The Transmission of Monetary Policy Shocks

Silvia Miranda-Agrippino[1] Giovanni Ricco[2]

[1]Northwestern University, Bank of England & CFM
[2]University of Warwick, CEPR & OFCE Sciences Po

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[▷]

What are the Effects of MP shocks?

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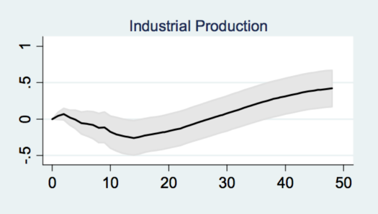
Ramey (2017)



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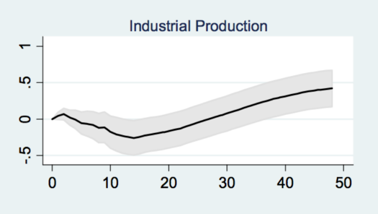

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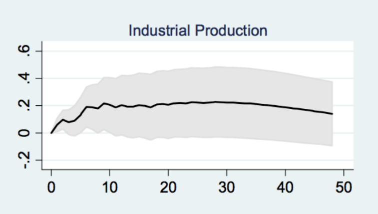

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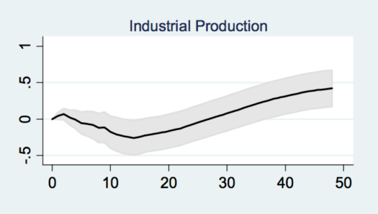

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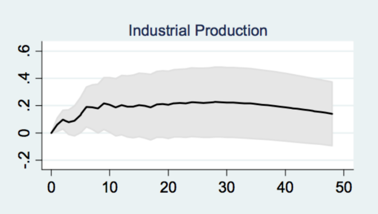

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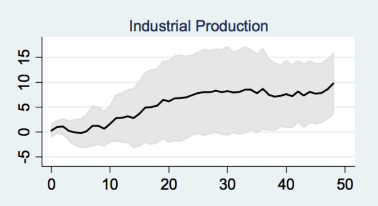

(c) GK LP-IV 90-12

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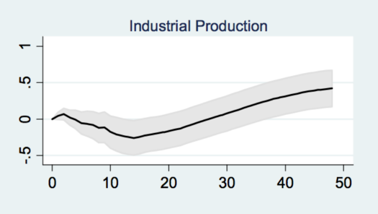

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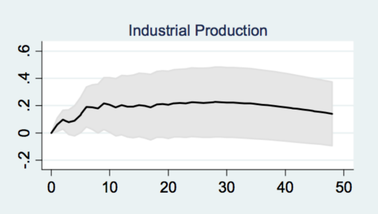

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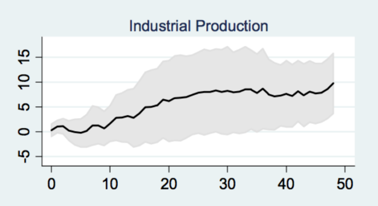

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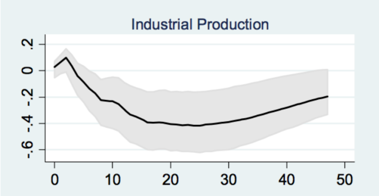

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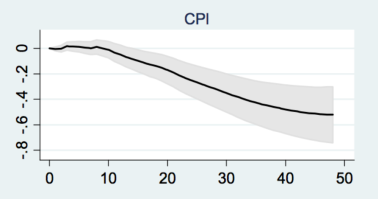

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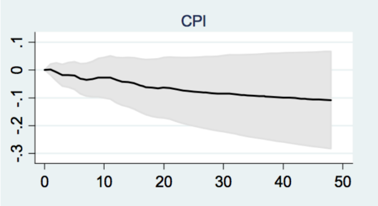

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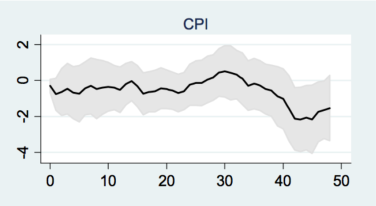

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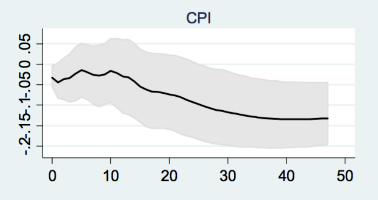

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   - ▷ **Fed Information Effect**/Signalling Channel of MP
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3. **Bayesian Local Projections (BLP)**
   - Robust to model misspecification

Related Literature: subset!

- **Identification MP Shocks:** Christiano et al (1999), Rudebush (1989), Kuttner (2001), Gürkaynak et al (2005), Romer & Romer (2004), Stock & Watson (2012, 2018), Mertens & Ravn (2013), Cochrane & Piazzesi (2002), Cloyne and Hürtgen (2014), Gertler & Karadi (2015), Caldara & Herbst (2016), Jarociński & Karadi (2019)
- **Information Frictions:** Mankiw & Reis (2002), Andrade et al (2014), Woodford (2001), Andrade & Le Bihan (2013), Reis (2006), Sims (2003), Coibion & Gorodnichenko (2010,2012), Nakamura and Steinsson (2017), Melosi (2016)
- **Local Projections & Direct Forecast:** Jordà (2005), Kilian & Kim (2009), and Marcellino et al (2006), Pesaran et al (2011), Plagborg-Moller & Wolf (2018)
- **BVAR:** Litterman (1986), Doan et al (1983), Sims and Zha (1998), Kadiyala and Karlsson (1997), Bańbura et al (2010), De Mol et al (2010), Giannone et al (2015), Chan et al (2015)
- **Model Misspecification:** Huber (1967), White (1982), Braun & Mittnik (1993), Zellner (1997), Kim (2002), Schorfheide (2005), Müller (2013)

Identification

The Identification Problem

- **Interest rate hike** to informationally constrained agents
  1. **MP shock**
     $\Longrightarrow$ lower output and inflation
  2. **Endogenous reaction** to demand shocks
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- Market surprises confound MP shocks with current and past macro shocks!
  $\Longrightarrow$ **price and output puzzles**

Market-Based Monetary Surprises

- Interest rates futures for agents' expectations

$$p_t^{(h)} = \mathbb{E}_t\left(i_{t+h}\right) + \zeta_t^{(h)}$$

[Rudebusch (1998), Kuttner (2001), Sack (2004), Gürkaynak, Sack, Swanson (2005)]

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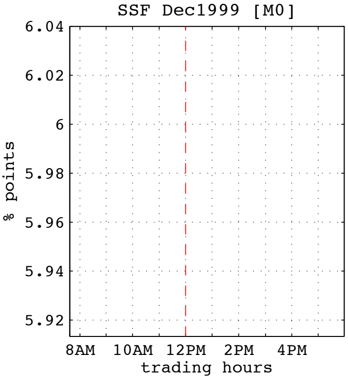

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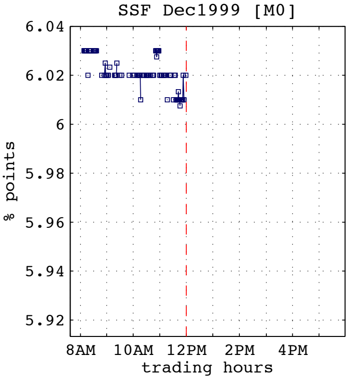

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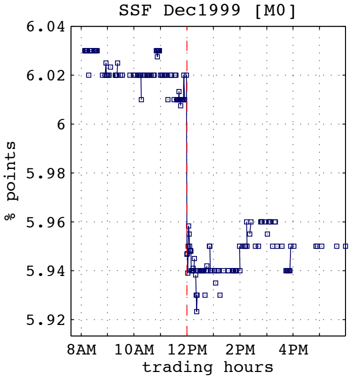

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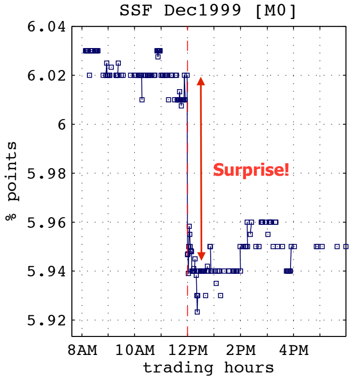

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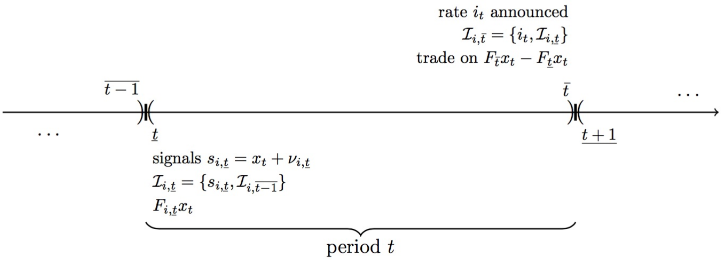
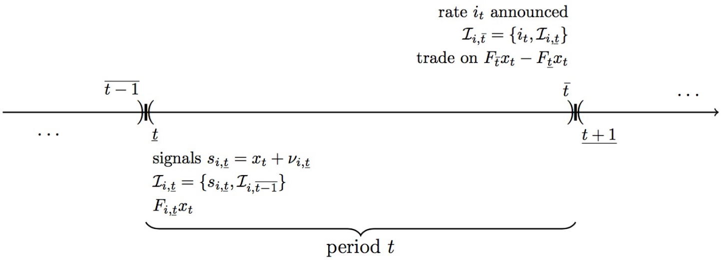
The HF Identification





1. Economy is an AR(1) process

$$x_t = \rho x_{t-1} + \xi_t \qquad \nu_t \sim \mathcal{N}(0, \sigma_\nu)$$

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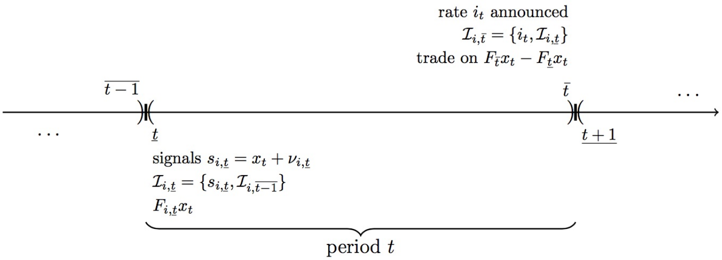


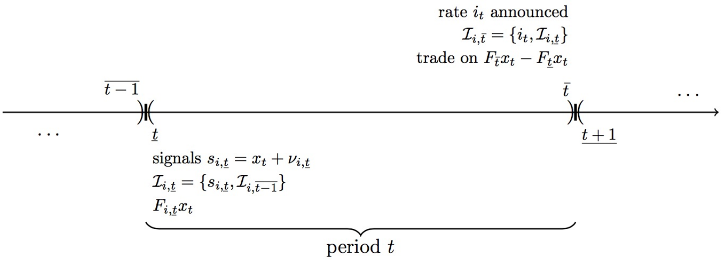
2. Agents and central bank observe private noisy signals

$$s_{i,\underline{t}} = x_t + \nu_{i,\underline{t}} \qquad \nu_{i,\underline{t}} \sim \mathcal{N}(0, \sigma_{n,\nu})$$

$$s_{cb,\underline{t}} = x_t + \nu_{cb,\underline{t}} \qquad \nu_{cb,\underline{t}} \sim \mathcal{N}(0, \sigma_{cb,\nu})$$

and form expectations

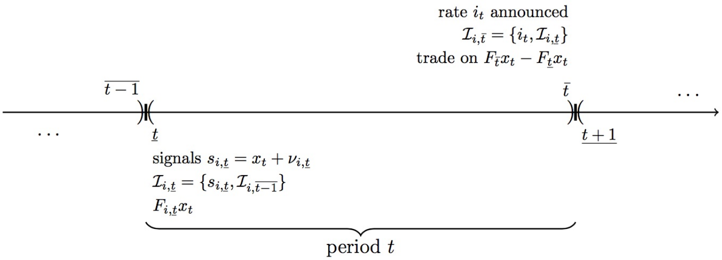
The HF Identification



3. Agents trade **futures** on the realization of the **policy rate** at various **maturities**

$$p(i_t), \qquad p(i_{t+1}), \qquad \ldots \qquad p(i_{t+n})$$

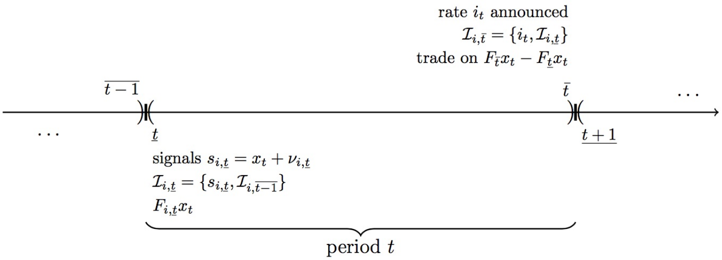
The HF Identification



4. The CB sets the policy rate

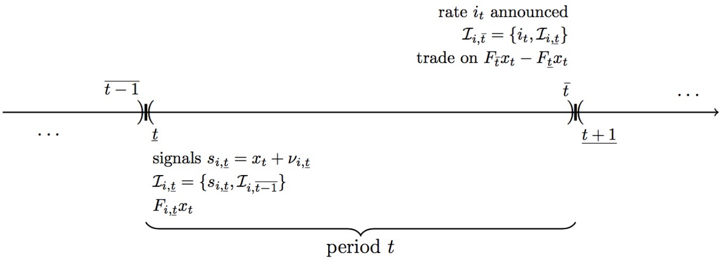
$$i_t = \phi_0 + \phi_x' F_{cb,\underline{t}} x_t + u_t + w_{t|t-1}$$

The HF Identification



5. Agents observe the policy rate, revise their expectations, and trade

$$p_{\bar{t}}(i_{t+1}) - p_{\underline{t}}(i_{t+1}) \propto F_{\bar{t}} x_t - F_{\underline{t}} x_t$$



Expectation Revision

$$\underbrace{F_{\bar{t}}x_t - F_{\underline{t}}x_t}_{\text{Exp. Revision at } t} = \underbrace{\kappa_x(F_{\overline{t-1}}x_t - F_{\underline{t-1}}x_t)}_{\text{Exp. Revision at } t-1}$$

$$+ \underbrace{\kappa_\xi \xi_t}_{\text{Shocks}} + \underbrace{\kappa_\nu \left[\nu_{cb,\underline{t}} - (1-K_1)\rho\nu_{cb,\underline{t-1}}\right]}_{\text{CB's Aggregate Noise}}$$

$$+ \underbrace{\kappa_z \left\{z_t - \rho(K_1 - K^{cb})z_{t-1} + (1-K_1)(1-K^{cb})\rho^2 z_{t-2}\right\}}_{\text{MP Shocks}}$$

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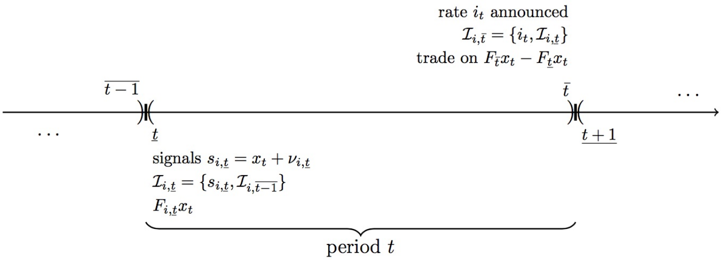

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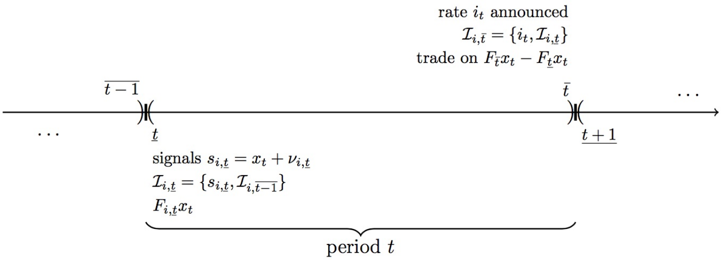

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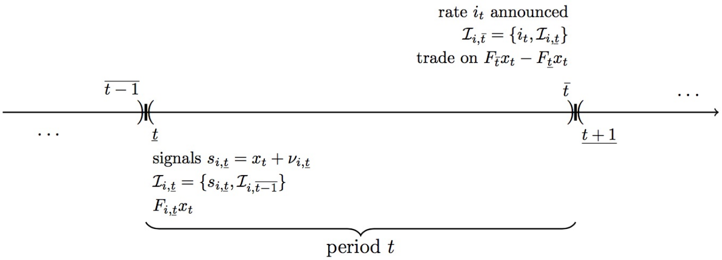

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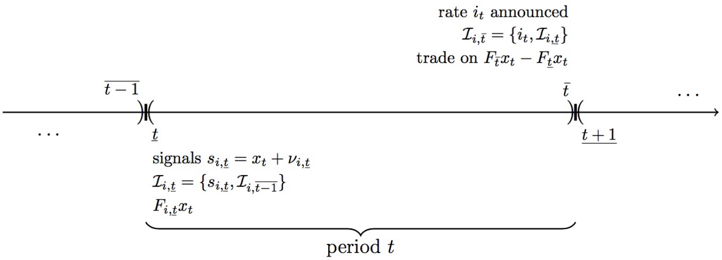

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Testing for Information Frictions #1: Greenbook Forecasts

- Dependent Variable: $\mathbf{FF4_t}$
  30-min surprises in 4^{th} fed funds futures at all FOMC announcements

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Inflation	2.538						
	(0.03)***						
Output		2.752					
		(0.02)***					
$h = -1$			2.024				
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$h = 0$				2.636			
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$h = 1$					2.436		
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$h = 2$						1.045	
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Testing for Information Frictions #2: State Variables

Table 3: Predictability of Monetary Policy Instruments

	$FF4_t$	$FF4_t^{\dagger}$	$FF4_t^{GK}$	MPN_t
$f_{1,t-1}$	-0.012**	-0.007**	-0.011***	-0.087***
	(0.006)	(0.003)	(0.004)	(0.021)
$f_{2,t-1}$	0.001	0.000	0.004	-0.009
	(0.003)	(0.002)	(0.002)	(0.010)
$f_{3,t-1}$	0.002	0.003	-0.001	0.000
	(0.005)	(0.004)	(0.004)	(0.012)
$f_{4,t-1}$	0.015**	0.008**	0.008*	0.060***
	(0.007)	(0.004)	(0.004)	(0.023)
$f_{5,t-1}$	0.002	-0.005	-0.000	0.002
	(0.007)	(0.004)	(0.004)	(0.026)
$f_{6,t-1}$	-0.011**	-0.009***	-0.006**	-0.003
	(0.005)	(0.003)	(0.003)	(0.011)
$f_{7,t-1}$	-0.010*	-0.009**	-0.005	-0.041**
	(0.006)	(0.004)	(0.004)	(0.016)
$f_{8,t-1}$	-0.001	-0.002	0.000	-0.028**
	(0.003)	(0.002)	(0.003)	(0.012)
$f_{9,t-1}$	-0.002	-0.001	-0.004	-0.036*
	(0.004)	(0.003)	(0.003)	(0.021)
$f_{10,t-1}$	-0.004	-0.001	0.000	0.030**
	(0.005)	(0.003)	(0.003)	(0.012)
constant	-0.014***	-0.006**	-0.011***	0.010
	(0.004)	(0.003)	(0.003)	(0.011)
R^2	0.075	0.097	0.145	0.182
F	2.297	2.363	3.511	3.446
p	0.011	0.009	0.000	0.000
N	239	239	268	216

Testing for Information Frictions #2: State Variables

Table 3: Predictability of Monetary Policy Instruments

	$FF4_t$	$FF4_t^{\dagger}$	$FF4_t^{GK}$	MPN_t
$f_{1,t-1}$	-0.012**	-0.007**	-0.011***	-0.087***
	(0.006)	(0.003)	(0.004)	(0.021)
$f_{2,t-1}$	0.001	0.000	0.004	-0.009
	(0.003)	(0.002)	(0.002)	(0.010)
$f_{3,t-1}$	0.002	0.003	-0.001	0.000
	(0.005)	(0.004)	(0.004)	(0.012)
$f_{4,t-1}$	0.015**	0.008**	0.008*	0.060***
	(0.007)	(0.004)	(0.004)	(0.023)
$f_{5,t-1}$	0.002	-0.005	-0.000	0.002
	(0.007)	(0.004)	(0.004)	(0.026)
$f_{6,t-1}$	-0.011**	-0.009***	-0.006**	-0.003
	(0.005)	(0.003)	(0.003)	(0.011)
$f_{7,t-1}$	-0.010*	-0.009**	-0.005	-0.041**
	(0.006)	(0.004)	(0.004)	(0.016)
$f_{8,t-1}$	-0.001	-0.002	0.000	-0.028**
	(0.003)	(0.002)	(0.003)	(0.012)
$f_{9,t-1}$	-0.002	-0.001	-0.004	-0.036*
	(0.004)	(0.003)	(0.003)	(0.021)
$f_{10,t-1}$	-0.004	-0.001	0.000	0.030**
	(0.005)	(0.003)	(0.003)	(0.012)
constant	-0.014***	-0.006**	-0.011***	0.010
	(0.004)	(0.003)	(0.003)	(0.011)
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	(0.006)	(0.003)	(0.004)	(0.021)
$f_{2,t-1}$	0.001	0.000	0.004	-0.009
	(0.003)	(0.002)	(0.002)	(0.010)
$f_{3,t-1}$	0.002	0.003	-0.001	0.000
	(0.005)	(0.004)	(0.004)	(0.012)
$f_{4,t-1}$	0.015**	0.008**	0.008*	0.060***
	(0.007)	(0.004)	(0.004)	(0.023)
$f_{5,t-1}$	0.002	-0.005	-0.000	0.002
	(0.007)	(0.004)	(0.004)	(0.026)
$f_{6,t-1}$	-0.011**	-0.009***	-0.006**	-0.003
	(0.005)	(0.003)	(0.003)	(0.011)
$f_{7,t-1}$	-0.010*	-0.009**	-0.005	-0.041**
	(0.006)	(0.004)	(0.004)	(0.016)
$f_{8,t-1}$	-0.001	-0.002	0.000	-0.028**
	(0.003)	(0.002)	(0.003)	(0.012)
$f_{9,t-1}$	-0.002	-0.001	-0.004	-0.036*
	(0.004)	(0.003)	(0.003)	(0.021)
$f_{10,t-1}$	-0.004	-0.001	0.000	0.030**
	(0.005)	(0.003)	(0.003)	(0.012)
constant	-0.014***	-0.006**	-0.011***	0.010
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Testing for Information Frictions #3: Autocorrelation

Table 2: Serial Correlation in Instruments for Monetary Policy

	$FF4_t$	$FF4_t^{\dagger}$	$FF4_t^{GK}$	MPN_t
instrument_{t-1}	0.065	-0.164***	0.380***	0.014
	(0.090)	(0.057)	(0.137)	(0.091)
instrument_{t-2}	-0.025	-0.048	-0.164**	0.227**
	(0.119)	(0.066)	(0.073)	(0.087)
instrument_{t-3}	0.145	-0.066	0.308**	0.381***
	(0.130)	(0.073)	(0.150)	(0.102)
instrument_{t-4}	0.179*	-0.007	-0.035	0.075
	(0.105)	(0.068)	(0.094)	(0.102)
constant	-0.016***	-0.011***	-0.011***	0.011
	(0.005)	(0.004)	(0.003)	(0.015)
R^2	0.026	0.001	0.168	0.172
F	1.459	2.279	2.965	7.590
p	0.217	0.063	0.021	0.000
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INTUITION ➔ Monetary policy shocks:

- ▷ surprise private agents, unforecastable
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3. Use the orthogonal proxy (MPI_t) as external instruments

Monetary Policy Instrument

1. At FOMC frequency ➔ **Signaling Channel**

$$FF4_m = \alpha_0 + \sum_{j=-1}^{3} \theta_j F_t^{cb} x_{q+j} + \sum_{j=-1}^{2} \vartheta_j \left[F_t^{cb} x_{q+j} - F_{t-1}^{cb} x_{q+j} \right] + MPI_m$$

Monetary Policy Instrument

2. Monthly aggregation

$$\overline{MPI}_t = \sum_{m \in t} MPI_m$$

3. At monthly frequency ➔ **Slow Absorption of Information**

$$\overline{MPI}_t = \phi_0 + \sum_{j=1}^{12} \phi_j \overline{MPI}_{t-j} + MPI_t$$

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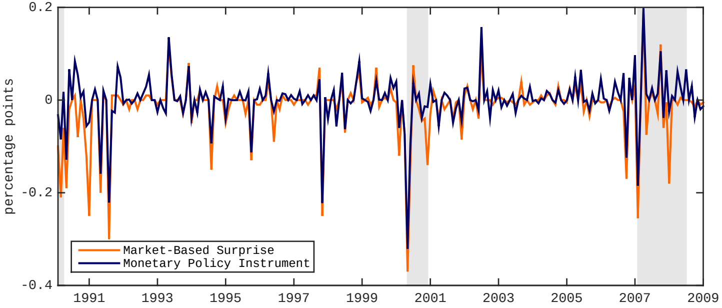

- Testing Environment

  1. Standard Monthly Monetary VARs (US) [Coibion (2012), Ramey (2016), Gertler and Karadi (2015), Caldara and Herbst (2017)]

Testing Environment & Identifying Assumptions

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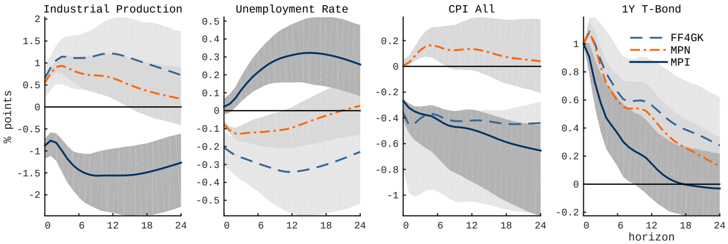
- Identifying Assumptions

  1. $\mathbb{E}[u_t z_t'] = \rho$ ➔ **Relevance**
  2. $\mathbb{E}[\xi_t z_t'] = 0$ ➔ **Exogeneity**

[Stock (2008), Mertens (2015), Stock and Watson (2018)]

Puzzles #1: Identification

- $y_t = [\ln(IP_t),\ UNRATE_t,\ \ln(CPI_t),\ \ln(CRBPI_t),\ 1YR_t]'$;



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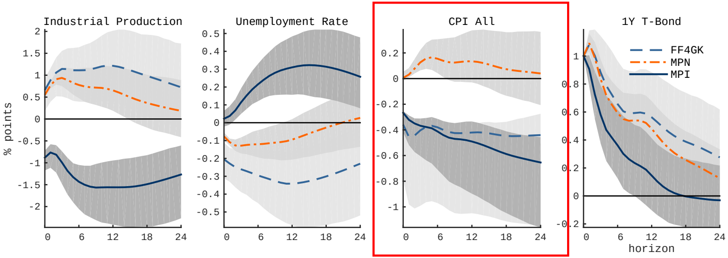

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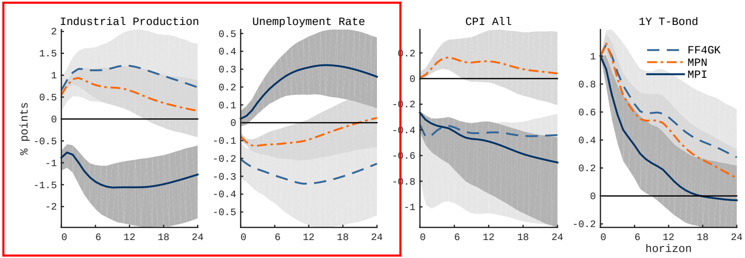

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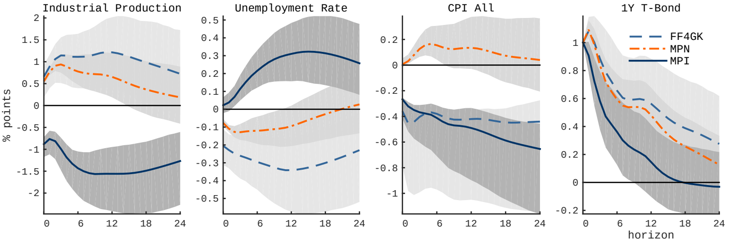

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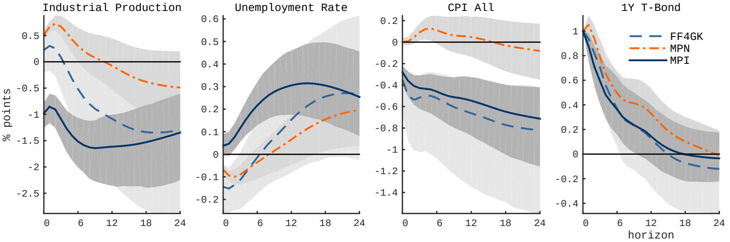

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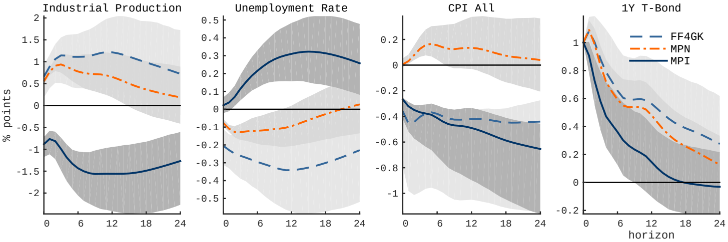

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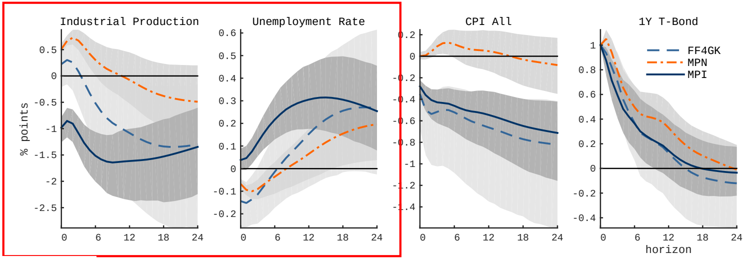
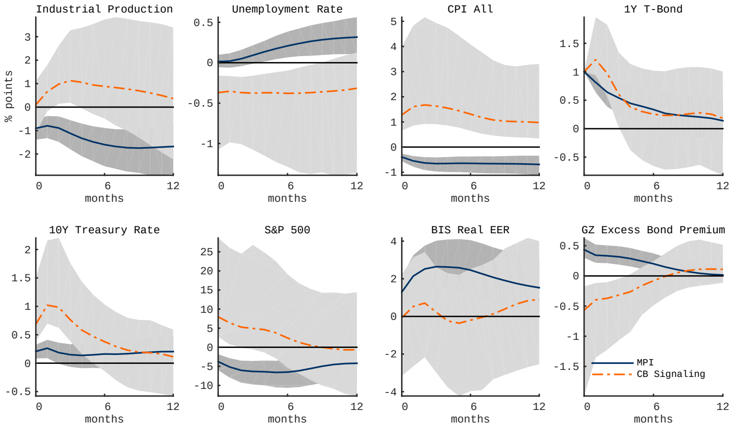


MP Shocks vs CB Information in HF Surprises



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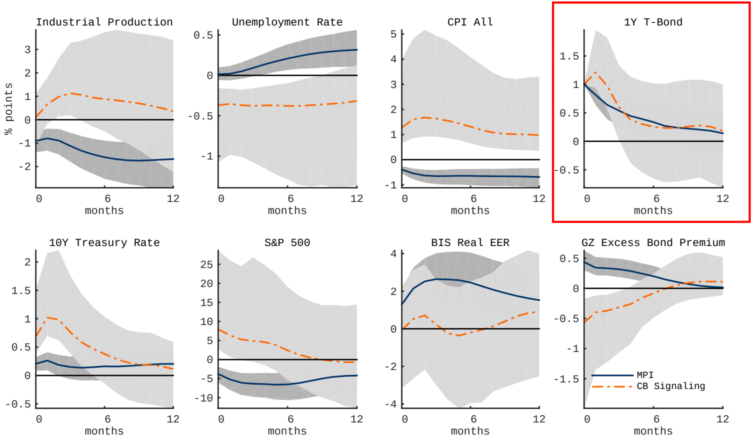

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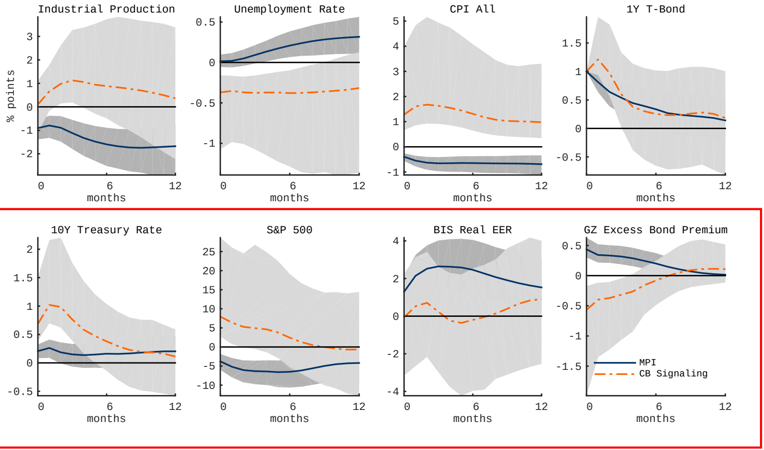

BANK OF ENGLAND

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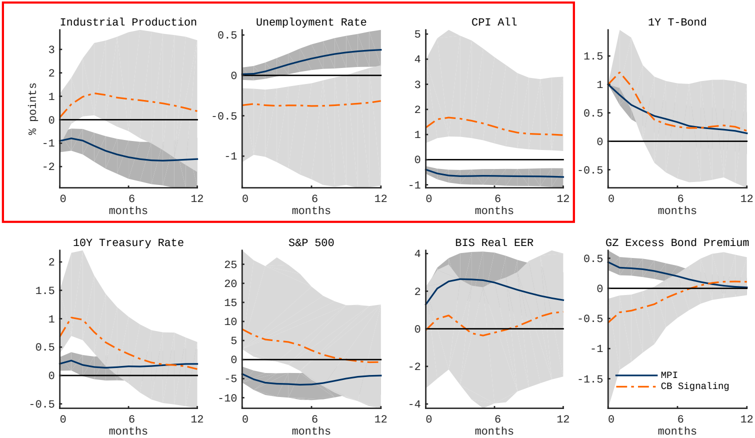

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Transmission & Model Dependence

VAR-IRFS

$$y_{t+1} = B y_t + u_{t+1}$$

$$\text{IRF}_h^{VAR} = B^h A_0^{-1}$$

- optimal and consistent only if the VAR captures the DGP

Estimation of the IRFs

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LP-IRFS

$$y_{t+h} = \widetilde{B}^{(h)} y_t + v_{t+h}$$

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- robust to misspecification but high estimation uncertainty

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- robust to misspecification but high estimation uncertainty

- Selecting between the two methods: empirical problem choosing between **bias** and **estimation variance**...
  (Schorfheide, 2005)

↓

standard tradeoff in Bayesian estimation!

BLP: Intuition

- Macro-variables approximately linear and described by a VAR(p)
  ➔ Regularize LP with NIW priors centred around VAR (pre-sample)

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BLP PRIOR

$$\Sigma_v^{(h)} | \gamma^{(h)} \sim IW\left(\Psi_0^{(h)}, d_0\right)$$

$$\beta^{(h)} | \Sigma_v^{(h)}, \gamma^{(h)} \sim N\left(\beta_0^{(h)}, \Sigma_v^{(h)} \otimes \Omega_0^{(h)}(\lambda^{(h)})\right)$$

BLP, VAR & LP

- Discipline LP with VAR prior on pre-sample

BLP POSTERIOR MEAN

$$B_{BLP}^{(h)} \propto \left(X'X + \left[\Omega_0^{(h)}(\lambda^{(h)}) \right]^{-1} \right)^{-1} \left((X'X) B_{LP}^{(h)} + \left[\Omega_0^{(h)}(\lambda^{(h)}) \right]^{-1} B_{VAR}^{h} \right)$$

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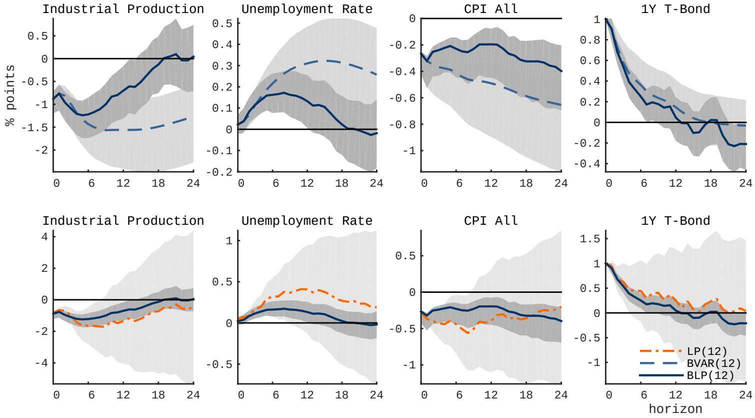
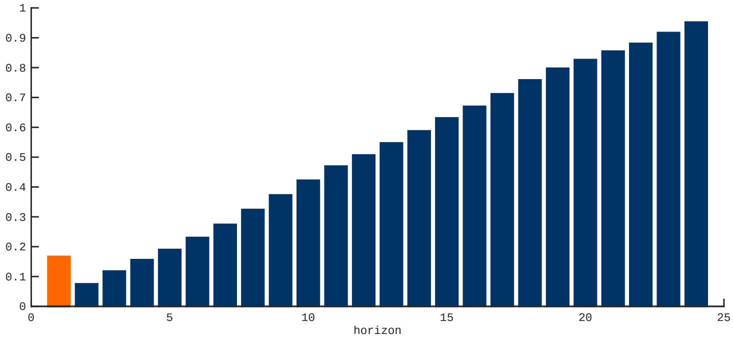
- $\lambda^{(h)}$ optimally spans between VAR and LP
  (Giannone, Lenza, and Primiceri, 2015)

1. $\lambda^{(h)} \to 0 \quad \Longrightarrow \quad B^{(h)}_{BLP} \to B^{h}_{VAR}$
2. $\lambda^{(h)} \to \infty \quad \Longrightarrow \quad B^{(h)}_{BLP} = B^{(h)}_{LP}$

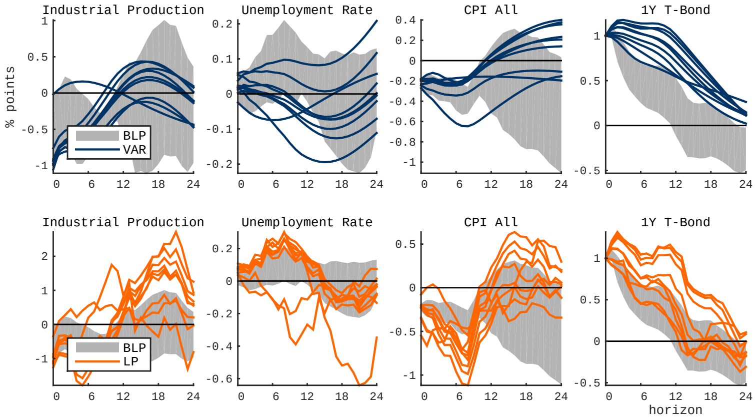
BLP, VAR & LP


Industrial Production
Unemployment Rate
CPI All
1Y T-Bond
% points
horizon
LP(12)
BVAR(12)
BLP(12)
0
6
12
18
24

Optimal Shrinkage



Puzzles #2: Specifications



Rolling 20-year subsamples

What are the Effects of Monetary Policy?

- **New identification strategy** that is coherent with imperfect & asymmetric information

↓

Neither price nor output puzzles

- a **novel flexible econometric method** that optimally bridges between VARs with LPs

↓

Results are robust
to common model misspecifications & samples

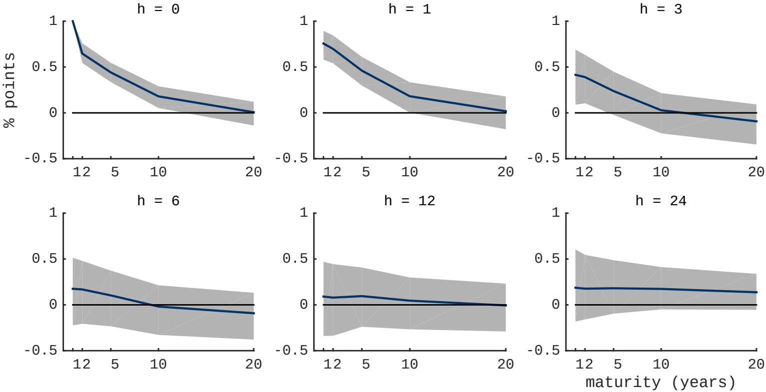
Additional Material

The Transmission of Monetary Policy Shocks

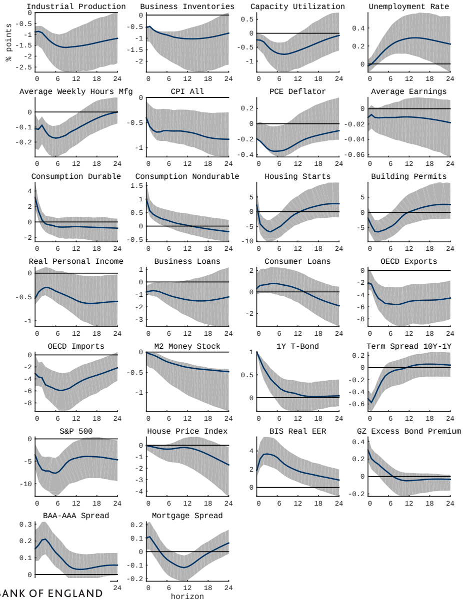
Empirical Setup

- Benchmark sample is 1979 to 2014
- Identification uses the full length of the orthogonal surprise, 1990 to 2009 (instrument)
- Expectations from 1993 (Consensus Economics Forecasts)
- Variables in (log) levels
- 12 lags (+ robustness)
- IRFs normalization: shock induces a 100bp increase in the 1year rate

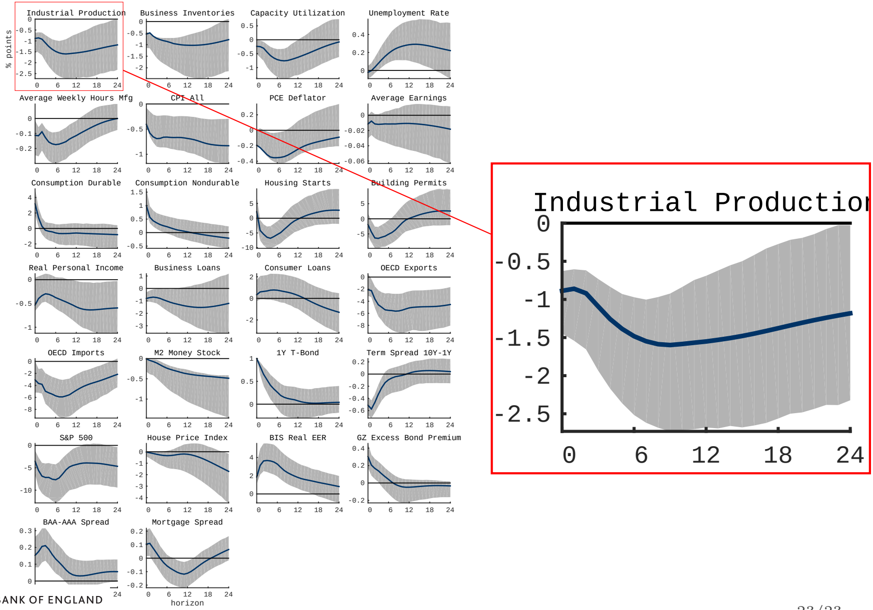
Interest Rate Channel



Large(r) Information Set:



Large(r) Information Set: Real Activity



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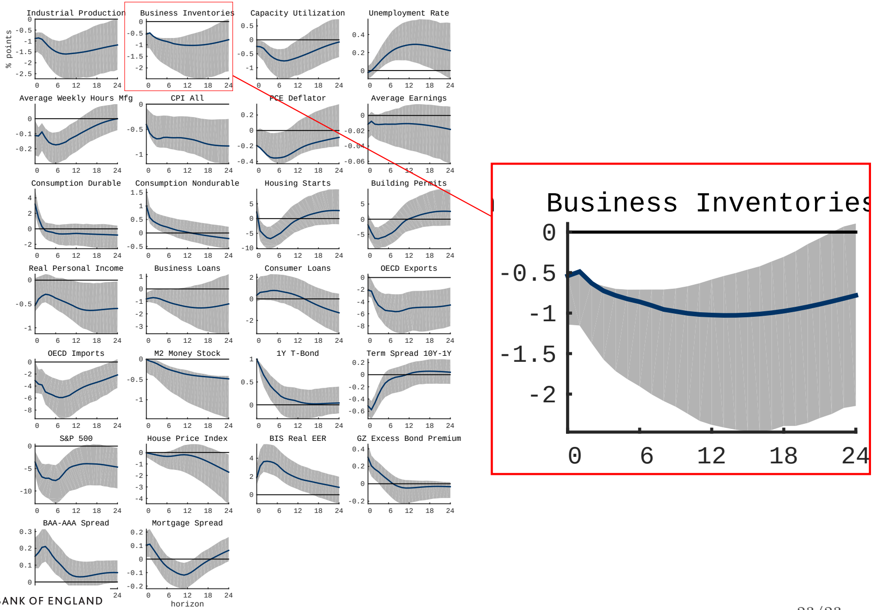

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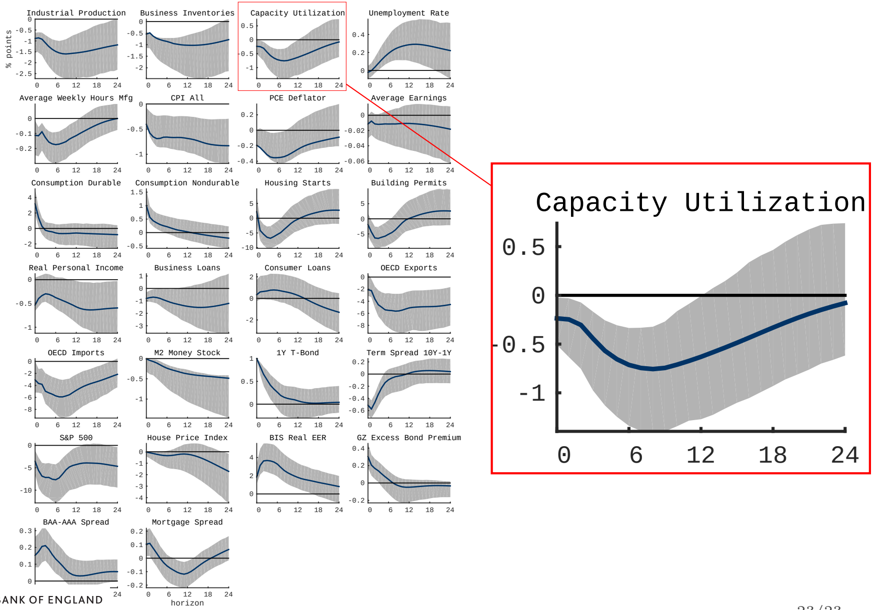
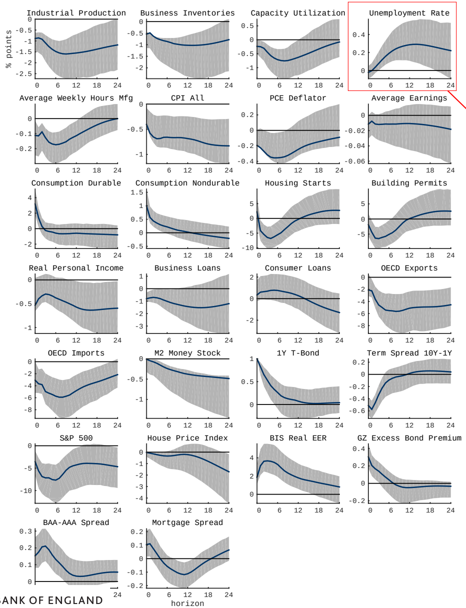
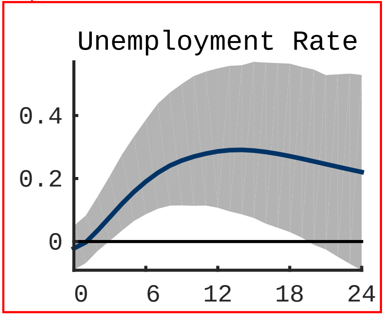


Large(r) Information Set: Real Activity





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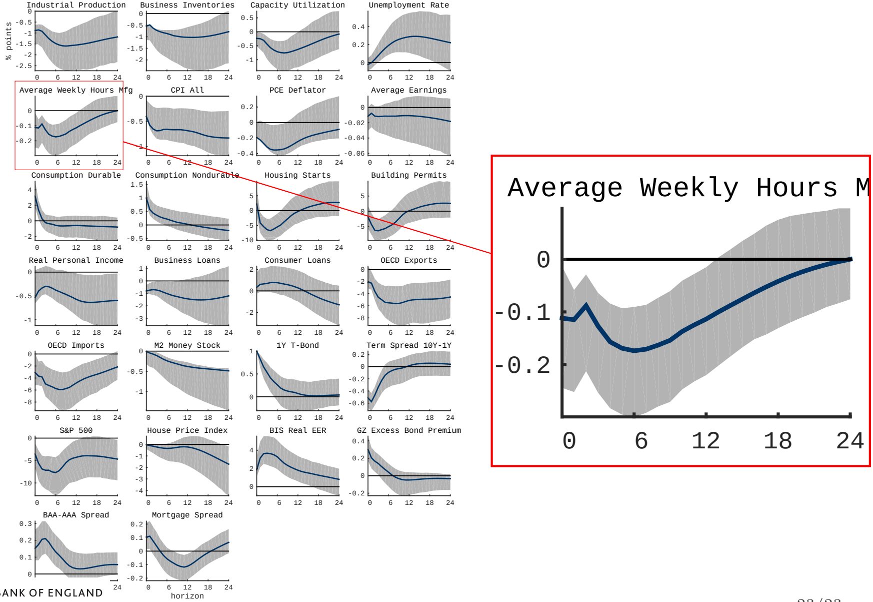

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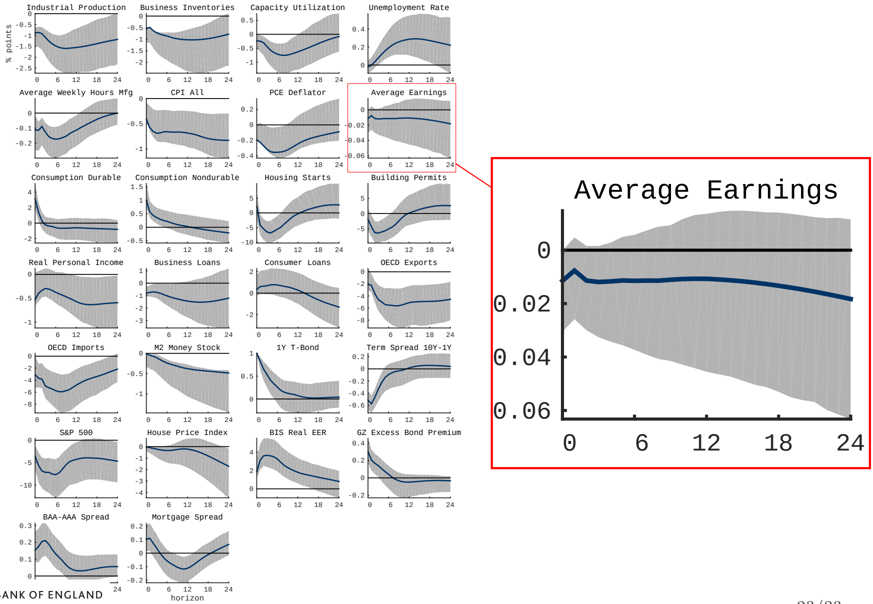

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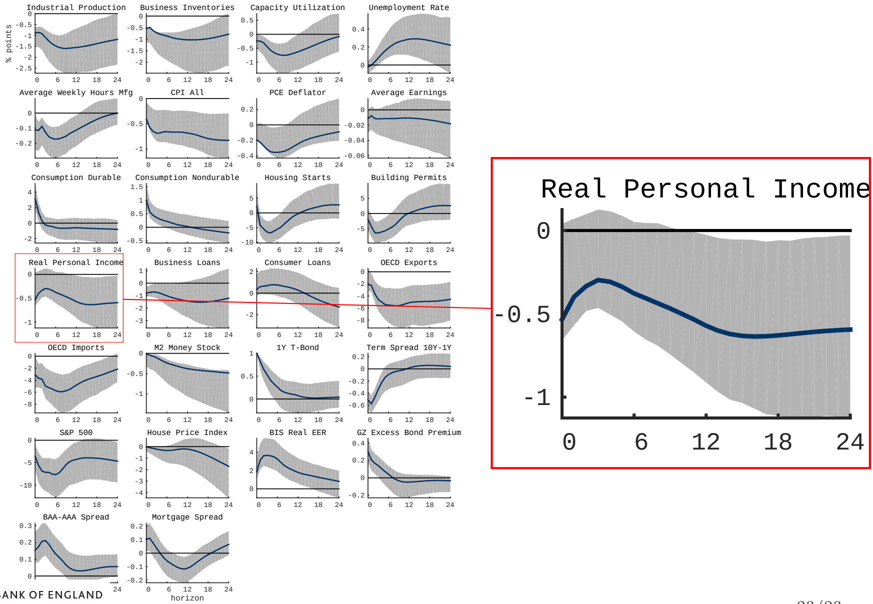
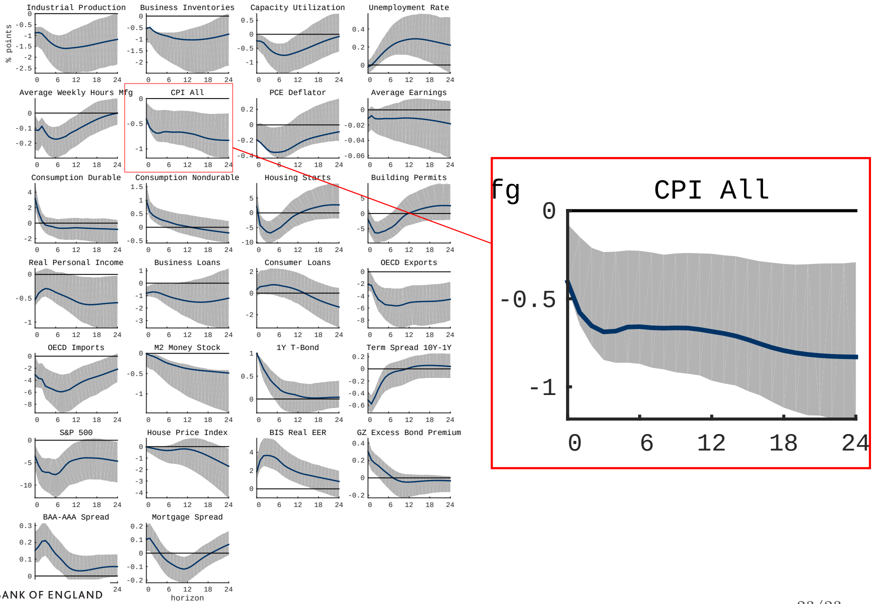


Large(r) Information Set: Prices



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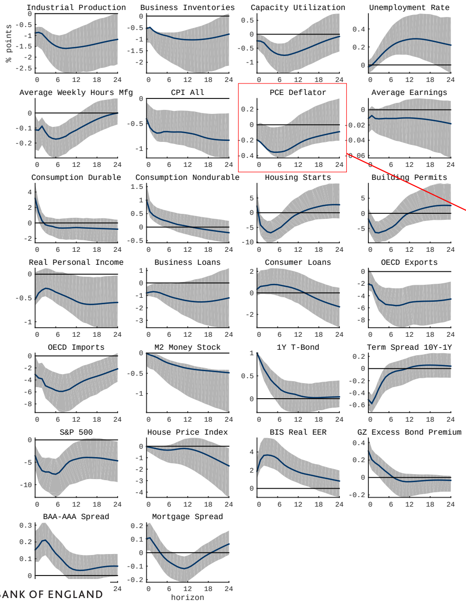
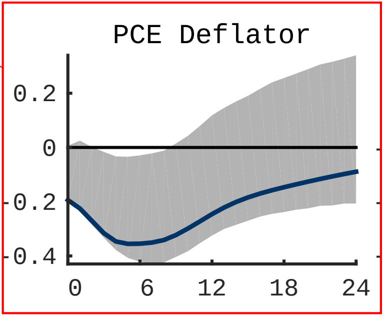
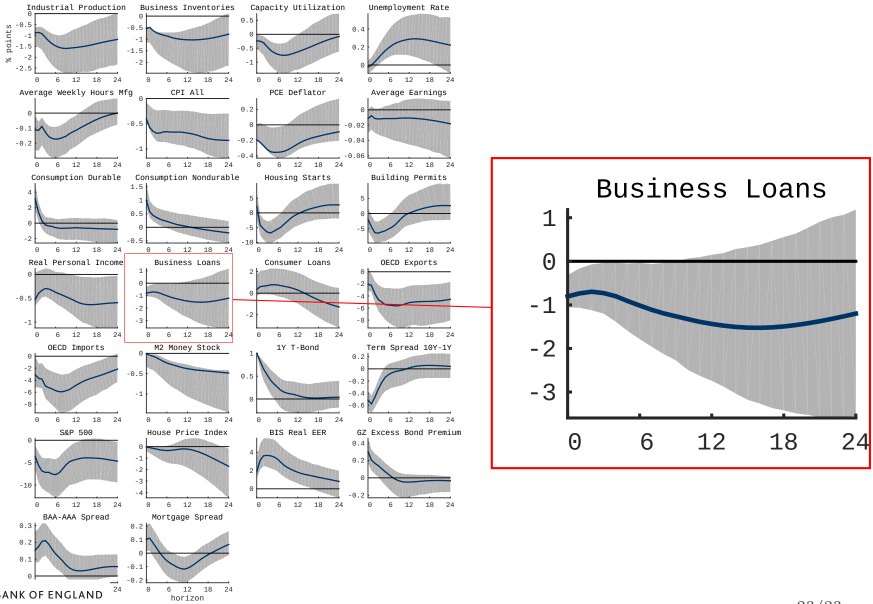




Large(r) Information Set: Credit



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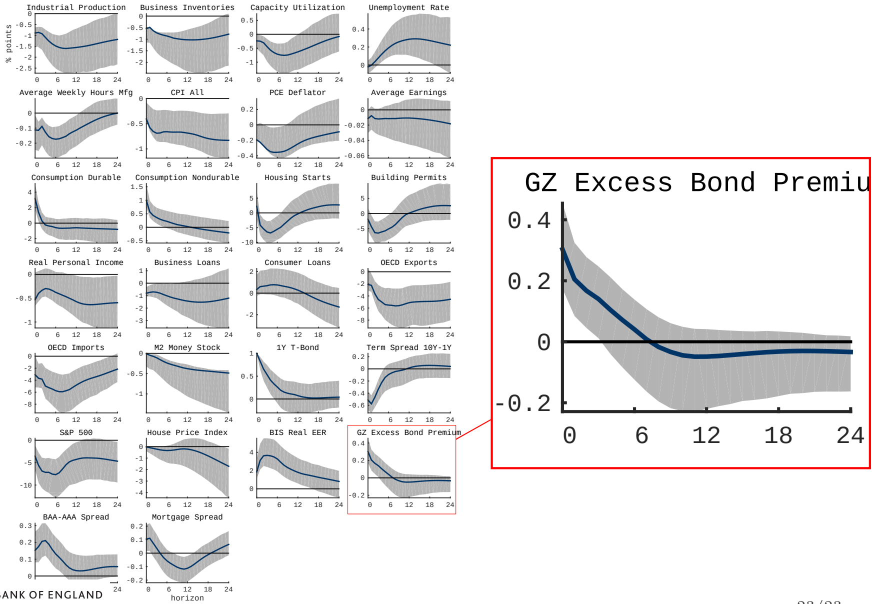

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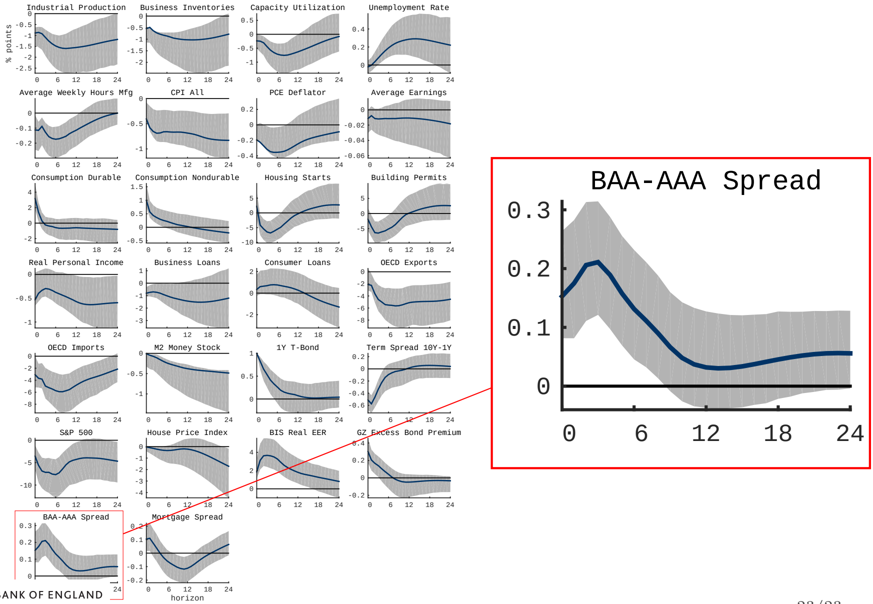
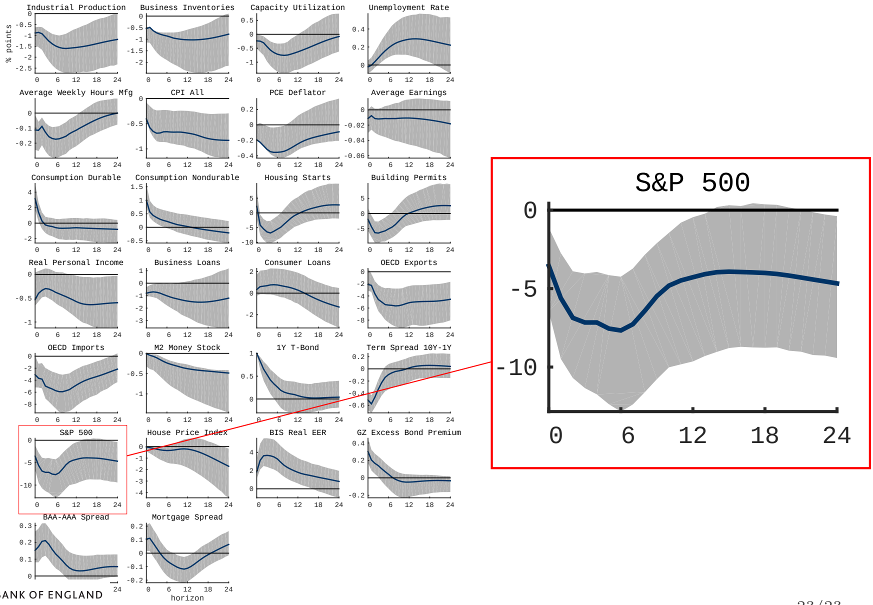


Large(r) Information Set: Other Assets



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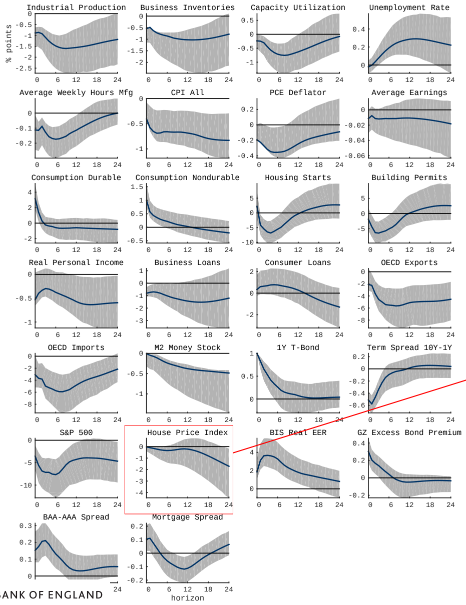
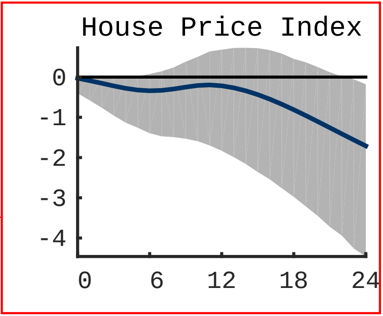
Large(r) Information Set: Other Assets





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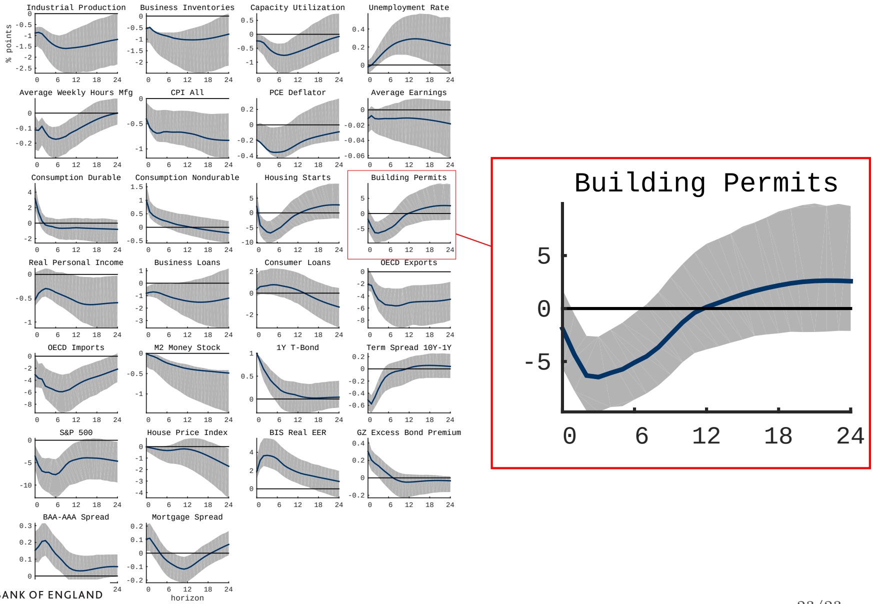
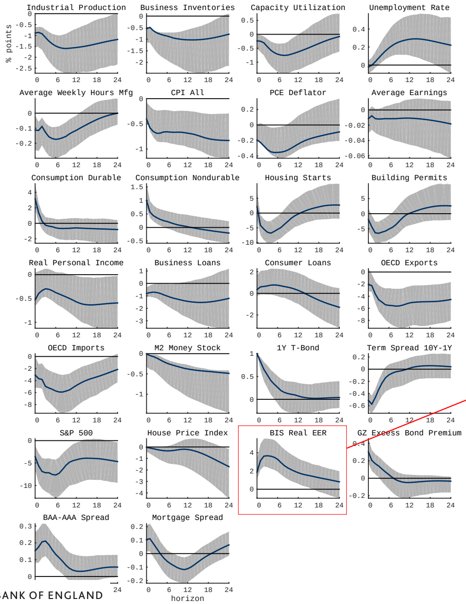
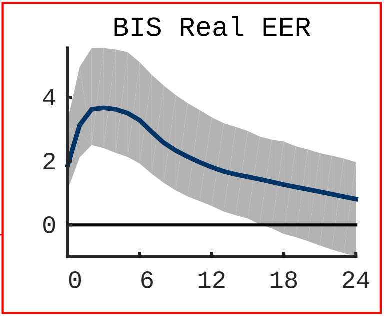


Large(r) Information Set: International Trade





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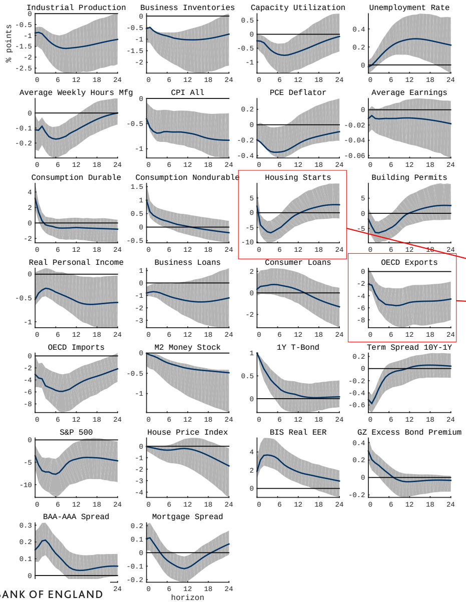

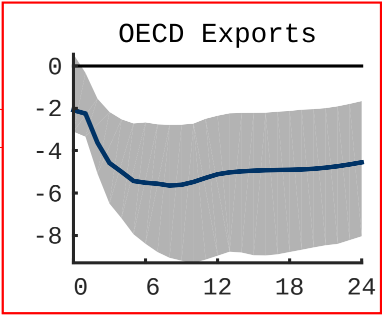

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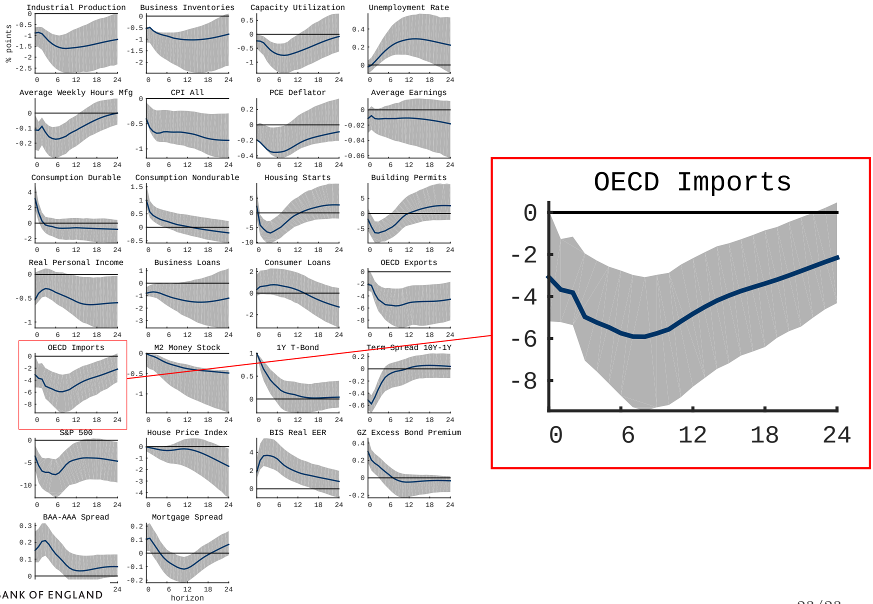
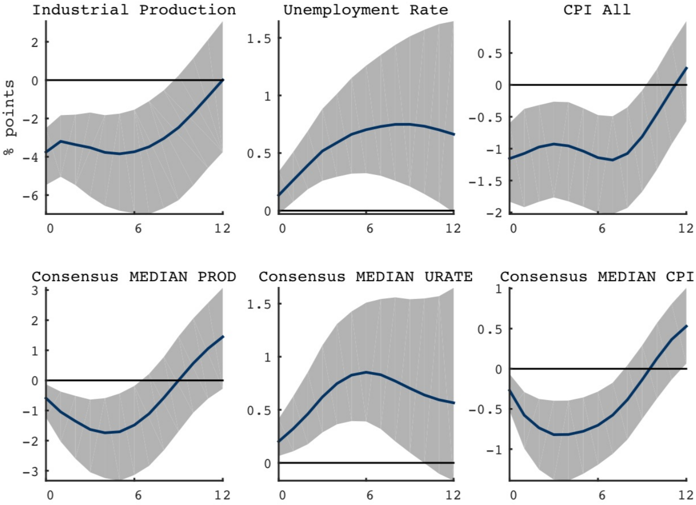
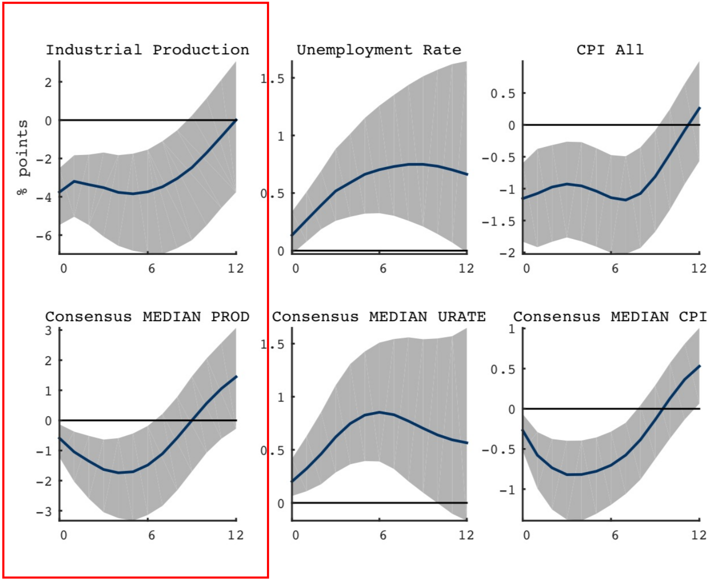


Expectations:



Expectations: Industrial Production



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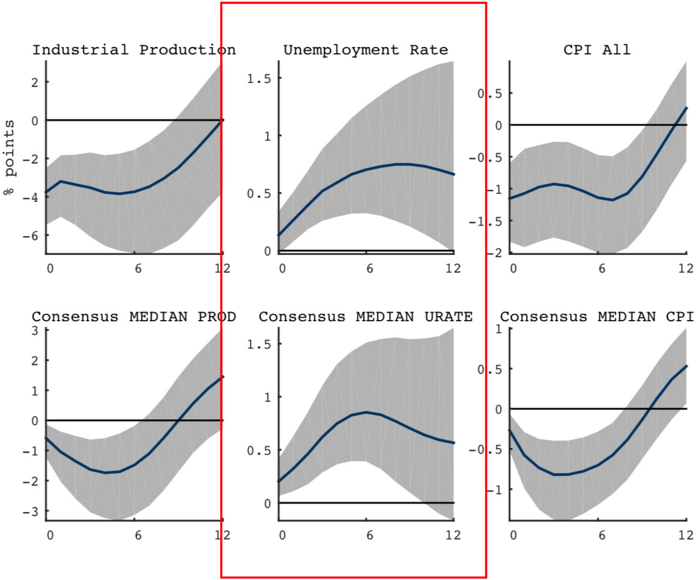
Expectations: Unemployment



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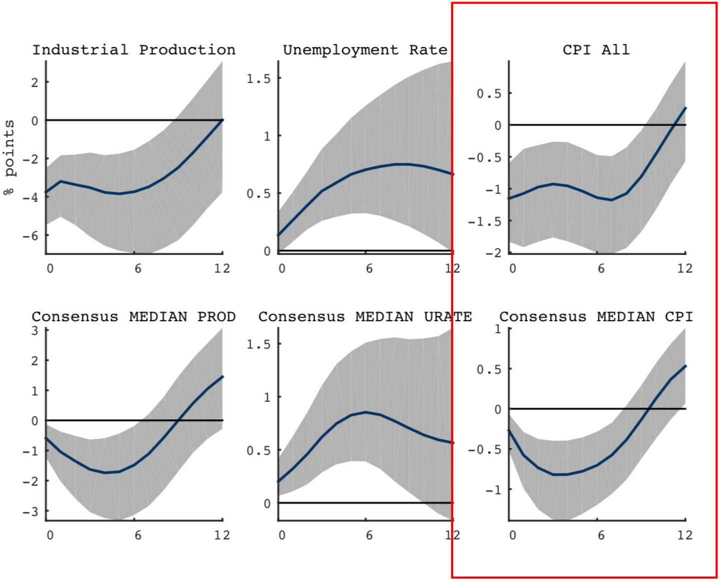
EXPECTATIONS: CPI



LOCAL PROJECTIONS

$$y_{t+h} = C^{(h)} + B_1^{(h)} y_{t-1} + ... + B_p^{(h)} y_{t-\tilde{p}} + \varepsilon_{t+h}^{(h)} \ ,$$

$$\varepsilon_{t+h}^{(h)} \sim N(0, \Sigma_\varepsilon^{(h)}) \qquad \forall \ h = 1, \ldots, H \ ,$$

- Residuals are serially correlated:

$$\varepsilon_{t+h}^{(h)} \sim \mathrm{MA}(h-1)$$

- Fully specified model $\rightarrow$ VARMA model...

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- Fully specified model → VARMA model...
- ... or misspecified likelihood (plus correction)

BLP PRIOR

$$\Sigma_v^{(h)} | \gamma^{(h)} \sim IW\left(\Psi_0^{(h)}, d_0\right)$$

$$\beta^{(h)} | \Sigma_v^{(h)}, \gamma^{(h)} \sim N\left(\beta_0^{(h)}, \Sigma_v^{(h)} \otimes \Omega_0^{(h)}(\lambda^{(h)})\right)$$

Prior mean:

- $\beta^{(h)} \equiv \text{vec}(b^{(h)}) = \text{vec}\left(\left[\tilde{c}, \tilde{B}^{(h)}, \ldots, \tilde{B}_p^{(h)}\right]'\right)$
- $\beta_0^{(h)} = \beta_{T_0}^{(0,h)} = \text{vec}\left(b_{T_0}^{(0,h)}\right)$ ➔ posterior mean of VAR(p) coefficients iterated at h-horizon (pre-sample)

BLP: Priors

BLP PRIOR

$$\Sigma_v^{(h)}|\gamma^{(h)} \sim IW\left(\Psi_0^{(h)}, d_0\right)$$

$$\beta^{(h)}|\Sigma_v^{(h)}, \gamma^{(h)} \sim N\left(\beta_0^{(h)}, \Sigma_v^{(h)} \otimes \Omega_0^{(h)}(\lambda^{(h)})\right)$$

Prior variance:

- $\Psi_0^{(h)} = \text{diag}\left(\left[(\sigma_1^{(h)})^2, \ldots, (\sigma_n^{(h)})^2\right]\right); \quad d_0 = n+2$
- $\underset{[(np+1)\times(np+1)]}{\Omega_0^{(h)}} = \begin{pmatrix} \epsilon^{-1} & 0 \\ 0 & \mathbb{I}_p \otimes \text{diag}\left(\left[\lambda^{(h)}/\sigma_i^{(h)}\right]^2\right) \end{pmatrix}$
- $\mathbb{V}ar[(\tilde{B}^{(h)})_{ij}|\Sigma_v^{(h)}] = \left(\lambda^{(h)}\frac{\sigma_i^{(h)}}{\sigma_j^{(h)}}\right)^2$

BLP: Likelihood

$$y_{t+h} = \tilde{c} + \tilde{B}^{(h)} y_t + ... + \tilde{B}_p^{(h)} y_{t-p} + v_{t+h}$$

$$v_{t+h} \sim N\left(0, \Sigma_v^{(h)}\right) \qquad \forall \;\; h = 1, \ldots, H$$

$$v_{t+h} \sim MA(h-1)$$

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$$v_{t+h} \sim MA(h-1)$$

- Frequentist solution: LS + HAC standard errors
- Our solution:
  i. misspecified likelihood ➔ $v_{t+h} \perp \text{span}\{y_t, \ldots, y_{t-p}\}$
  ii. correction to posterior variance ➔ $\mathbb{E}\left[\Sigma_v^{(h)}\right] = \Sigma_{v,HAC}^{(h)}$

Alternative: fully specified VARMA likelihood

BLP POSTERIOR

$$\Sigma_{\varepsilon}^{(h)}|\gamma^{(h)}, \mathrm{y} \sim IW\left(\Psi^{(h)}, d\right)$$

$$\beta^{(h)}|\Sigma_{\varepsilon}^{(h)}, \gamma^{(h)}, \mathrm{y} \sim N\left(\tilde{\beta}^{(h)}, \Sigma_{\varepsilon}^{(h)} \otimes \Omega^{(h)}\right)$$

BLP: Posterior

BLP POSTERIOR

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Misspecified parametric model:

- Likelihood is asymptotically Gaussian and centred at the MLE
- Posterior variance-covariance is underestimated

BLP POSTERIOR

$$\Sigma^{(h)}_{\varepsilon,HAC}|\gamma^{(h)}, \mathrm{y} \sim IW\left(\Psi^{(h)}_{HAC}, d\right),$$
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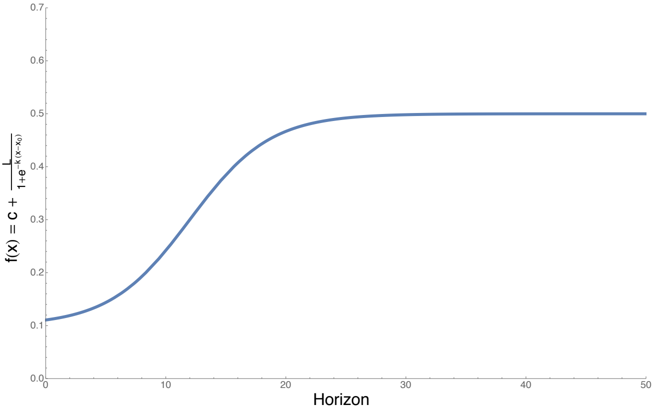
Alternative method: VARMA → GLS estimator

BLP: Hyperprior

$$\lambda^{(h)} \sim \Gamma\left(k^{(h)}, \theta^{(h)}\right)$$

- mode $= 0.4$
- standard deviation $=$ logistic function over h



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