

The Term Structure of Monetary Policy Uncertainty

Technical Appendix*

Brent Bundick[†] Trenton Herriford[‡] A. Lee Smith[§]

February 2022

*The views expressed herein are solely those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Kansas City or the Federal Reserve System.

[†]Federal Reserve Bank of Kansas City. Email: brent.bundick@kc.frb.org

[‡]University of Texas at Austin. Email: trenton.herriford@utexas.edu

[§]Federal Reserve Bank of Kansas City. Email: andrew.smith@kc.frb.org

A Additional Regression Results

This appendix provides additional regression results replacing our baseline EDX factors derived from options prices using the VIX methodology with alternative interest rate uncertainty measures derived from option-implied kernel probability densities using the methodology in Swanson (2006).¹

As we note in the paper, our regression results are very similar whether we use our baseline EDX measures or these kernel probability density (PDF) measures of option-implied volatility. Tables A.1, A.2, A.3, and A.4 replicate the analysis shown in Tables 4, 5, 6, and 8 from the main text using these alternative PDF measures. These robustness exercises confirm that our particular approach to constructing option-implied volatility measures are not driving our results as we continue to find strong evidence that the term structure of interest rate uncertainty:

- Plays an important role in transmitting FOMC announcements to Treasury markets (see Table A.1),
- This transmission does not take place through the interaction of first-moment monetary policy surprises with the term structure of interest rate uncertainty (see Table A.2),
- Instead, this transmission to Treasury markets occurs largely through real forward rates (see Table A.3),
- And, movements in real yields appear to reflect movements in risk/term premiums rather than expected rates (see A.4).

¹We are grateful to Eric Swanson for generously sharing his code with us.

References

- Adrian, Tobias, Richard K. Crump, and Emanuel Moench.** 2013. “Pricing the Term Structure with Linear Regressions.” *Journal of Financial Economics*, 110: 110–138.
- Hanson, Samuel G., and Jeremy C. Stein.** 2015. “Monetary Policy and Long-Term Real Rates.” *Journal of Financial Economics*, 115: 429–448.
- Swanson, Eric T.** 2006. “Have increases in Federal Reserve transparency improved private sector interest rate forecasts?” *Journal of Money, Credit and Banking*, 791–819.

Table A.1: Monetary Policy Surprises & The Term Structure of Monetary Policy Uncertainty: Robustness to using PDF-Measures of Implied Volatility

	Dependent Variable: Δ 10-yr Treasury Yield				
	Excluding First Moment Monetary Policy Surprises		Including First Moment Monetary Policy Surprises		
PDF Level	1.04*** [0.00]	1.04*** [0.00]	0.45** [0.01]	0.16 [0.26]	0.18 [0.30]
PDF Slope		1.52*** [0.00]	0.86*** [0.00]	0.66*** [0.00]	0.79*** [0.00]
D 2-yr			0.66*** [0.00]		
Target				0.00 [0.99]	
Path				0.60*** [0.00]	
PNS4					0.54*** [0.00]
R ²	0.14	0.32	0.58	0.60	0.56
PDF F-test	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]

The PDF F-test row shows the [p-value] for the hypothesis test that the regression coefficients on the PDF Level and PDF Slope are jointly zero. Eicker-White standard errors are used to calculate [p-values] shown below coefficient estimates. Number of observations: 207. The sample period is January 1994 – December 2019. All changes in yields and the PDF measures are calculated over a one-day window around scheduled FOMC meetings.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table A.2: Monetary Policy Surprises Interacted with The Term Structure of Monetary Policy Uncertainty: Robustness to using PDF-Measures of Implied Volatility

Dependent Variable: Δ 10-yr Treasury Yield						
	Δ 2-yr Treas Yield		Target & Path Factors		Policy News Surprise (PNS)	
PDF Level	0.58*** [0.00]	0.55*** [0.00]	0.24* [0.09]	0.27* [0.08]	0.27 [0.12]	0.27 [0.11]
PDF Slope		0.75*** [0.00]		0.44** [0.02]		0.64*** [0.00]
Δ 2-yr	1.02*** [0.00]	0.96*** [0.00]				
Target			-0.24 [0.45]	-0.11 [0.79]		
Path			1.03*** [0.00]	1.06*** [0.00]		
PNS					1.05*** [0.00]	1.03*** [0.00]
Δ 2-yr x L PDF 4Q	-0.28* [0.09]	-0.17 [0.38]				
Δ 2-yr x L EDX 5Q-1Q		-0.17 [0.60]				
Target x L PDF 4Q			0.19 [0.47]	0.11 [0.67]		
Target x L PDF 5Q-1Q				-0.04 [0.93]		
Path x L PDF 4Q			-0.34** [0.01]	-0.10 [0.53]		
Path x L PDF 5Q-1Q				-0.44* [0.08]		
PNS x L PDF 4Q					-0.40** [0.01]	-0.22 [0.12]
PNS x L PDF 5Q-1Q						-0.30 [0.19]
R ²	0.56	0.59	0.61	0.63	0.55	0.58
PDF F-test	[0.00]	[0.00]	[0.09]	[0.02]	[0.12]	[0.00]

The PDF F-test row shows the [p-value] for the hypothesis test that the regression coefficients on the PDF Level and PDF Slope are jointly zero. Eicker-White standard errors are used to calculate [p-values] shown below coefficient estimates. Number of observations: 207. The sample period is January 1994 – December 2019. All changes in yields and the PDF measures are calculated over a one-day window around scheduled FOMC meetings.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table A.3: The Response of US Treasury Forwards Around FOMC Announcements: Robustness to using PDF-Measures of Implied Volatility

Maturity	Nominal Forward Rates				Real Forward Rates				Inflation Forward Rates			
	Δ 2-yr	PDF Level	PDF Slope	R ²	Δ 2-yr	PDF Level	PDF Slope	R ²	Δ 2-yr	PDF Level	PDF Slope	R ²
5-Year	0.84***			0.30	0.65***			0.24	0.19**			0.05
	[0.00]				[0.00]				[0.01]			
10-Year	0.59***	1.04***	0.85***	0.55	0.48***	0.92***	0.49***	0.45	0.11	0.12	0.36**	0.11
	[0.00]	[0.00]	[0.00]		[0.00]	[0.01]	[0.01]		[0.18]	[0.42]	[0.02]	
15-Year	0.29***			0.07	0.35***			0.15	-0.06			0.004
	[0.01]				[0.00]				[0.56]			
20-Year	0.18			0.03	0.30***			0.10	-0.12			0.01
	[0.17]				[0.00]				[0.42]			
5-Year	0.27*	0.81***	0.56***	0.25	0.30***	0.47**	0.43**	0.31	-0.03	0.35**	0.12	0.06
	[0.08]	[0.01]	[0.01]		[0.00]	[0.02]	[0.01]		[0.78]	[0.03]	[0.35]	
10-Year	0.20*	0.15	0.39**	0.10	0.27***	0.31**	0.31*	0.23	-0.06	-0.16	0.08	0.02
	[0.07]	[0.42]	[0.02]		[0.00]	[0.04]	[0.08]		[0.55]	[0.46]	[0.54]	
15-Year	0.11	-0.13	0.44***	0.08	0.21**	0.36**	0.26	0.17	-0.11	-0.49	0.18	0.11
	[0.54]	[0.51]	[0.01]		[0.01]	[0.04]	[0.10]		[0.42]	[0.10]	[0.34]	

In each of the three panels, each row reports coefficients from the following regression both with and without our EDX factors: $\Delta f_t^{X(n)} = a_X(n) + b_X(n)\Delta y_t^{\$(2)} + \beta_X^L(n)L_t + \beta_X^S(n)S_t + \Delta \varepsilon_t^{X(n)}$, where $\Delta f_t^{X(n)}$ is the change in the forward nominal rate ($X(n) = \$(n)$), the forward real rate ($X(n) = TIPS(n)$), or the forward break-even inflation rate ($X(n) = \pi(n)$) at maturity n , $\Delta y_t^{\$(2)}$ is the change in the two-year zero-coupon nominal yield, L_t is our level factor, and S_t is our slope factor (derived from changes in PDF 1Q through PDF 5Q around FOMC meetings). All changes in yields and the PDF measures are calculated over two days, following Hanson and Stein (2015). The sample period is January 1999 through February 2012, dropping 5 LSAP dates omitted by Hanson and Stein (2015), resulting in 107 observations. Eicker-White standard errors are used to calculate [p-values] shown below coefficient estimates. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table A.4: 10-yr Yield Decomposition: Monetary Policy Surprises & The Term Structure of Monetary Policy Uncertainty

	Full Sample:					Non-ZLB Sample:			
	Δ 10-yr Risk Neutral Yield			Δ 10-yr Term Premium		Δ 10-yr Term Premium			
PDF Level	0.05	-0.24**	-0.24**	0.44**	0.43**	0.44	0.22	0.24	0.24
	[0.34]	[0.02]	[0.02]	[0.02]	[0.02]	[0.03]**	[0.28]	[0.21]	[0.27]
PDF Slope	0.01	-0.07	-0.05	0.89***	0.76***	0.88***	0.56***	0.46**	0.54**
	[0.95]	[0.55]	[0.67]	[0.00]	[0.00]	[0.00]	[0.01]	[0.05]	[0.02]
Δ 2-yr	0.73***			-0.07			-0.17**		
	[0.00]			[0.51]			[0.02]		
Target		0.22***			-0.22**			-0.21*	
		[0.00]			[0.04]			[0.06]	
Path		0.59***			0.02			-0.05	
		[0.00]			[0.83]			[0.39]	
PNS			0.61***			-0.05			-0.11*
			[0.00]			[0.58]			[0.09]
PDF F-test	[0.62]	[0.05]	[0.04]	[0.00]	[0.00]	[0.00]	[0.02]	[0.07]	[0.04]
R ²	0.87	0.79	0.78	0.11	0.16	0.11	0.08	0.13	0.06

The PDF F-test row shows the [p-value] for the hypothesis test that the regression coefficients on the PDF Level and PDF Slope are jointly zero. Eicker-White standard errors are used to calculate [p-values] shown below coefficient estimates. The “Full Sample” period is January 1994 – December 2019 resulting in 207 observations. The “Non-ZLB Sample” period is January 1994 – December 2019, excluding December 2008 – December 2015, resulting in 150 observations. The risk neutral yield and term premium measures are the [Adrian, Crump and Moench \(2013\)](#) estimates provided by the Federal Reserve Bank of New York. All changes in yields and the PDF measures are calculated over a one-day window around scheduled FOMC meetings.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$