Master's Thesis Conference

Modelling the Yield Curve in the United States and the Euro Area

Alexander Schulz

WU Wien

Ocotber 25, 2024

1. The Yield Curve and the Macroeconomy

2. Methodology
   - The Nelson Siegel Model
   - SVAR

3. Empirical Results
   - Data
   - Analysis US
   - Analysis EA

The Yield Curve in 2022

The Yield Curve in 2022

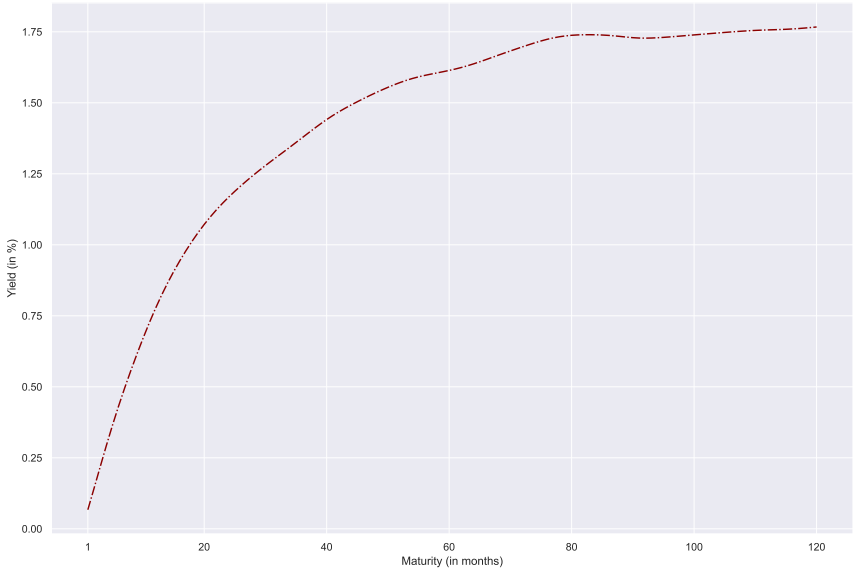

Figure: US Treasury Yield Curve, January 2022

The Yield Curve in 2022

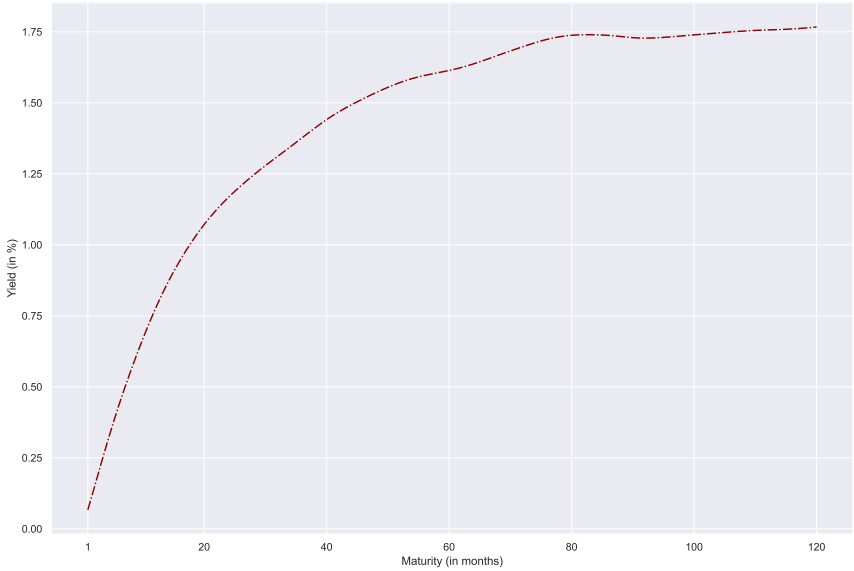

Figure: US Treasury Yield Curve, January 2022

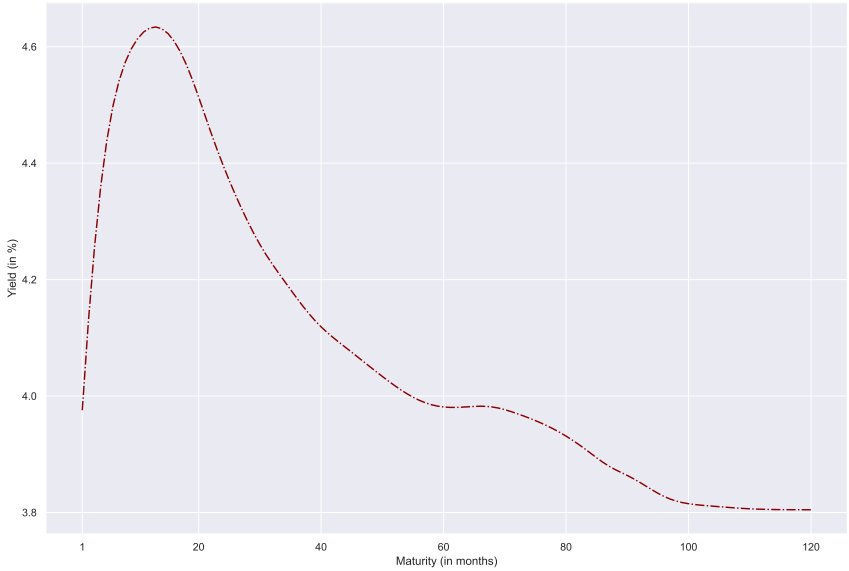

Figure: US Treasury Yield Curve, December 2022

The Yield Curve and the Macroeconomy

The Yield Curve and the Macroeconomy

Macro-to-Yields Channel

The Yield Curve and the Macroeconomy

Macro-to-Yields Channel

- The short-end of the yield curve (usually) follows monetary policy very closely

The Yield Curve and the Macroeconomy

Macro-to-Yields Channel

- The short-end of the yield curve (usually) follows monetary policy very closely
- The long-end of the yield curve represents — based on the expectation hypothesis by Hicks (1946) — expectations regarding the future state of the economy

The Yield Curve and the Macroeconomy

Macro-to-Yields Channel

- The short-end of the yield curve (usually) follows monetary policy very closely
- The long-end of the yield curve represents — based on the expectation hypothesis by Hicks (1946) — expectations regarding the future state of the economy

Yields-to-Macro Channel

The Yield Curve and the Macroeconomy

Macro-to-Yields Channel

- The short-end of the yield curve (usually) follows monetary policy very closely
- The long-end of the yield curve represents — based on the expectation hypothesis by Hicks (1946) — expectations regarding the future state of the economy

Yields-to-Macro Channel

- Yields are central for the transmission of monetary policy — especially considering unconventional monetary policy tools such as QE and Forward Guidance (see: Gürkaynak, Sack, and Swanson (2005), Gürkaynak and Wright (2012), Altavilla et al. (2019), and Swanson (2021))

The Yield Curve and the Macroeconomy

Macro-to-Yields Channel

- The short-end of the yield curve (usually) follows monetary policy very closely
- The long-end of the yield curve represents — based on the expectation hypothesis by Hicks (1946) — expectations regarding the future state of the economy

Yields-to-Macro Channel

- Yields are central for the transmission of monetary policy — especially considering unconventional monetary policy tools such as QE and Forward Guidance (see: Gürkaynak, Sack, and Swanson (2005), Gürkaynak and Wright (2012), Altavilla et al. (2019), and Swanson (2021))
- Yields are also highly relevant for fiscal policy (public debt)

The Yield Curve and the Macroeconomy

Macro-to-Yields Channel

- The short-end of the yield curve (usually) follows monetary policy very closely
- The long-end of the yield curve represents — based on the expectation hypothesis by Hicks (1946) — expectations regarding the future state of the economy

Yields-to-Macro Channel

- Yields are central for the transmission of monetary policy — especially considering unconventional monetary policy tools such as QE and Forward Guidance (see: Gürkaynak, Sack, and Swanson (2005), Gürkaynak and Wright (2012), Altavilla et al. (2019), and Swanson (2021))
- Yields are also highly relevant for fiscal policy (public debt)
- An inversion of the yield curve has (historically) been a very accurate predictor of recessions

Methodology

Methodology

The methodology employed in this thesis follows the two-step approach introduced by Diebold and Li (2006) and serves as a simplified approach compared to the one-step state space representation introduced by Diebold, Rudebusch, and Aruoba (2006)

Methodology

The methodology employed in this thesis follows the two-step approach introduced by Diebold and Li (2006) and serves as a simplified approach compared to the one-step state space representation introduced by Diebold, Rudebusch, and Aruoba (2006)

1. Step 1: Nelson-Siegel decomposition of the respective yield curve with maturities 3, 6, 9, 12, 15, 18, 21, 24, 30, 36, 48, 60, 72, 84, 96, 108 and 120 months

Methodology

The methodology employed in this thesis follows the two-step approach introduced by Diebold and Li (2006) and serves as a simplified approach compared to the one-step state space representation introduced by Diebold, Rudebusch, and Aruoba (2006)

1. Step 1: Nelson-Siegel decomposition of the respective yield curve with maturities 3, 6, 9, 12, 15, 18, 21, 24, 30, 36, 48, 60, 72, 84, 96, 108 and 120 months
2. Step 2: Identification via an SVAR using short-run zero-restrictions

Nelson Siegel Model

Nelson Siegel Model

Following the representation of Diebold and Li (2006), the yield curve is assumed to be represented by the Nelson and Siegel (1987) three factor model

$$y_t(\tau) = L_t + S_t \left(\frac{1 - \mathrm{e}^{-\lambda\tau}}{\lambda\tau} \right) + C_t \left(\frac{1 - \mathrm{e}^{-\lambda\tau}}{\lambda\tau} - \mathrm{e}^{-\lambda\tau} \right) + \varepsilon_t \qquad (1)$$

Nelson Siegel Model

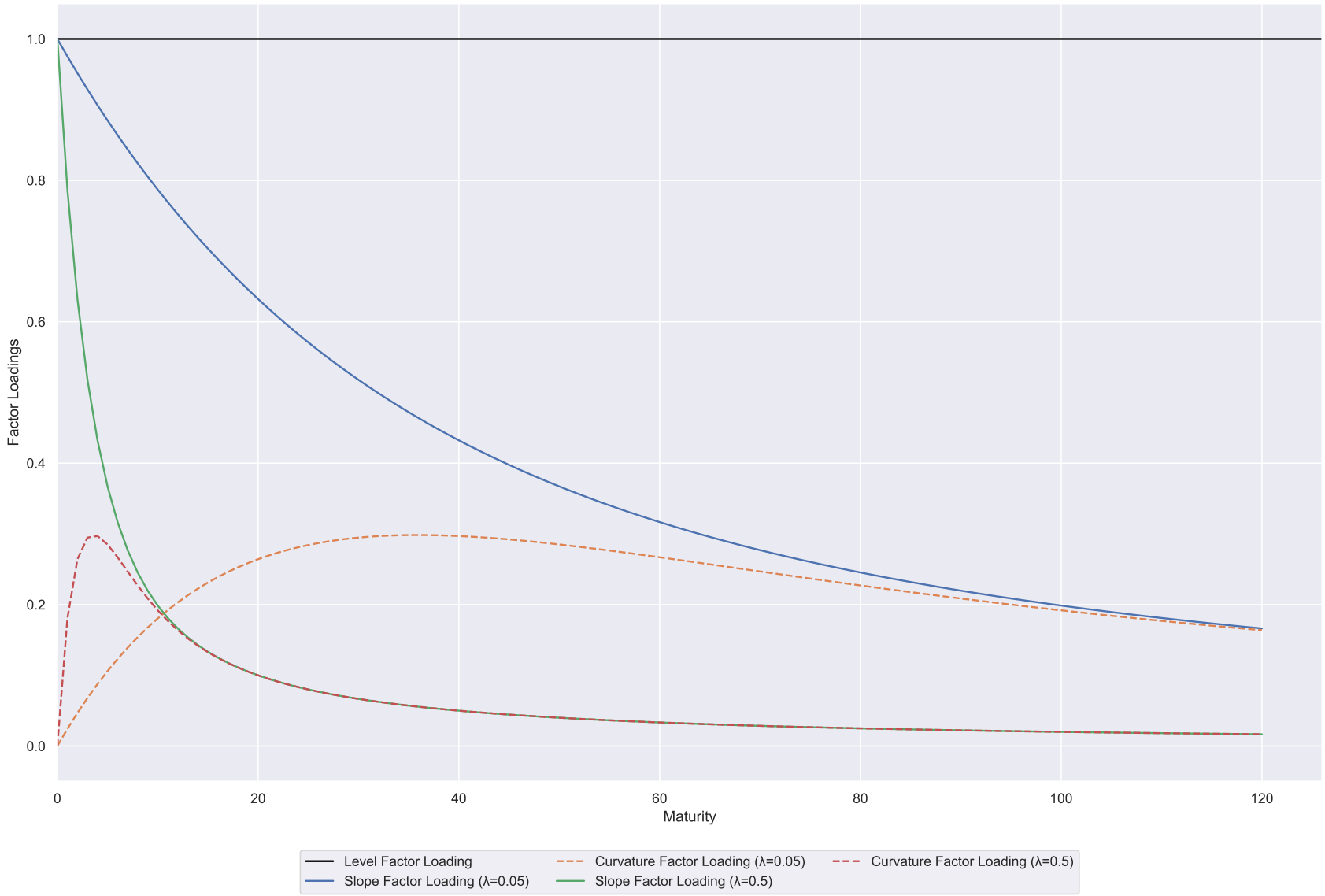

Figure: Exemplary Nelson-Siegel Factor Loadings

Nelson Siegel Model

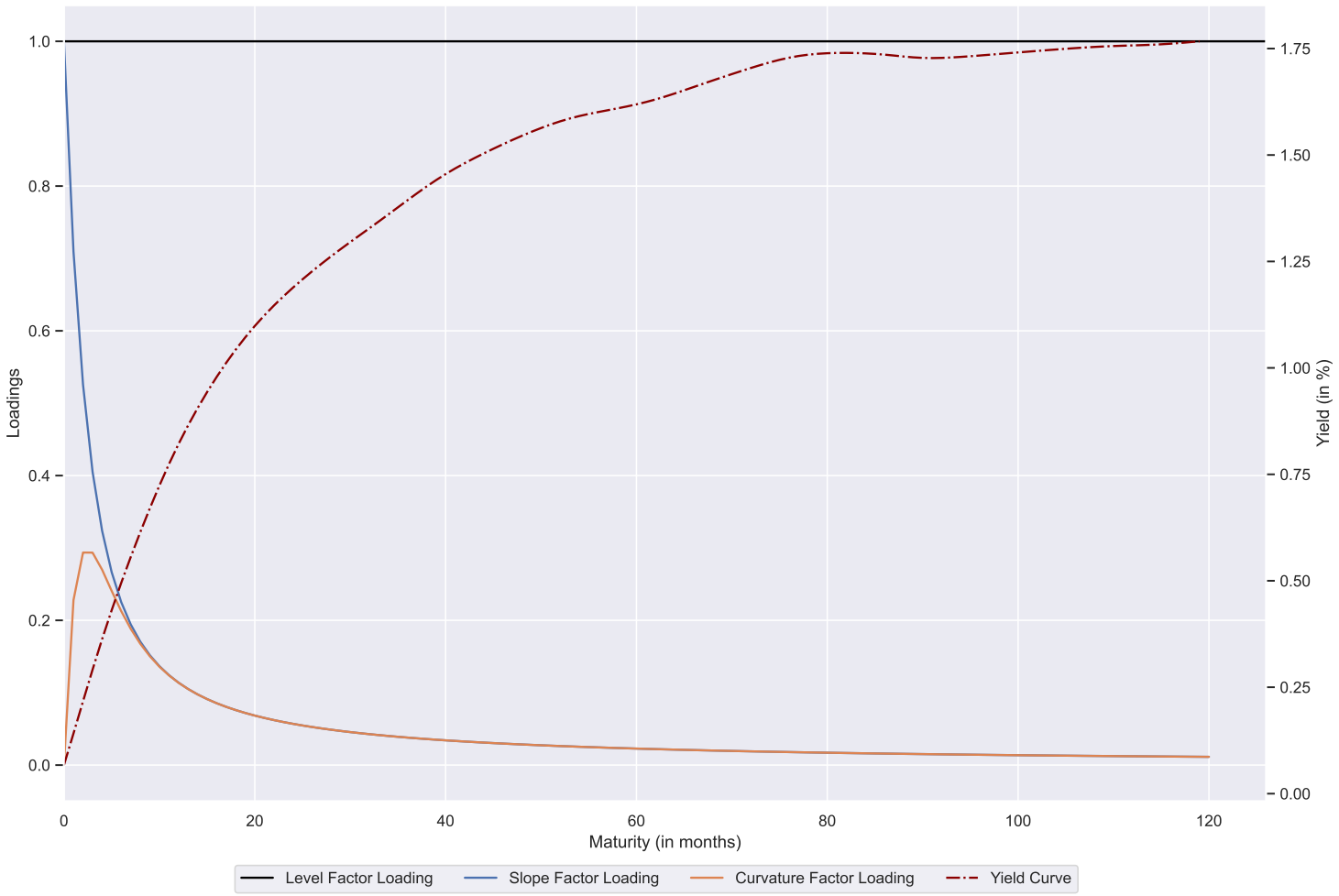

Figure: Actual Nelson-Siegel Factor Loadings as of January 2022, US

SVAR

SVAR

$$\boldsymbol{Y_t} = [IP_t,\ \pi_t,\ i_t,\ FS_t,\ L_t,\ S_t,\ C_t,\ M_t]$$

SVAR

$$\boldsymbol{Y_t} = [IP_t,\ \pi_t,\ i_t,\ FS_t,\ L_t,\ S_t,\ C_t,\ M_t]$$

$$\boldsymbol{Y}_t = \sum_{p=1}^{p} \boldsymbol{A}_p \mathbf{Y}_{t-p} + \varepsilon_t,\ \varepsilon_t \sim \mathcal{N}(0, \boldsymbol{\Sigma}_\varepsilon) \tag{2}$$

SVAR

$$\boldsymbol{Y_t} = [IP_t,\ \pi_t,\ i_t,\ FS_t,\ L_t,\ S_t,\ C_t,\ M_t]$$

$$\boldsymbol{Y}_t = \sum_{p=1}^{p} \boldsymbol{A}_p \boldsymbol{Y}_{t-p} + \varepsilon_t,\ \varepsilon_t \sim \mathcal{N}(0, \boldsymbol{\Sigma}_\varepsilon) \tag{2}$$

$$\boldsymbol{B}_0 \boldsymbol{Y}_t = \boldsymbol{B}_p \boldsymbol{Y}_{t-p} + \boldsymbol{\omega}_t,\ \boldsymbol{\omega}_t \sim \mathcal{N}(0, \boldsymbol{I})$$

$$\underbrace{\boldsymbol{B}_0^{-1} \boldsymbol{B}_0}_{\boldsymbol{I}} \boldsymbol{Y}_t = \underbrace{\boldsymbol{B}_0^{-1} \boldsymbol{B}_p}_{\boldsymbol{A}_p} \boldsymbol{Y}_{t-p} + \underbrace{\boldsymbol{B}_0^{-1} \boldsymbol{\omega}_t}_{\varepsilon_t} \tag{3}$$

Cholesky Decomposition

$$\begin{bmatrix} u_t^{IP} \\ u_t^{\pi_t} \\ u_t^{i_t} \\ u_t^{FS_t} \\ u_t^{L_t} \\ u_t^{S_t} \\ u_t^{C_t} \\ u_t^{M_t} \end{bmatrix} = \begin{bmatrix} b_0^{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_0^{21} & b_0^{22} & 0 & 0 & 0 & 0 & 0 & 0 \\ b_0^{31} & b_0^{32} & b_0^{33} & 0 & 0 & 0 & 0 & 0 \\ b_0^{41} & b_0^{42} & b_0^{43} & b_0^{44} & 0 & 0 & 0 & 0 \\ b_0^{51} & b_0^{52} & b_0^{53} & b_0^{54} & b_0^{55} & 0 & 0 & 0 \\ b_0^{61} & b_0^{62} & b_0^{63} & b_0^{64} & b_0^{65} & b_0^{66} & 0 & 0 \\ b_0^{71} & b_0^{72} & b_0^{73} & b_0^{74} & b_0^{75} & b_0^{76} & b_0^{77} & 0 \\ b_0^{81} & b_0^{82} & b_0^{83} & b_0^{84} & b_0^{85} & b_0^{86} & b_0^{87} & b_0^{88} \end{bmatrix} \begin{bmatrix} w_t^{IP} \\ w_t^{\pi_t} \\ w_t^{i_t} \\ w_t^{FS_t} \\ w_t^{L_t} \\ w_t^{S_t} \\ w_t^{C_t} \\ w_t^{M_t} \end{bmatrix} \tag{4}$$

Data

Data US

- Sample: January 1976 – December 2022
- Industrial Production (FRED: INDPRO)
- CPI (FRED: CPIAUCSL)
- Federal Funds Effective Rate (FRED: DFF)
- S&P 500 (Yahho Finance: ^GSPC)
- Excess Bond Premium (EBP)[1]
- β factors based on yields data provided by Liu and Wu (2021))[2]

[1] source: Fed Note Data
[2] source: Liu-Wu Yield Data

Data EA

- Sample: October 2004 – September 2022
- Industrial Production (FRED: EA19PRINTO01GYSAM)
- Inflation (FRED: CPHPTT01EZM659N)
- 3M Interbank Rate (FRED: IR3TIB01EZM156N)
- Eurostoxx 50 (Yahho Finance: ^STOXX50E)
- Credit Risk EA[3]
- β factors based on yields data provided by the ECB[4]

[3] source: Banque de France
[4] source: dataset "All years - AAA"

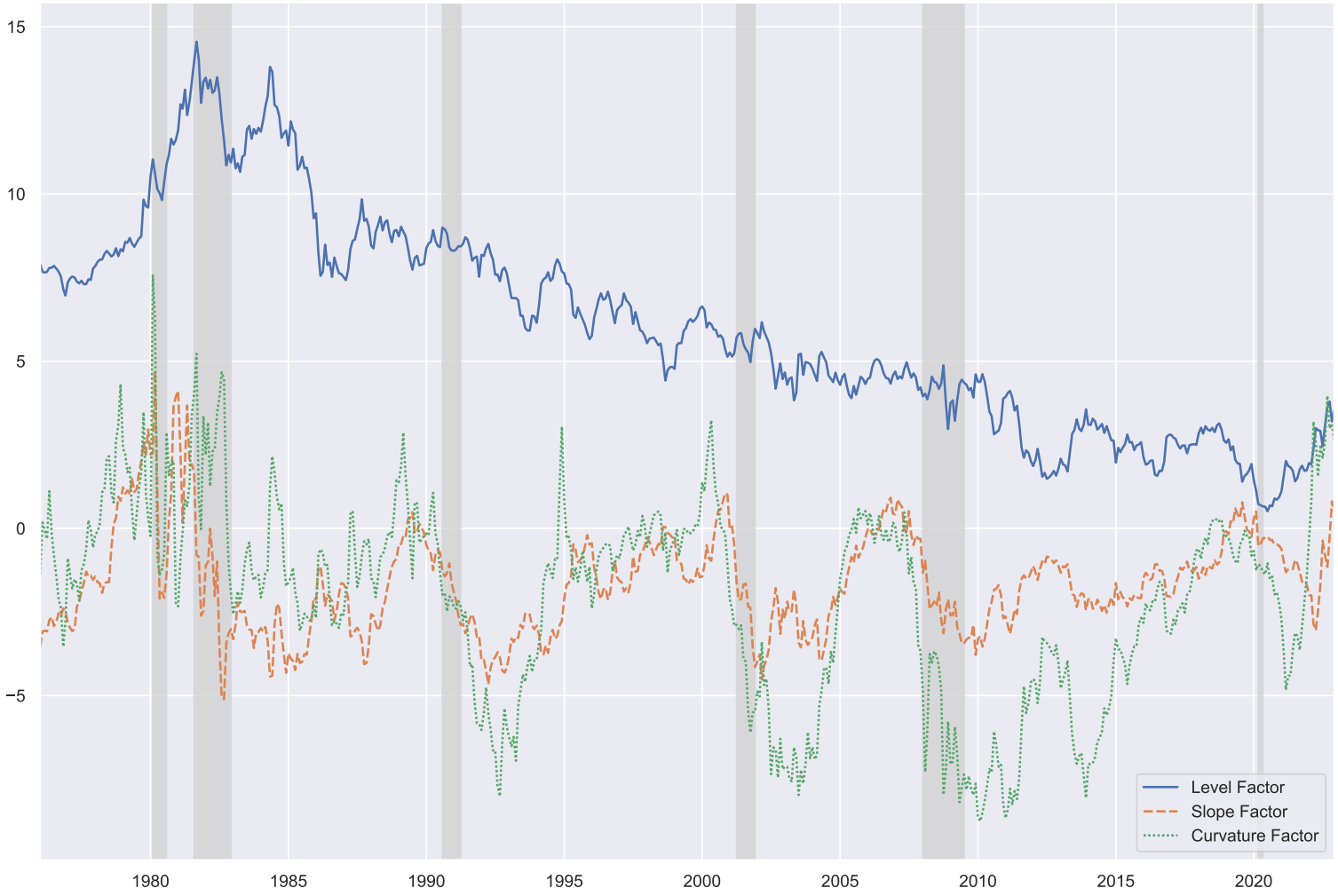

Figure: Estimated level, slope and curvature factor, US

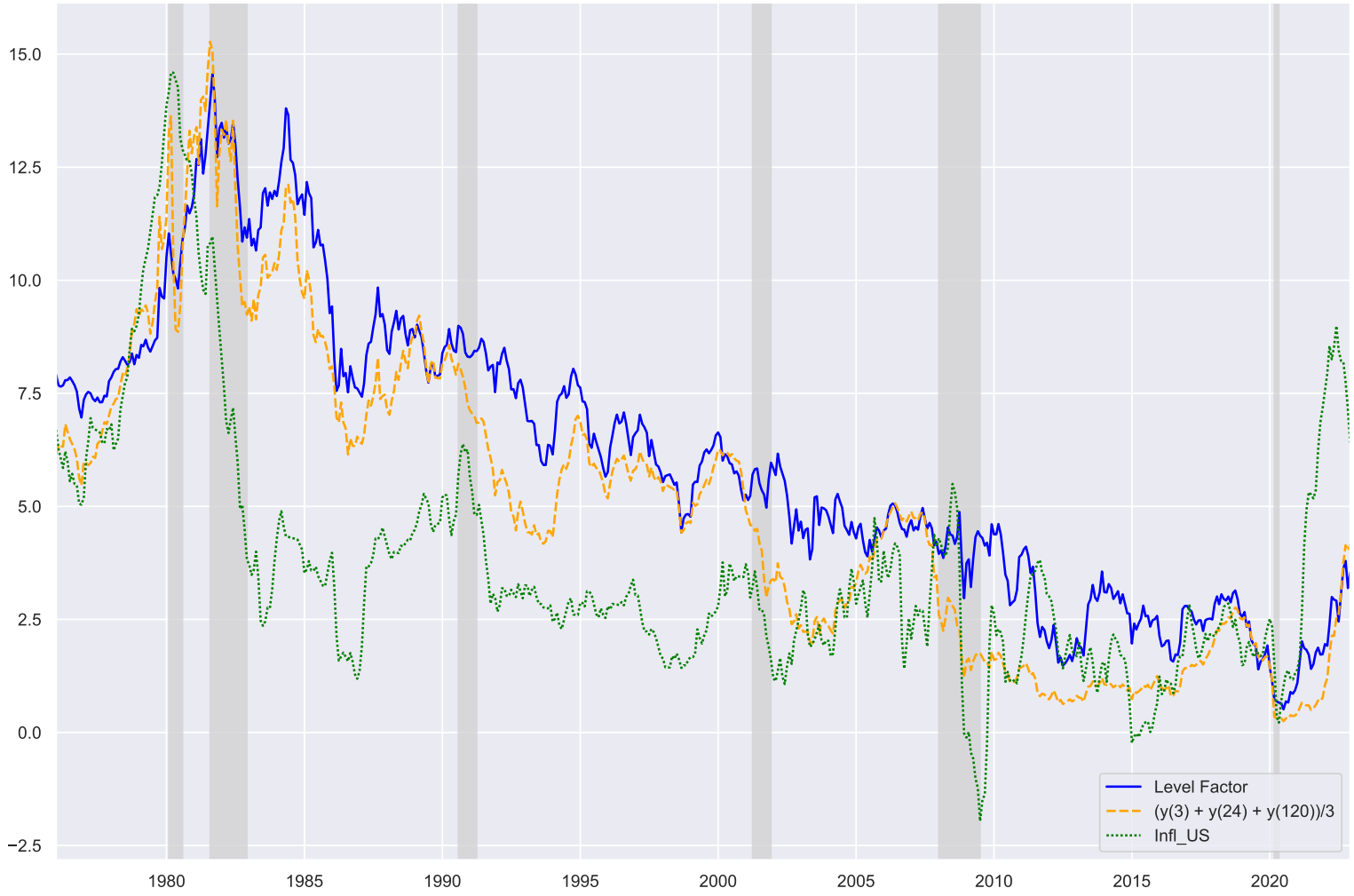

Figure: Level factor, empirical proxy and inflation, US

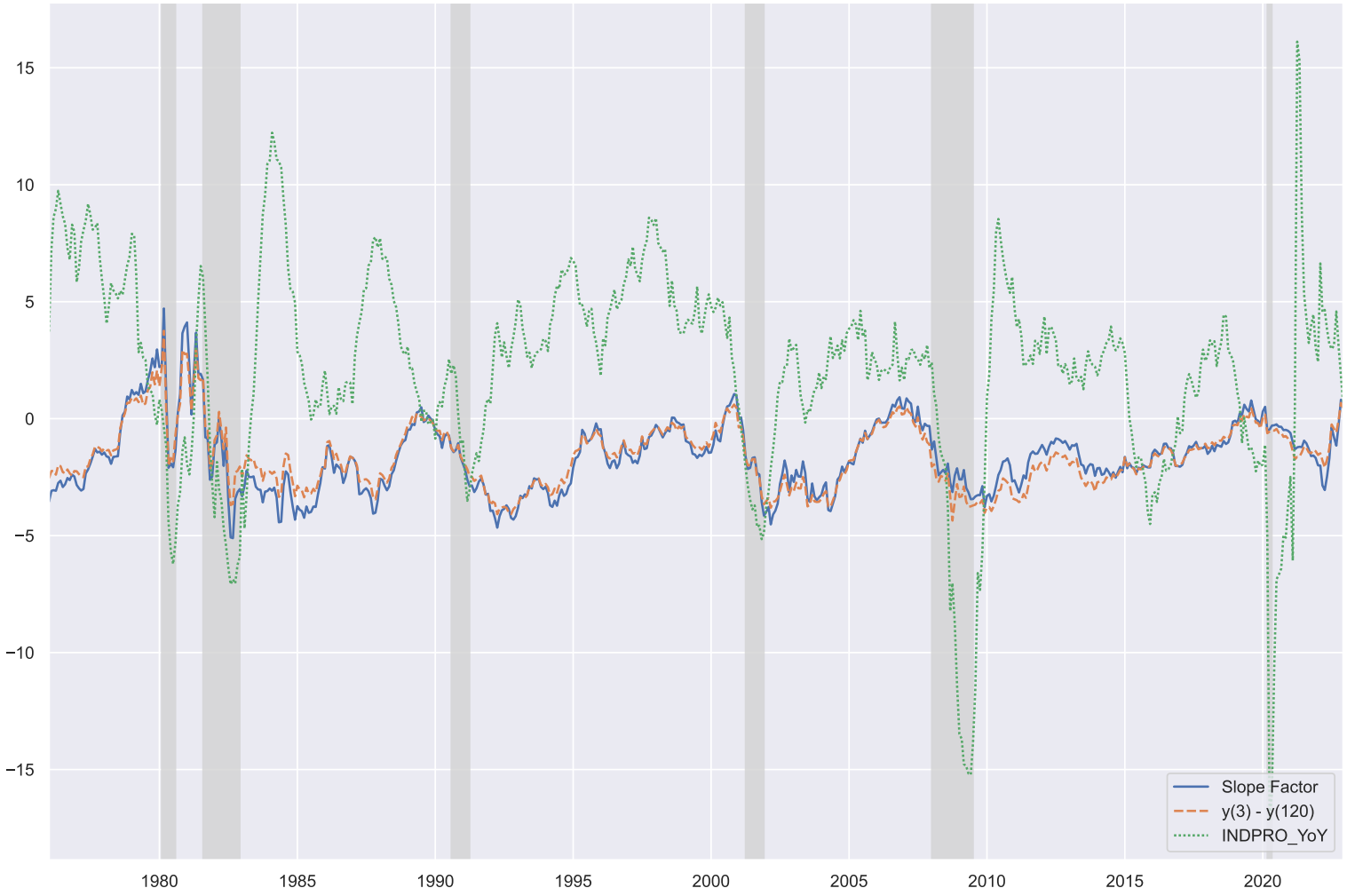

Figure: Level factor, empirical proxy and inflation, US

IRF US

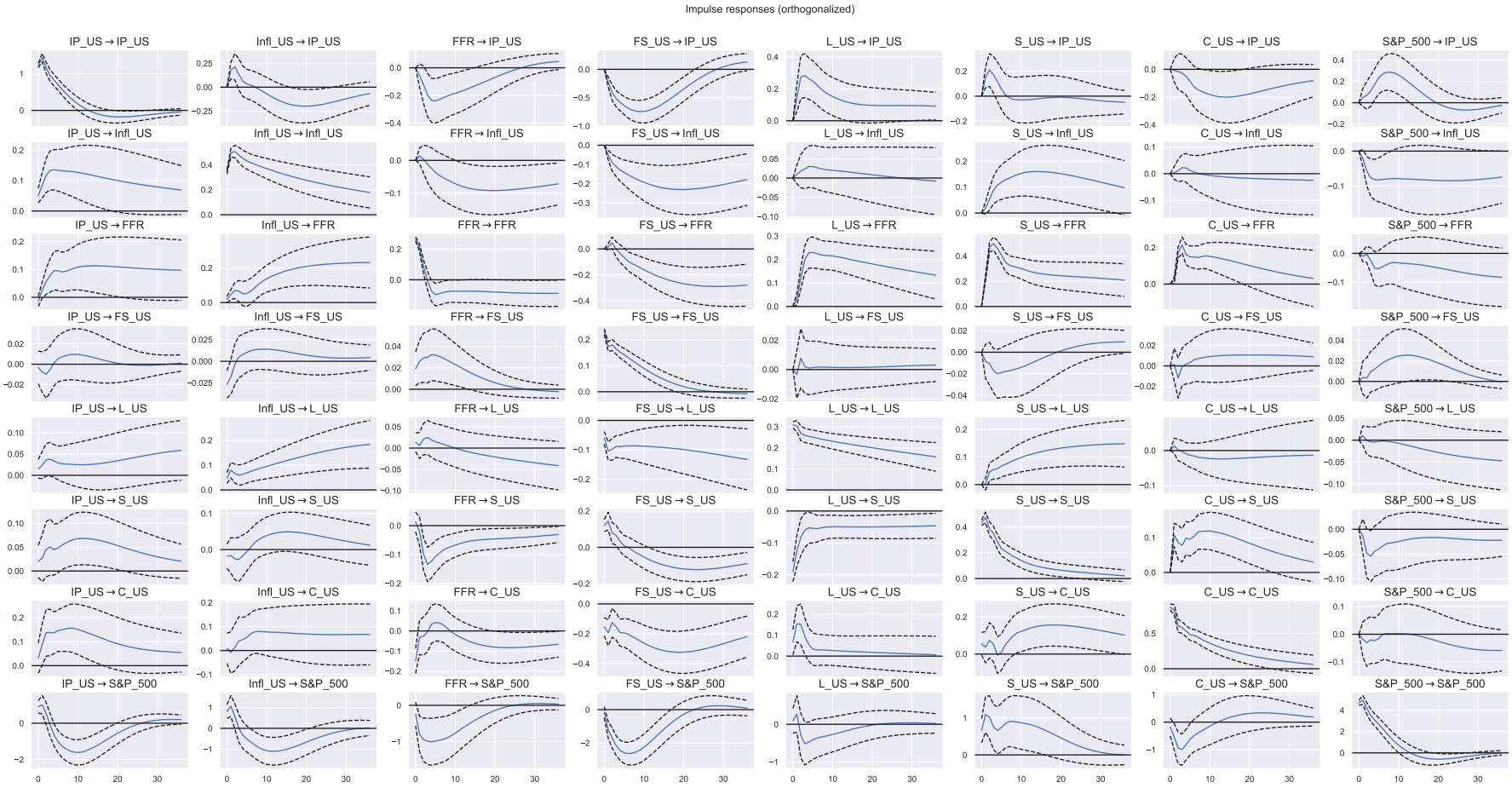

Figure: Impulse Responses SVAR(6), US

IRF US

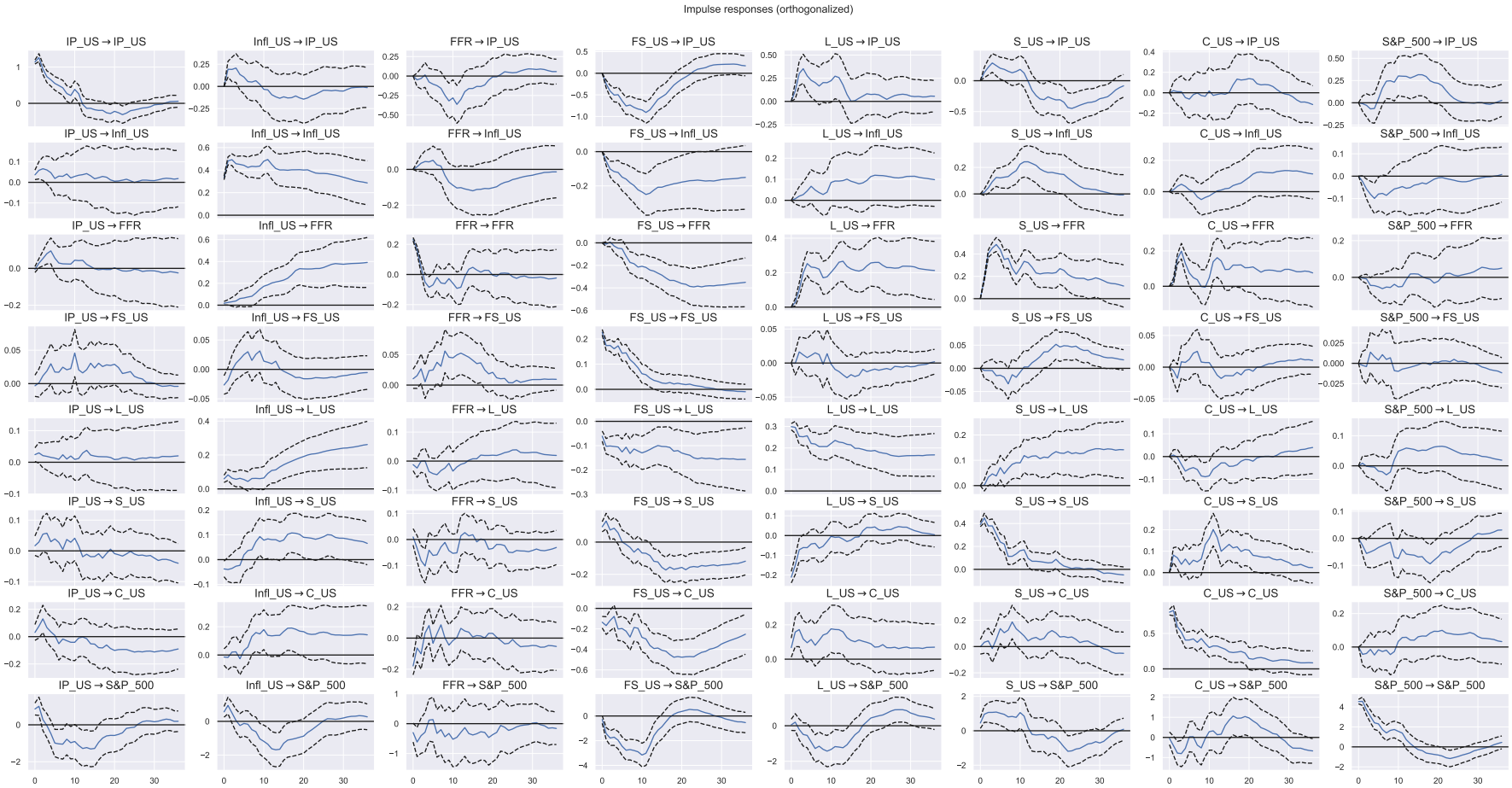

Figure: Impulse Responses SVAR(12), US

IRF EA

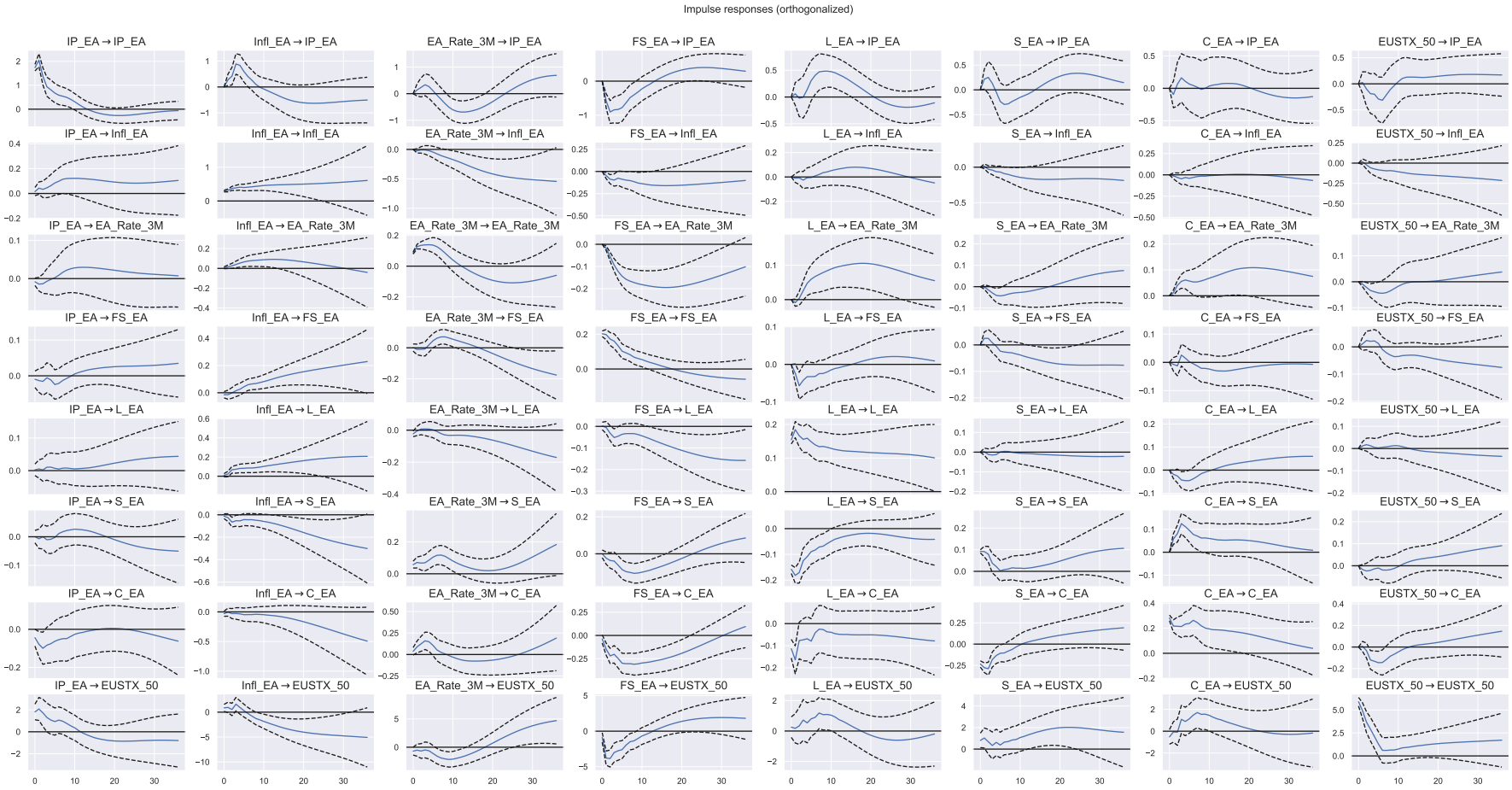

Figure: Impulse Responses SVAR(6), EA

IRF EA

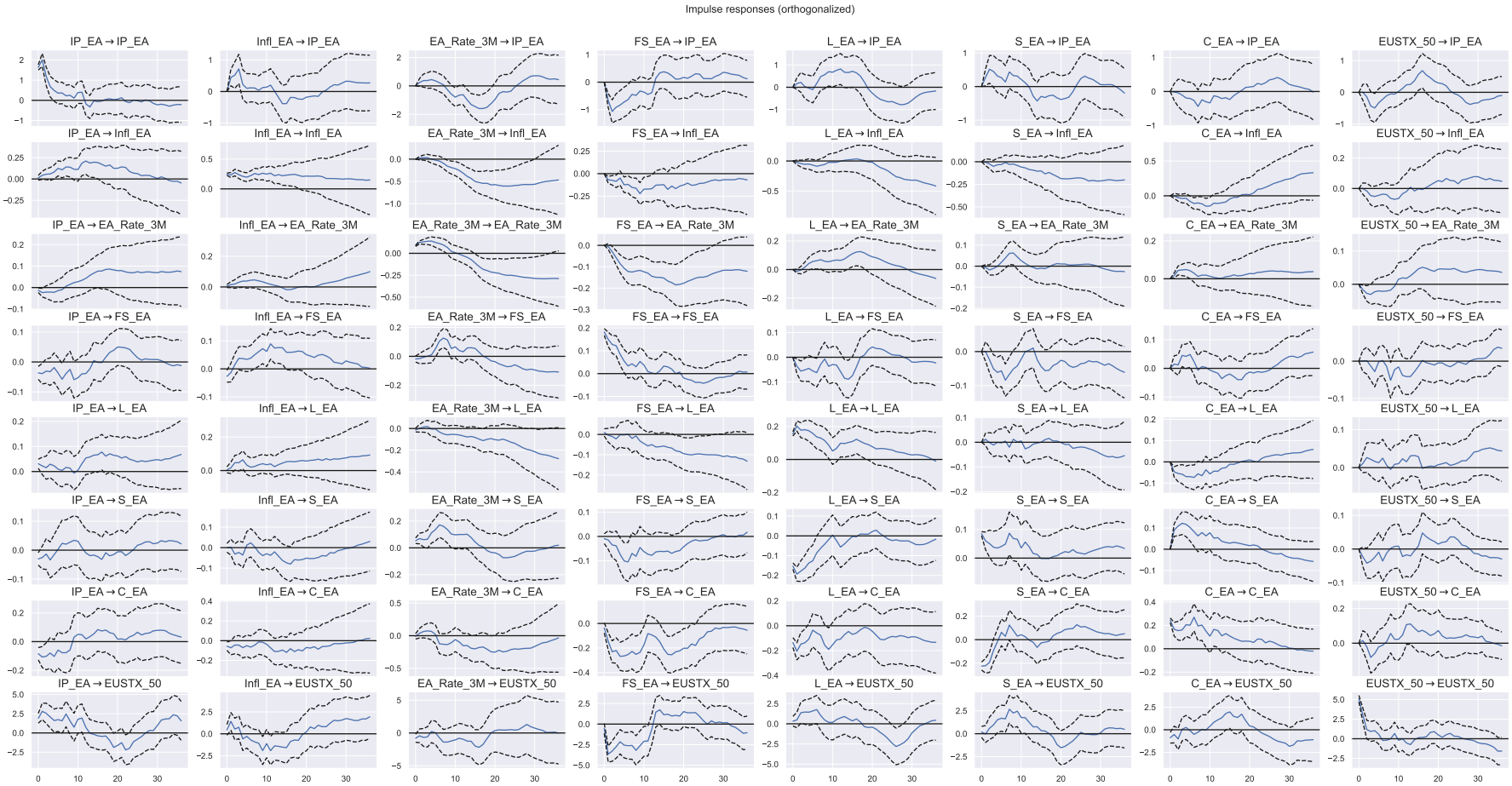

Figure: Impulse Responses SVAR(12), EA

Management Summary

Management Summary

- Level factor (L_t) seems to be a good approximation of long-run inflation expectations — especially assuming a real interest rate given by $r = i_t - L_t$

Management Summary

- Level factor (L_t) seems to be a good approximation of long-run inflation expectations — especially assuming a real interest rate given by $r = i_t - L_t$
- Inflation expectations (L_t) seem to become somewhat unanchored given an aggregate supply (π_t) or aggregate demand (IP_t) shock in both the US and the EA

Management Summary

- Level factor (L_t) seems to be a good approximation of long-run inflation expectations — especially assuming a real interest rate given by $r = i_t - L_t$
- Inflation expectations (L_t) seem to become somewhat unanchored given an aggregate supply (π_t) or aggregate demand (IP_t) shock in both the US and the EA
- Slope Factor (S_t) is associated with an economic contraction only in the EA

Management Summary

- Level factor (L_t) seems to be a good approximation of long-run inflation expectations — especially assuming a real interest rate given by $r = i_t - L_t$
- Inflation expectations (L_t) seem to become somewhat unanchored given an aggregate supply (π_t) or aggregate demand (IP_t) shock in both the US and the EA
- Slope Factor (S_t) is associated with an economic contraction only in the EA
- A monetary policy shock (i_t) induces a decrease in the level factor (L_t), underlining the high credibility and transparency of the Fed and ECB

References I

- Altavilla, Carlo et al. (2019). "Measuring euro area monetary policy". In: *Journal of Monetary Economics* 108, pp. 162–179. ISSN: 0304-3932.
- Diebold and Li (2006). "Forecasting the term structure of government bond yields". In: *Journal of Econometrics* 130.2, pp. 337–364. ISSN: 0304-4076.
- Diebold, Rudebusch, and Aruoba (2006). "The macroeconomy and the yield curve: a dynamic latent factor approach". In: *Journal of econometrics* 131.1-2, pp. 309–338.
- Gürkaynak, Sack, and Swanson (May 2005). "Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements". In: *International Journal of Central Banking* 1.1.
- Gürkaynak and Wright (June 2012). "Macroeconomics and the Term Structure". In: *Journal of Economic Literature* 50.2, pp. 331–67.
- Hicks, John R. (1946). *Value and Capital, 2nd Edition*. Clarendon Press, Oxford.

References II

- Liu and Wu (2021). "Reconstructing the yield curve". In: *Journal of Financial Economics* 142.3, pp. 1395–1425.
- Nelson, Charles R and Andrew F Siegel (1987). "Parsimonious modeling of yield curves". In: *Journal of business*, pp. 473–489.
- Swanson (2021). "Measuring the effects of federal reserve forward guidance and asset purchases on financial markets". In: *Journal of Monetary Economics* 118, pp. 32–53. ISSN: 0304-3932.