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Monetary Policy Uncertainty and the Response of the Yield Curve to Policy Shocks*

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Abstract

This paper studies the non-linear response of the term structure of interest rates to monetary policy shocks. We show that uncertainty about monetary policy changes the way the term structure responds to monetary policy. A policy tightening leads to a significantly smaller increase in long-term bond yields if policy uncertainty is high at the time of the shock. We also look at the decomposition of bond yields into expectations about policy and the term premium. The weaker response of yields is driven by the fall in term premia, which fall even more if uncertainty about policy is high. These findings are robust to the measurement of monetary policy uncertainty and the definition of the monetary policy shock. We argue that *short-term* uncertainty about monetary policy tends to make yields of longer maturities relatively more attractive. As a consequence, investors demand lower term premia. This intuition is supported by the fact that *long-term* monetary policy uncertainty leads to opposite effects with term premia increasing even more after a policy shock.

Keywords: Monetary policy uncertainty, term structure, term premium, unconventional monetary policy, local projections

JEL classification: E43, E58, G12

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1 Introduction

The term structure of interest rates, that is, the range of bond yields across the maturity spectrum, is closely tracked by central bankers and market participants. The reason for this is twofold. First, long-term interest rates should contain information about the public's expectations about future monetary policy. Central banks use the term structure to study the stance of monetary policy perceived by markets. Second, the term structure itself can be a policy target. Unconventional monetary policies such as forward guidance and asset purchases, which the Federal Reserve (Fed) implemented after the financial crisis, were designed to reduce long-term interest rates and, hence, to flatten the yield curve at the zero lower bound. The latter dimension implies that monetary policy can to some extent affect nominal interest rates for longer maturities. This paper studies the Fed's ability to steer bond yields if the public is uncertain about the future direction of monetary policy.

It is well established that monetary policy can move the term structure (Evans and Marshall, 1998; Cochrane and Piazzesi, 2002). In fact, the effect of monetary policy on longer-term yields is at the core of the monetary transmission mechanism. However, researchers derive this finding using linear regression models for large samples of time series without allowing for the connection between policy shocks and bond yields to vary over time. Here we study a specific source of non-linearity, the changing degree of uncertainty about future monetary policy. Even though monetary policy is now better communicated and more predictable than in the past, policy anticipation is less then perfect. This gives rise to a considerable degree of monetary policy uncertainty. Empirical evidence suggests that the degree of uncertainty about monetary policy can be large and volatile (see, among others, Husted et al., 2016). This motivates us to analyze whether monetary policy is less effective in driving bond yields if households and market participants have doubts about monetary policy in the future, which are incorporated in long-term yields.

In this paper, we provide new stylized facts on the response of the yield curve to monetary policy. We proceed follows. First, we use data on fitted yields and estimates of term premia, respectively, on U.S. governments bonds from Adrian et al. (2013a) and Kim and Wright (2005) and related yields, term premia and the implicit expectations components of yields on different maturities to a monetary policy shock. The shock is a surprise change in the (shadow) federal funds rate and is derived from an orthogonalized auxiliary VAR model estimated on monthly U.S. data.

A series of local projections (Jordà, 2005) generates impulse response functions following a monetary policy shock. They show that bond yields increase after a policy tightening and term premia fall. Let us for a moment set aside the interpretation of the latter finding.

Second, we use several measures of monetary policy uncertainty, which are news-based, market-based or survey-based. Among them are the narrative index provided by Husted et al. (2016), the inter-quartile range of 3-month T-bill forecasts from the Survey of Professional Forecasters and the 3-month Merrill Lynch MOVE index of implied bond market variability. For reasons to be discussed below, these measures are interpreted to reflect uncertainty about monetary policy in the near future. These uncertainty measures are used in order to condition the impulse response of the term structure variables to a monetary policy shock on monetary policy uncertainty. Local projections are sufficiently flexible to estimate the non-linear term structure response to monetary policy shocks resulting from the interaction between the shock and the level of uncertainty. Our results suggest that the response of yields to a policy impulse is significantly reduced if uncertainty at the time the shock occurs is high. If uncertainty is two standard deviations above its sample mean, the response of 10-year yields can even become negative. To corroborate this findings, we also estimate a battery of state-dependent local projections, for which we differentiate between two regimes, a high-uncertainty and a low-uncertainty regime. The model is able to provide us with regime-specific impulse response functions.

Third, in order to assess whether the muted policy effect on yields is coming from the response of the expectations component or the term premium, we estimate impulse responses conditional on uncertainty of these two components of bond yields. Interestingly, the response of expectations of future short-rates is insensitive to monetary policy uncertainty. However, term premia fall even stronger the higher is the degree of policy uncertainty at the time the shock hits. Hence, it is the term premium response that is behind the reduced grip of policy on bond yields, the measurement of monetary policy uncertainty and the nature of the monetary policy shock. Using Romer and Romer (2004) shocks, which are not derived from (linear) VAR model, yields to similar results. The findings also survive when we estimate state-dependent impulse response functions rather than interacted responses. Hence, this paper establishes a new stylized fact: the response of bond yields to policy shocks is muted if uncertainty is large, and this is due to the response of term premia, which fall even stronger than under certainty about future policy.

The fall in term premia after a surprise tightening of monetary policy is well documented, see the evidence provided by Crump et al. (2017) and also the model results derived by Rudebusch and Swanson (2012). The term premium is the compensation that investors demand in order to be willing to hold longer-term securities instead of a revolving sequence of investments into short-term debt. If policy tightens, the return on nominal securities increases. At the same time, the policy tightening leads to a fall in real economic activity and consumption. Hence, returns increase in a state of the world in which investors appreciate the additional interest rate income. As a result, investors require a smaller premium to hold bonds. This effect is larger for longer maturities. The presence of uncertainty about future monetary policy amplifies the fall in term premia. This is because the uncertainty about policy translates into uncertainty about nominal returns, which makes a longer maturity relatively more attractive compared to a shorter maturity. Hence, the term premia falls more strongly after a policy tightening if uncertainty is large. Put differently, our results suggest that for very low levels of monetary policy uncertainty, monetary policy becomes *more* effective in influencing the yield curve.

We lend additional support to this finding by also looking on uncertainty about long-term inflation measured as the inter-quartile range of 10-year ahead information forecasts from the Survey of Professional Forecasters. In contrast to the measures of monetary policy uncertainty discussed before, this proxies uncertainty in the long-term, in which inflation is the dominating risk for investors into nominal securities. If we use this measure to interact monetary policy shocks, we find opposing results: term premia fall less if uncertainty is high. This is because long-term uncertainty, in contrast to short-term uncertainty, makes longer maturities less attractive for investors following a policy shock. As a result, term premia increase rather than fall.

The results put forward in this paper offer several implications for the design and the evaluation of monetary policy. The response of the term premium is one important channel for the transmission of unconventional policies such as forward guidance. The effects of monetary policies designed to reduce long-term bond yields can become less effective if monetary policy uncertainty is large. In this case, term premia would increase and partly offset the stimulating policy impulse. For monetary policy uncertainty being very low, monetary policy becomes more effective and term premia fall even stronger. This calls for monetary policy to be as predictable as possible in order to avoid large swings in monetary policy uncertainty. Likewise, under uncertainty the yield on long-term bonds becomes a noisy indicator of the policy stance as the effect of policy is obscured by the offsetting influence of monetary policy uncertainty. Finally, our results also offer a perspective on interest rate "conundrums" (Alan Greenspan) seen in recent years. A policy tightening that goes hand in hand with flat or even falling bond yields could be the result of elevated levels of monetary policy uncertainty.

This paper rests on several strands of the empirical literature. First, since Baker et al. (2016) proposed their Economic Policy Uncertainty (EPU) index, the literature on the effects of uncertainty shocks has exploded. Although the Baker et al. (2016) index comprises a subindex on monetary policy, which we also use below in our robustness section, the EPU index is much broader and covers all fields of economic policy. This literature focuses on the broadly defined EPU and does not study the interaction of monetary policy with uncertainty.

Aastveit et al. (2017) present a paper that is closely related to this paper. They show that high levels of general policy uncertainty reduce the influence of Fed policy on real economic variables such as consumption and investment. In a similar vein, Castelnuovo and Pellegrino (2017) present results from a nonlinear vector autoregression and an estimated DSGE model which support the notion that uncertainty dampens the effects of monetary policy. While they focus on the end of the monetary policy transmission process, we study the early stage of the transmission from the central bank to interest rates. Although these authors look at broadly defined economic policy uncertainty, our results are consistent with their findings.

Another closely related paper comes from Andrade et al. (2016). These authors study forward guidance under heterogeneous beliefs of market participants. They extend a New-Keynesian model of monetary policy by heterogeneous interpretations of forward guidance announcements of the Fed. Their results show that ambiguity of policy signals can reduce the effectiveness of policies such as forward guidance. We show more general results suggesting that monetary policy uncertainty in general, not just ambiguity about forward guidance, reduces policy effectiveness.

A second strand of the literature studies the impact of empirical measures of uncertainty, often incorporated in survey data, on the term structure. The earliest contribution comes from Jordà and Salyer (2003). They show that greater uncertainty about monetary policy leads to a decline in nominal interest rates. They model uncertainty as a mean preserving spread in the distribution of money growth. Buraschi and Jiltsov (2005), Arnold and Vrugt (2010), Dick et al. (2013), Buraschi et al. (2014) and D'Amico and Orphanides (2014) propose models that use survey information and find that uncertainty about monetary policy or the inflation target, respectively, is a main driver of bond market volatility and the size of the term premium, respectively. The authors use information from surveys of financial professional forecasters to proxy uncertainty. D'Amico and Orphanides (2014) show that the probability distribution of inflation forecasts from the Survey of Professional Forecasters (SPF) becomes an even more important driver of bond premia in periods of high inflation.

A third strand studies the effects of long-term inflation uncertainty on the term structure of interest rates. Cogley (2005) estimates a Bayesian VAR model that establishes a link between uncertainty about the inflation target and risk premia on long-term U.S. bonds. In a much cited contribution, Wright (2011) relates the fall in term premia in a cross-country data set to the fall in inflation uncertainty.

A fourth strand presents articulate term structure models which incorporate uncertainty. Ulrich (2013) explains term premia on U.S. bonds through Knightian uncertainty about trend inflation. Creal and Wu (2014) build a term structure model where second moments, which reflect uncertainty, have effects on several macroeconomic variables including the yield curve. A general equilibrium model of the term structure is presented by Leippold and Matthys (2015). They show that an increase in policy uncertainty, either broadly defined using the EPU index or narrowly defined using the EPU-subindex on monetary policy, leads to lower bond yields but a high volatility of bond yields. Sinha (2016) presents a dynamic stochastic general equilibrium (DSGE) model for the yield curve. Uncertainty, which is calibrated with options data, reduces long-term bond yields.

In contrast to the literature, we do not look at the effect of uncertainty on the yield curve as such. Rather, we study the response of the yield curve to monetary policy shocks when future monetary policy is uncertain. It is the interaction of monetary policy shocks and uncertainty, that is, the nonlinear nature of the response of the yield curve that we are interested in.

The remainder of this paper is organized as follows. Section two introduces the data series used in this study. Among them are several alternative measures of monetary policy uncertainty. Section three estimates the main model and discusses its findings, while section four sheds light on the robustness of our findings. A state-dependent model is estimated in section five. Finally, section six draws some policy conclusions.

2 Data

In this section we explain the data used in this paper. We start with data on bond yields and then discuss our benchmark measure of monetary policy uncertainty.

2.1 Yield curve data

To conceptualize the empirical approach of this paper, let us reconsider that the continuously compounded yield on an n-period discount bond, $y_t(n)$, can be decomposed as follows

$$
\begin{aligned}
y_t(n) &= \frac{1}{n}\mathbb{E}_t\left[i_t + i_{t+1} + \ \dots \ + i_{t+n-1}\right] + tp_t(n) && (1)\\
&= y_t^{\exp}(n) + tp_t(n) && (2)
\end{aligned}
$$

where i_t is the risk free nominal short-term interest rate and $tp_t(n)$ is the nominal term premium. Note that this decomposition describes an identity. In the absence of the term premium, the expectations hypothesis of the term structure of interest rates implies that the long-term yield equals the average expected short-term rate of the life of the bond. The term premium is the compensation investors demand for bearing interest rate risk. Hence, a time-varying term premium reflects the deviations of bond yields from what is implied by the expectations hypothesis. We refer to $y_t^{\exp}(n)$ as the expectations component of bond yields.

In the following we study how all three components of Equation (1) respond to monetary policy shocks and whether these responses are affected by monetary policy uncertainty. For that purpose we use the results from the estimated linear term structure model of Adrian et al. (2013a). Throughout the paper, we focus on maturities of $n = 1, 2, 5, 10$ years.

These authors use the zero coupon yield data constructed by Gurkaynak et al. (2007) and provide estimated term premia for all maturities. The expectations components is then computed as the difference between yields and estimated term premia. Figure (21) depicts all three elements of Equation (1).

In the robustness section we will also use an alternative dataset on the yield curve based on the estimation of Kim and Wright (2005), which is also often used in the term structure literature. This dataset is shown in Figure (22).[1]

2.2 Monetary policy uncertainty

In this paper, we use several alternative measures of monetary policy uncertainty, MPU_t. We will distinguish between measures of short-term monetary policy uncertainty and long-term uncertainty.

Benchmark measure of monetary policy uncertainty. Our benchmark measure of monetary policy uncertainty is the newspaper-based indicator proposed by Husted et al. (2016). They construct a monetary policy uncertainty indicator, which counts the uncertainty-related newspaper articles on the Fed in the *New York Times*, the *Wall Street Journal* and the *Washington Post* in a sample from 1985 to 2016. The

[1]A comparison between both datasets is provided by Li et al. (2017).

source of this series a well a of all other data series used in this paper is provided in Table (21). Thus, the index reflects the uncertainty perceived by the public. Its construction is similar to the work of Baker et al. (2016), who propose a newspaper-based index of general U.S. economic policy uncertainty. Since the raw data is very volatile, we construct a 12-month moving average, $\widehat{MPU}_t$. The weighted average exhibits a smooth cycle in policy uncertainty. For the empirical analysis below, we also demean this series and normalize it by its standard deviation

$$\widetilde{\widehat{MPU}}_t = \frac{\widehat{MPU}_t - \overline{MPU}}{\sigma_{MPU}},$$

where $\overline{MPU}$ is the sample mean of the moving average index and σ_{MPU} is the standard deviation of the weighted index. This shows policy uncertainty in terms of standard deviations from its mean. Below, we will study scenarios of monetary policy shocks emanating from situations with policy uncertainty being one or two standard deviations above its mean. The same demeaning and normalization is applied to all other series such that the level and the fluctuations of uncertainty are comparable across measures. However, the other measures are not smoothed by taking moving averages as they appear much less volatile.
Figure (1(a)) shows the MPU index. Interestingly, policy uncertainty fluctuates around a constant mean. It can be seen that policy uncertainty peaks before major policy changes. In 2002/2003, in a phase of unusually low interest rates, uncertainty is high due to uncertainty about the begin of the tightening cycle, that finally started in 2004. Likewise, policy uncertainty increases sharply before the lift-off of the federal funds rate in December 2015 after almost seven years with the policy rate at the zero lower bound.[2] In 2008/9, in contrast, monetary policy uncertainty is extremely low. Given the decline in both real activity and inflation and the increase in financial stress, the future course of monetary policy appears to have been relatively undisputed. It is worth mentioning the the post-2008 period of policy being constrained by the zero lower bound did not lead to a markedly higher degree of policy uncertainty.

Alternative measures of short-term monetary policy uncertainty. The first alternative measure is the variation of the Husted et al. (2016) MPU index which restricts the uncertainty terms in newspaper articles to appear in a proximity of at most 10 words to the words "Federal Reserve" or "monetary policy". This measure is plotted in Figure (1(b)). The second proxy is the inter-quartile range of forecasts

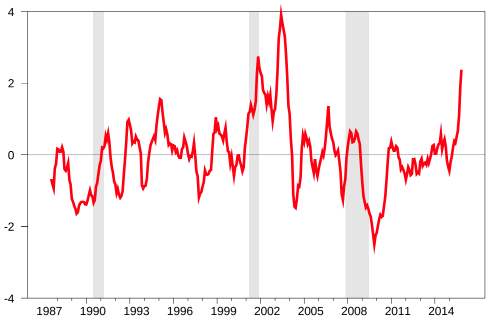
[2]In December 2015, when the Fed indeed tightened policy, which is not included in this sample, uncertainty falls to more normal levels.

from the Survey of Professional Forecasters (SPF).[3] As a substitute for the Husted et al. (2016) indicator, we use the 12 months ahead survey forecasts of 3-month T-bill rates. Forecasters covered by the Survey of Professional Forecasters are asked to give their expected 3-month T-bill several quarters ahead. We exploit this information and use the cross-section dispersion of T-bill expectations measured as the inter-quartile range that is, the difference between the 75th percentile and 25th percentile of the cross-sectional forecast distribution. Since the survey is conducted on a quarterly basis, we interpolate the forecast dispersion from a quarterly to a monthly frequency. The forecast dispersion is plotted in Figure (1(c)). Uncertainty about future interest rates peaks in the late 1980s, in the aftermath of the 2001 recession and in 2008/9 at the height of the financial crisis. Remarkably, uncertainty falls to a low, two standard deviations below its mean, during 2011/2012 when the Fed communicated to keep interest rates low for some time into the future. According to the measure plotted here, these policies successfully reduced forecast dispersion.

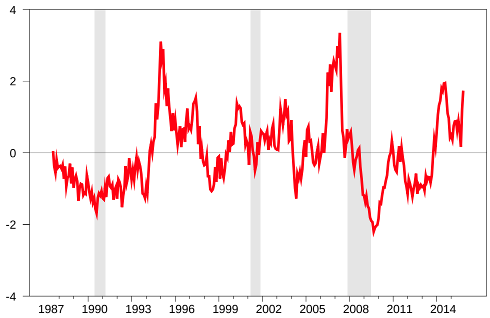
[3]In this case we measure uncertainty by forecast disagreement. See Lahiri and Sheng (2010) for an analysis.

Figure 1: Measures of monetary policy uncertainty in the short and the long-run

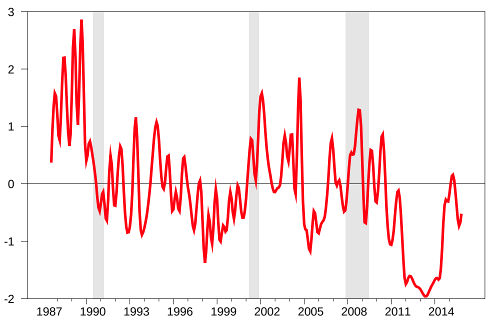
(a) MPU index of Husted et al. (2016)



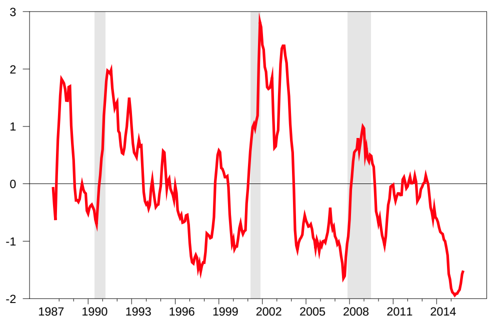
(b) MPU10 index of Husted et al. (2016)



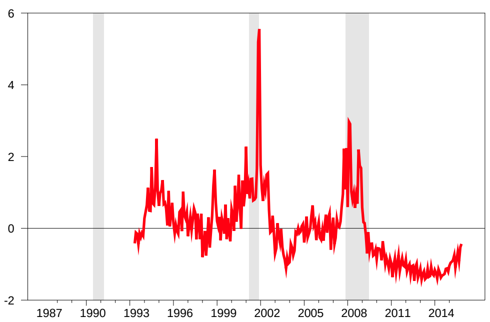
(c) Dispersion of 3-month SPF T-bill forecasts



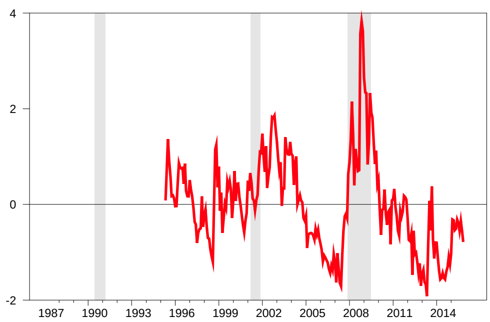
(d) Monetary component of Baker et al. (2016) EPU index



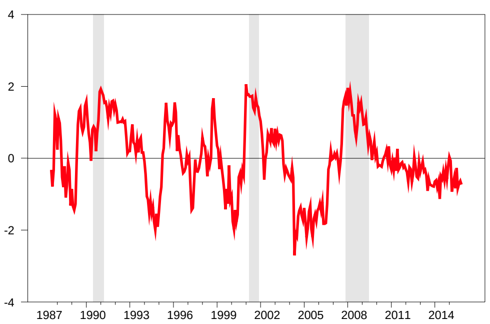
(e) 3M3M of Istrefi and Mouabbi (2017)



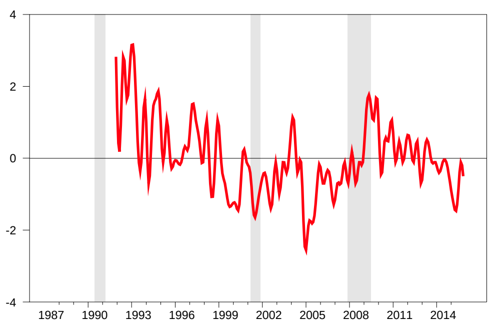
(f) 3M MOVE index



(g) Disagreement from Michigan Survey



(h) Dispersion of 10-year SPF inflation forecasts



Notes: All variables are measured in standard deviations from their sample means. The shaded areas reflect NBER recession dates.

The third alternative measure of uncertainty is the monetary policy-related subcategory of the general Baker et al. (2016) economic policy uncertainty indicator. The Baker et al. (2016) index of aggregate economic policy uncertainty is composed of different subindicators for specific fields of policy. Among them is the subindex for uncertainty about monetary policy. Both indicators are derived from an analysis of newspaper articles on monetary policy. As shown in Husted et al. (2016), both indicators are positively correlated but but often diverge. This series is shown in Figure (1(d)). The fourth measure is the subjective interest rate uncertainty index of Istrefi and Mouabbi (2017). They construct this series from the Consensus Economics survey. The specific measure we use is the uncertainty the 3-month interest rate three month ahead (3M3M), which is shown in Figure (1(e)). Another short-term measure is the MOVE (Merrill Lynch Option Volatility Estimate Index) index reflecting the implied volatility of one-months Treasury options three months ahead, see Figure (1(f)).
The last measure reflects the disagreement of households about future interest rates. One question of the Michigan Survey is whether households expect interest rates in the next 12 months to increase, remain unchanged or decrease. A fourth category is "don't know". To derive a measure of disagreement, we drop the "don't know" answer and rescale the shares of the other answers such that they add up to 100. We then calculate the Lacy (2006) measure of disagreement, which has been widely used in the literature. [4] The standardized measure of disagreement of households is shown in Figure (1(g)).

A measures of long-term monetary policy uncertainty. The measures presented before are supposed to be indicator of short-term uncertainty. That is, both measure investors' uncertainty about monetary policy in the next one or two years. Below we also need an indicator that reflects long-term uncertainty, for example, uncertainty about the inflation target pursued by the Fed in the long-run. This should be the main source of risk of investors in safe, nominal Treasury securities. For that purpose, we use the dispersion of the forecasts for the 10-year inflation forecasts included in the SPF. The underlying SPF forecasts are about the average inflation rate over the coming 10 years. Figure (1(h)) depicts the series of long-run inflation

[4] The disagreement measure is calculated as follows

$$MPU_t^{Michigan} = \sum_{i=1}^{2} F_t^i \left(1 - F_t^i\right),$$

where F_t^i is the cumulative relative frequency of the i-th answer category. The sum goes over two of the three categories since $1 - F_t^i$ captures all other alternatives to answer i.

uncertainty in units of standard deviations from its sample mean. The series reaches a low in 2005, suggesting that during the Great Moderation before the financial crisis uncertainty about the long-run inflation rate was not an issue for forecasters. After the crisis, long-term uncertainty fluctuated mildly around its sample mean. Interestingly, the correlation between the normalized inter-quartile ranges for the one year ahead 3-month T-bill rate and the 10-year ahead inflation rate is essentially zero. Hence, both indicators are orthogonal and reflect strictly different horizons of monetary policy uncertainty. Likewise, the correlation between long-term uncertainty and the other measures of short-term uncertainty is either very low or negative. Figure (6) shows a scatter plot of the measure of long-term uncertainty against the 1-year and 10-year term premia. The figure supports the notion of long-term uncertainty as 10-year term premia are much more closely associated to this measure than 1-year term premia.

3 The empirical approach

This section introduces non-linear models to shed light on the transmission of policy to the term structure of interest rates.

3.1 Interacted local projections

We provide impulse responses to monetary policy shocks, ϵ_t, based on local projections (Jordà, 2005).[5] Local projections are preferable over vector autoregressions (VAR) due to their ability to handle non-linearities. Here, we extend the linear local projection with an interaction term that reflects the intertwined nature of monetary and monetary policy uncertainty. Each of the three elements from Equation (1), $y_t \in (y_t(n), y_t^{\exp}(n), tp_t(n))$, is separately regressed on the monetary policy shock at t, ε_t, as well as lags of the vector $\mathbf{x}_t$, which includes y_t as well as other potential control variables

$$y_{t+h} = \alpha_h + \beta_h \varepsilon_t + \delta_h' \sum_{s=1}^{q} \mathbf{x}_{t-s} + u_{t+h}. \tag{3}$$

This equation can be understood as one equation of a VAR system. Plotting the estimated β_h as a function of the horizon h gives the dynamic response of the dependent variable to a policy shock at t. The estimated β_h reflects the unconditional impact of a policy shock on h-periods ahead yields. We set $q = 2$, and the vector $\mathbf{x}_t$ includes the dependent variable as well as our measure of monetary policy uncertainty,

[5] Aastveit et al. (2017) also obtain their findings from non-linear local projections.

$\widetilde{MPU}_t$. If ε_t is a true shock, that is, an unexpected change in monetary policy, it should be uncorrelated with contemporaneous macroeconomic variables. Therefore, we do not include additional control variables. The source of the monetary policy shock is discussed below.

Since the dependent variable is dated h periods ahead, the error terms will exhibit serial correlation. We follow Jordà (2005) and apply a Newey-West correction to our estimation errors. The maximum lag for the Newey-West correction is set to $h + 1$. The Newey-West corrected errors are used to construct confidence bands around our estimates.

One advantage of local projections is the flexibility to account for an interaction of policy effects. To shed light on whether the yield-response is stronger or weaker in times of high uncertainty about monetary policy, we extend this linear model to account for the interaction of a policy shock and the standardized measure of monetary policy, $\widetilde{MPU}_t$.

$$y_{t+h} = \alpha_h + \beta_h \varepsilon_t + \gamma_h \left(\varepsilon_t \times \widetilde{MPU}_t \right) + \delta_h' \sum_{s=1}^{q} \mathbf{x}_{t-s} + u_{t+h}. \tag{4}$$

The overall effectiveness of monetary policy now consists of the unconditional effect, β_h, plus an effect that is conditional on policy uncertainty

$$\frac{\partial y_{t+h}}{\partial \varepsilon_t} = \beta_h + \gamma_h \times \widetilde{MPU}_t. \tag{5}$$

Below, we plot $\beta_h + \gamma_h \times \widetilde{MPU}_t$ as a function of h for different levels of $\widetilde{MPU}_t$. In particular, we look as impulse responses originating from levels of monetary policy uncertainty one or two standard deviations above its mean. We estimate the model for the maturities mentioned before using monthly data over the sample period 1987:8 to 2011:15. The sample begins with Alan Greenspan taking office as chair of the Fed and ends in the month before the "lift-off" of the Federal funds target rate in December 2015 after several years in which policy was constrained by the effective lower bound.

3.2 Monetary policy shock

It remains to specify the monetary policy shock, ε_t. Since linear projections, in contrast to VAR models, do not account for the mutual interaction between monetary policy and the business cycle, and hence identifying assumptions cannot be used to isolate shocks, a shock must be put into the model as an explanatory variable. Hence, we need to estimate an auxiliary model to identify a monetary policy shock.

We derive the shock from an estimated vector autoregression (VAR) model for the U.S. economy that includes four variables: the log of industrial production, the log of the Consumer Price Index, the Wu and Xia (2016) shadow federal funds rate and the Financial Stress Index calculated by the Federal Reserve Bank of Chicago. Industrial production and consumer prices reflect the domestic business cycle and are standard inputs for monetary VAR models. Since the Fed's conventional policy instrument, the federal funds rate, has been bounded by zero between 2009 and 2015, we use the shadow federal funds rate instead. The shadow rate is the federal funds rate we would observe in the absence of the zero lower bound. It reflects the unconventional policy measures implemented by the Fed such as asset purchases and forward guidance. Finally, any monetary VAR model covering the post-2007 period would remain incomplete without accounting for financial stress which has been, besides real activity and prices, an important determinant of Fed policy.

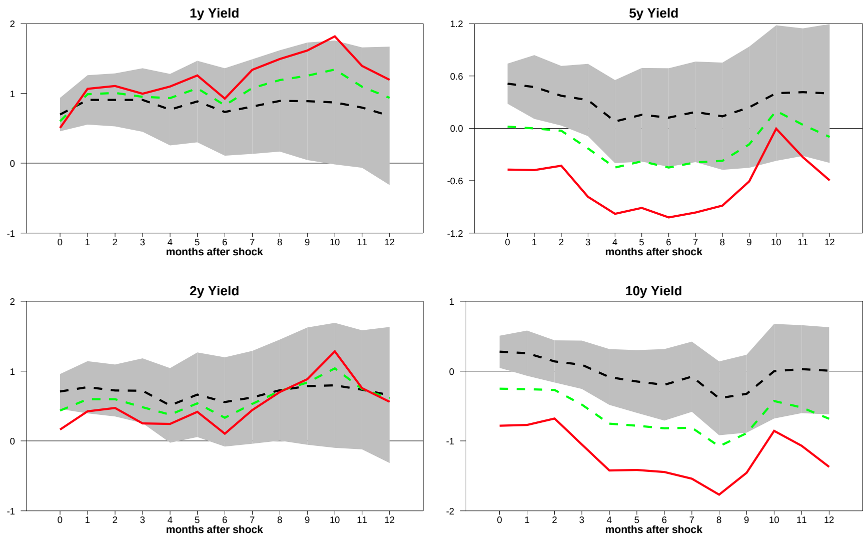
In the spirit of Christiano et al. (1999), a monetary policy shock is identified by using a Choleski ordering of the variables. The specific ordering used here is the order by which the variables have been introduced in the previous paragraph. This implies that a monetary policy shock is restricted to contemporaneously affect financial stress, but affects real activity and prices with a one-period delay. The resulting shock series, which is depicted in Figure (7), is used for estimating the term structure effects in this paper.

There is one caveat to be discussed at this point. The shock is derived from a linear VAR model in which the policy transmission is linear and the systematic response of policy to the state of the economy is linear too. It is then put into non-linear local projections in order to estimate the state-dependent effect of monetary policy on the term structure. It could be argued that if bond yields respond non-linearly to policy, so should industrial production and prices. However, the question we want to address is whether policy that is set in a linear way has non-linear effects on yields. As a robustness check, we will also present results from using a Romer and Romer (2004) shock that is not derived from a VAR model below. These authors calculate the intended target rate for the federal funds rate at each meeting of the Federal Open Market Committee and control the series for the effects of the Greenbook forecasts of inflation and real activity on intended policy. The resulting series gives the shock component of policy decisions. As a natural consequence of this approach, Romer-Romer shocks cannot be calculated if the federal funds rate is bounded by the zero lower bound.

3.3 Results

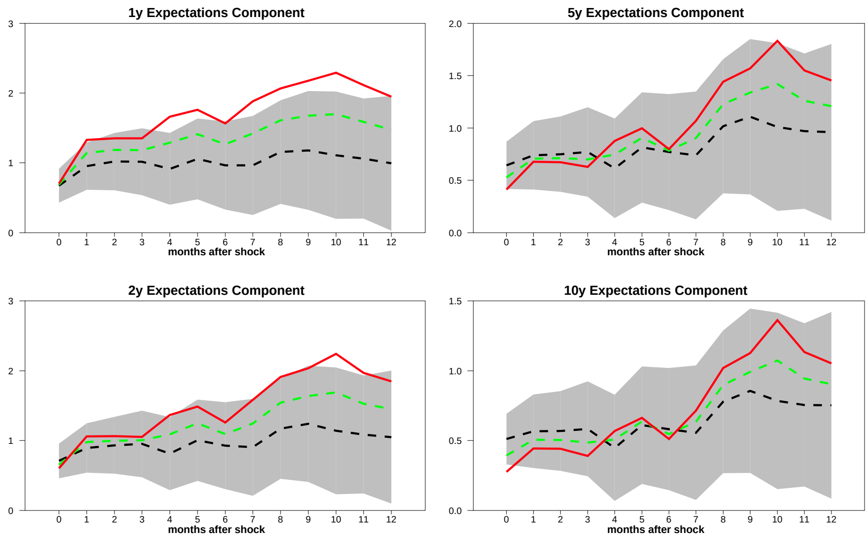
The resulting impulse response functions for bond yields are plotted in Figure (2). In this figure as well as in all subsequent ones, the black, dashed line shows the unconditional response of yields to an identified monetary policy tightening of 100 basis points, which corresponds to the estimated β_h coefficient. We find that on impact, yields at all four maturities significantly increase. As expected, the response is stronger at the short end of the yield curve, hence the shock leads to a tilting of the yield curve. Furthermore, the response is more persistent at the 1-year horizon than at the 10-year horizon. Note that this response is not conditional on the degree of monetary policy uncertainty.

Figure 2: Response of yields to a monetary policy shock



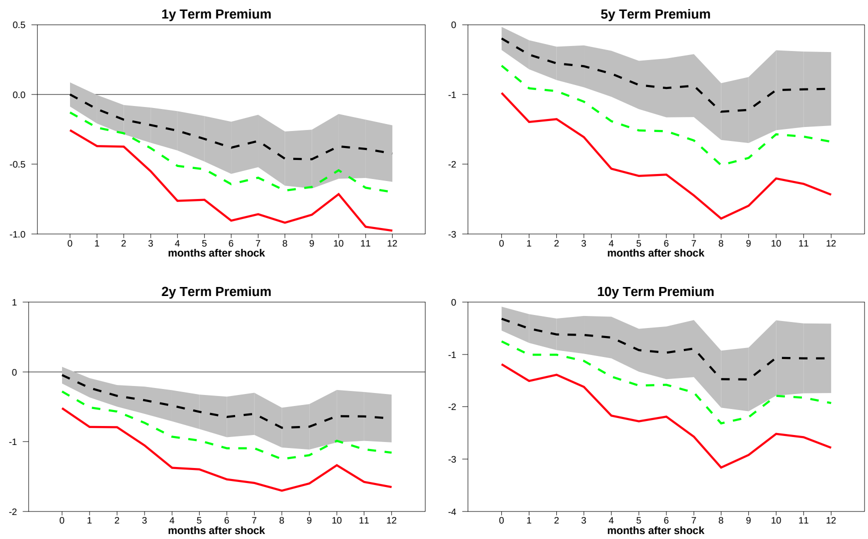
Notes: The black, dotted line is the unconditional response of bond yields to a monetary policy shock with a 90% confidence band. The green, dotted (red, solid) line reflects the response for uncertainty being one or two standard deviations above its mean.

Figure 3: Response of expectations components to a monetary policy shock



Notes: The black, dotted line is the unconditional response of bond yields to a monetary policy shock with a 90% confidence band. The green, dotted (red, solid) line reflects the response for uncertainty being one or two standard deviations above its mean.

Figure 4: Response of term premia to a monetary policy shock



Notes: The black, dotted line is the unconditional response of bond yields to a monetary policy shock with a 90% confidence band. The green, dotted (red, solid) line reflects the response for uncertainty being one or two standard deviations above its mean.

To visualize how elevated levels of uncertainty affect the transmission to the yield curve, we now plot the full response given in Equation (5) for a level of monetary policy uncertainty that is one (green, dashed line) or two standard deviations (red, solid line), respectively, above its sample mean. For shorter maturities, that is, one and two year maturities, we find that the impulse responses under uncertainty lie within the confidence band around the unconditional estimate. This implies that monetary policy at the time the shock hits the term structure play no role for the adjustment of short-term yields. However, for longer term yields, in our case five and ten year maturities, a higher degree of uncertainty leads to a significantly smaller response of bond yields. For an uncertainty level that is two standard deviations above its mean, the response of the ten year yield even changes its sign. Overall, these results imply that monetary policy uncertainty severely impairs the Fed's ability to affect long term interest rates.

Given the decomposition of bond yields in Equation (1), we now look at the two components of bond yields, the expectations component and the term premium, respectively. The results for the expectations components are shown in Figure (3). The unconditional responses suggest that expectations about future short rates increase for all maturities. Under elevated levels of uncertainty, this response is not changed significantly. This is because the impulse responses under monetary policy uncertainty are located within the confidence interval around the unconditional response. Hence, even higher levels of uncertainty do not hamper the Fed's ability to affect expectations about future policy. In light of the decomposition of yields, this finding implies that the response of the expectations component cannot explain the strong impact of uncertainty on fitted yields discussed in the previous paragraph.

This leaves us with the term premium as the remaining element of (1) to explain the reduced effectiveness of policy under uncertainty.[6] Figure (4) shows the responses of the estimated term premia to the policy shock. We find the response of term premia to unconditional policy shocks to be negative. Hence, a policy tightening leads to a reduction in term premia. The sign of this response is consistent with the results of Adrian et al. (2013b) and Crump et al. (2017). It is also consistent with the idea that monetary policy shocks depress consumption growth and lead to higher returns on risk-free assets. Hence, an increase in the bond's payoff when consumption growth is expected to be low should make investors more willing to invest in longer-term bonds and lead to a lower risk premium.[7]

The question now is whether higher monetary policy uncertainty enforces or dampens this effect. Our central finding is that a policy tightening under uncertainty lead to an even larger drop in the term premium. As Figure (4) shows, shocks emanating from states with uncertainty being one or two standard deviations larger than the

[6] As a matter of fact, "explain" does not mean a structural interpretation.

[7] The sign of this response is consistent with the findings of Rudebusch and Swanson (2012).

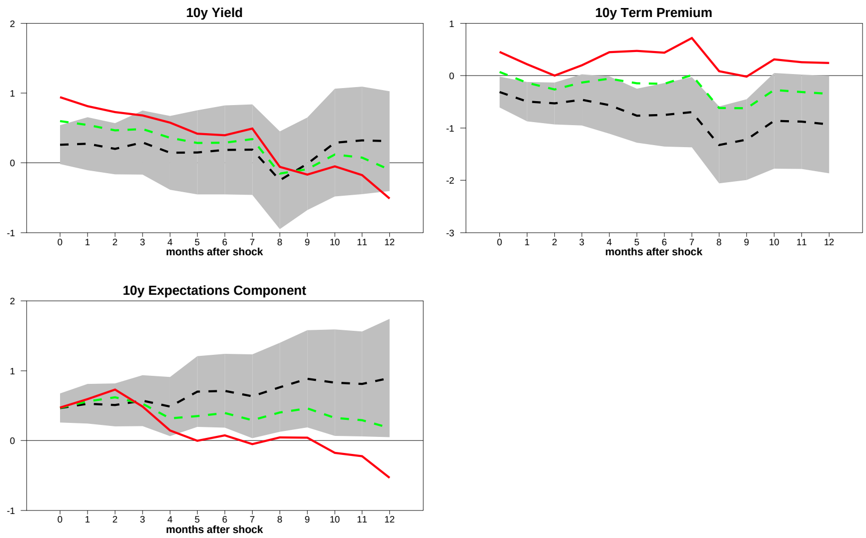
sample average lead to responses that are outside the confidence band around the unconditional estimates. Hence, it is the negative response of the term premium that holds the key to the smaller reaction of yields under uncertainty. The fall in the term premium after the shock is larger under uncertainty. This result is corroborated in several alternative specifications below.

What is the intuition behind this finding? As mentioned before, it is intuitive that the compensation demanded by investors in order to invest in the long end of the yield curve falls if policy tightens. This is the unconditional response. Under monetary policy uncertainty, investors are unsure about the short rate in the near future. Hence, the longer end of the yield curve becomes relatively more attractive than the short end. Investors would be reluctant to repeatedly invest into the short end. Consequently, the term premium falls even more than under certainty.

3.4 Long-term monetary policy uncertainty

This interpretation rests on the assumption that the uncertainty we measure with the Husted et al. (2016) index is about the short to medium run only. Put differently, if our intuition is correct, the beliefs about monetary policy in the long-run, e.g. the anchoring of inflation expectations, should not be affected by current policy uncertainty. To shed light on the impact of monetary policy shocks under long-term uncertainty, we re-estimate the model for an alternative measure of uncertainty. This measure is the inter-quartile range of 10-year ahead inflation forecast from the Survey of Professional Forecasters as introduced before. Importantly, the disagreement about 10-year ahead inflation forecasts is supposed to capture long-run uncertainty.

Figure 5: Responses to a monetary policy shock: long-term uncertainty



Notes: The black, dotted line is the unconditional response of bond yields to a monetary policy shock with a 90% confidence band. The green, dotted (red, solid) line reflects the response for uncertainty being one or two standard deviations above its mean.

Figure (5) contains the responses of the long end of the yield curve to the monetary policy shock conditional on long-run inflation uncertainty.[8] As mentioned before, the long-run risk for buyers of nominal bonds should be inflation as opposed to short-run policy uncertainty. We find support for our conjecture: conditional on uncertainty, the response of yields is changed only marginally. Now the term premium response to monetary policy is muted if uncertainty is large - exactly the opposite of what we find under short-term interest rate uncertainty. Put differently, uncertainty about the long-term inflation perspective makes longer maturities less attractive for bond investors such that the term premium does not fall if policy tightens.

To conclude this section, let us stress that the model is non-linear but symmetric. This means that the effects for a policy easing rather than tightening would be of identical size in absolute terms. A policy easing, such as implied by the unconventional measures the Fed implemented while the economy was at the zero lower bound, reduces long-term interest rates even more when uncertainty about policy is relatively low.

We have now shown our main finding. The following section strengthens this evidence by estimating models with alternative yield curve data, other proxies for monetary policy uncertainty and different model specifications.

[8]The results for the other maturities are available upon request.

4 Robustness

This section presents evidence that corroborates and extends the results from the previous sections. To save space, we estimate each modification for the 10-year maturity and the Adrian et al. (2013a) dataset only. [9]

MPU10 index of Husted et al. (2016). The results are very similar to the findings from the baseline model. To save space, these results are not shown in this paper.

Cross-sectional dispersion of 3-months T-bill expectations. A more direct measure of monetary policy uncertainty is the difference of interest rate forecasts among forecasters at a given point in time. Here we use the inter-quartile range of the 3-months T-bill forecasts from the Survey of Professional Forecasters.
The resulting estimates, again only for the 10-year maturity, are shown in Figure (8). In this case we do not only plot the unconditional response to policy shocks and the response for uncertainty being one standard deviation above its mean, but also the response for uncertainty being two standard deviations *below* its mean. The latter corresponds to the level of uncertainty during the period of unconventional monetary policies. We again find that contractionary policy shocks, originating in times of high uncertainty, lower the term premium even more than shock from normal times. For exceptionally *low* levels of uncertainty, such as during 2011/12, we find a positive response of the term premium to a tightening shock. This implies that a policy easing, which was implemented at that time, did have the expected effects and led to a lowering of term premia.

Baker et al. (2016) subindex in monetary policy uncertainty. In this robustness exercise, we replace the Husted et al. (2016) index with the Baker et al. (2016) subindex on monetary policy. Figure (9) reveals that the response of the term premium to a surprise tightening is significantly reduced if uncertainty is high - very much like in the baseline model. In this specification, however, the expectations part of the 10-year yield increases more strongly under uncertainty.

3M3M index of Istrefi and Mouabbi (2017). The results are shown in Figure (10). Following a monetary policy tightening, bond yields fall if uncertainty is large. This result is again driven by the response of the term premium. The response of the expectations component, however, is not affected by the degree of uncertainty. The

[9] All other combinations of data, monetary policy uncertainty proxy and shock series are available upon request.

effect of uncertainty is smaller than for other uncertainty proxies.

3M MOVE index. The MOVE index of implicit short-term Treasury volatility is a measure of monetary policy that is often used by market participants. When we replace our benchmark uncertainty measure by the MOVE index, we obtain the results shown in Figure (11). The response of bond yields to a Fed tightening is slightly reduced when uncertainty is two standard deviations above its mean, which is driven by the response of the term premium. Compared to the other results based on alternative measures of policy uncertainty, however, we obtain the smallest effect of uncertainty.

Disagreement on 12-months interest rate from Michigan Survey. Figure (12) presents the impulse response functions for monetary policy uncertainty measured by the disagreement among households about future interest rates. High levels of disagreement give rise to a smaller response of bonds yields. Again, the response of the 10-year term premium holds the key for understanding this effect. Term premia fall more strongly under higher levels of disagreement.

Romer and Romer (2004) shocks. The baseline model uses an identified monetary policy shock stemming from an estimated VAR model to shock the yield curve. As mentioned before, it could be argued that a shock derived from a linear VAR model overstates the degree of non-linearity in the adjustment of the yield curve. This is because any ommitted non-linearity in the VAR is reflected in the shocks and, ultimately, also in the term structure results. Therefore, we check the robustness of our findings by using a shock that has not been derived from a linear VAR. The shock we choose is the famous Romer and Romer (2004)-type shock, which is derived from the records of meetings of the Federal Open Market Committee (FOMC) and is orthogonal to the Fed's projections of the business cycle. Here we use the estimates by Johannes Wieland as contained in the web appendix to Ramey (2016). A light limitation is that Romer-Romer shock series covers the sample up to 2007:12 only. Figure (13) presents the resulting impulse response functions. The fall in the term premium is exacerbated if uncertainty about monetary policy is high, which is the main result of this paper. In contrast to some of the previous estimates, however, the 10-year expectations component increases less strongly under uncertainty. Both factors limit the impact of monetary policy shocks on the yield curve.[10]

[10] We also have results (not shown here) from a model with the change in the (shadow) federal funds rate as a policy shock. This corresponds to a naive interpretation of the shock that lacks the notion of a surprise change in policy. All main results are unchanged.

Kim-Wright (2005) yield curve estimates. While the Adrian et al. (2013a) data is widely used in academic research, other estimates of the yield curve are available. In particular, the Kim and Wright (2005) dataset is a popular alternative. In order to check whether our results still hold, we change the yield curve estimates in our model. Figure (14) reports the results based on the 10-year yield and term premia estimated by Kim and Wright (2005) and the corresponding expectations component. The results remain very similar to our baseline findings.

The role of NBER recession dates. It is well known that the effects of monetary policy on the real economy differ between phases of the business cycle (see Tenreyro and Thwaites, 2016). It could be argued that the loss in effectiveness of monetary policy with respect to bond yields reflects recessions, with monetary policy uncertainty simply being larger during recessions than during boom periods. To disentangle both factors, we run a regression in which the monetary policy shock interacts not with the degree of uncertainty, but with a dummy that is one during an NBER-dated recession and zero otherwise. If our results are driven by the business cycle, we expect to find that term premia fall more strongly during recessions such as in the baseline results. Figure (15) plots the impulse responses. We find that the response during recessions does not systematically differ from the unconditional response of the yield curve. Hence, our baseline findings originate from fluctuations in monetary policy uncertainty and not from different states of the business cycle.

The endogenous nature of monetary policy uncertainty. The empirical model used before interacts the monetary policy shock with a *given* level of monetary policy uncertainty. Thus, we assume monetary policy to be exogenous. This is a strong assumption that we might want to relax as a surprise change in the monetary policy stance, hence, a shock, potentially also reveals information and affects monetary policy uncertainty. Furthermore, recent monetary policies such as forward guidance have specifically been designed to affect the public's expectations and, as a result, to change monetary policy uncertainty.
Figure (16) compares monetary policy uncertainty, measured by all seven indicators, three months before a forward guidance announcements to three months after the announcements. We draw on Del Negro et al. (2015) and Swanson (2017) and pick August 2011 and January 2012 as months in which important forward guidance information was issued by the Fed in its post-meeting statements. We see that in most cases monetary policy uncertainty is lower in the months after the announcement

than before. Hence, monetary policy seems to have an effect on uncertainty.
We construct a measure of monetary policy uncertainty that is purely exogenous, that is, orthogonal to the monetary policy shock. Creating such a measure requires us to extract the endogenous reactions of uncertainty to other macroeconomic variables. Here, we resort to the auxiliary VAR model used before to identify the monetary policy shock. We extend this model and add our benchmark measure of monetary policy uncertainty to this model. We then identify an uncertainty shock, a change in monetary policy uncertainty that is orthogonal to the other four variables in the system. This is accomplished by imposing that within a given period, monetary policy uncertainty responds to output, prices and monetary policy but not financial stress. Hence, the uncertainty variable is ordered forth and a simple Cholesky identification is imposed. This allows us to extract the shock component of uncertainty, which is orthogonal to the information contained the VAR model. This shock component is then used as an interacting variables in our local projections. The resulting impulse responses are shown in Figure (17). The results do not change qualitatively.

5 The state-dependent transmission of policy shocks to the term structure

Another way of looking at non-linear monetary policy transmission to the yield curve is to separate two regimes that are characterized by different degrees of monetary policy uncertainty. Suppose there are two observable regimes, I and II. We construct a dummy variable, I_t, which is one if the economy is in regime I and zero if the economy is in regime II. For $I_t = 1 \; \forall \; t$ the model collapses to the linear benchmark presented before. State I stands for a regime with high monetary policy uncertainty and state II is the corresponding state with a low degree of uncertainty

$$I_t = \begin{cases} 1 & \text{if } \widetilde{MPU}_t > \tau \\ 0 & \text{if } \widetilde{MPU}_t \leq \tau, \end{cases}$$

where τ is the threshold that separates both states. We set $\tau = 0.5$, that is, the economy is in the high-uncertainty state if monetary policy uncertainty is more than 0.5 standard deviations higher than its long-run average. The model can now be generalized to

$$
\begin{aligned}
y_{t+h} \;=\;& I_{t-1}\left[\alpha_h^I + \beta_h^I \varepsilon_t + \left(\delta_h^I\right)' \sum_{s=1}^{q} \mathbf{x}_{t-s}\right] \\
&+ (1 - I_{t-1})\left[\alpha_h^{II} + \beta_h^{II} \varepsilon_t + \left(\delta_h^{II}\right)' \sum_{s=1}^{q} \mathbf{x}_{t-s}\right] + u_{t+h}.
\end{aligned} \tag{6}
$$

In this model the constant, the impact of policy shocks and the influence of the control variables are allowed to differ across regimes. The estimated β_h^I reflects the impact of monetary policy in the high-uncertainty state and β_h^{II} is the dynamic multiplier of policy shock in the low-uncertainty state.

It is important to recognize that we do not need to assume that the system stays in one regime during the entire adjustment to shocks. It is sufficient that the economy is in a given state at the time the shock occurs. In contrast to VAR models, we do not derive impulse responses from iterating the coefficient matrices. This is one of the major advantages of local projections when it comes to estimating state-dependent impulse response functions.

The results are shown in Figures (18) to (20). Each figure contains the responses in the low uncertainty-state and the high uncertainty-state together with the respective confidence bands. The results are fully in line with the findings obtained from the interacted model discussed before. The longer the maturity, the more the responses of fitted bond yields diverge when uncertainty is high, see Figures (18). For the 10-year yields, policy shocks lead to an increase in yields independently of the level of uncertainty. When uncertainty is large, however, the impact turns negative. Figure (19) shows that this pattern of yields is not reflected in the responses of the expectations components. Across all maturities, both responses overlap, suggesting no significant difference between the regimes. It is again the response of the term premia that is reflected in the behavior of yields. Term premia, see Figures (20), fall as a response to monetary policy, and fall even stronger if the policy shock occurs in a high uncertainty-regime. Hence, the results from the state-dependent model are completely consistent with those from the interacted model.

6 Conclusions

In this paper we studied the response of bond yields to monetary policy shocks. In particular, we conditioned the response to policy shocks on the degree of monetary policy uncertainty. We find that monetary policy uncertainty affects the way the yield curve responds to monetary policy. If uncertainty is large, a policy shock leads to a smaller increase in long-term yields compared to a situation with a low degree of uncertainty. This is because term premia fall even stronger as a reaction to a policy shock if future monetary policy is uncertain.

We argue that this is in line with the notion of the term premium as a compensation for interest rate risk. A tightening leads to a contraction in economic activity at a time when the return on nominal bonds increases. Standard asset pricing models suggest that in this case investors should demand a lower premium for holding longer term maturities. Uncertainty about monetary policy makes shorter maturities less attractive compared to longer maturities since policy uncertainty reflects uncertainty about the future short rate. As a result, investors demand even lower term premia when buying longer-term securities.

Our results have several implications for monetary policy. First, the Fed and other central banks increasingly rely on the management of expectations ("forward guidance") to steer monetary conditions if the policy rate is constrained by the effective lower bound. The aim of this policy is to lower long-term bond yields. Our results suggest that a monetary policy easing, e.g through promising to keep policy rates low, is fully effective in lowering yields only if monetary policy uncertainty is at or below its sample average. If policy uncertainty is large, which has been the case during some episodes at the effective lower bound, policy is less effective in reducing yields. Our results thus call for monetary policy to be as predictable as possible in order to be fully effective.

Second, the information content of the yield curve about the stance of monetary policy should be taken with a grant of salt. Often shifts in the yield curve are interpreted as reflecting changes in the expected stance of monetary policy. Not only is it difficult to account for the role of the unobserved term premium, but also is the link between changes in policy and the movement of long-term yields obscured by the presence of non-linearities. Our results point to a non-linear relationship between policy impulses and the yield curve that complicates the extraction of information from the yield curve.

Third, our results can add a new perspective on explaining Alan Greenspan's "conundrum". Between 2004:6 and 2005:2 the Fed tightened monetary policy by raising the target for the federal funds rate by 150 basis points. Surprisingly, during this tightening cycle the long end of the yield curve remained essentially flat.[11] According to the expectations hypothesis of the term structure, we would have expected an increase in long rates. Alan Greenspan, the Fed chair at this time, famously coined

[11] See Backus and Wright (2007) and Hanson et al. (2017) for another interpretation on this period.

this inconsistency a "conundrum".

If, at the time of the tightening cycle, uncertainty about monetary policy was high, our results suggest that 10-year bond yields can indeed remain flat or even decline after a shock. We find that uncertainty was indeed elevated during the 2004:6 to 2005:2 sample. Uncertainty was roughly one standard deviation higher than the sample mean. The previous finds suggest that an insignificant response of bond yields or even a negative response due to a fall in term premia is well within the range of possible outcomes.

One main question remains: does the non-linearity in the response of the yield curve transmit to the response of the real economy to monetary policy? Some preliminary results (not shown here) suggest that yields on corporate bonds and the dollar exchange rate also exhibit a smaller response to Fed policy if uncertainty is large. Likewise, Aastveit et al. (2017) show that consumption and investment respond less if general economic policy uncertainty, not uncertainty specifically about monetary policy, is high. This suggests that monetary policy uncertainty could also lead to a less effective transmission of monetary policy to the real economy. We leave this question for future research.

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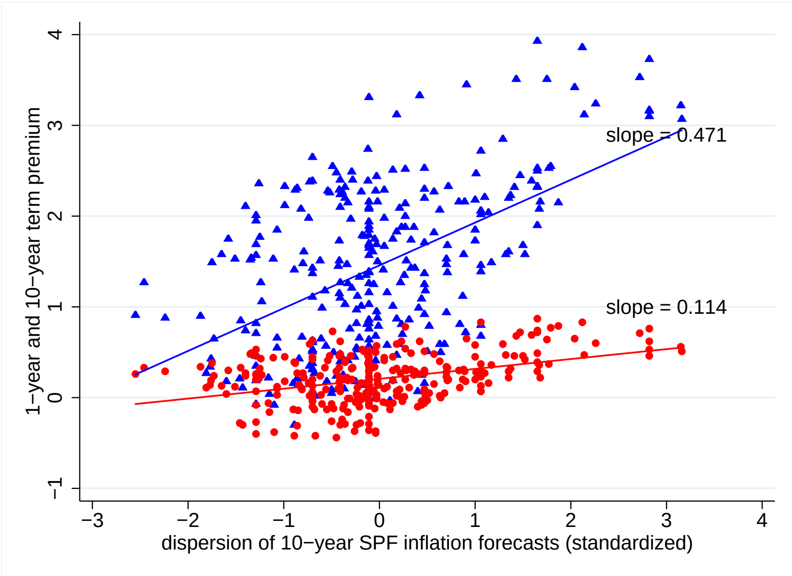
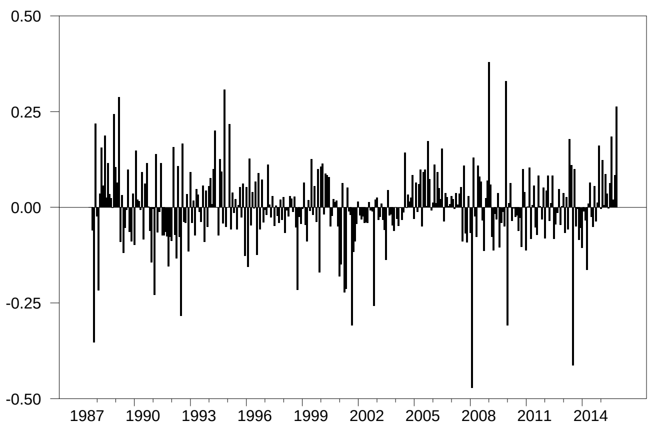
Appendix: Figures

Figure 6: Term premia against long-term inflation uncertainty



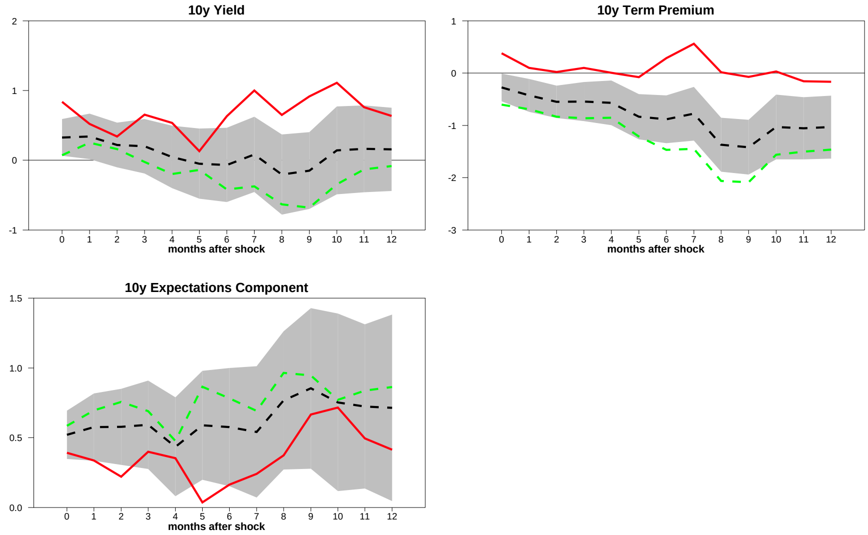
Notes: The 1-year (10-year) term premia are represented by red (blue) circles (triangles).

Figure 7: VAR-based monetary policy shock



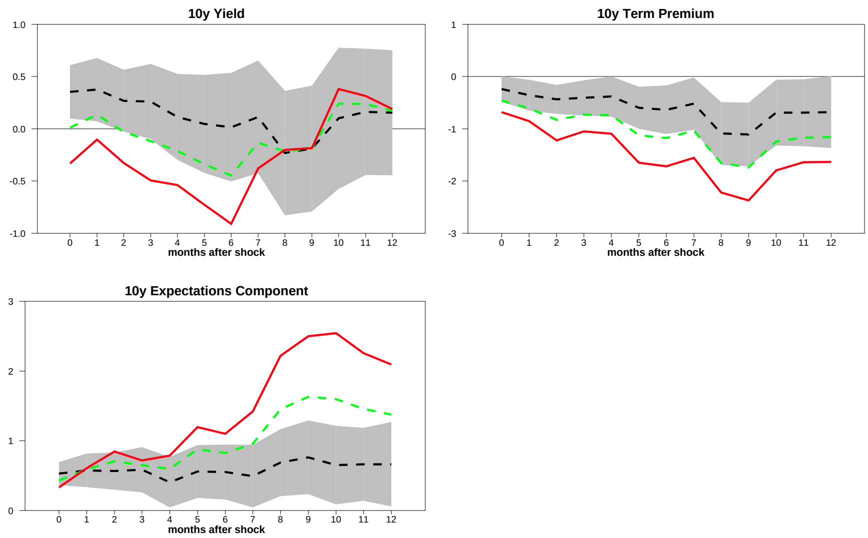
Notes: Monetary policy shock obtained from four variable VAR model including log(IP), log(CPI), Wu-Xia shadow rate and the Chicago Fed Financial Stress index identified with a Cholesky ordering.

Figure 8: Responses to a monetary policy shock: Dispersion of 3-month T-bill forecasts



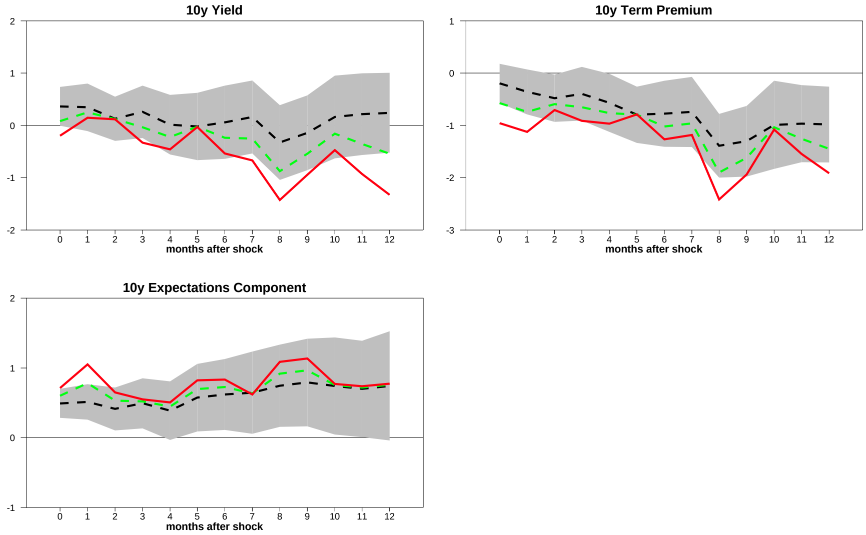
Notes: The black, dotted line is the unconditional response of bond yields to a monetary policy shock with a 90% confidence band. The green, dotted (red, solid) line reflects the response for uncertainty being one (two) standard deviations above (below) its mean.

Figure 9: Responses to a monetary policy shock: Baker et al. (2016) index



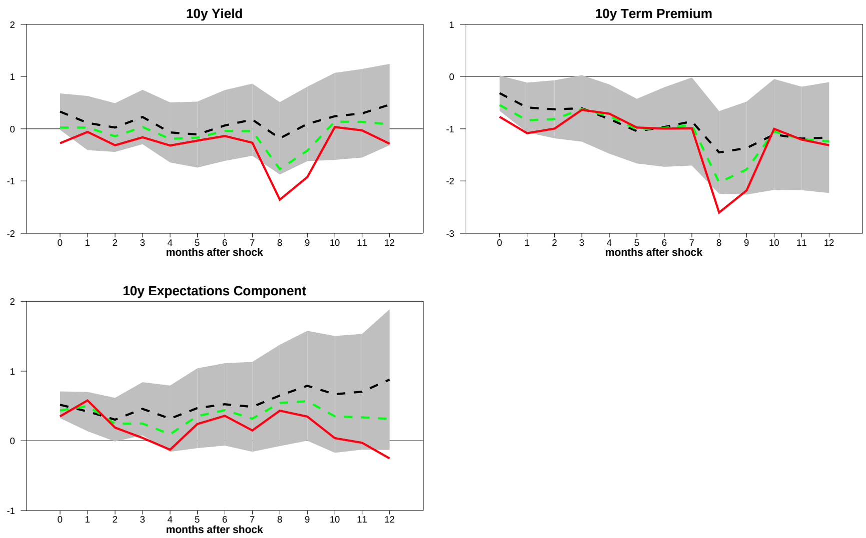
Notes: The black, dotted line is the unconditional response of bond yields to a monetary policy shock with a 90% confidence band. The green, dotted (red, solid) line reflects the response for uncertainty being one or two standard deviations above its mean.

Figure 10: Responses to a monetary policy shock: 3M3M of Istrefi and Mouabbi (2017)



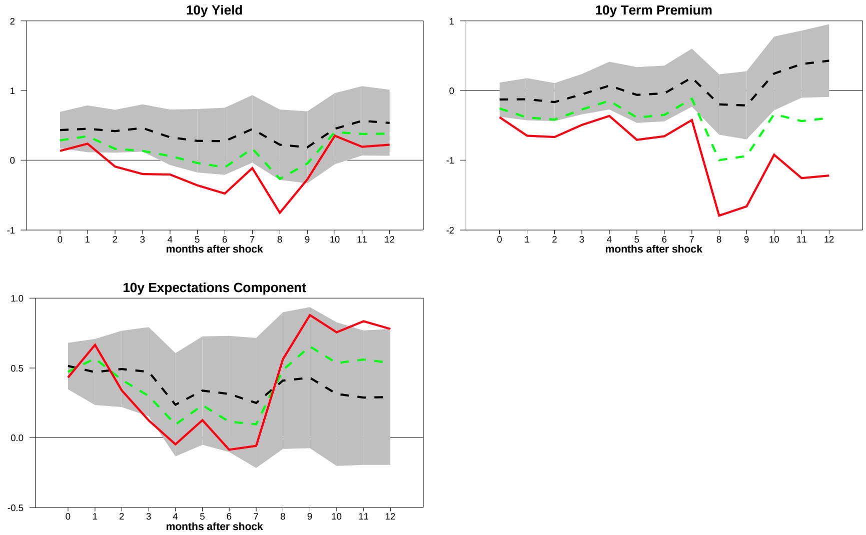
Notes: The black, dotted line is the unconditional response of bond yields to a monetary policy shock with a 90% confidence band. The green, dotted (red, solid) line reflects the response for uncertainty being one or two standard deviations above its mean.

Figure 11: Responses to a monetary policy shock: 3M MOVE index



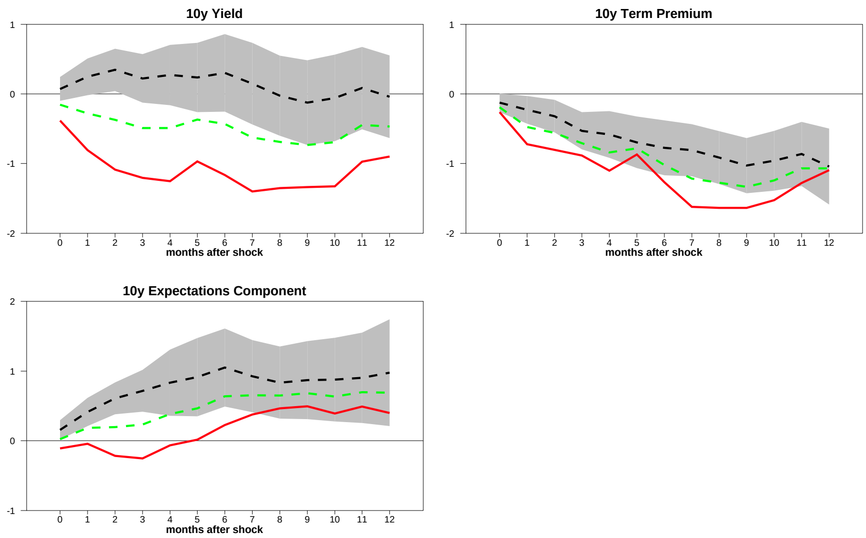
Notes: The black, dotted line is the unconditional response of bond yields to a monetary policy shock with a 90% confidence band. The green, dotted (red, solid) line reflects the response for uncertainty being one or two standard deviations above its mean.

Figure 12: Responses to a monetary policy shock: disagreement on 12-months interest rate from Michigan Survey



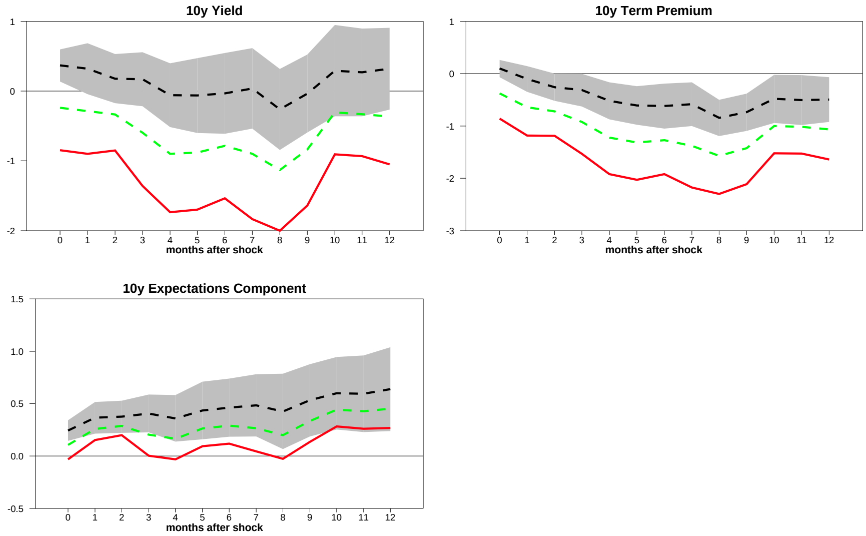
Notes: The black, dotted line is the unconditional response of bond yields to a monetary policy shock with a 90% confidence band. The green, dotted (red, solid) line reflects the response for uncertainty being one or two standard deviations above its mean.

Figure 13: Responses to a monetary policy shock: Romer and Romer (2004) shock



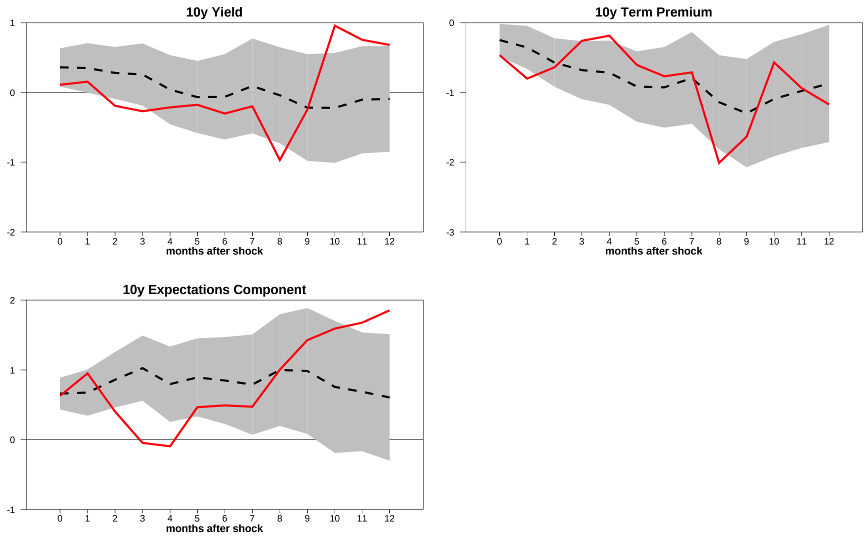
Notes: The black, dotted line is the unconditional response of bond yields to a monetary policy shock with a 90% confidence band. The green, dotted (red, solid) line reflects the response for uncertainty being one or two standard deviations above its mean.

Figure 14: Responses to a monetary policy shock: Kim and Wright (2005) data



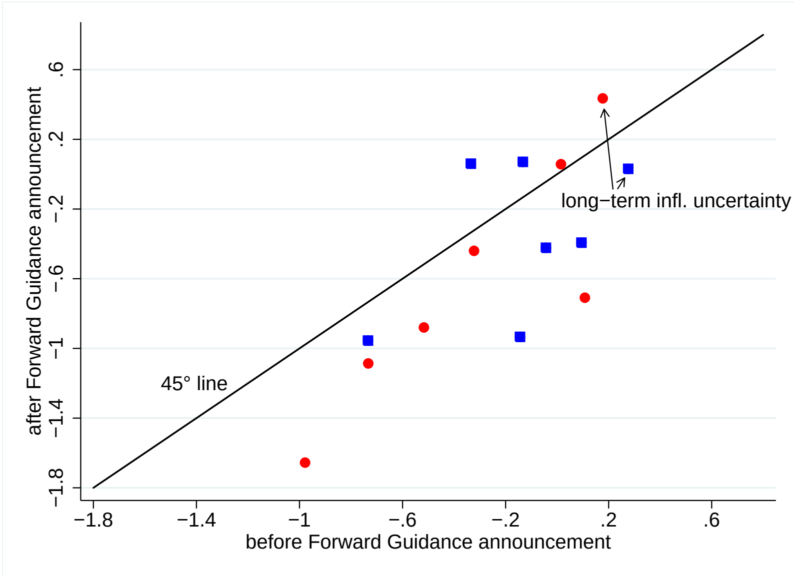
Notes: The black, dotted line is the unconditional response of bond yields to a monetary policy shock with a 90% confidence band. The green, dotted (red, solid) line reflects the response for uncertainty being one or two standard deviations above its mean.

Figure 15: Responses to a monetary policy shock: NBER recessions



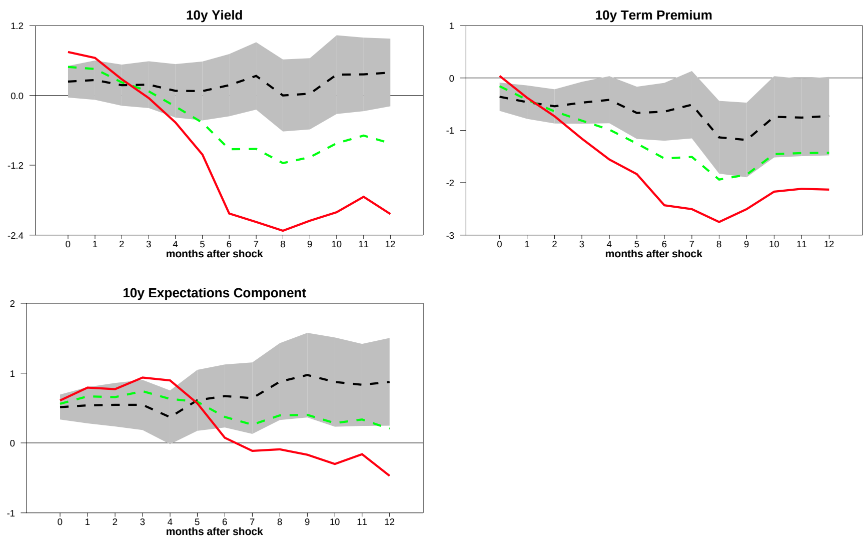
Notes: The black, dotted line is the unconditional response of bond yields to a monetary policy shock with a 90% confidence band. The red, solid line reflects the response during NBER-dated recessions.

Figure 16: Monetary policy uncertainty before/after forward guidance announcements



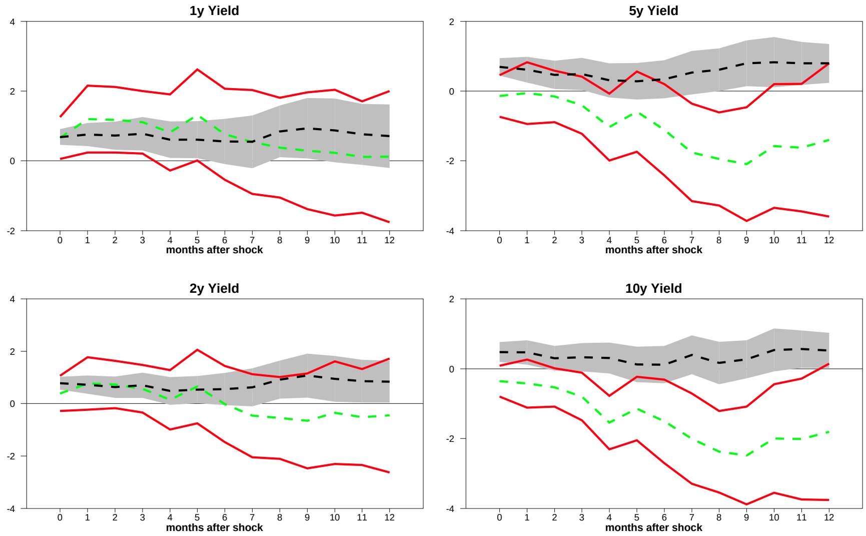
Notes: Monetary policy uncertainty in the three months after a forward guidance announcements compared to the three months before for each uncertainty measure (in standard deviations). The red (circles) reflect the August 2011 announcement, the blue (squares) the January 2012 announcement.

Figure 17: Responses to a monetary policy shock: exogenous component of monetary policy uncertainty



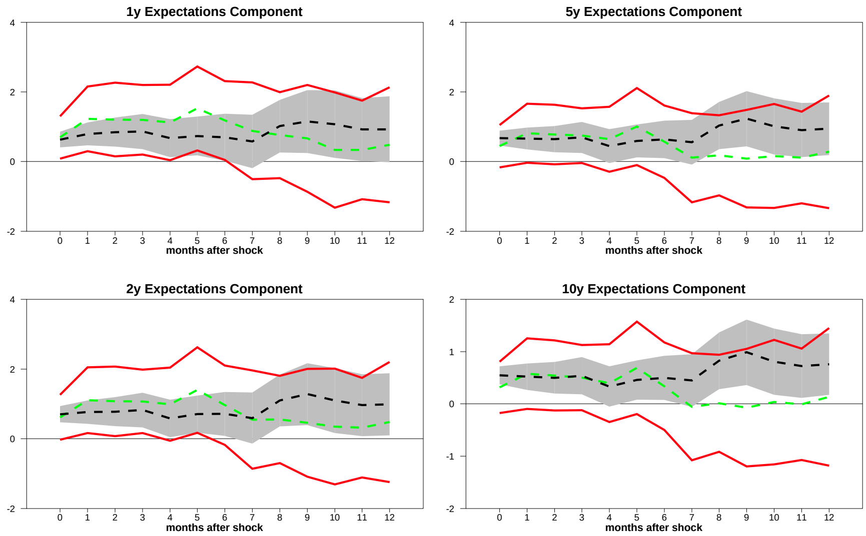
Notes: The black, dotted line is the unconditional response of bond yields to a monetary policy shock with a 90% confidence band. The green, dotted (red, solid) line reflects the response for the exogenous part of uncertainty identified through a VAR model being one or two standard deviations above its mean.

Figure 18: State-dependent response of yields to a monetary policy shock



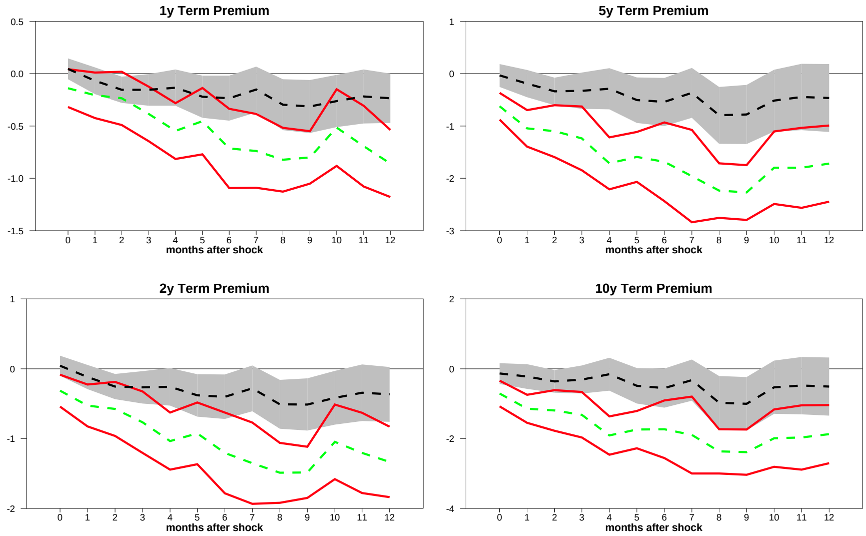
Notes: The black, dotted line is the response to a monetary policy shock in the low-uncertainty state with a 90% confidence band. The green, dotted (red, solid) line (confidence band) reflects the response in the high-uncertainty state.

Figure 19: State-dependent response of expectations components to a monetary policy shock



Notes: The black, dotted line is the response to a monetary policy shock in the low-uncertainty state with a 90% confidence band. The green, dotted (red, solid) line (confidence band) reflects the response in the high-uncertainty state.

Figure 20: State-dependent response of term premia to monetary policy shock



Notes: The black, dotted line is the response to a monetary policy shock in the low-uncertainty state with a 90% confidence band. The green, dotted (red, solid) line (confidence band) reflects the response in the high-uncertainty state.

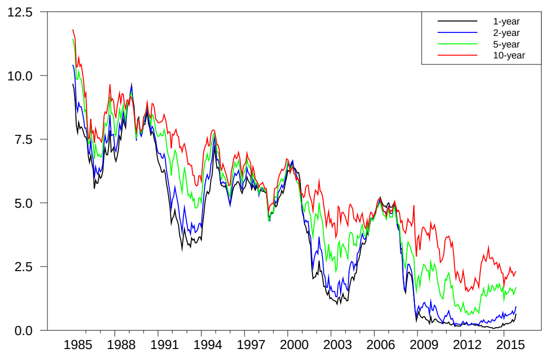
Appendix: Data Sources

Series	Source	demeaned and standardized	Details
MPU index of Husted et al. (2016)	website of Husted et al. (2016) IFDP Note	yes	12-months weighted average
MPU10 index of Husted et al. (2016)	website of Husted et al. (2016) IFDP Note	yes	12-months weighted average
Dispersion of 3-month SPF T-bill forecasts	Philadelphia Fed website	yes	
Monetary component of Baker et al. (2016) EPU index	policyuncertainty.com	yes	12-months weighted average
3M3M of Istrefi and Mouabbi (2017)	from authors	yes	
3M MOVE index	Datastream	yes	
Disagreement on 12-months interest rate from Michigan Survey	Michigan Survey website	yes	Lacy (2006) measure
Dispersion of 10-year SPF inflation forecasts	Philadelphia Fed website	yes	
Adrian et al. term structure data	NY Fed website		
Kim-Wright term structure data	FRED St. Louis Fed website		
Romer-Romer shocks	website of Valerie Ramey appendix to Ramey (2016)		

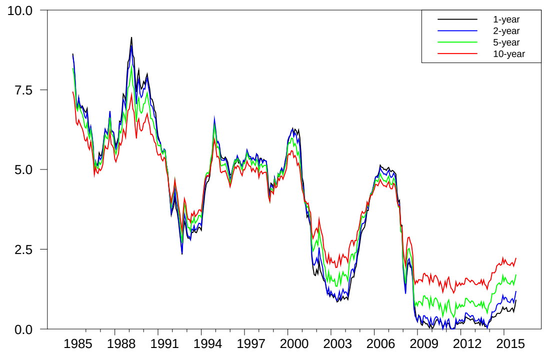
Appendix: Data Series

Figure 21: Term structure data

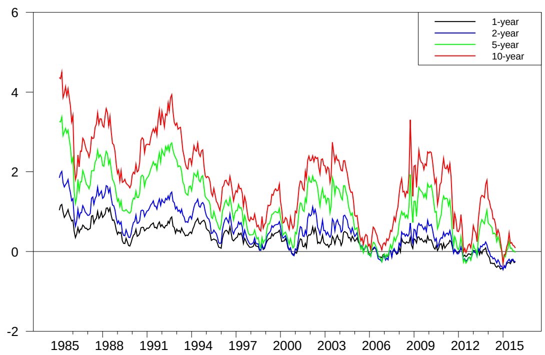
(a) Yields



(b) Expectations Components



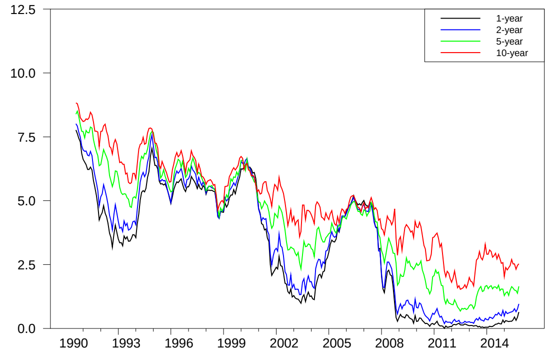
(c) Term Premia



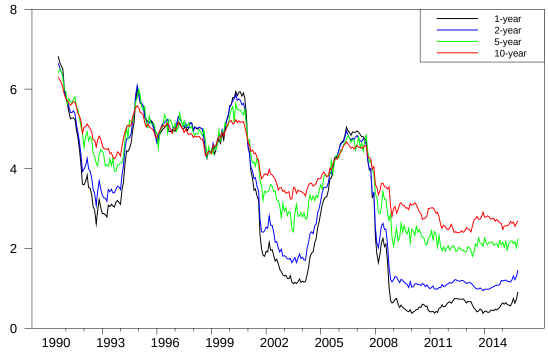
Notes: Fitted yields, estimated term premia and implicit expectations components from Adrian et al. (2013a)

Figure 22: Term structure data

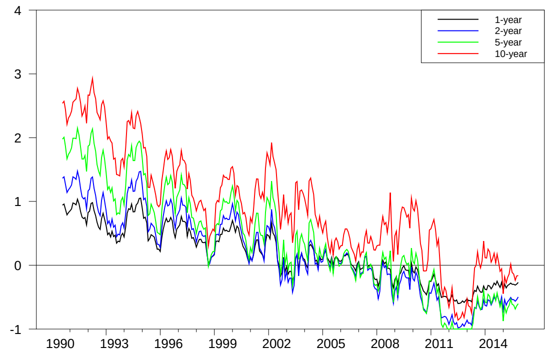
(a) Yields



(b) Expectations Components



(c) Term Premia



Notes: Fitted yields, estimated term premia and implicit expectations components from Kim and Wright (2005)