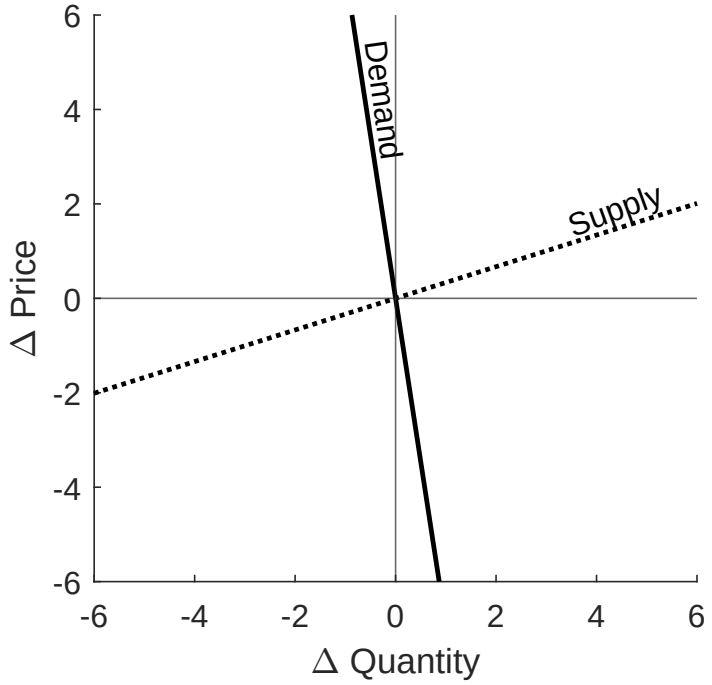
Model 1

flat Demand, steep Supply

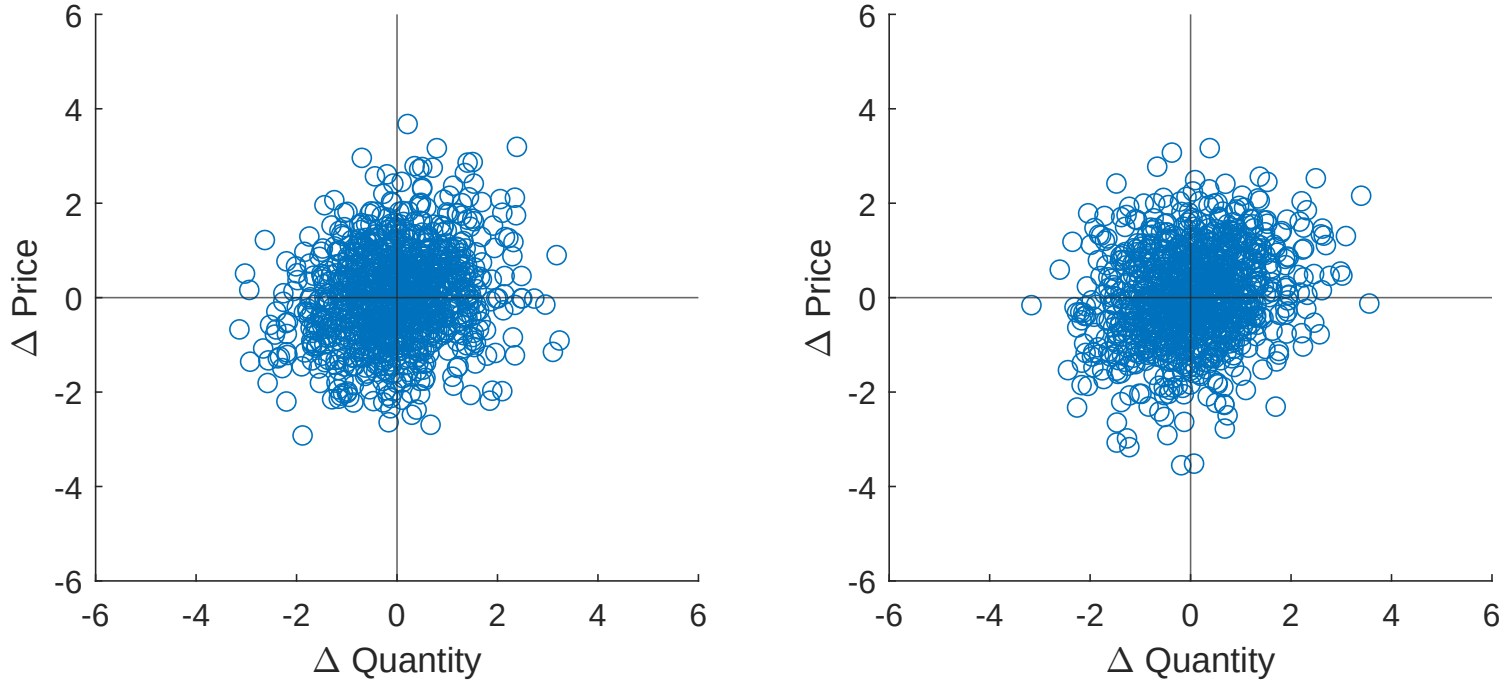


Model 2

steep Demand, flat Supply

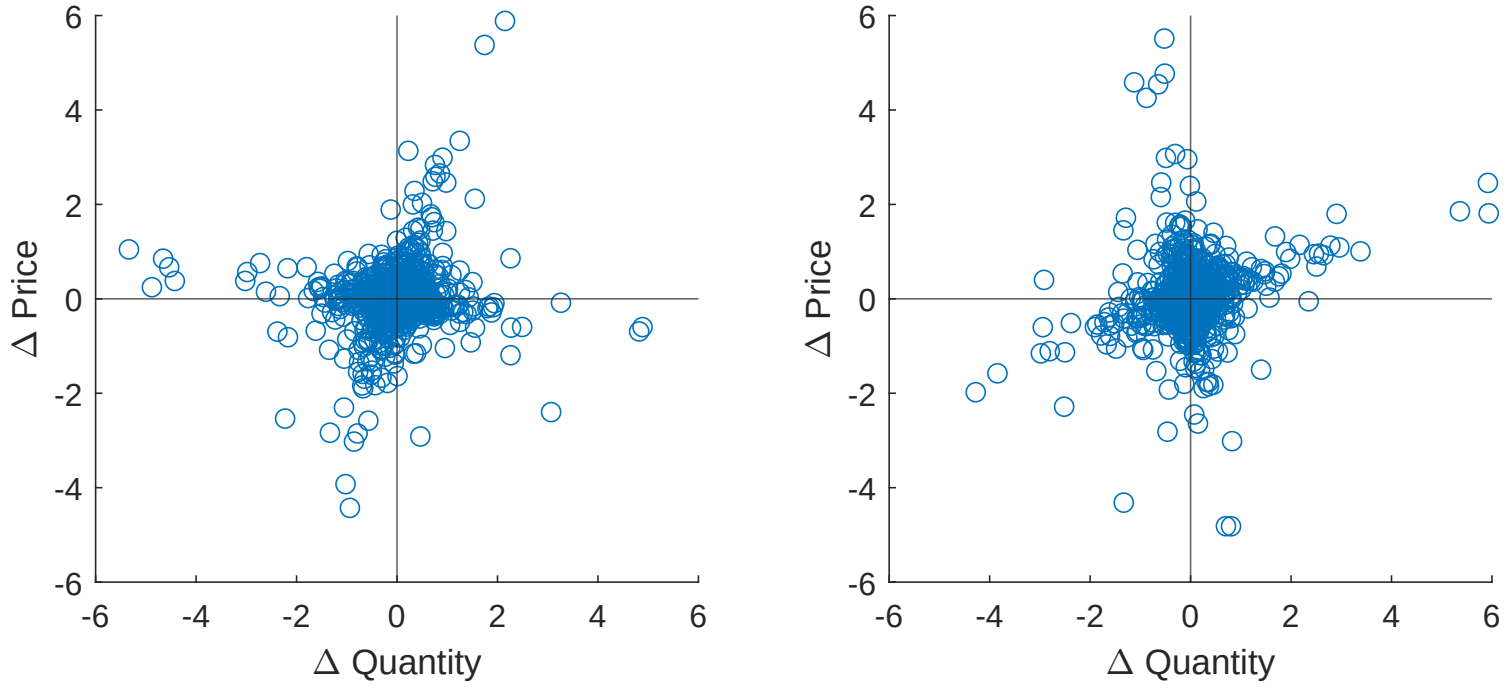


Gaussian demand and supply shocks: Model 1 and 2 are indistinguishable



Both plots: $\mathrm{Var}(\Delta Q) = \mathrm{Var}(\Delta P) = 1$, $\mathrm{corr}(\Delta Q, \Delta P)$=0.2

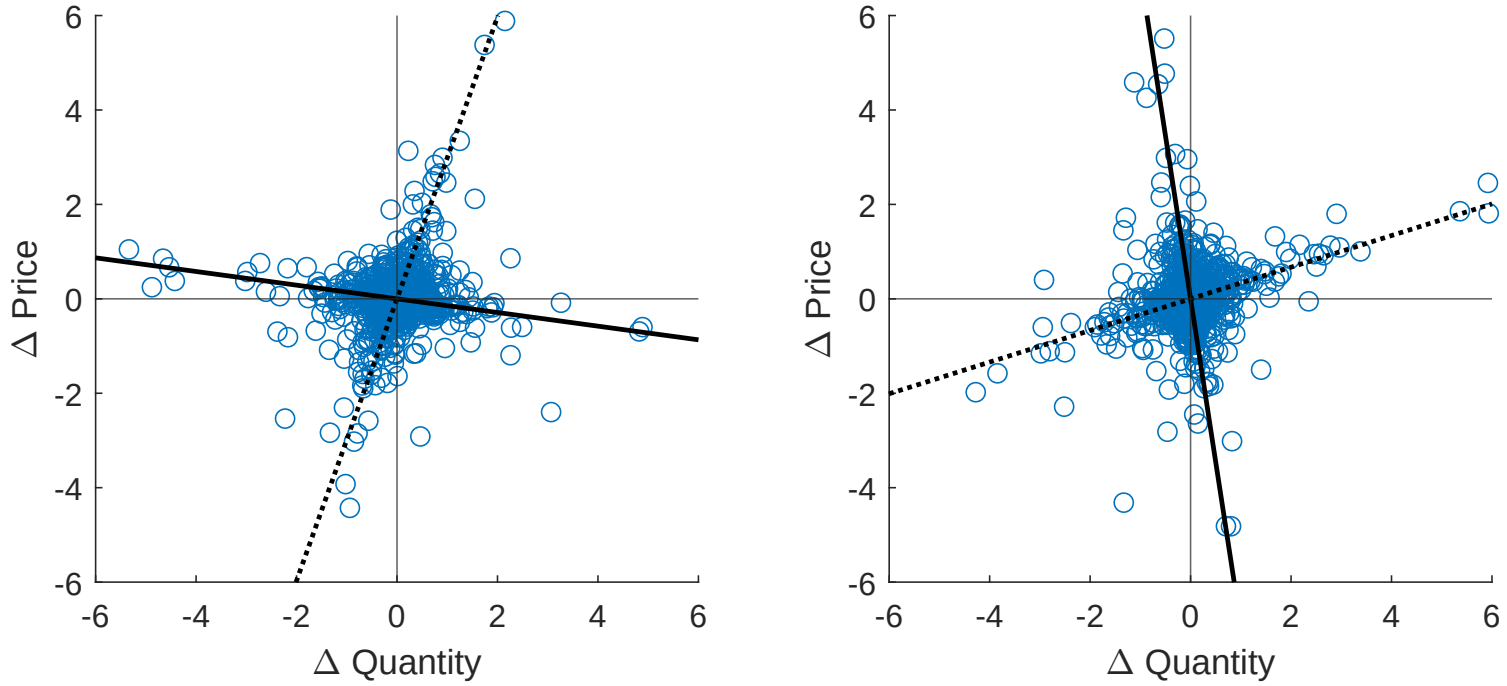
Student-t shocks: data from Model 1 and 2 look differently



Both plots: $\text{Var}(\Delta Q) = \text{Var}(\Delta P) = 1$, $\text{corr}(\Delta Q, \Delta P)$=0.2

One of the shocks often small $\rightarrow$ observations cluster near the Demand and Supply curves.

Student-t shocks: data from Model 1 and 2 look differently



Both plots: $\text{Var}(\Delta Q) = \text{Var}(\Delta P) = 1$, $\text{corr}(\Delta Q, \Delta P)$=0.2

One of the shocks often small $\rightarrow$ observations cluster near the Demand and Supply curves.

Econometric model

$$y_t = C' \, u_t \qquad\qquad u_{t,n} \sim \text{i.i.d. Student-t}(v)$$

$y_t = (y_{1,t}, ..., y_{N,t})'$ - vector of N observed variables.

$u_t = (u_{1,t}, ..., u_{N,t})'$ - unobserved **structural (independent) shocks**

C - $N \times N$ matrix. $C(i, j)$ - **effect of shock** i on variable j

Likelihood function

Y, U - matrices collecting T observations on y_t, u_t.

$$Y = U\,C \qquad\qquad u_{t,n} \sim \text{i.i.d. Student-t}(v)$$

Reparameterize $W = C^{-1}$. Log-likelihood:

$$\log p(Y|W, v) = T \log|\det W| - \frac{v+1}{2} \sum_t \sum_n \log(1 + u_{t,n}^2/v) + TN \log c(v)$$

- Maximum Likelihood estimation
- Simulate the shape of the likelihood with Metropolis-Hastings, 10,000,000 draws.

Shock identification

$$Y = U\,C$$

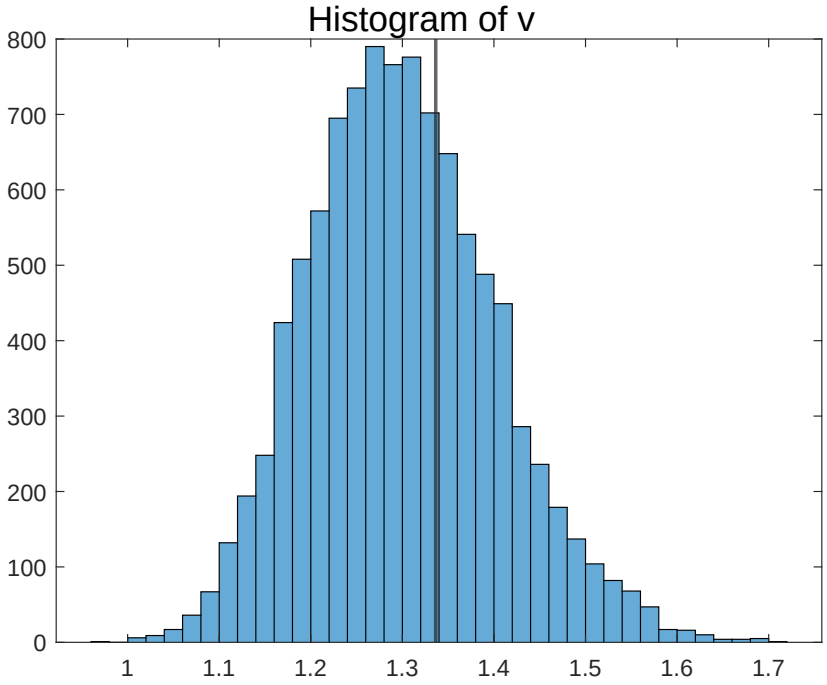
Continuum of decompositions into **orthogonal** shocks:

$$UC = UQQ'C = \tilde{U}\tilde{C} \qquad \text{for any orthogonal } Q.$$

- U Gaussian: UC and $\tilde{U}\tilde{C}$ have the same likelihood. Lack of identification

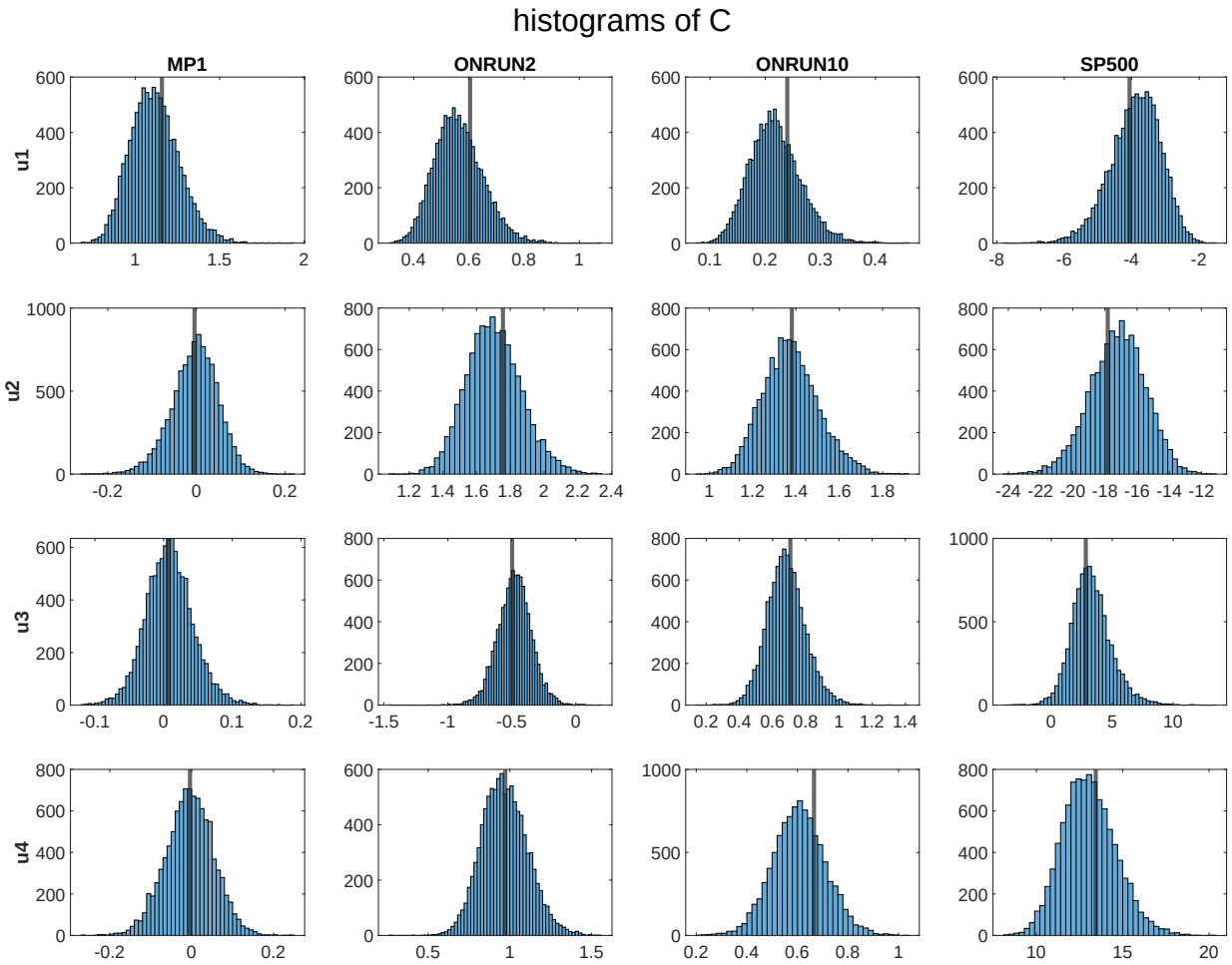
- U non-Gaussian: UC and $\tilde{U}\tilde{C}$ have different likelihood.

The likelihood (or the flat-prior posterior) of v

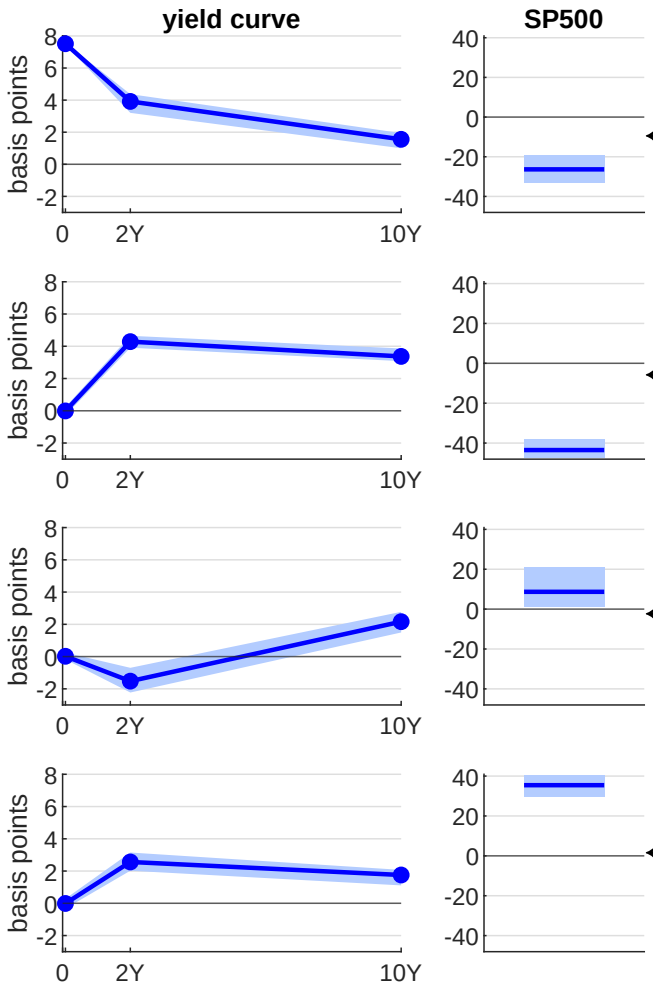


Implies very non-Gaussian shocks. ($v = 1$ corresponds to the Cauchy distribution.)

The likelihood (or the flat-prior posterior) of C



The responses of variables to shocks (1std shock, 95% band)



← Standard monetary policy

← Forward guidance (Odyssean)

← Long term rate shock (LSAP)

← Delphic forward guidance (information)

Variance decomposition: u1,u2,u4 pervasive

	MP1	ONRUN2	ONRUN10	SP500
u1	**1.00**	**0.38**	**0.11**	**0.19**
	(0.00)	(0.04)	(0.03)	(0.05)
u2	0.00	**0.42**	**0.50**	**0.48**
	(0.00)	(0.04)	(0.09)	(0.04)
u3	0.00	0.04	**0.25**	0.01
	(0.00)	(0.03)	(0.08)	(0.02)
u4	0.00	**0.16**	**0.14**	**0.32**
	(0.00)	(0.04)	(0.03)	(0.06)
Total	1.00	1.00	1.00	1.00

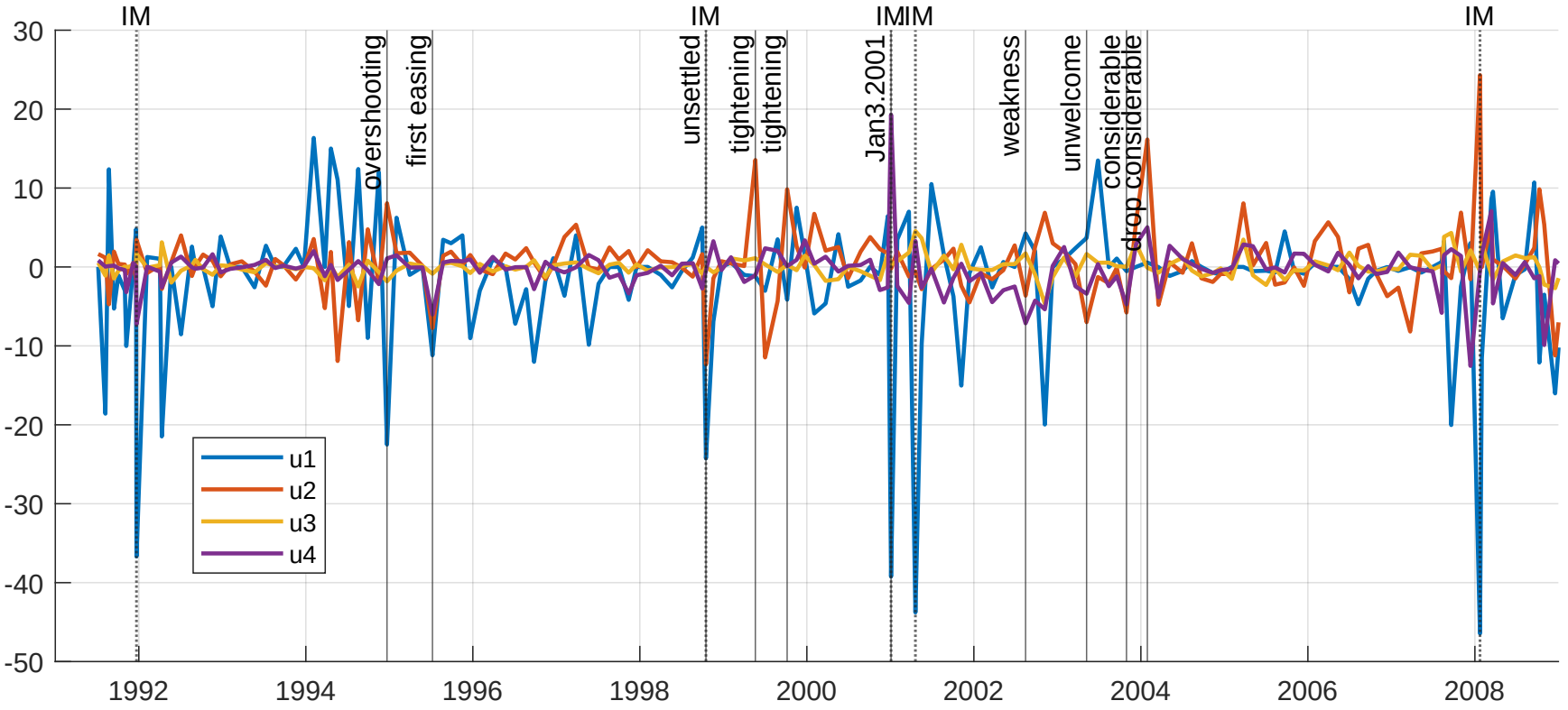
Shares of the sample variance, standard deviations in parenteses

Comparison with the decompositions of other papers

Pairwise rank correlations with baseline shocks u_1, u_2, u_3 and u_4

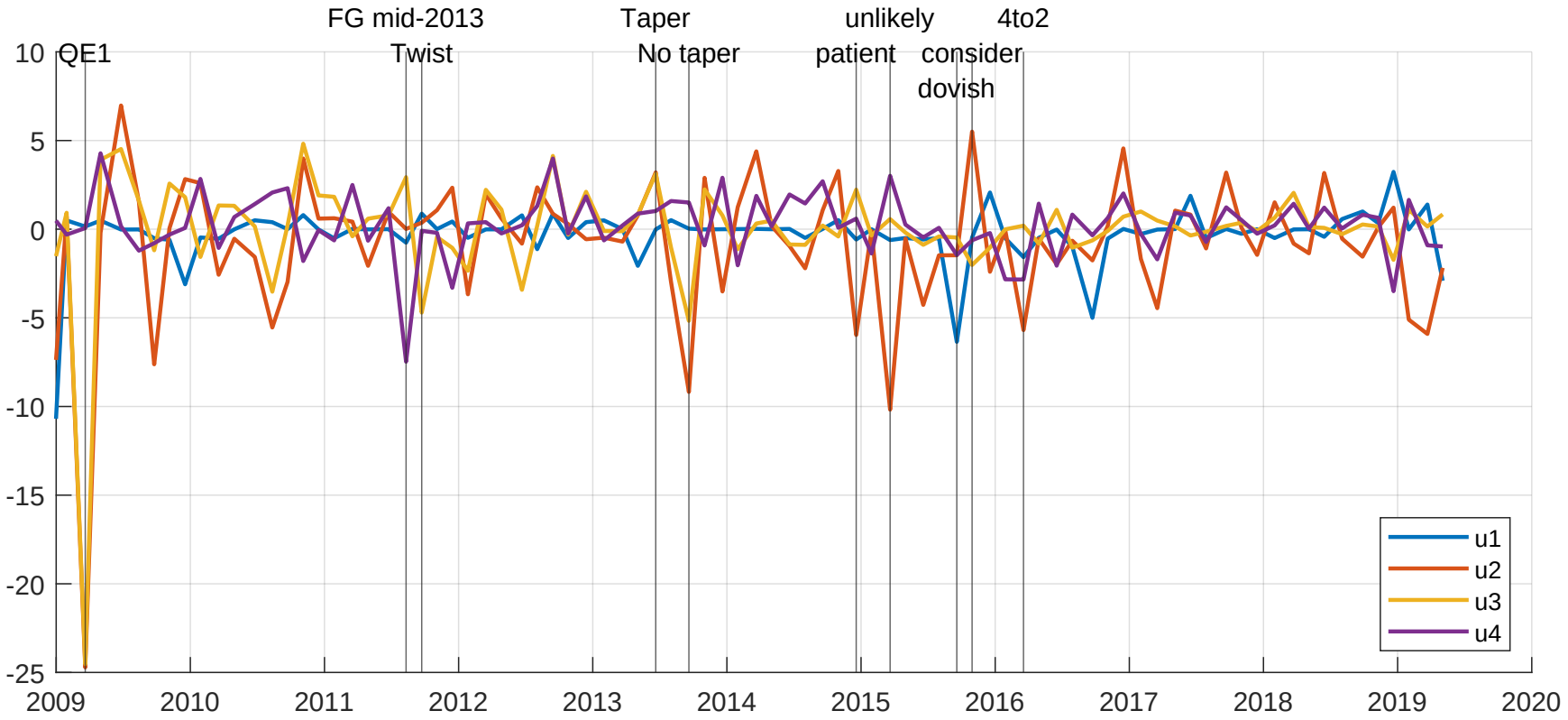
	Obs.	u_1		u_2		u_3		u_4
Swanson (2021)	240	FF:	0.76	FG:	0.74	LSAP:	0.66	FG:	0.48
JK (2020)	221	MP:	0.50	MP:	0.62	MP:	-0.05	CBI:	0.58

Shocks over time: 1991-2008

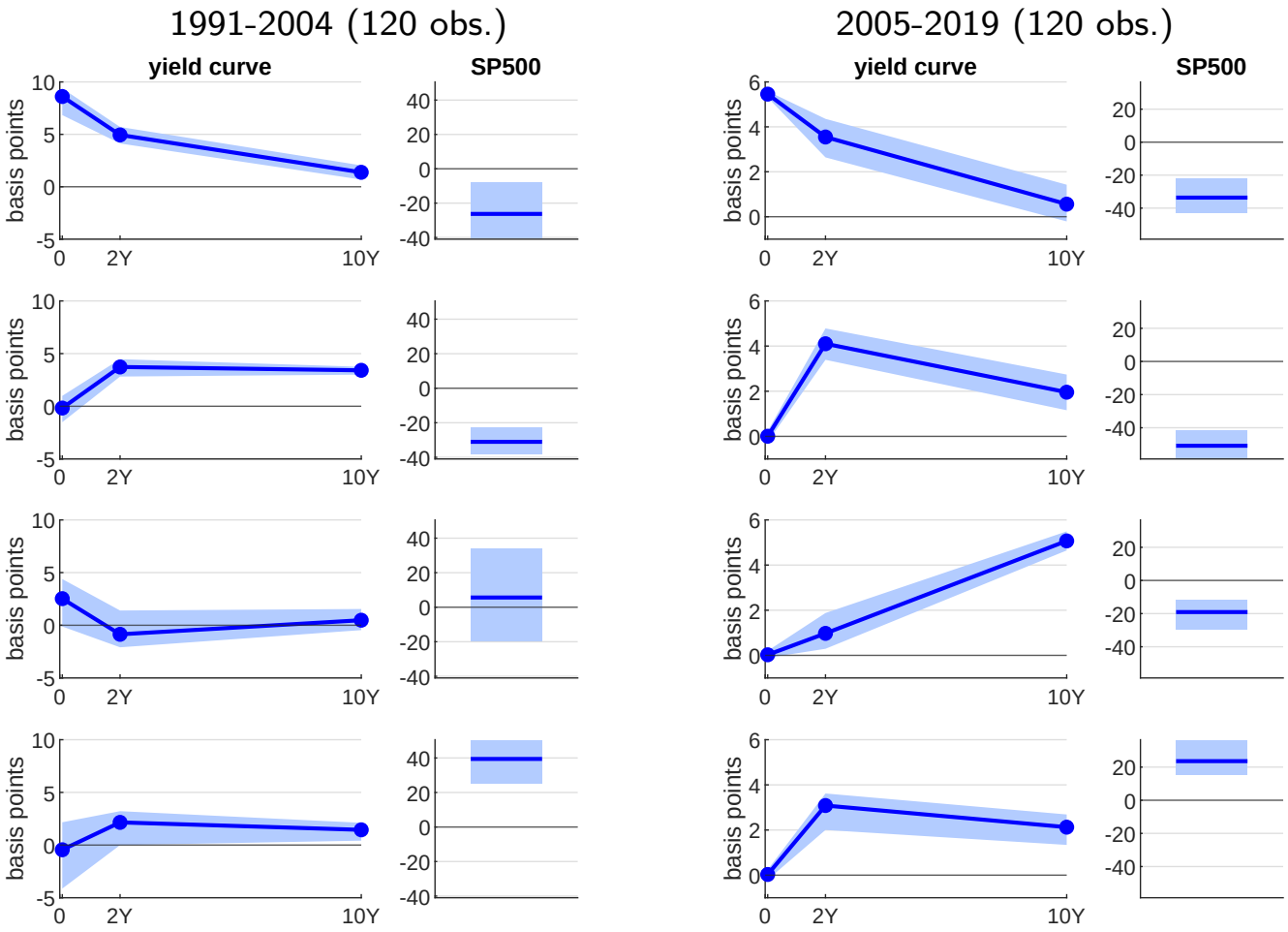


IM = "inter-meeting"

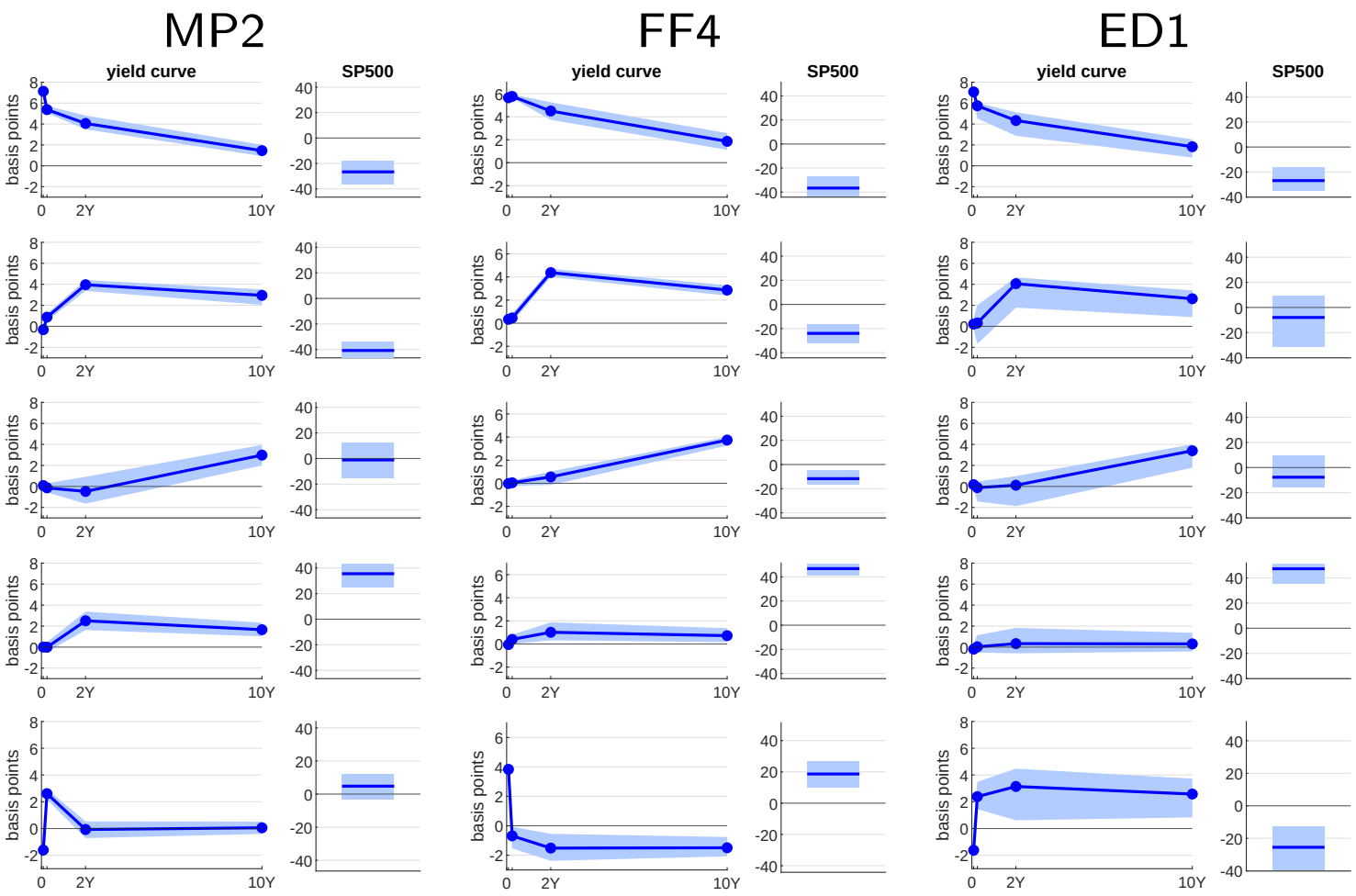
Shocks over time: 2009-2019



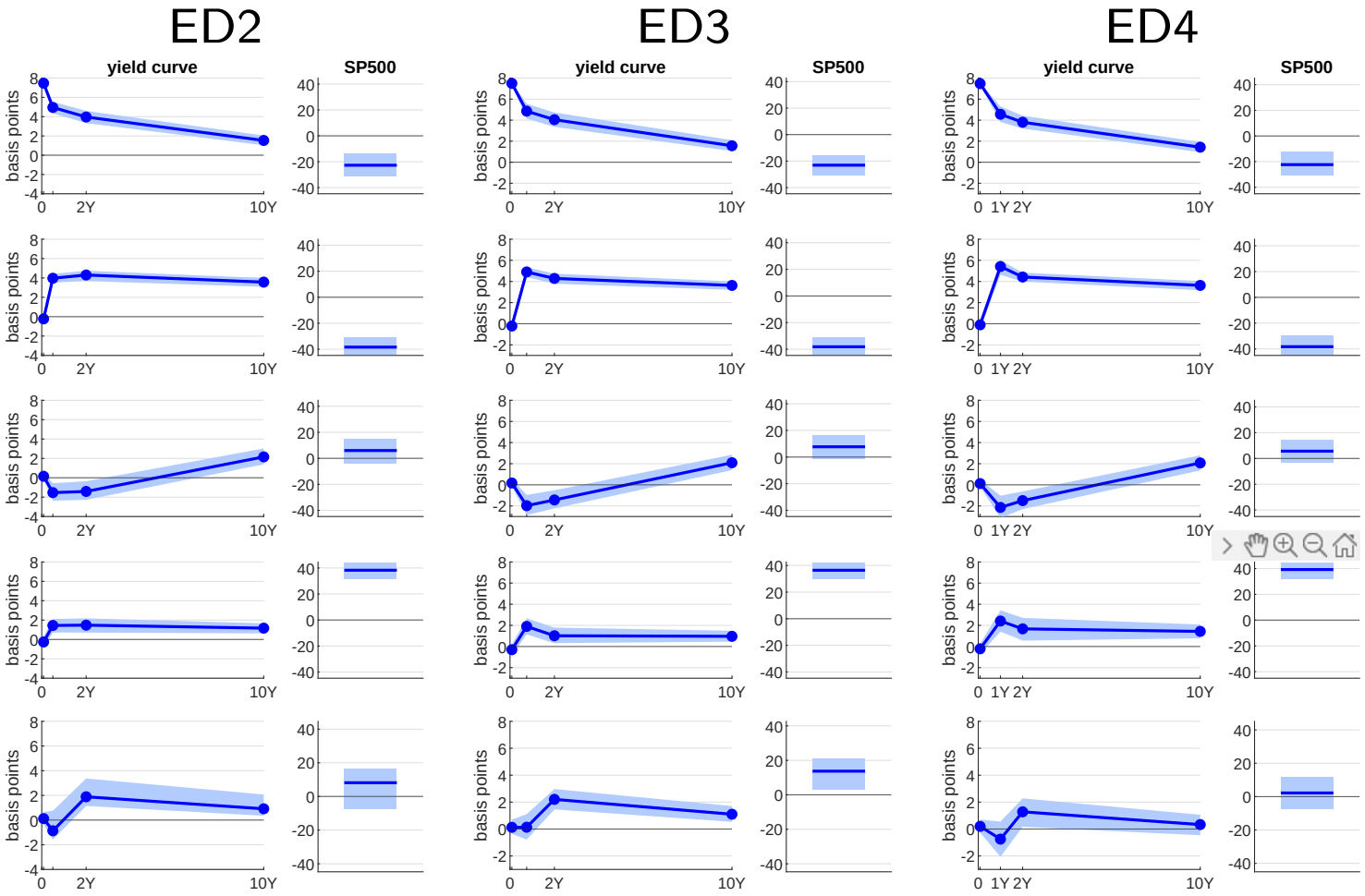
First vs second half of the sample



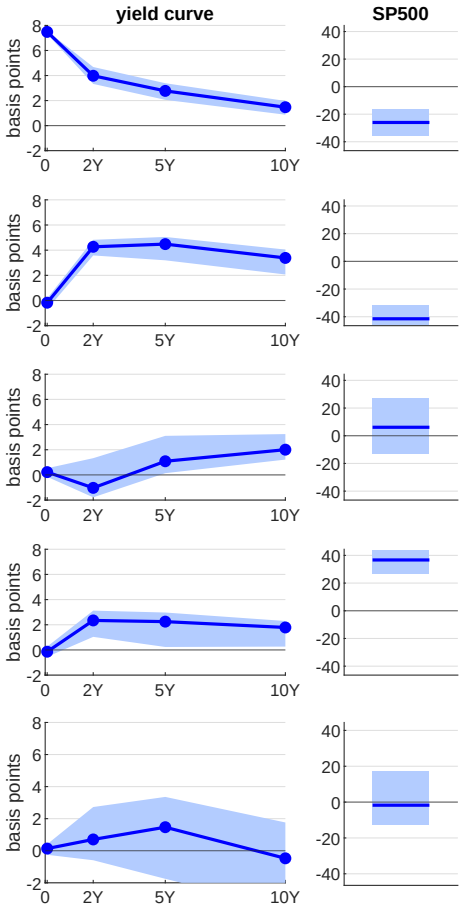
Adding variables (1) other short rates



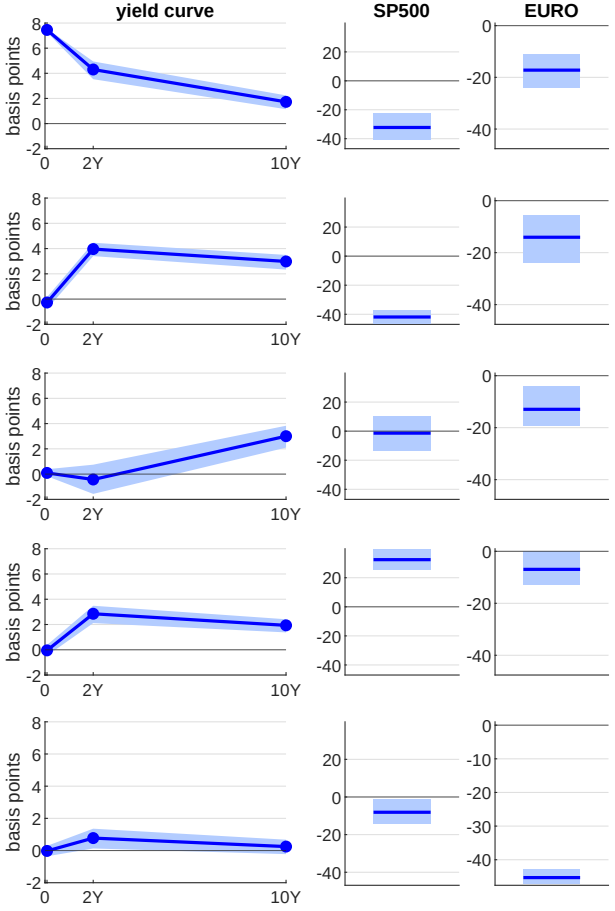
Adding variables (2) other short rates



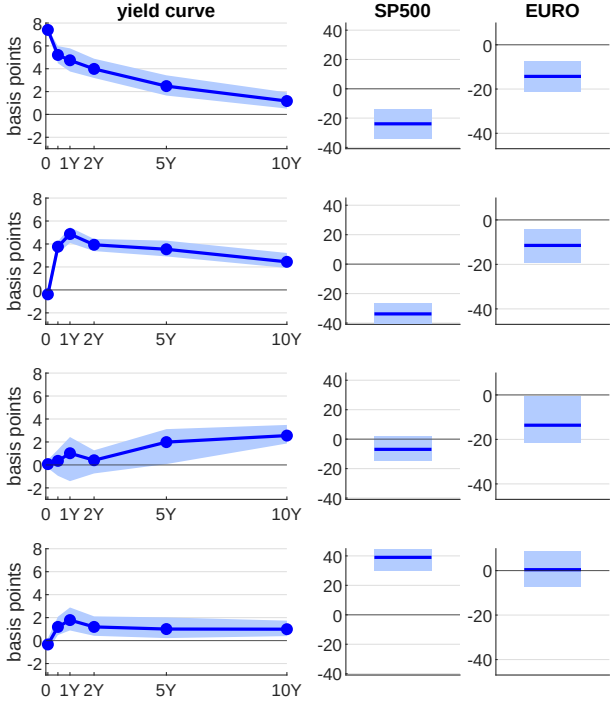
ONRUN5



EURO



ED2,ED4,ONRUN5,EURO

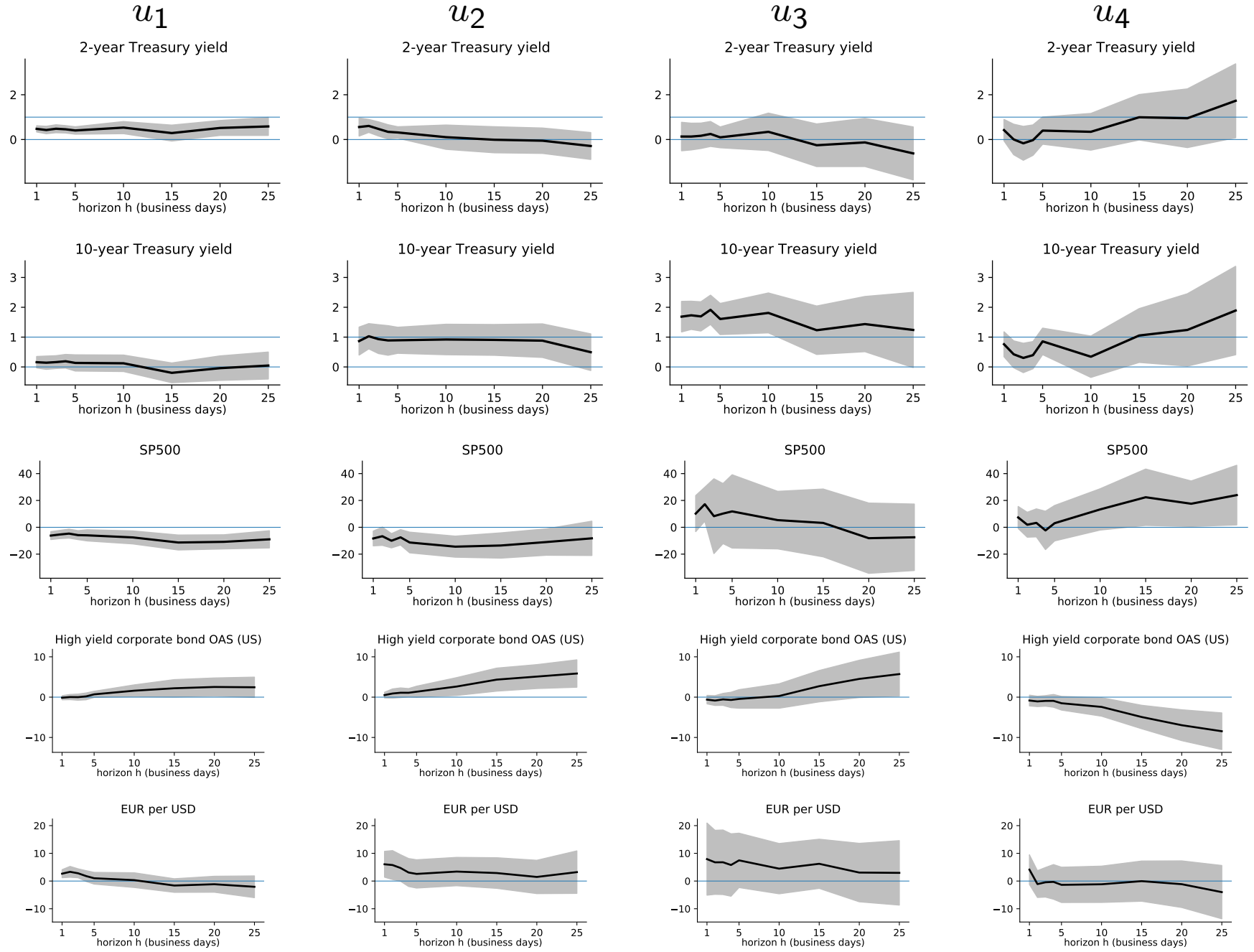


Longer term effects: local projections with daily variables

$$x_{t+h} - x_{t-1} = \alpha + \beta_h^i u_t^i + e_t$$

- x_t - daily financial variable (Treasury yield, log S&P500 index etc.)
- t - day of the FOMC announcement
- $h = 1, 3, 5, 10, 15, 20, 25$ business days
- $u_t^i \quad i = 1, 2, 3, 4$ - shocks identified above, included one-by-one
- Estimate the equation with OLS, heteroskedasticity-consistent errors

Local projection results in the baseline specification



90% bands (+/-1.645 std.dev)

Conclusions

- The high kurtosis of financial market responses tightly pins down four main monetary policy shocks:

  1. Standard monetary policy
  2. Odyssean forward guidance
  3. Asset purchases
  4. Delphic forward guidance

Pairwise rank correlations with baseline shocks u_1, u_2, u_3 and u_4

	Obs.	u_1		u_2		u_3		u_4
Changing the sample								
Drop January 3, 2001	239	u_1:	1.000	u_2:	0.998	u_3:	0.994	u_4:	0.998
Drop QE1 (March 18, 2009)	239	u_1:	0.998	u_2:	0.998	u_3:	0.998	u_4:	0.997
Sample 1999-2004	120	u_1:	0.942	u_2:	0.879	u_3:	0.913	u_4:	0.969
Sample 2005-2019	120	u_1:	0.935	u_2:	0.824	u_3:	0.885	u_4:	0.955
Adding variables								
+EURO	240	u_1:	0.997	u_2:	0.945	u_3:	0.968	u_4:	0.998
+ED2,ED4,ONRUN5	240	u_1:	0.968	u_2:	0.812	u_3:	0.611	u_4:	0.777
Other papers								
Swanson (2020)	240	ff:	0.759	fg:	0.741	lsap:	-0.660	fg:	0.476
JK (2020)	221	MP:	0.501	MP:	0.623	MP:	-0.047	CBI:	0.578
JK (2020) Appendix	237	MP:	0.523	MP:	0.691	MP:	-0.051	CBI:	0.777

Rolling window (100 obs) - without QE1