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Monetary Policy Uncertainty and Inflation Expectations

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Gabriel Arce-Alfaro and Boris Blagov[1]

Monetary Policy Uncertainty and Inflation Expectations

Abstract

Do inflation expectations react to changes in the volatility of monetary policy? Yes, but only until the global financial crisis. This paper investigates whether increasing the dispersion of monetary policy shocks, which is interpreted as elevated uncertainty surrounding monetary policy, affects the inflation expectation formation process. Based on U.S. data since the 1980s and a stochastic volatility-in-mean structural VAR model we find that monetary policy uncertainty reduces both inflation expectations and inflation. However, after the Great Recession this link has disappeared, even when controlling for the Zero Lower Bound.

JEL-Code: C11, C32, E52

Keywords: Monetary policy uncertainty; inflation expectations; SVAR volatility-in-mean; time-varying coefficients

March 2021

1 Gabriel Arce-Alfaro, RGS Econ and UDE; Boris Blagov, RWI. *- We would like to thank Christoph Hanck, Ludger Linnemann, Torsten Schmidt, participants at the 35th European Economic Association Annual Congress, 28th Society for Nonlinear Dynamics and Econometrics Annual Symposium and 13th RGS-Econ Doctoral Conference for their helpful comments and suggestions.* *– All correspondence to: Boris Blagov, RWI, Hohenzollerstr. 1-3, 45128 Essen, Germany, e-mail: boris.blagov@rwi-essen.de*

1. Introduction

"Inflation targeting, at least in its best-practice form, consists of two parts: a policy framework of constrained discretion and a communication strategy that attempts to focus expectations and explain the policy framework to the public. Together, these two elements promote both price stability and well-anchored inflation expectations." - Bernanke (2003)

The seminal contribution of Lucas (1976) has highlighted the importance of expectations for the effectiveness of economic policy. Inflation expectations play a key role for wage and price setting (Clarida et al., 2000; Svensson, 2000). As a consequence, over the past 40 years, the conduct of monetary policy has markedly changed with increasing emphasis on communication and transparency (Bernanke and Woodford, 1997; Blinder et al., 2008). For example, in 1994 the Federal Open Market Committee (FOMC) began releasing statements regarding their monetary policy decisions and in 2012 the U.S. Federal Reserve (FED) officially adopted an inflation target of 2%. Since the global financial crisis, the main monetary policy instrument - the federal funds rate (FED funds) - has been constrained by the zero lower bound (ZLB). Therefore, managing inflation expectations has become even more important for the transmission mechanism for monetary policy.
The effectiveness of monetary policy relies in part on the ability of economic agents to anticipate monetary policy movements. Consequently a large part of monetary economics has dealt with studying the effects of unanticipated monetary policy shocks. However, a growing literature has also considered a different take on the relationship - how does unpredictability of monetary policy affect the economy? This is referred as monetary policy uncertainty (MPU). Although MPU has been studied not least due to its relevance for central bank credibility (e.g., Stulz, 1986; Swanson, 2006; Neely, 2005), it has gained considerable emphasis since the global financial crisis, along with other types of uncertainty.[1]
A commonality across the empirical MPU literature findings is that, irrespective of the chosen proxy, an increase in monetary policy uncertainty suppresses economic activity,

[1] See for example Bauer et al. (2012); Kang et al. (2014); Chang and Feunou (2014); Mumtaz and Zanetti (2013); Istrefi and Piloiu (2014); Mumtaz and Theodoridis (2015); Sinha (2016); Creal and Wu (2017); Kurov and Stan (2018); Hansen et al. (2018); Istrefi and Mouabbi (2018); Husted et al. (2020); Bauer et al. (2019); Alessandri and Mumtaz (2019).

increases unemployment and leads to a decline in prices. The theoretical underpinnings of these findings suggest that the consumption channel plays an important role - risk averse agents hold back consumption, which creates a decline in demand (Mumtaz and Zanetti, 2013). Essentially, MPU shocks are a materialization of negative demand shocks and hence propagate through the expectations of economic agents. However, the focus of the inflation expectations literature has mostly been on the effects of monetary policy shocks, not of monetary policy uncertainty shocks (e.g., Leduc et al., 2007a; Canova and Gambetti, 2009; Leduc and Sill, 2013). Not controlling for the uncertainty component might overlook an important aspect in the inflation expectation formation process. Hence, in this paper we investigate empirically the link between monetary policy uncertainty and inflation expectations.

To do so, an important question is how to measure monetary policy uncertainty. MPU has been typically defined as some function of the ability of economic agents to forecast monetary policy instruments, i.e., interest rates. One example is measuring surprises to agents via options and yield curve movements (e.g., Swanson, 2006; Bauer et al., 2012; Chang and Feunou, 2014). More recently, natural language processing (less formally text analysis) has also been employed to create monetary policy uncertainty proxies, either through newspaper-based articles (Baker et al., 2016; Husted et al., 2020) or the FOMC meetings (Hansen et al., 2018).

A further example, popular in structural models, is to postulate specific distributional assumptions on key target central bank variables, either the money supply (Stulz, 1986) or, more recently, the interest rates (Mumtaz and Zanetti, 2013; Creal and Wu, 2017; Alessandri and Mumtaz, 2019). In these contributions MPU is modelled in the second order moment, i.e., the variance of the central bank policy instrument. An increase in MPU is then defined as an increase of the variance of monetary policy shocks. The hypothesis is that larger monetary policy shocks worsen forecasts of economic agents and thus make it harder to anticipate the correct movements of the target variable.

We incorporate monetary policy uncertainty following the latter approach and estimate a structural VAR (SVAR) with stochastic volatility-in-mean to study the interaction between monetary policy uncertainty and inflation expectations. Capturing the joint dynamics of inflation, inflation expectations, and economic activity is natural in the framework of SVARs. Our work is related to the growing literature which focuses on the effects of economic policy uncertainty on the economy (Bloom, 2009; Baker et al., 2016; Mumtaz and Zanetti, 2013; Bachmann et al., 2019). We focus specifically on monetary policy uncertainty, departing from recent works which look at the macroeconomic effects of changes in broader measures of uncertainty (Istrefi and Piloiu, 2014; Fernández-Villaverde et al., 2015).

In a sample spanning from 1985 to 2019 we find that, on average, in the U.S. short run inflation expectations do indeed decline following a MPU shock, although not in the same magnitude as inflation, suggesting that expectations are rigid. On the other hand, long-run inflation expectations, which are typically found not to react to monetary policy shocks (Canova and Gambetti, 2009), do not seem to be affected by MPU shocks. Furthermore we show that the relationship between monetary policy uncertainty and inflation expectations has not remained stable over time. Since the great recession, short run inflation expectations have not reacted to MPU shocks, while inflation has. These findings suggest that, while MPU might have been important in the past for the expectation formation process, this has not been the case over the past decade even when we control for the zero lower bound.

The reminder of this paper is structured as follows. The next section lays out the methodology used in this article. Section 3 is devoted to the summary of the dataset. Section 4 and 5 discuss the results and section 6 concludes.

2. Modeling monetary policy uncertainty

This section presents the adopted empirical strategy for estimating the effects of uncertainty on inflation expectations. We follow the approach of modelling monetary policy uncertainty as a second moment shock to the monetary policy instrument (e.g. Stulz, 1986). We adopt the framework of Mumtaz and Zanetti (2013), estimating a stochastic volatility-in-mean SVAR, which has already been employed for the analysis of monetary policy uncertainty on economic activity (Mumtaz and Zanetti, 2013; Alessandri and Mumtaz, 2019). In this setup, MPU is captured by the time-varying variance of monetary policy shocks, which are extracted from the central bank interest rate series. In the spirit of Swanson (2006) an increase in the variance lowers the ability of economic agents to forecast interest rates.[2] For the remainder of this paper, we will use the terms uncertainty and volatility interchangeably.[3]

An appealing property of the model is that it constitutes a one-step procedure in modelling uncertainty, i.e. both the coefficients and the uncertainty measure are estimated jointly from the data, thus providing an important feedback loop. This is in contrast to a model, where the proxy is constructed first from an exogenous source and then put into a model.[4]

2.1. SVAR with stochastic volatility in-mean

The framework of Mumtaz and Zanetti (2013) may be summarized by the following key equations. The VAR is given by

$$Z_t = c_t + \sum_{j=1}^{P} \beta_j Z_{t-j} + \sum_{m=0}^{M} \gamma_m \tilde{h}_{t-m} + \Omega_t^{1/2} e_t, \quad e_t \sim N(0, I_K), \tag{1}$$

where Z_t is a vector of endogenous variables of dimension $K \times 1$ and the vector $\tilde{h}_t = [h_{1t}, \ldots h_{Kt}]'$ contains the log volatilities of the K structural shocks. The shocks are extracted from the reduced form variance-covariance matrix Ω_t using an orthogonal decomposition $\Omega_t = A^{-1} H_t A^{-1\prime}$ and A^{-1} specifies the contemporaneous effects. The processes for the log-volatilities are assumed to be autoregressive of first order, of the form

$$\tilde{h}_t = \Theta \tilde{h}_{t-1} + \eta_t, \quad \eta_t \sim N(0, \xi), \quad \mathbb{E}(e_t \eta_t) = 0, \tag{2}$$

such that Θ is a $K \times K$ diagonal matrix and $\eta_t = [\eta_{1t}, \ldots, \eta_{Kt}]'$. Furthermore we assume that the first and second moment shocks are uncorrelated.[5]

Let r_t denote the monetary policy instrument in the vector of endogenous variables, Z_t. Then h_{rt} is our MPU measure, which affects the levels of the rest of the variables

[2] This definition of uncertainty is popular in the literature. For example Jurado et al. (2015) frame financial and macroeconomic uncertainty as the variance of a time-varying forecast error from a dynamic factor model.

[3] We do acknowledge that there is a difference between implied and realized volatility. Our results draw on a measure based on realized interest rate volatility. See Bachmann et al. (2019) for a discussion on the subject.

[4] For discussion of one-step versus two-step estimations of uncertainty indices see Bianchi et al. (2018).

[5] This assumption eases the computational burden but it may be relaxed, as for example in Alessandri and Mumtaz (2019).

through the γ coefficients. The innovations η_t in eq. 2 are the uncertainty shocks in our framework with η_{rt} being the MPU shock. An increase in η_{rt} means that the monetary policy instrument may take a wider range of values as the shock dispersion increases.

2.2. Estimation strategy

Due to the presence of the volatility terms in eq. (1) the conventional maximum likelihood approach is not applicable. The model is estimated via Bayesian methods with Gibbs sampling, i.e., drawing the parameters iteratively from their conditional distributions.

The parameters may be divided into several blocks based on their distributional assumptions. The reduced-form coefficients $B = [\beta, \gamma]$, the stochastic volatility block $\mathcal{H} = \{H_1, ..., H_T\}$, where H is a diagonal matrix containing the $\tilde{h}$, the parameters Θ in the equation, and the contemporaneous responses A.

In order to capture the heteroskedasticity introduced through the stochastic volatility an additional matrix, Q, is required at the estimation stage of B. This matrix will play an important role in the time-varying specification of the model that we will explore in the next section, as it controls the amount of parameter time-variation that the model permits.

In order to simplify the exposition we introduce notation $\Psi = \{A, B, Q, \mathcal{H}, \Theta\}$, which collects the different blocks of parameters. Let Ψ^{-i}, denote the exclusion of the i-th block such that $\Psi^{-B} = \{A, Q, \mathcal{H}, \Theta\}$.

To conduct inference we draw the i-th block from the conditional probability distribution $p(i|\Psi^{-i})$, which is derived as a function of a conjugate prior distribution $\overline{p}(i)$. The prior for the reduced-form coefficients B and $\tilde{h}$ is based on a GLS estimation on a training sample. For arbitrary starting values the estimation proceeds in the following iterative procedure:

1. Conditional on $\mathcal{H}$, A may be drawn as a linear regression from $p(A|\Psi^{-A})$, given the form in eq. (2) in conjunction with the algorithm of Cogley and Sargent (2005).

2. The reduced-form parameters, B, are obtained from a linear regression with heteroskedasticity and may be estimated via GLS. Following Carter and Kohn (1994)

we introduce stochastic volatility via a matrix Q, employ the Kalman filter for $t = 1, ..., T$ to get $\beta_{T|T}$ and $\gamma_{T|T}$ and draw the parameters from $p(\beta_{T|T}, \gamma_{T|T}|Q, \Psi^{-B,-Q})$.

3. Conditioning on the draws for B, Q may be drawn from an inverse Wishart distribution.

4. For the stochastic volatility estimation we follow Cogley and Sargent (2005), where the draws for $\mathcal{H}$ may be obtained using a Metropolis-Hastings algorithm conditional on the model parameters.

3. Data and estimation

Our data set consists of five macroeconomic variables: the civilian unemployment rate, the long-run and short-run inflation expectations, the consumer price index (CPI) inflation rate and the monetary policy rate. Given that our measure of uncertainty relies on volatility of the variables, the Zero Lower Bound presents a significant issue. For this reason we choose the shadow short rate (SSR) as a proxy for the main monetary policy instrument. Thus, we also capture the unconventional monetary policy measures which are reflected in the SSR. For robustness we also consider the model with federal funds rate (FED Funds).

The key variables of interest in our study are the inflation expectations. We use the proxies developed in Haubrich et al. (2012), where expectations are extracted using a term-structure model of the interest rates. These data have several appealing properties. First and foremost, the financial sector is a crucial channel for the expectations of economic agents, thus proxies based on interest rate data should provide timely adjustment of inflation expectations. Second the expectation measures are available both for short and long-term (1 year ahead and 5 years ahead), starting in 1981. In contrast, the long run expectations of the Survey of Professional Forecasters (SPF) only starts in 2005. Third, the data is at a monthly frequency. This increases the degrees of freedom in our highly parametrized non-linear model. Finally, the term-structure model accounts for liquidity and risk-premia. This is an important difference to other measures of inflation expectations based on interest rate data, like the treasury inflation-protected securities

(TIPS) that do not account for such premia. Nevertheless, it is important to note that the measure of Haubrich et al. (2012) is not drastically different from other popular inflation expectations proxies, such as the SPF. We plot both on Figure 1.

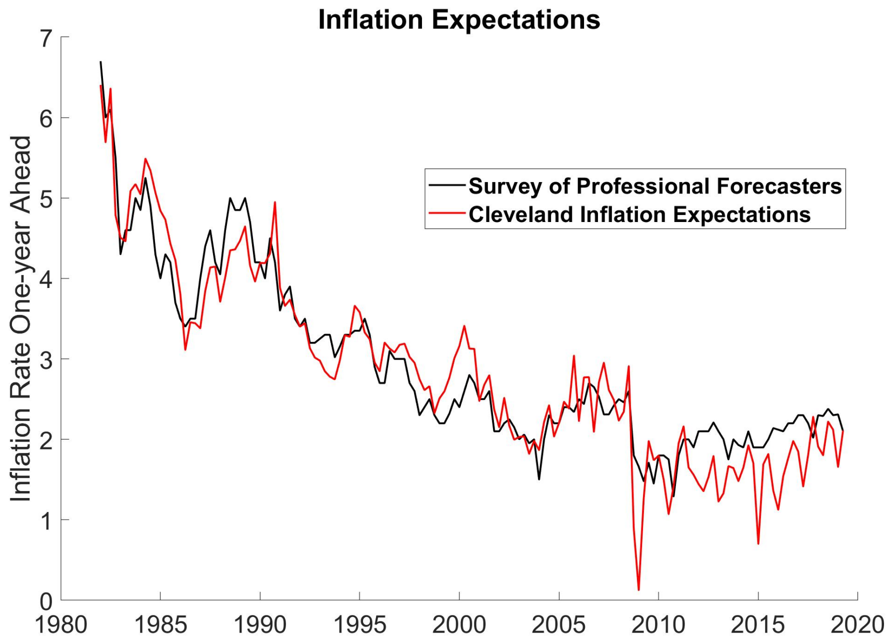

Figure 1: One-year ahead inflation expectations from the Survey of Professional Forecasters and from Haubrich et al. (2012). Quarterly frequency. Source: Federal Reserve Bank of Philadelphia and the Federal Reserve Bank of Cleveland.

The unemployment rate, CPI inflation, and the FED Funds were obtained from the Federal Reserve Bank of St. Louis Database. The shadow short rate (SSR) was obtained from Wu and Xia (2016).[6] Finally we use the estimations from Haubrich et al. (2012) for the long-run and short-run inflation expectations taken from the Federal Reserve Bank of Cleveland. The sample ranges from January 1981 to June 2019.

3.1. Statistical identification and inference

To determine the optimal number of lags in eq. (1) we employed information criteria tests on the reduced-form specification without stochastic volatility terms. The proposed lag lengths are 2 and 12 for BIC and AIC, respectively. Since the monthly data grants us

[6]Our findings are robust to the choice of SSR as we have also considered the alternative by Leo Krippner.

with many degrees of freedom we choose the 12 lag specification for the baseline scenario.[7] It is worth mentioning that the main findings are consistent under both specifications.
Following the estimation strategy from Section 2.2 we initialize the model estimation using the first 10 years as training sample. We use 100 000 iterations of the Gibbs sampler, of which the first 95 000 are discarded as burn-in. We test for the convergence of the chain with standard procedures and present the results in the Appendix B.
To identify the monetary policy shocks we use Cholesky decomposition with a lower triangular matrix, where following the sticky-information literature (Castelnuovo and Surico, 2010a), we order inflation expectations above inflation. Thus, we assume that they do not respond within the same month to new information regarding the interest rates or inflation.[8] Apart from that we follow standard ordering of unemployment, inflation, and the monetary policy rate (Christiano et al., 1999). Nevertheless, we test our results to different specifications and find that they are consistent to the baseline. This is due to the fact that we are interested in the impulse responses following a shock to the stochastic volatilities, η. Thus, a major determinant of the effects of uncertainty shocks are the γ coefficients and variable ordering plays a secondary role. This holds as long as the estimated stochastic volatilities h remain the same across orderings. This is an advantage of the framework over setups where the uncertainty measure is an additional series whose level is shocked (e.g. Istrefi and Piloiu, 2014).

4. The effects of monetary policy uncertainty shocks

Figure 2 plots the estimated MPU series. We have two different specifications, the SSR model (which incorporates the shadow short rate as the monetary policy instrument) and the model with the FED funds rate instead (solid and dashed lines, respectively). Figure 2 emphasizes the need to account for the ZLB if volatility is used as a measure of uncertainty. During the Great Recession, the FED funds rate was practically flat for several years, giving as a result a period of very low volatility in the monetary policy instrument. This would imply almost no uncertainty after 2009. The estimated MPU measure is in line

[7] In the following chapters we will also present the estimated model with 2 lags, to which the results are robust.
[8] This has been found to be true for SPF data, see Coibion and Gorodnichenko (2015).

with others, such as Mumtaz and Zanetti (2013) or Mumtaz and Theodoridis (2020), even though we use monthly data.

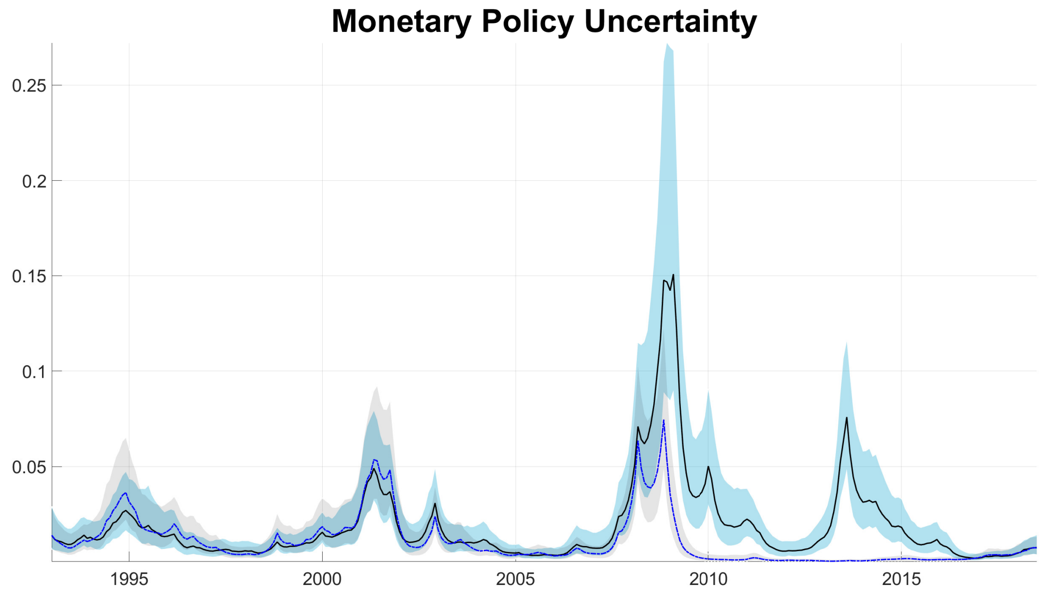

Figure 2: Measure of monetary policy uncertainty. Median response (line) and 68% probability intervals (shaded areas). The black line represents the estimate from a model with the shadow short rate, while the dashed line the model with the federal funds rate.

As a by-product of the estimation, we can also report the volatility of the shocks to short and long run inflation expectations, which could be interpreted as uncertainty surrounding the inflation expectations. While these series are not the primary object of interest they might be used to validate the chosen proxies for inflation expectations. They are plotted on Figure 3. While long run inflation expectations display a low and stable level of uncertainty, short run inflation expectations uncertainty increased during the Great Recession and remained elevated compared to the period before the 2008 crisis.[9] This picture is compatible with standard macroeconomic theory - long run inflation expectations appear to be well anchored as their uncertainty level does not appear to fluctuate even through dramatic events such as the global financial crisis. Moreover, these estimates may also be seen through the lens of central bank credibility. Constant uncertainty surrounding the long run expectations suggests trust in the monetary authority - a crucial condition for

[9]The estimated volatilities in the model with FED Funds are almost identical to the ones obtained with the SSR. Estimates are shown in the appendix, Figure A.1.

an efficient transmission of monetary policy.

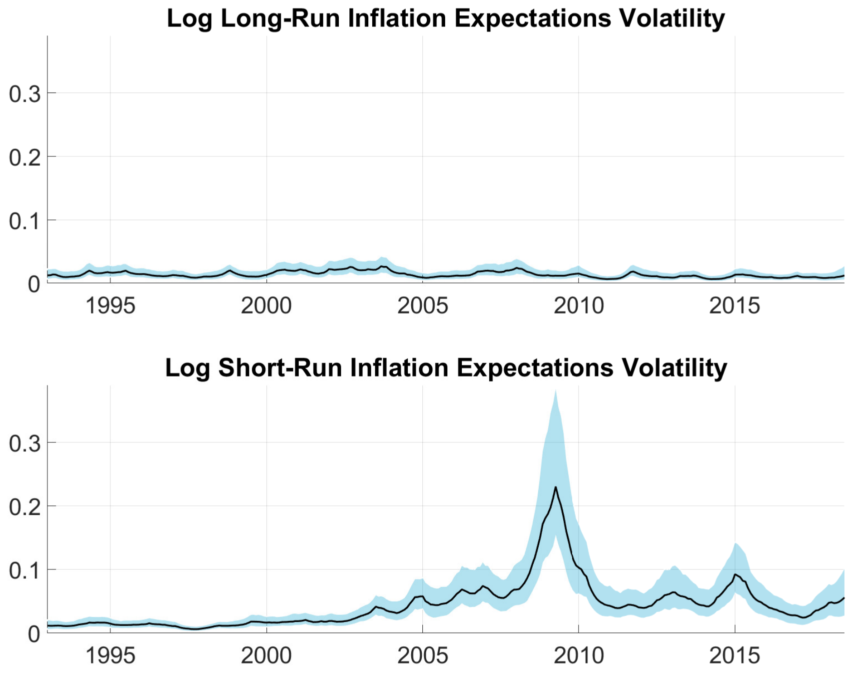

Figure 3: Measure of inflation expectations uncertainty. Median response (solid line) and 68% probability intervals (shaded area).

4.1. Impulse response analysis

In Figure 4 we plot the estimated responses of the variables to a MPU shock from the baseline model with the SSR, as well as the model with the FED Funds. The dynamics across models are to a large extent similar with the distinction that the findings are amplified when accounting for the volatility under the period of the ZLB. A MPU shock has a negative effect on the demand side, increasing the unemployment rate. This results mirrors the findings of Mumtaz and Zanetti (2013) and Alessandri and Mumtaz (2019) who report a contraction in GDP following a MPU increase due to risk aversion and consumption smoothing behaviour. We find a less pronounced response when using the FED Funds.

With falling demand, deflationary pressures build up and it is expected that inflation would follow along with the interest rates. This reasoning suggests that expectation about future inflation should also fall. We observe that inflation expectations do react as suggested by theory.

The estimation incorporates both short and long run inflation expectations. The former decline more strongly than the latter and the finding that long run expectations react at all to monetary policy uncertainty is surprising. This result bears further investigation. In the next chapter we will show that while the result does not appear extensively robust across specifications it does hold strong for the first part of the sample.

Initially inflation expectations react more sluggish than inflation due to the identification assumption: a MPU shock hitting in time point 0 influences the variable initially only through the γ coefficients and contemporaneously inflation expectations do not react to changes to inflation by assumption. However, we find that also over a longer horizon, inflation expectations do not respond as strong as inflation does.[10] After two years, the change in prices falls roughly by 0.3 percentage points (pp) on average, while short run inflation expectations drop by half, around 0.15 pp. Long run inflation expectations react even less, with a median decline of less than 0.1 pp. Thus, even abstracting from the identification assumption we find results consistent with literature, namely the presence of rigidity in the expectation formation process, as in Coibion and Gorodnichenko (2015).

[10]These findings are robust to changes in the variable order.

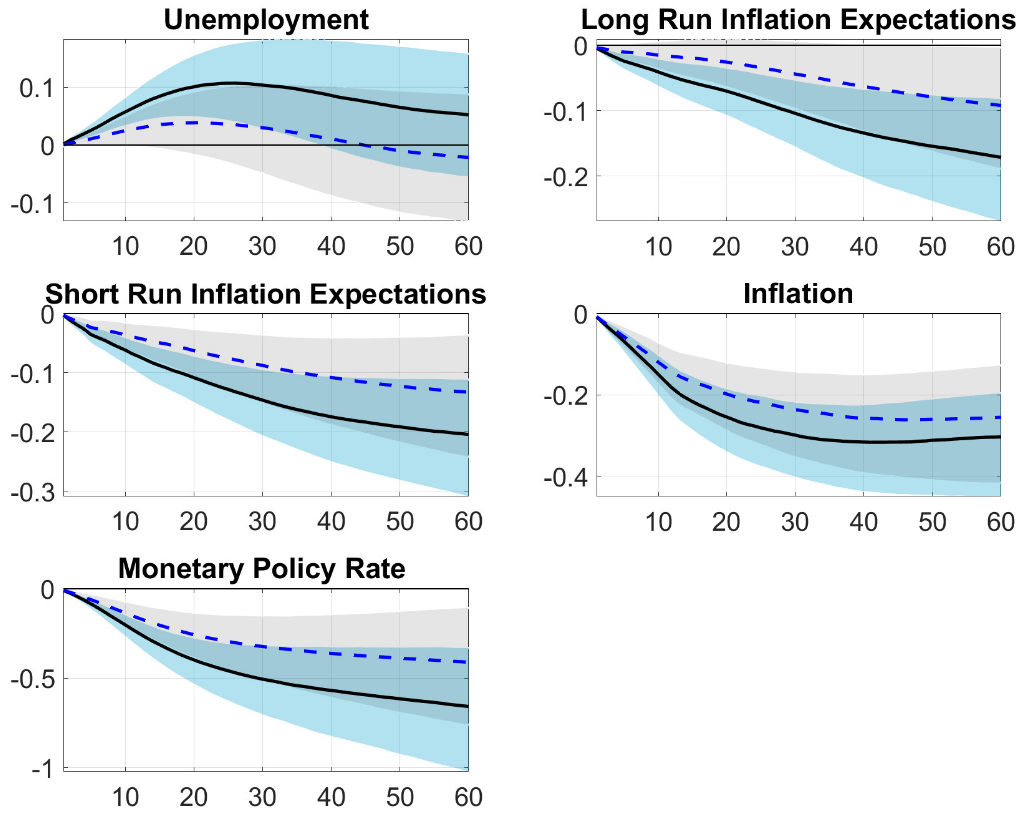

Figure 4: Median responses to a monetary policy uncertainty shock. Model with shadow short rate (solid line) and model with the federal funds rate (dashed line). The shaded areas show the 68% probability interval.

5. Evolving responses of inflation expectations

The model presented in the previous sections captures the average response of inflation expectations to uncertainty shocks over the full sample, which spans from the 1980s to 2019. Throughout that period the U.S. economy has experienced significant events, from the great moderation to the global financial crisis, which could have contributed to changes between the relationships of economic variables. Furthermore, it has been shown that inflation expectations depend on the own experience of the economic agents, i.e. people that lived through periods of high inflation expect, on average, higher inflation (Malmendier and Nagel, 2016; Draeger and Lamla, 2018). Finally, a large part of the literature on uncertainty has shown that the relationship between uncertainty and economic activity might be non-linear (Caggiano et al., 2014; Alessandri and Mumtaz, 2019, e.g.), and specifically monetary policy shocks (Castelnuovo and Pellegrino, 2018). Therefore we deem important to investigate whether the inflation expectations formation process has evolved over time and how the link between monetary policy uncertainty and expectations has behaved throughout different periods.

In order to investigate if there has been changes over time, we extended the model from 2.1 by allowing the coefficients to change over time, along the lines of Primiceri (2005) and Mumtaz and Theodoridis (2020). To this end, we sketch the necessary modifications to the previous model setup.

5.1. Model with time-varying coefficients

We introduce time-varying parameters (TVP) for the coefficients of the estimated VAR, β and γ, thus capturing potential changes among the economic variables and how uncertainty is perceived over time. Equation (1) is modified to incorporate time-variation in the following way

$$Z_t = c_t + \sum_{j=1}^{P} \beta_{j,t} Z_{t-j} + \sum_{m=0}^{M} \gamma_{m,t} \tilde{h}_{t-m} + \Omega_t^{1/2} e_t, \quad e_t \sim N(0, I_K), \tag{3}$$

We postulate a random walk process for the coefficients

$$B_t = B_{t-1} + v_t, \qquad v_t \sim N(0, Q), \tag{4}$$

where $B_t = [\beta_t, \gamma_t]'$ is defined as in Section 2 and Q governs the amount of time-variation in the parameters.

The Q matrix is a crucial aspect of the TVP model. The linear version from the previous section is nested here for extremely low values of Q, while high values permit larger jumps in the parameters. Given that the random walk process introduces potential explosiveness, exceptionally high values could make inference impossible. To deal with this issue, in the seminal contribution of Primiceri (2005), Q is scaled a-priori via an additional parameter, k_Q. This choice is of specific importance. Our goal is to find the appropriate amount of time-variation without imposing overly strong restrictions on the parameters movement nor running into estimation difficulties. In Primiceri (2005) k_Q is chosen using a grid-search with the aim to maximize the marginal likelihood of the model with an optimal value of $k_Q = 0.01$ for U.S. data. However, our data set is monthly, hence there is no guarantee that this is an appropriate choice for this application.

We follow recent advancements in Bayesian computation of TVP models and treat k_Q as a hyperparameter to be estimated from the data. We follow Amir-Ahmadi et al. (2018) and use a random walk metropolis hasting algorithm with an inverse gamma distribution as a prior. We plot the posterior distributions for the SSR and FED funds on Figure 5a and Figure 5b, respectively. For our data set the corresponding estimate of k_Q leads to a value of 0.063. We use the median of the posterior density of k_Q to calculate the impulse response functions of the TVP model.

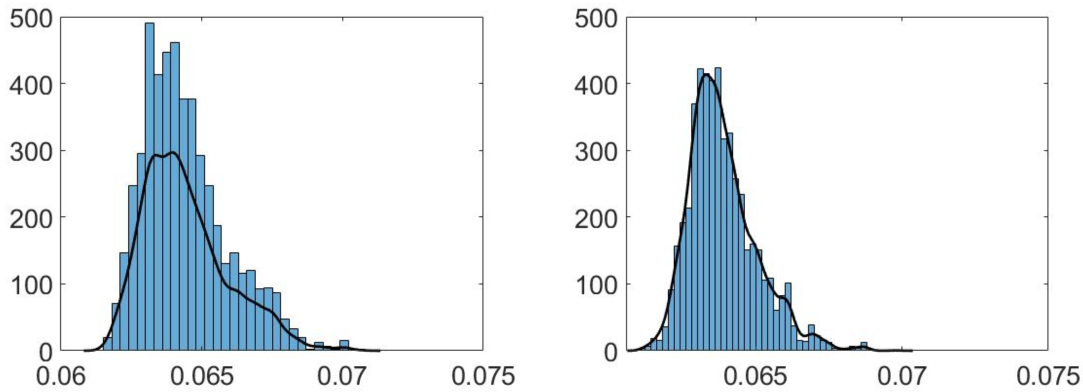

Figure 5: Posterior densities of the time-variation parameter k_Q. Left: Shadow short rate model. Right: Federal funds rate model.

The strong evidence for time-variation in the data is also supported in the estimated stochastic volatilites. As the relationship between the variables change, the degrees of freedom for the model to fit the data increase, hence the stochastic volatility declines. We find that while the most important events of the estimated MPU remain the same across both specifications, the MPU estimated under the TVP model is markedly lower after the dot-com bubble.

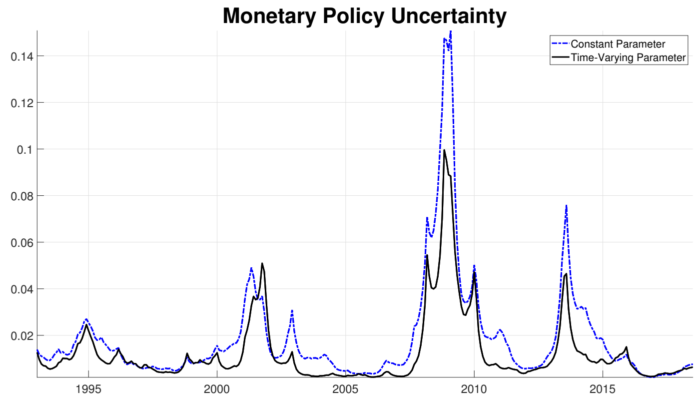

Figure 6: Median estimates of Monetary Policy Uncertainty

5.2. Impulse response analysis

Figure 7 illustrates how the response to a monetary policy uncertainty shock has varied over time, plotting the different responses from 1992 until 2019 in a five-year horizon [11]. In general, we can observe that the median response of all variables to a monetary uncertainty shock has varied over time. While unemployment shows a stronger effect around the Great Recession, short and long run inflation expectations seem to react less strongly thereafter. On the other hand, inflation does not present such a strong trend after the arise of the 2008 crisis. Additionally, the reaction of the monetary policy instrument to an MPU shock has also weakened since the financial crisis.

While Figure 7 clearly shows an evolving relationship among the variables, we are interested in analyzing the responses combined with their corresponding credibility intervals. To provide a better understanding about how the responses differ over time, we analyze the median response to a monetary policy uncertainty shock during four different years: i) 1993 as the first full sample period estimated after training sample and lag-values. ii) 2003: as a boom period after the recovery of the dot-com crash iii) 2008: to look to the effects during the Great Recession and iv) 2018: the last full year of estimates. For ease of readability we plot only the responses from the SSR model and relegate the Fed funds model to the appendix.

[11]The individual time-varying responses are shown in Appendix C.

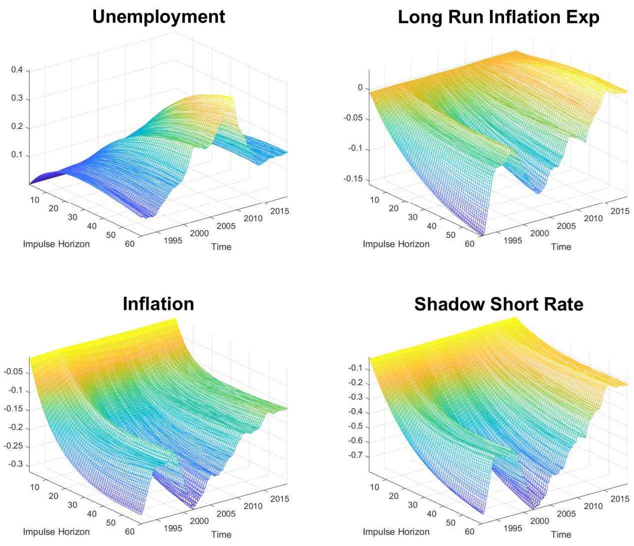

Figure 7: Impulse responses following a MPU shock from a TVP-VAR with stochastic volatility-in-mean over 60 months.

Figure 8 shows the response of long run inflation expectations to a monetary policy uncertainty shock. We find that with the exception of the beginning of the sample, the median response of long-run inflation expectations is close to zero. The 68% error bands suggest that this response is not different from zero for the remaining part of the sample. Given the inherent differences between the TVP and the constant parameter models, direct comparisons are difficult. Nonetheless, one important difference is worth noticing. In contrast with the constant parameter case, long-run inflation expectations appear to have a response close to zero for the majority of the sample in the TVP case. These findings are of particular interest since long run inflation expectations are associated with the level of credibility the central bank maintains. As mentioned before, this is a necessary condition for monetary policies to be effective and in a context where forward-guidance and other sets of unconventional measures have been implemented, central banks have to carry a high level of credibility in order for these policies to be effective.

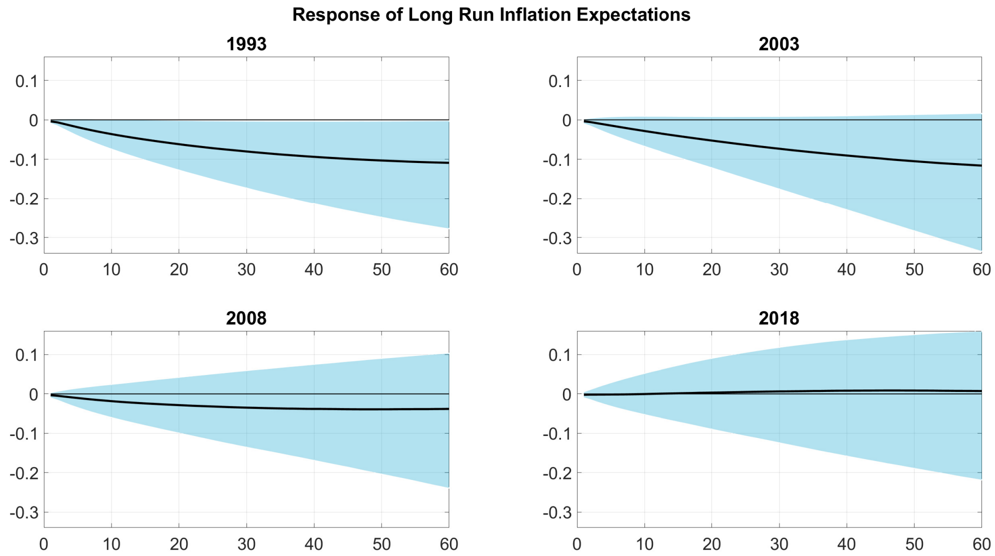

Figure 8: Impulse response of long run inflation expectations following a monetary policy uncertainty shock for specific periods, yearly average. Solid line denotes the median response and shaded area is the 68% probability intervals.

This result is in contrast with the response of short-run inflation expectations depicted in Figure 9, where we observe that the 68% error bands show a decline in the short-run inflation expectations for the periods preceding 2008 financial crisis. Since then, similarly to the long run expectations case, after the beginning of the Great Recession this effect has dissipated. Our findings display a clear pre- and post-financial crisis dynamics of inflation expectations toward MPU shocks.

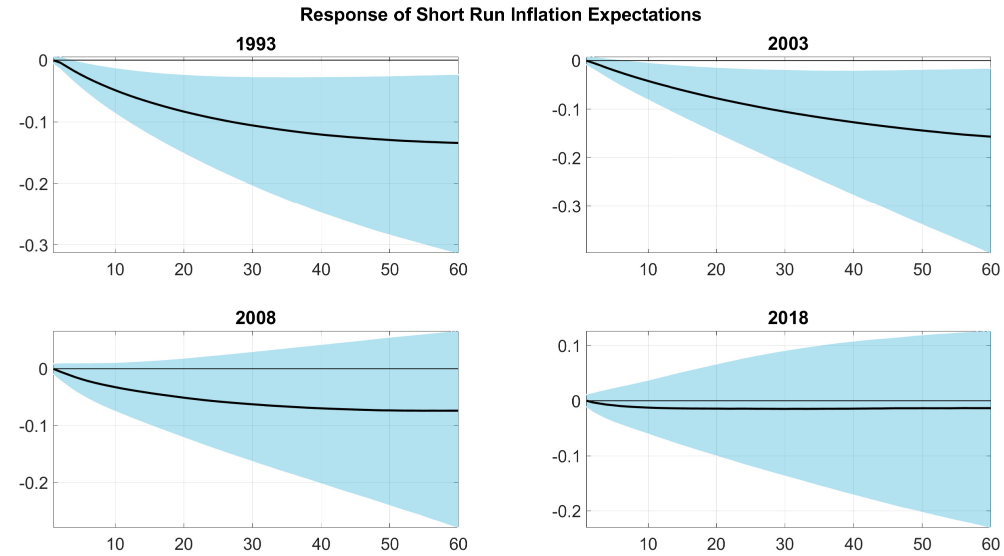

Figure 9: Impulse response of short run inflation expectations following a monetary policy uncertainty shock for specific periods, yearly average. Solid line denotes the median response and shaded area is the 68% probability intervals.

In contrast to the response of short and long run inflation expectations, inflation presents a negative response throughout the entire sample. This result is shown in Figure 10 where 68% error bands indicate a decline in inflation that is different from zero after a MPU shock. Additionally, one can observe that this decline is stronger compared to the response of short run inflation expectations. Nonetheless, the magnitude of the response has been more pronounced at the beginning of the century and has become weaker in recent periods.

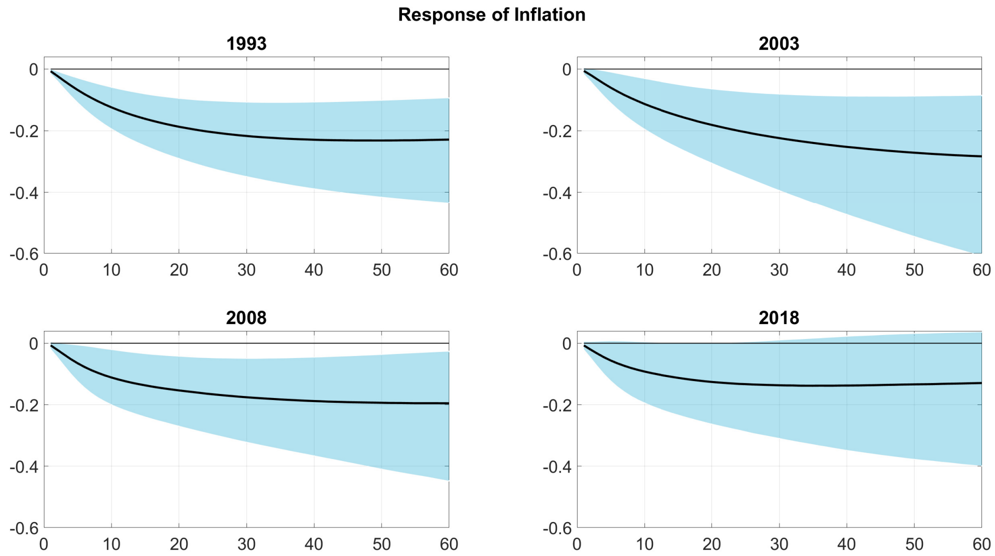

Figure 10: Impulse response of inflation following a monetary policy uncertainty shock for specific periods, yearly average. Solid line denotes the median response and shaded area is the 68% probability intervals.

The reaction of inflation is in line with the literature (e.g. Mumtaz and Zanetti, 2013). However, these results suggest that MPU shocks have become less important over time. The impulse responses of the remaining two variables, depicted on Figure 11, reinforce this notion. Unemployment has always increased following a MPU shock, albeit in different magnitude. By far the strongest response is estimated to be during the financial crisis, a result probably exacerbated through omitted variable bias as additional information is needed in the model to capture the sharp increase in unemployment during the crisis. Nevertheless, even in good times, a standard deviation shock in MPU increases unemployment by about 0.2 percentage points.

The monetary policy rate, namely the SSR in this specification, declines, supporting the notion of MPU shock being a negative demand shock (Leduc and Liu, 2016). The common theme of the model findings - insignificance towards the end of the sample bears good news for policy makers. If MPU shocks do not affect the monetary policy instrument, their ability to hamper the monetary transmission mechanism declines.

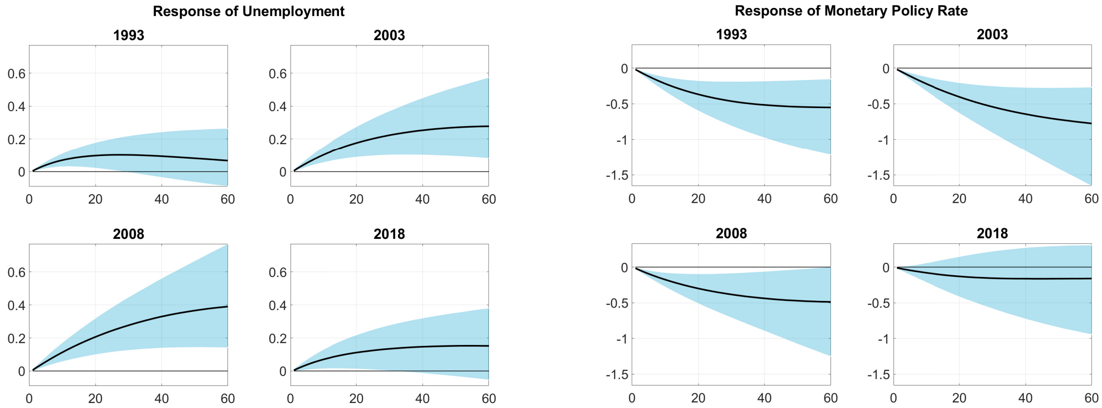

Figure 11: Impulse responses unemployment and monetary policy rate following a monetary policy uncertainty shock for specific periods, yearly average. Median response and 68% probability intervals.

6. Concluding remarks

In this paper we investigate the evolution of monetary policy uncertainty on the economy, with a special focus on the consequences unexpected increases of MPU on inflation expectations. Using monthly data for the US we estimate a SVAR with stochastic volatility-in-mean. Starting with a constant parameter specification we find further evidence that MPU shocks act as negative demand shocks with rising unemployment and decreasing price level. More importantly, we find that inflation expectations react negatively to an increase in the monetary policy uncertainty with a different magnitude for long and short inflation expectations. These results are amplified when accounting for the period of the zero lower bound.

Considering the evidence that inflation expectations differ across age groups and personal experience, we then estimate a model where we allow the parameters among the model variables to change over time. We treat the question of how much parameter evolution is allowed in the model as open and estimate it from the data.

This extension allows us to observe that long run and short run inflation expectations have reacted differently to MPU shocks in the 90s as opposed to today. Long run inflation expectations have remained mostly robust and unperturbed by MPU shocks apart from the beginning of the 90s. On the other hand, short run inflation expectations have had a pronounced negative response up to the Great Recession. After the 2008 crisis, short run

inflation expectations have become less and less affected by MPU shocks. This finding is surprising given that most episodes associated with high MPU have occurred post 2008. This distinction between long and short run inflation expectations suggests a level of rigidity surrounding long run inflation expectations associated with a credible central bank. Contrary to short run inflation expectations, inflation reacts negatively throughout the whole sample and more strongly than the inflation expectations in the short run.
Overall we find that MPU shocks have become less important over time. This is true not only for inflation expectations and inflation but also for unemployment and the interest rate. These findings suggests that monetary policy uncertainty might be less obstructing for the conduct of monetary policy than perceived. Neither interest rates react nowadays to MPU shocks as they did in the past, nor inflation expectations appear to respond as much as historically observed.

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A. Appendix

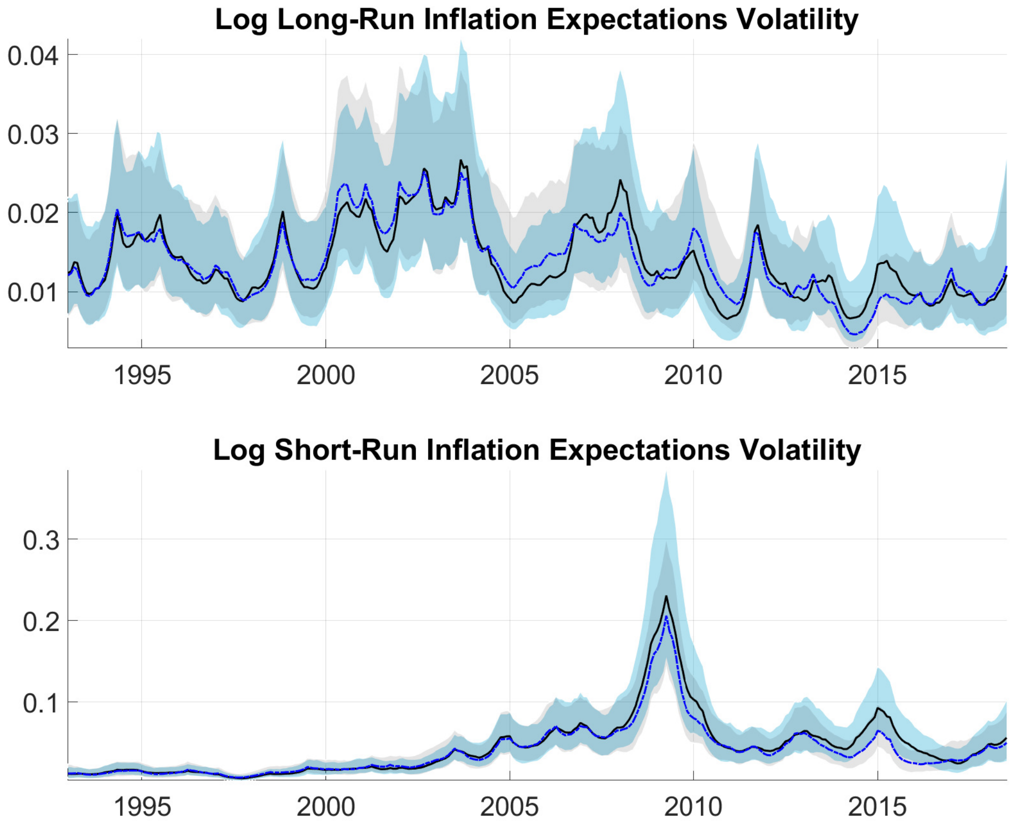

Figure A.1: Log-volatilities of short and long run inflation expectations based on a model with the SSR (solid line) and a FED Funds model (blue dashed line) with 68% probability intervals.

B. Convergence

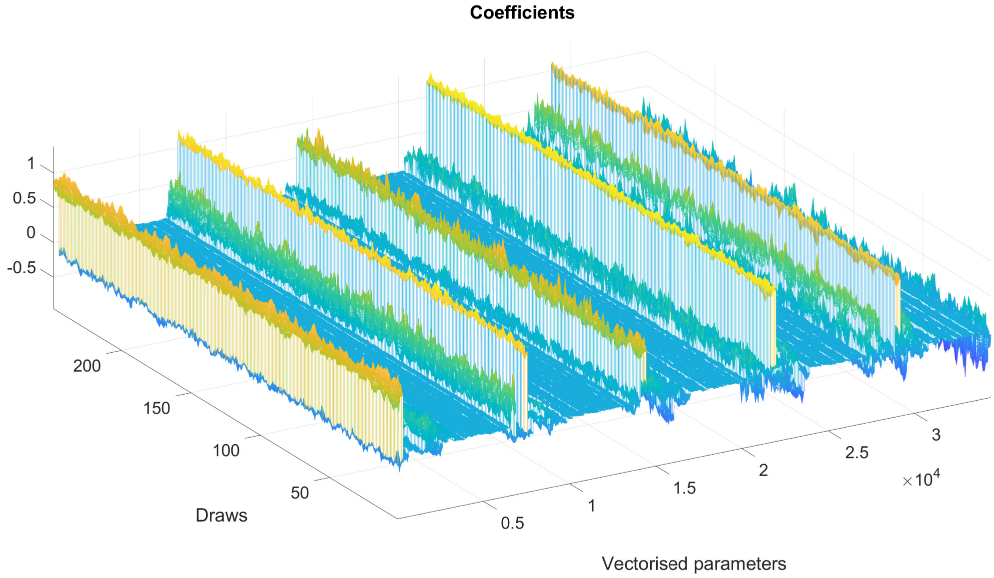

Figure B.1: Recursive means of the VAR coefficients.

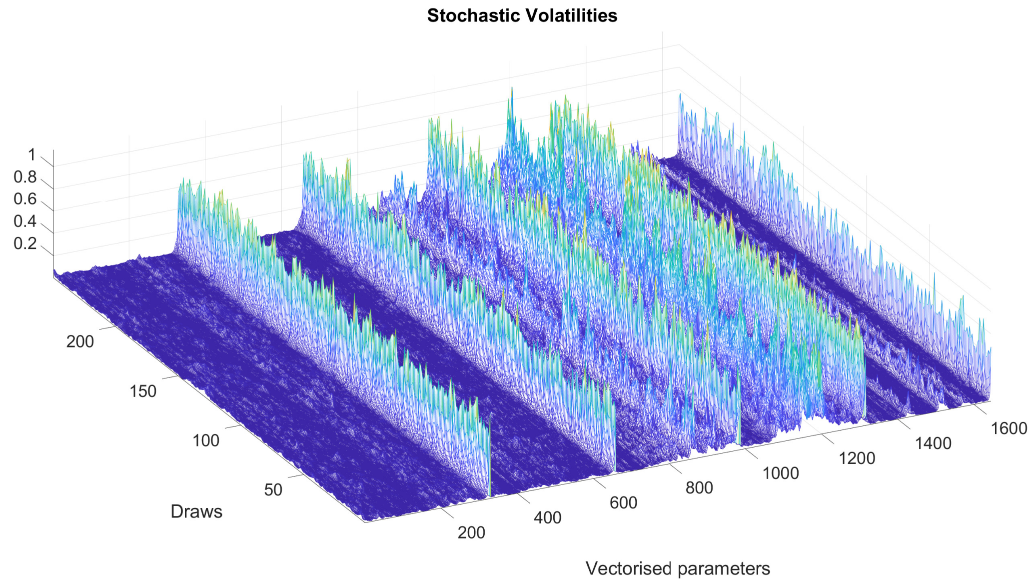

Figure B.2: Recursive means of the log-volatilities.

C. Time-varying responses

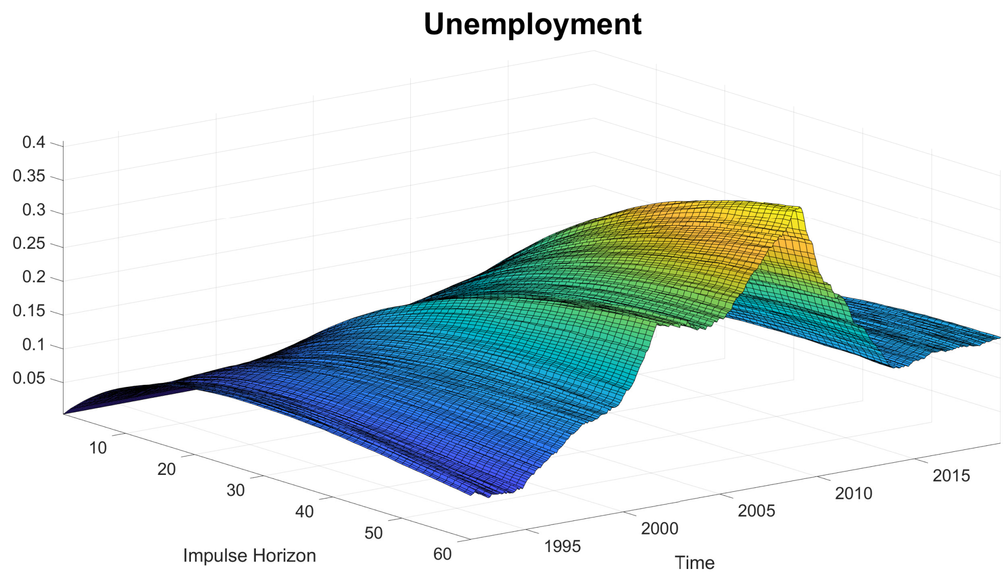

Figure C.1: Median response of unemployment to a monetary policy uncertainty shock.

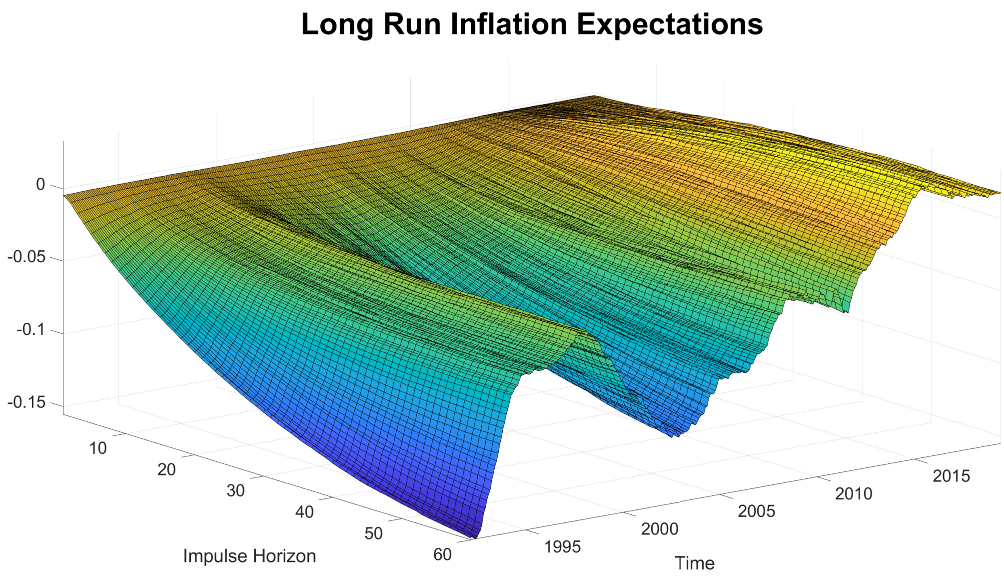

Figure C.2: Median response of long-run inflation expectations to a monetary policy uncertainty shock.

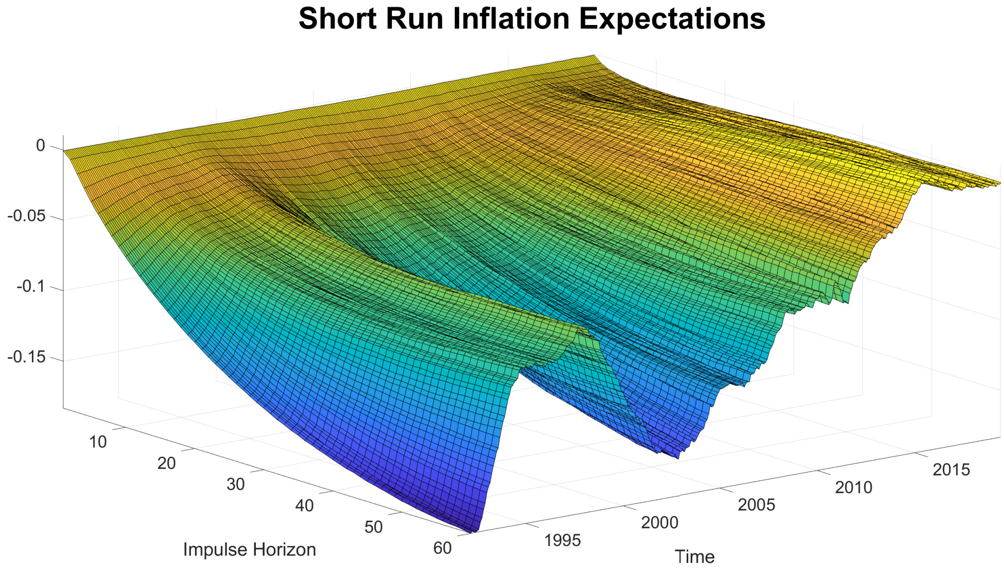

Figure C.3: Median response of short-run inflation expectations to a monetary policy uncertainty shock.

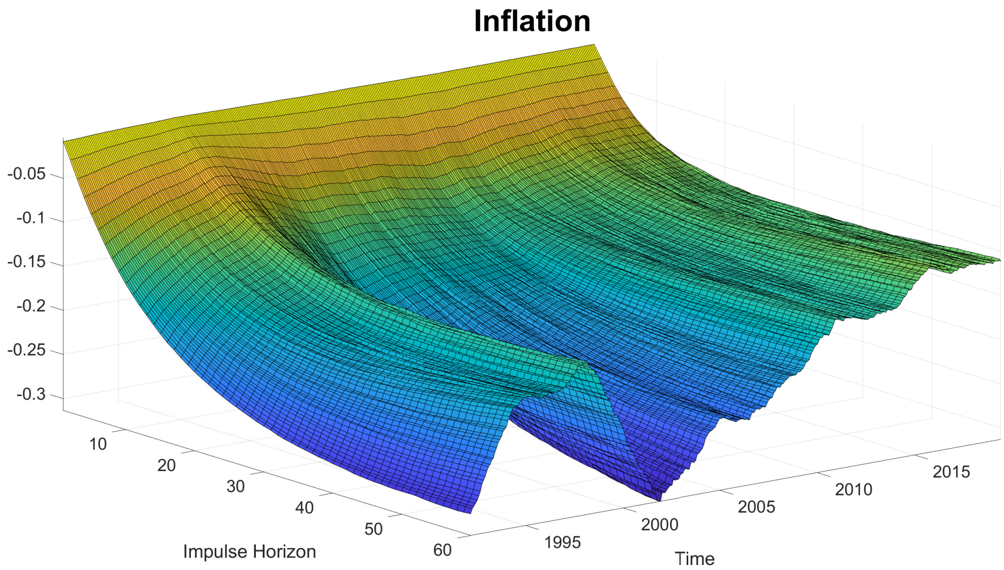

Figure C.4: Median response of inflation to a monetary policy uncertainty shock.

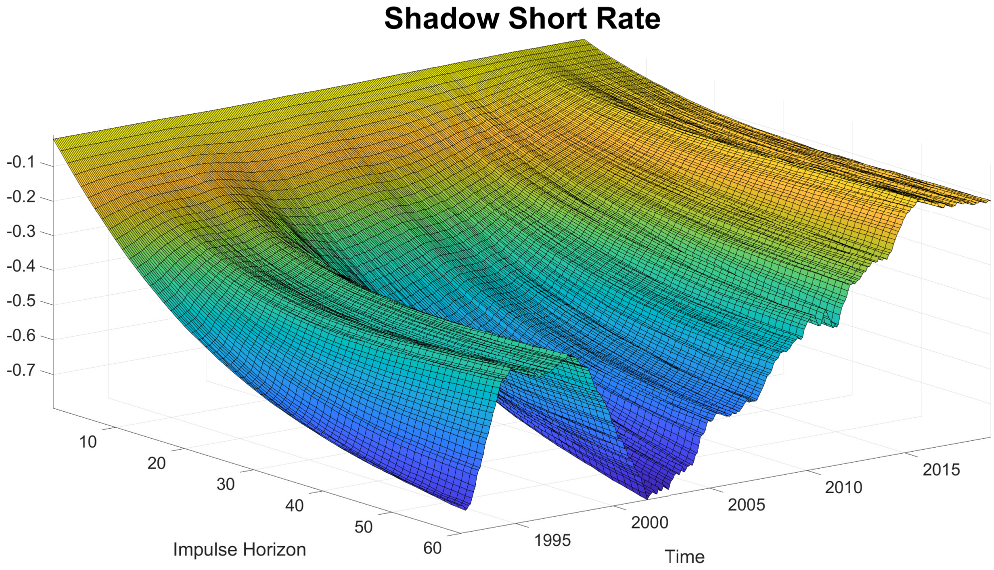

Figure C.5: Median response of the monetary policy rate to a monetary policy uncertainty shock.