# Online Appendix for Clustered Local Projections for Time-Varying Models*

Ana María Herrera†, Elena Pesavento‡, Alessia Scudiero§

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**Abstract**

We propose a *clustered* local projection (*clustered LP*) method to estimate impulse response functions in a class of time-varying models where parameter variation is linked to a low-dimensional matrix of observables. We show that the clustered LP recovers the conditional average response when the driving variables are exogenous and a weighted average of the conditional marginal effects when they are endogenous. We propose an iterative estimation method that first classifies the data using k-means, estimates impulse response functions via GMM, and evaluates differences across clustered LP estimates. Our Monte Carlo simulations illustrate the ability of *clustered LP* to approximate the conditional average response function. We employ our technique to examine how uncertainty influences the transmission of a contractionary monetary policy shock to the 5- and 10-year U.S. nominal Treasury yields. Our estimation results suggest macroeconomic and monetary policy uncertainty operate through complementary but distinct channels: the former primarily amplifies the risk compensation embedded in the term premium, while the latter governs the speed and persistence with which markets revise their expectations about the future rate path following a monetary policy shock.

JEL Classification: C32, E17, E42, E52, E60, E63.
Keywords: Time-varying parameter VAR, time-varying local projections, clustered local projections, monetary policy transmission, uncertainty.

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†University of Kentucky, Email: amherrera@uky.edu
‡Emory University, Email: epesave@emory.edu. - Corresponding author.
§Emory University, Email: alessia.scudiero@emory.edu

# B Smooth-Threshold VAR with Bivariate $Z_{t-1}$

This appendix describes in detail the DGP for the smooth-threshold bivariate model. Recall that the simulations for the Bivariate Smooth-Threshold VAR are based on a lagged smooth-threshold model with four regimes, where the regime transition depends on the two components of $\mathbf{Z_t}$. More precisely, the DGP for $\mathbf{Z_t}$ is assumed to follow a bivariate VARMA$(p_z, m_z)$ process:

$$\mathbf{Z}_t = \sum_{k=1}^{p_z} \mathbf{A}_k \mathbf{Z}_{t-k} + \mathbf{u}_t,$$

where the error term follows a vector MA$(m_z)$ structure,

$$\mathbf{u}_t = \mathbf{e}_t + \sum_{j=1}^{m_z} \Theta_j \mathbf{e}_{t-j}, \qquad \mathbf{e}_t \sim \mathcal{N}(0, \Sigma_e).$$

We set $p_z = 2$, $m_z = 3$, and $n_z = 2$. The autoregressive coefficient matrices are

$$\mathbf{A}_1 = \begin{bmatrix} 0.7 & -0.1 \\ 0.2 & -0.4 \end{bmatrix}, \qquad \mathbf{A}_2 = \begin{bmatrix} -0.04 & 0.02 \\ -0.2 & 0.05 \end{bmatrix}.$$

The MA coefficient matrices are diagonal and given by:

$$\Theta_1 = \begin{bmatrix} 0.9 & 0 \\ 0 & 0.9 \end{bmatrix}, \qquad \Theta_2 = \begin{bmatrix} 0.6 & 0 \\ 0 & 0.6 \end{bmatrix}, \qquad \Theta_3 = \begin{bmatrix} 0.30 & 0 \\ 0 & 0.30 \end{bmatrix}.$$

Finally, the shock covariance matrix is given by

$$\Sigma_e = \begin{bmatrix} 1 & 0.8 \\ 0.8 & 1 \end{bmatrix}.$$

The chosen parameters ensure that $\mathbf{Z}_t$ is stationary, while allowing moderate persistence typical of macroeconomic time series.

As in the univariate case, the structural coefficients $\boldsymbol{\psi}_t = (\beta_t,\ \gamma_{1,t},\ \gamma_{2,t})'$ evolve as a weighted combination of regime-specific parameters collected in $\mathbf{P}$, with weights determined by $\mathbf{Z}_{t-1}$ and small idiosyncratic disturbances $\eta_{k,t} \sim \mathcal{N}(0, \sigma^2_{\text{par}})$, $\sigma^2_{\text{par}} = 0.0009$. The regime-specific parameters in $\mathbf{P}$ are chosen to ensure stationarity and to avoid oscillatory behavior in impulse responses.

$$\beta_t = \sum_{k=1}^{K} \xi_k(\mathbf{Z}_{t-1})\,\beta_k \;+\; \eta_{1,t}, \tag{1}$$

$$\gamma_{1,t} = \sum_{k=1}^{K} \xi_k(\mathbf{Z}_{t-1})\,\gamma_{1,k} \;+\; \eta_{2,t}, \tag{2}$$

$$\gamma_{2,t} = \sum_{k=1}^{K} \xi_k(\mathbf{Z}_{t-1})\,\gamma_{2,k} \;+\; \eta_{3,t}, \tag{3}$$

$$\mathbf{P} = \begin{bmatrix} \beta_1 & \beta_2 & \beta_3 & \beta_4 \\ \gamma_{1,1} & \gamma_{1,2} & \gamma_{1,3} & \gamma_{1,4} \\ \gamma_{2,1} & \gamma_{2,2} & \gamma_{2,3} & \gamma_{2,4} \end{bmatrix} = \begin{bmatrix} -2.1 & -1.5 & 1.3 & 2.3 \\ 0.7 & 0.4 & 0.9 & 1.2 \\ 0.1 & 0.2 & -0.1 & -0.3 \end{bmatrix},$$

Each of the components of $\xi_k(\mathbf{Z}_{t-1})$ represents the smooth weight assigned to the regime $k$ at time $t$. We set the parameter values in the threshold vector to simulate four non-absorbing states: $Z_{1,t-1}$ and $Z_{2,t-1}$ above their mean, $Z_{1,t-1}$ and $Z_{2,t-1}$ below their mean, $Z_{1,t-1}$ above its mean and $Z_{2,t-1}$ below its mean, and $Z_{1,t-1}$ below its mean and $Z_{2,t-1}$ above its mean. Thus,

$$\boldsymbol{\tau} = \begin{bmatrix} \tau_1 \\ \tau_2 \end{bmatrix} = \begin{bmatrix} -0.38 \\ -0.031 \end{bmatrix}.$$

Smooth transitions are obtained by applying a logistic function $G_i$ along each dimension. For the smoothness parameter $\lambda = 5$, we define

$$G_1(Z_{t-1,1};\lambda) = \frac{1}{1+\exp\big(-\lambda[\,Z_{t-1,1}-\tau_1\,]\big)}, \tag{4}$$

$$G_2(Z_{t-1,2};\lambda) = \frac{1}{1+\exp\big(-\lambda[\,Z_{t-1,2}-\tau_2\,]\big)}, \tag{5}$$

Using the functions $G_i$, we construct the four regime weights $\xi_k(\mathbf{Z}_{t-1})$:

$$\begin{aligned}
\xi_1(\mathbf{Z}_{t-1}) &= \big(1-G_1(Z_{t-1,1};\lambda)\big)\big(1-G_2(Z_{t-1,2};\lambda)\big),\\
\xi_2(\mathbf{Z}_{t-1}) &= \big(1-G_1(Z_{t-1,1};\lambda)\big)G_2(Z_{t-1,2};\lambda),\\
\xi_3(\mathbf{Z}_{t-1}) &= G_1(Z_{t-1,1};\lambda)\big(1-G_2(Z_{t-1,2};\lambda)\big),\\
\xi_4(\mathbf{Z}_{t-1}) &= G_1(Z_{t-1,1};\lambda)G_2(Z_{t-1,2};\lambda),
\end{aligned}$$

with

$$\sum_{k=1}^{4}\xi_k(\mathbf{Z}_{t-1}) = 1, \qquad 0 \le \xi_k(\mathbf{Z}_{t-1}) \le 1 \quad \text{for } k = 1,\dots,4.$$

# C The Uncertainty Channel of Monetary Policy Transmission to Treasury Yields: Shorter Maturities and Alternative Monetary Policy Measures

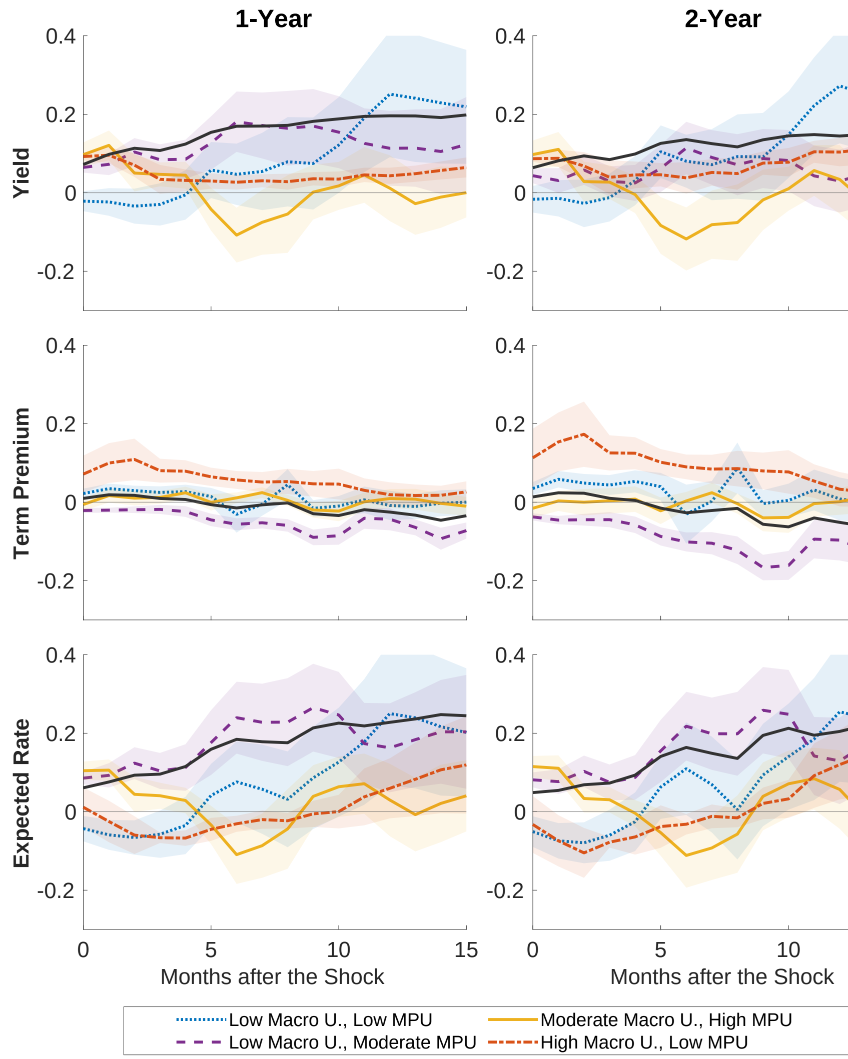
This appendix reports a set of additional empirical estimates. We first evaluate whether the heterogeneity we uncovered in the responses of the 5- and 10-year yields is present for shorter maturities. Then, we examine the robustness of the results to using temporal aggregation scheme and an alternative monetary policy measure.

## C.1 Shorter Maturities

The reader may wonder whether the heterogeneity we uncovered in the response of the 5- and 10-year yields is also present for shorter maturities. Recall that in the first step k-means groups the observations based on the values of the *MPU* and *MacroUncer*; hence the grouping is unchanged across maturities. Figure 1 presents clustered LP estimates for the 1- and 2-year yields. For comparison, we also plot the estimates obtained via a linear LP. As is the case for longer maturities, the clustered LP estimates reveal significant heterogeneity in the response of the short-term yields to a contractionary monetary policy shock.

The most striking difference relative to the 5- and 10-year yields lies in the term premium response: at shorter maturities, the term premium responses are substantially smaller, while the expected rate responses remain comparable in magnitude to those at longer maturities. With the term premium channel largely muted, the expected rate becomes the primary driver of yield movements, producing magnitudes and orderings different from those observed at longer maturities. This contrast highlights the central role of the term premium in shaping the dynamics of longer-maturity yields — and explains why short- and long-maturity yields exhibit systematically different patterns across uncertainty regimes. Of note is the fact that the linear LP tends to overestimate the medium-run response of the one- and two-year yields and misses the heterogeneity in responses across clusters, especially for the expected rate component.

Figure 1: Clustered Local Projections: 1- and 2-Year Yield (Baseline Shocks)

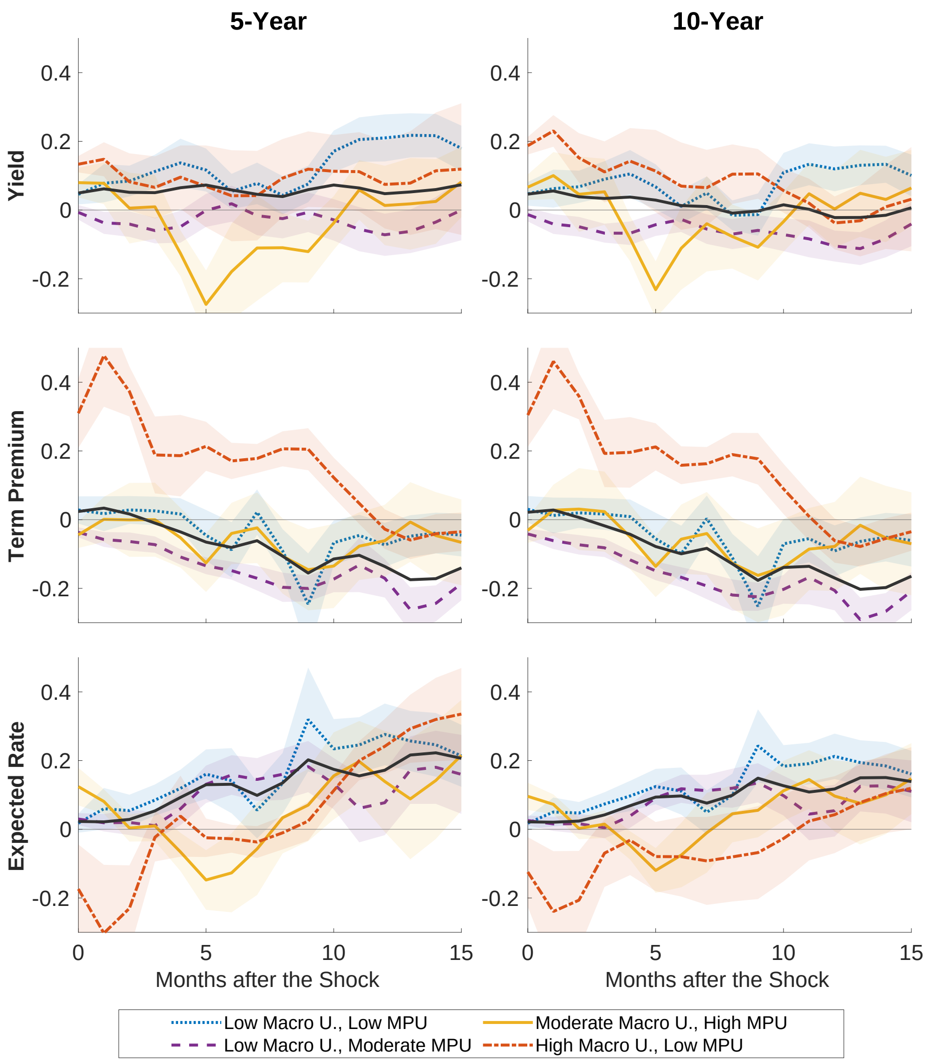



*Notes:* Clustered Local Projections Impulse Response Functions of the 1- and 2-year yield and its components to a one-standard deviation monetary policy shock under different monetary policy and macroeconomic uncertainty regimes. Shaded areas represent 68% confidence intervals. The estimated linear LP response is plotted in black.

## C.2 Alternative Temporal Aggregation

The results reported in the paper employ the same temporal aggregation scheme as Bauer and Swanson (2023) to convert daily surprises into monthly shocks (i.e., adding daily surprises

Figure 2: Alternative Temporal Aggregation: Clustered LP for 5- and 10-Year Yield




*Notes:* The figure reports the clustered LP Impulse Response Functions of the 5- and 10-year yield and their components to a one-standard deviation monetary policy shock under different monetary policy and macroeconomic uncertainty regimes. Shaded areas represent 68% confidence intervals. The estimated linear LP response is plotted in black. The monetary policy shock is measured using Bauer and Swanson (2023) series aggregated to a monthly frequency using Kilian (2024) methodology.

throughout the month). However, alternative aggregation schemes have been proposed in the literature. In particular, Kilian (2024) suggests weighting daily surprises by the ratio of days left in the month when the surprise hits and accounting for the effect of that surprise on the following month. Thus, we use the series of monetary policy surprises of Bauer and Swanson (2023) at the FOMC frequency (non-orthogonalized) and aggregate them to the monthly frequency in the following manner. Let $T_m$ be the number of trading days in month $m$ and $d$ be the index of a given trading day within that month, the surprise on day $d$ receives a weight of $(T_m - d + 1)/T_m$ in the current month and a weight of $(d-1)/T_m$ in the following month. The monthly proxy is then the sum of the current-month weighted surprises plus the carry-over from the preceding month, so that each daily surprise is fully allocated across at most two consecutive months. Note that on non-FOMC trading days, the shock is set to zero before aggregation, but because of the weighting scheme, non-FOMC months may have non-zero values, capturing the potential effect of shocks happening late in the previous month.

The results obtained using the Kilian-weighted Bauer and Swanson (2023) shock series are broadly consistent with the baseline for both maturities, with the qualitative ordering of yield responses across groups preserved in most cases. The main exception is the low *MacroUncer*, low *MPU* regime (blue dotted line). For 5-year maturity, it moves from insignificant over the first four horizons to positive and significant, a shift driven by the expected rate turning positive under the Kilian-weighted specification.

Two further differences are worth noting. First, the response in the moderate *MacroUncer*, high *MPU* regime (yellow solid line) turns negative around five months after the shock for both maturities, relative to the baseline, reflecting a more negative expected rate response. Second, the response for the low *MacroUncer*, moderate *MPU* regime (purple dashed line) turns negative for the 5-year maturity, but is positive and persistent in the response in the high *MacroUncer*, low *MPU* regime (red dash-dotted line). Finally, we note that using a linear LP would largely miss the heterogeneity in the response of the term premium and the expected rate to monetary policy shocks during uncertain times, especially during times of high *MacroUncer*.

## C.3 Alternative Monetary Policy Shocks Series

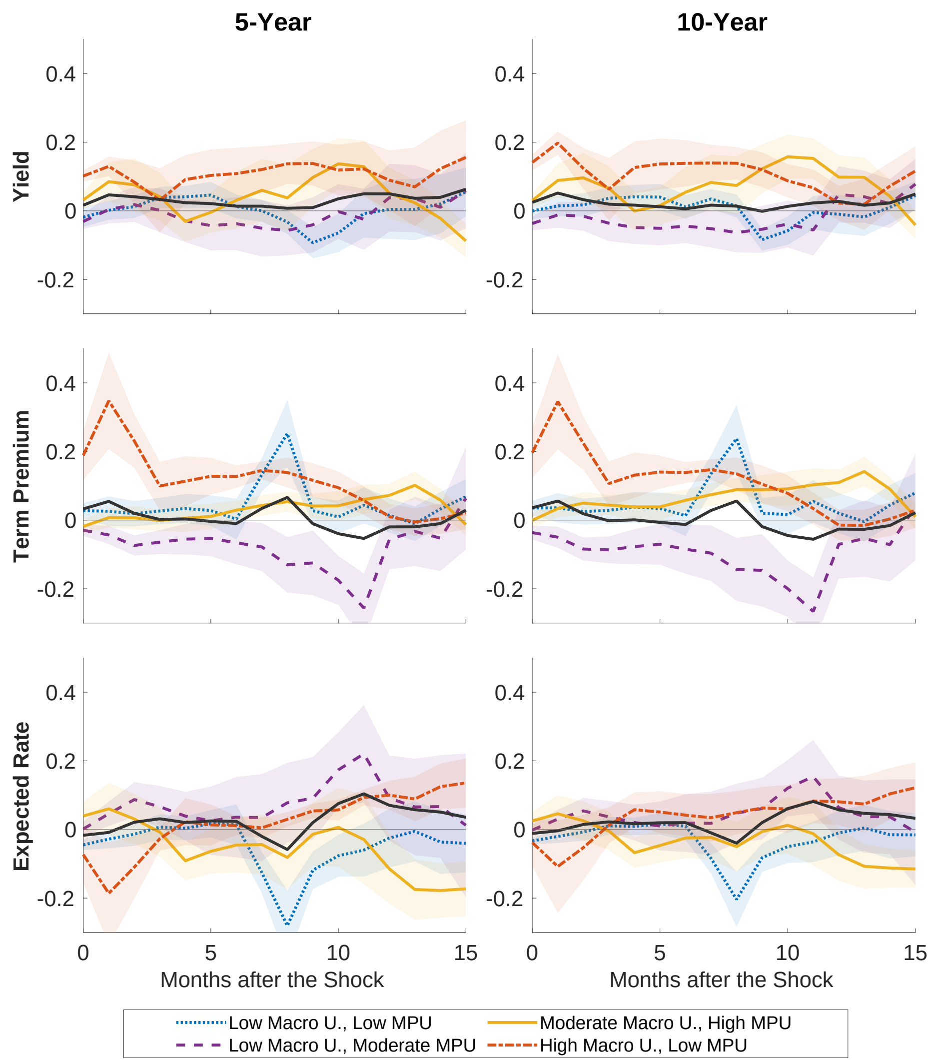
An alternative monetary policy shock measure used in the literature is the change in the 2-year nominal Treasury yield from the day before to the day after each FOMC announcement (see, e.g., Hanson and Stein (2015) and Tillman (2020)). We evaluate whether our results are robust to using this alternative shock series. To do so, yield data are taken from the updated Gürkaynak, Sack, and Wright (2007) series published by the Federal Reserve Board. The FOMC meeting dates are drawn from two sources: Romer and Romer (2004) and the U.S. Monetary Policy Event-Study Database of Acosta et al. (2025). On non-FOMC trading days, the daily surprise is set to zero.

Figure 3 reports the clustered LP estimates for this alternative monetary policy shock measure when the shocks are aggregated from daily to monthly frequency by adding the surprises in each month. As the figure illustrates, our finding of a heterogeneous response across different *MacroUncer* and *MPU* is robust to using this alternative measure. The differences between the responses across the regime are similar to those found in the baseline specification, especially for the term premium and the expected rate. The term premium panel retains a broadly similar ordering and magnitude across all regimes, suggesting that differences in yield responses are driven primarily by the expected rate component. The main differences are the less persistent and somewhat muted response of the yields in the medium-run and the response for the low *MacroUncer*, low *MPU* regime (blue dotted line). While the results for the baseline specification show a negative expected rate response over the first five horizons followed by a positive one, the alternative shock series produces the exact opposite pattern.

It is also worth noting that the linear LP estimates would lead the researcher to conclude that monetary policy is rather ineffective in altering the 5- and 10-year yields, while the clustered LP estimates would lead them to conclude that it has a differential effect in different states and is able to increase the yield during high *MacroUncer* / low *MPU* times.

We also explore the effect of using the alternative temporal aggregation scheme for this

Figure 3: Alternative Monetary Policy Measure: Clustered LP for 5- and 10-Year Yield

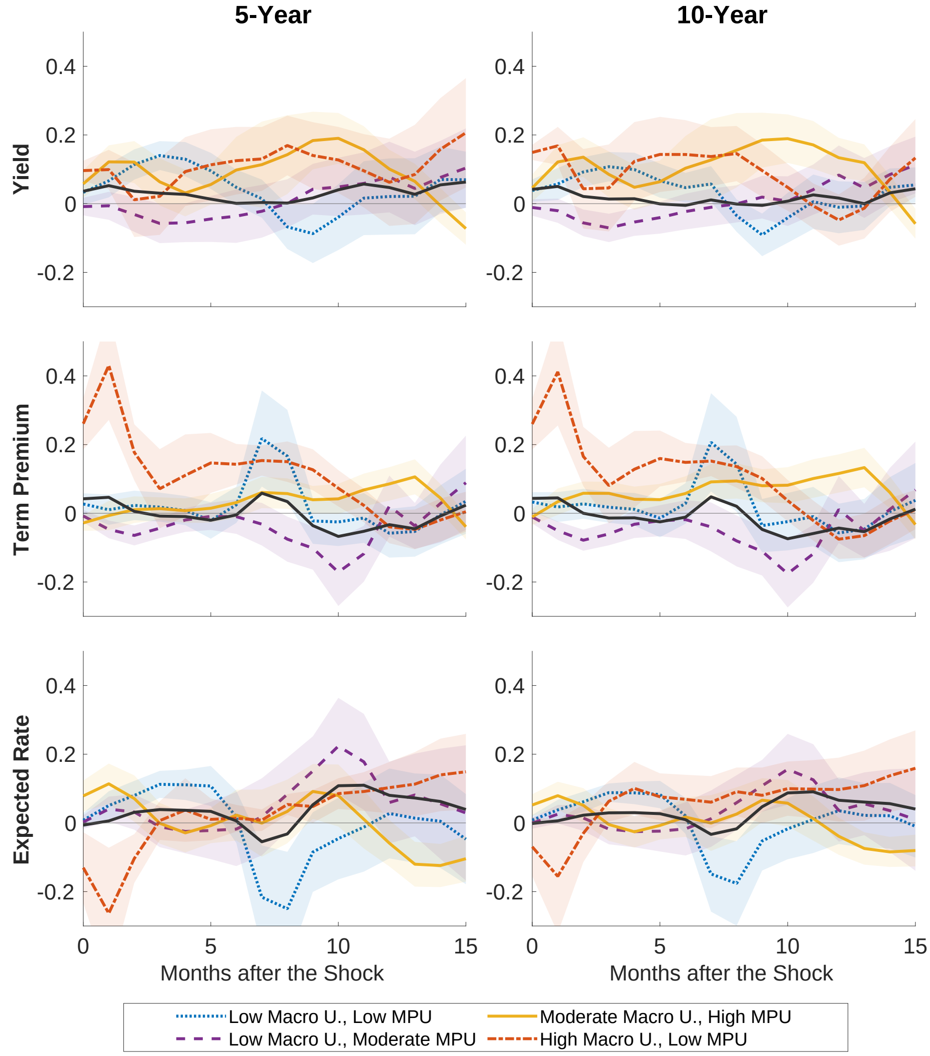



*Notes:* The figure reports clustered LP responses for the 5- and 10-year yields and their components to a one-standard deviation monetary policy shock under different monetary policy and macroeconomic uncertainty regimes.Shaded areas represent 68% confidence intervals. The estimated linear LP response is plotted in black.

measure of monetary policy. The corresponding impulse responses are reported in Figure 4. The use of the alternative shock series and the temporal aggregation scheme leaves the main findings virtually unchanged. Indeed, the responses are almost identical to those obtained when we use the alternative monetary policy measure, but aggregate to the monthly frequency by adding up the surprises in each month. More specifically, the 5- and 10-year maturity responses over the first four horizons are consistent across shock series. Finally, the low *MacroUncer*, low *MPU* regime (blue dotted line) and the high *MacroUncer*, low *MPU* regime (red dash-dotted line) display slightly bigger and smaller yield responses, respectively, under the alternative shock series, but remain broadly consistent with the baseline.

Overall, the main conclusions of the baseline are preserved across maturities and different shock series, lending support to the robustness of the results.

Figure 4: Alternative Monetary Policy Measure and Temporal Aggregation: Clustered LP for 5- and 10-Year Yield




*Notes:* Clustered Local Projections Impulse Response Functions of the 5- and 10-year yield and its components to a one-standard deviation monetary policy shock under different monetary policy and macroeconomic uncertainty regimes. Shaded areas represent 68% confidence intervals. The estimated linear LP response is plotted in black.

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