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## Inflation Expectation Uncertainty, Inflation and the Outputgap

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# **INFLATION EXPECTATION UNCERTAINTY, INFLATION AND THE OUTPUT GAP**

Angela Fuest\* and Torsten Schmidt

## **ABSTRACT**

This article examines the effect of inflation expectation uncertainty on inflation, inflation expectations and the output gap. For monetary policy, guiding inflation expectations provides an instrument to affect economic conditions. However, expectation uncertainty may undermine monetary policy's ability to stabilise the economy. Using a VAR model with stochastic volatility in mean, this paper shows that inflation expectation uncertainty has negative effects on the inflation rate and the output gap. This result is replicable with a model, in which uncertainty is approximated by a cross-sectional survey measure. (*JEL* E31, C32)

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## I. INTRODUCTION

In the wake of the global financial crisis, central banks worldwide began rapidly lowering their policy rates in order to stimulate economic activity and reduce the risk of deflation. For instance, the level of the target federal funds rate, which had been 5.25 percent in mid-2006, was cut to the range of 0-0.25 percent between September 2007 and December 2008. Thus, the policy rate of the Federal Reserve had effectively reached the zero lower bound. At this point, traditional interest rate policy was no longer feasible to provide positive stimuli to the economy, and policymakers resorted to unconventional monetary policy measures, such as quantitative easing. Another strategy for central banks was the use of forward guidance, i.e. communication about the likely future course of monetary policy. This approach aims at influencing economic conditions in the present by guiding market expectations.

However, uncertainty at the zero lower bound may cause economic contractions, undermining the effectiveness of forward guidance (Basu and Bundick 2015). Thus, in this paper, we empirically explore the effects of inflation expectation uncertainty. For this purpose, we employ a vector autoregressive (VAR) model with stochastic volatility in mean, incorporating the variables of the New Keynesian Phillips Curve (NKPC): the inflation rate, the output gap and expected inflation. Previous studies have largely focused on either the relationships between inflation uncertainty, real uncertainty, the inflation rate and output growth (e.g. Grier and Perry 2000) or the links between inflation expectations and the inflation rate (e.g. Canova and Gambetti 2010). We add to the literature by directly investigating the response of inflation expectations, the inflation rate and the output gap to inflation expectation uncertainty. The use of two measures for inflation

expectation uncertainty – stochastic volatility and disagreement – distinguishes our approach from previous studies.

There are several hypotheses about inflation uncertainty and real uncertainty. Theoretically, the direction and the sign of the relationship between inflation uncertainty and inflation are ambiguous. In his Nobel Lecture, Friedman (1977) argues that in a high inflation environment, the monetary policy response becomes more unpredictable, which leads to increased uncertainty about future inflation. Ball (1992) formalises this idea in a Barro-Gordon (1983) type model, in which there is asymmetric information between the public and the monetary policymaker. In a low inflation environment the public expects the monetary authority to keep the inflation rate low. However, in a high inflation environment the public does not know whether future policymakers will readily disinflate or be reluctant to bear the costs of disinflation. Hence, a higher level of inflation increases uncertainty about future inflation. However, Ungar and Zilberfarb (1993) suggest that higher inflation may actually reduce inflation uncertainty. During high inflation episodes, forecast errors become more costly. Thus, economic agents have a stronger incentive to invest in inflation forecasting, which might diminish or offset the effect predicted by the Friedman-Ball hypothesis or even result in a negative relationship between inflation and inflation uncertainty. Nevertheless, causality may run into the reverse direction. Cukierman and Meltzer (1987) use a Barro-Gordon type model to show that inflation uncertainty affects the level of the inflation rate. In this model with asymmetric information the policymaker prefers a certain degree of ambiguity and control mechanisms that are less efficient. This enables the monetary authority to create large positive monetary surprises to stimulate output. As a result uncertainty about inflation causes inflation to be higher on average. Conversely, Holland (1995) postulates that inflation uncertainty

may decrease inflation. Because a rise in uncertainty creates welfare costs, monetary authorities may take actions to reduce inflation in response to increased uncertainty.

Other theories concern the effect of inflation uncertainty on the real economy. Friedman (1977) argues that inflation uncertainty undermines the signalling effect of prices and distorts the efficient allocation of resources and thus may reduce real growth. Uncertainty may also dampen growth by inhibiting irreversible investment (Pindyck 1991). However, in a cash-in-advance framework by Dotsey and Sarte (2000), inflation variability increases investment and growth via a precautionary savings motive. Other theories concern the relationship between real uncertainty and inflation or output. Increased output uncertainty may lead to a higher inflation rate (Devereux 1989) and to higher real output growth (Black 1987).

The empirical evidence for these theories is ambiguous. Overall, the findings give support to the Friedman-Ball hypothesis that inflation positively affects inflation uncertainty (Grier and Perry 1998; Fountas and Karanasos 2007). However, evidence for the Cukierman-Meltzer hypothesis is rather mixed. Fountas (2010) and Berument, Yalcin, and Yildirim (2009), for instance, find a positive impact of inflation uncertainty on the inflation rate for industrialised countries and the US, respectively. In contrast, the results of Grier and Perry (1998) indicate that more uncertainty lowers average inflation in the UK, the US and Germany, in accordance with the conjecture by Holland (1995). On the other hand, Kontonikas (2004), Grier and Perry (2000) and Fountas, Karanasos, and Kim (2006) find no effect of inflation uncertainty on the inflation rate in the UK, the US and Germany, respectively.

Hence, on the one hand, many studies have focused on inflation and output growth and their uncertainty, but the relationship between these variables and inflation expectations and the

uncertainty surrounding these expectations has not been considered so far in this strand of literature. On the other hand, studies which analyse the relationship between expected inflation and the inflation rate generally neglect the role of uncertainty.

In this group of empirical literature there are two strands that use survey data as a direct measure of inflation expectations. The first one employs VAR analyses (e.g. Clark and Nakata 2008; Canova and Gambetti 2010), showing that expectations are an essential part of inflation dynamics. Leduc, Sill, and Stark (2007) find that shocks to expectations play a greater role for the variability of inflation than monetary policy shocks. The other branch of literature estimates versions of the NKPC, employing survey data as a proxy for inflation expectations to study the relationship between the inflation rate and expectations. Roberts (1995) shows that inflation dynamics in the US may be well represented by a forward-looking NKPC in which expectations are approximated by data from the Michigan Surveys of Consumers.

Few studies explore the direct link between inflation expectations and uncertainty. First, some authors investigate the relationship between the level of inflation and inflation expectation uncertainty. For instance, Ungar and Zilberfarb (1993) examine inflation forecasts of economists and executives in Israel and their unpredictability measured by forecast errors. In this study, the level of the inflation rate has a positive effect on uncertainty surrounding inflation expectations. This link, however, is only significant during episodes in which inflation is high. Similarly, Arnold and Lemmen (2008) observe inflation expectations from the European Commission's Consumer Survey and find a positive relationship between inflation and disagreement within the Eurozone.

Second, other analyses focus on the relationship between the level of expected inflation and inflation expectation uncertainty. Zarnowitz and Lambros (1987) examine disagreement and

uncertainty on the basis of the ASA-NBER survey<sup>1</sup> in the US. Their results give support to the hypothesis that higher expected inflation leads to more uncertainty about inflation expectations. However, there is only a weak influence of disagreement on the mean inflation forecast. In contrast, in the analysis by Rich and Tracy (2010) disagreement and inflation expectations based on the Survey of Professional Forecasters (SPF) are positively correlated, whereas no link between forecast uncertainty and expected inflation is found.

Accordingly, this study adds to the literature by exploring the linkages between expectations, uncertainty and real activity more comprehensively. We analyse the effect of inflation expectation uncertainty on the inflation rate, the output gap and the level of expected inflation by means of a VAR model with stochastic volatility in mean. Inflation expectations are approximated by survey data from the University of Michigan's Surveys of Consumers. In order to analyse the impact of different properties of expectation uncertainty on inflation and real activity, we employ two different measures: an endogenous volatility measure from the VAR model and an exogenous disagreement measure from consumer surveys.

Our results reveal that inflation expectation uncertainty is not significantly related to changes of inflation expectations. However, inflation expectation uncertainty negatively affects the inflation rate. Similarly, there is a negative effect of inflation expectation uncertainty on the output gap. Accordingly, expectations are an important channel through which uncertainty affects the

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<sup>1</sup> The ASA-NBER survey was taken over by the Federal Reserve Bank of Philadelphia in 1990 and renamed Survey of Professional Forecasters.

economy. The results are robust with regard to the measure of inflation expectation uncertainty and to the measure of economic activity.

The outline of the paper is as follows. In the following section, we describe the measures of inflation expectations and uncertainty employed in this analysis. We further present the main features of the VAR model with stochastic volatility, the data and the estimation procedure. In section three we discuss the empirical results. Section four concludes.

## II. EMPIRICAL SPECIFICATION

### A. *Measures of Inflation Expectations*

A critical issue of our analysis is the choice of an appropriate measure of inflation expectations. Following a wide range of literature (e.g. Roberts 1995; Canova and Gambetti 2010), we employ a direct measure of inflation expectations obtained from surveys. There is no clear consensus in the literature whether expectations in the NKPC are to be modelled by rational expectations or to be approximated by other measures such as survey data. Fuhrer (2012) and Nunes (2010) employ both rational and survey expectations in the estimation of the NKPC to analyse the role of expectations for inflation dynamics. However, while Fuhrer (2012) concludes that price setting is dominated by survey expectations, Nunes (2010) finds a greater role for rational expectations. Roberts (1995) and Adam and Padula (2011) find that inflation dynamics in the US may be well represented by a forward-looking NKPC when expected inflation is approximated by survey data. Conversely, other studies suggest that a version of the NKPC with backward-looking components



– the so-called Hybrid NKPC – performs better than the forward-looking version when survey expectations are employed in the estimation (Henzel and Wollmershäuser 2008; Zhang, Osborn, and Kim 2009).

Another strand of literature also uses survey data in a direct approach to examine inflation dynamics. Instead of a Phillips curve, these studies employ VAR models in which survey forecasts of inflation enter as an endogenous variable (e.g. Leduc, Sill, and Stark 2007; Clark and Nakata 2008; Canova and Gambetti 2010). Moreover, survey expectations have been shown to outperform model-based forecasts by e.g. Ang, Bekaert, and Wei (2007), Grothe and Meyler (2015) and Gil-Alana, Moreno, and Pérez de Gracia (2012). Taken together, these studies suggest that survey data contain information about inflation expectations that can be used in empirical analyses.

An additional issue is whether some individuals have better information about future inflation and therefore form more precise expectations. Surveys usually reflect either the expectations of professional forecasters or the perceptions of private households. The most prominent surveys in the US are the SPF, the Livingston Survey and the Surveys of Consumers by the University of Michigan. The first two target economists and industry professionals; the SPF is conducted quarterly, while the Livingston survey is published bi-annually. The Michigan Survey was established in 1946 and is based on monthly interviews with a representative sample of approximately 500 US households, which are asked about different aspects of their personal

finances, business conditions and buying conditions, including their perception of past and future price developments.<sup>2</sup>

Research by Ang, Bekaert, and Wei (2007) points to the accuracy of households' forecasts of inflation in the Michigan Survey, which perform well relative to professional forecasts from the SPF and the Livingston survey. While survey inflation expectations may have become less accurate in recent years (Trehan 2015), Fuhrer (1988) points out that even in case survey forecasts are inefficient and subject to measurement errors, they may contain independent information. He shows that consumer sentiment data from the Michigan Survey provide useful information above that which is given in standard macroeconomic variables.

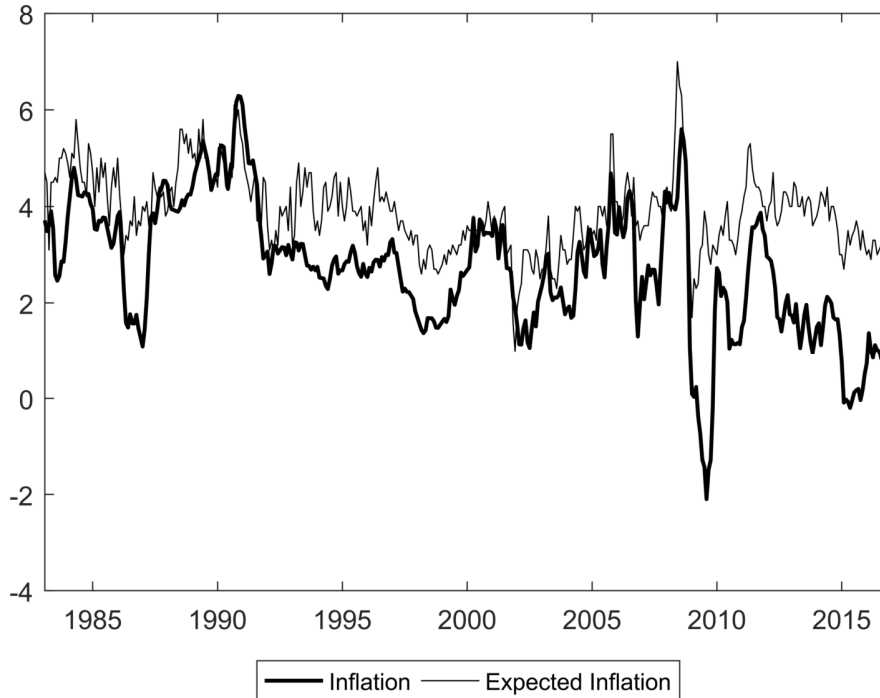
A further argument for using consumer survey data is provided by Coibon and Gorodnichenko (2015). They argue that small and medium-sized enterprises are influential drivers of price setting in the US, and that the attitudes of these firms are well represented by the sentiments of private households. In their study, consumers' expectations from the Michigan Survey are more relevant than professional forecasts for inflation dynamics in a Phillips curve framework. Consequently, we employ expectations from the Surveys of Consumers from the University of Michigan in our study, which allows us to conduct the analysis on the basis of monthly data.

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<sup>2</sup> The assessment of households' inflation expectations is based upon two questions. Consumers are first asked "During the next 12 months, do you think that prices in general will go up, or go down, or stay where they are now?" and subsequently "By about what percent do you expect prices to go (up/down), on the average, during the next 12 months?". For further information on the procedure to construct estimates of households' price expectations see Curtin (1996).

**FIGURE 1**

US Inflation and Michigan Consumer Survey Inflation Expectations



*Notes:* Inflation is computed from the Consumer Price Index for All Urban Consumers: All Items (FRED Database); Expected Inflation is the expected change of prices over the next 12 months as calculated by the Michigan Surveys of Consumers.

Consequently, we employ expectations from the Surveys of Consumers from the University of Michigan in our study, which allows us to conduct the analysis on the basis of monthly data.

Figure 1 shows monthly US inflation rates and average inflation expectations captured in the Michigan Surveys of Consumers between January 1983 and December 2016. During the 1980s and the first half of the 2000s, expected inflation followed actual inflation relatively closely. However, since the Great Recession consumers tend to overestimate actual inflation. Overall, the inflation rate is more volatile than inflation expectations.

## *B. Uncertainty Measures*

This study explores how inflation expectation uncertainty and economic variables are interlinked. To answer this question, we use two distinct measures of expectation uncertainty: a time-series measure and a cross-section measure.

The time-series literature provides in principle two types of time-varying volatility models that can be applied to consider uncertainty. The first is the family of generalised autoregressive conditional heteroskedasticity (GARCH) models (Engle 1982; Bollerslev 1986), in which the conditional variance is modelled as a deterministic function of previous observation and past variances (Kim, Shephard, and Chib 1998). Empirical studies that analyse links between uncertainty and inflation or real growth frequently employ GARCH models, in which the conditional variance serves as a proxy for uncertainty (e.g. Grier and Perry 2000; Elder 2004). The second framework that features time-varying variance is the stochastic volatility model (for an overview see e.g. Shephard and Andersen 2008). In this model, the variance is a random variable that follows a latent stochastic process (Kim, Shephard, and Chib 1998). Stochastic volatility models have also been used in the context of uncertainty. For instance, Berument, Yalcin, and Yildirim (2009) study the effect of inflation uncertainty on inflation by means of a stochastic volatility in mean model, while Lemoine and Mougin (2010) analyse the relationship between output volatility and output growth using this approach. There is some evidence that SV models perform better than GARCH models (Kim, Shephard, and Chib 1998; Chan and Grant 2016). Accordingly, we opt to employ the more dynamic approach and use an SV model for our benchmark analysis.

The second measure of expectation uncertainty that we use in this study is driven by the survey data itself. It originates from the literature on disagreement among forecasters, which is defined as the cross-sectional dispersion of survey responses. While some authors make use of the standard deviation of survey forecasts around the mean (e.g. Zarnowitz and Lambros 1987; Holland 1995), in recent studies disagreement is quantified by the interquartile range of point forecasts (Mankiw, Reis, and Wolfers 2004; Dovern, Fritsche, and Slacalek 2012). To what extent disagreement is an appropriate proxy for uncertainty is subject to debate in the literature. While e.g. Zarnowitz and Lambros (1987) find that disagreement understates uncertainty, Giordani and Söderlind (2003) conclude that disagreement approximates inflation uncertainty reasonably well.

Accordingly, in our analysis, we employ the stochastic volatility in mean model, in which a change in the volatility of an inflation expectation shock is used to assess the effects of inflation expectation uncertainty. We additionally estimate a model, in which disagreement serves as a proxy for expectation uncertainty.

### *C. Empirical Model*

As a first step in our analysis, we estimate a VAR model, in which the uncertainty measure is determined endogenously. Specifically, we employ a three variable VAR with stochastic volatility in mean based on the specification by Mumtaz and Zanetti (2013). In this model, the stochastic volatilities are added as additional regressors into the observation equations. This allows analysing the link between the endogenous variables and time-varying volatility. The univariate stochastic

volatility in mean model originates from Koopman and Uspensky (2002). In our analysis, the trivariate VAR with stochastic volatility in mean is given by

$$Z_t = c + \sum_{j=1}^p \beta_j Z_{t-j} + \sum_{i=0}^q \gamma_i \tilde{h}_{t-i} + \Omega_t^{1/2} e_t, \quad e_t \sim N(0,1), \quad (1)$$

where  $(Z_t)$  is a vector of three endogenous variables, namely expected inflation, the inflation rate and the output gap. Vector  $(\tilde{h}_t)$  contains the log volatility of the corresponding structural shocks. Thus, this model allows for direct effects of the volatility of a structural shock on the endogenous variables. Consequently, the impact of uncertainty on the variables of interest can be studied in a dynamic approach. Analogous to Cogley and Sargent (2005), the conditional variance-covariance matrix is decomposed as

$$\Omega_t = A^{-1} H_t A^{-1'} , \quad (2)$$

where the decomposition matrix  $(A)$  is lower triangular, and  $(H_t)$  is a diagonal matrix:

$$H_t = \begin{pmatrix} \exp(h_{1t}) & 0 & 0 \\ 0 & \exp(h_{2t}) & 0 \\ 0 & 0 & \exp(h_{3t}) \end{pmatrix}. \quad (3)$$

The log volatilities follow an AR(1) process, so that the transition equation is given by

$$\tilde{h}_t = \theta \tilde{h}_{t-1} + \eta_t, \quad \eta_t \sim N(0, Q), E(e_t, \eta_t) = 0, \quad (4)$$

with  $(\theta)$  being a diagonal matrix. The matrix  $(Q)$  is assumed to be a diagonal matrix. An innovation in  $(\eta_t)$  can be interpreted as a shock to the volatility of the respective structural shock.<sup>3</sup>

We select the lags for the endogenous regressors in the VAR equation based on the Ljung-Box test, rejecting the null hypothesis of autocorrelated residuals at six lags. Furthermore, the mean equation incorporates two lags of the log volatility in addition to the contemporaneous volatility.

As mentioned above, expected changes in prices over the next twelve months from the Michigan Survey of Consumers serve as a proxy for inflation expectations in our analysis. Data for the other variables are obtained from the FRED database by the Federal Reserve Bank of St. Louis. The measure for inflation is the year on year change of the Consumer Price Index for All Urban Consumers. The output gap is determined as the difference between industrial production and potential output, where potential output is obtained by employing the HP-filter (Hodrick and Prescott 1997) to the industrial production series. Our sample runs from January 1983 to March 2017. We test the variables for non-stationarity and reject the presence of unit roots (Table 1).

**TABLE 1**  
Unit Root Tests: Augmented Dickey-Fuller test

	Test Statistic	Probability
Output Gap	-6.4926	0.0000
Expected Inflation	-6.4196	0.0043
Inflation	-3.7505	0.0030

*Notes:*  $H_0$ : Variable has a unit root. The test equations for inflation and expected inflation include a constant and a trend; the test equation for the output gap does not include additional regressors. The lag length is based on the Schwarz information criterion (maximum lags set to 17).

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<sup>3</sup> The estimation of the non-linear state space model is based on a Gibbs sampling algorithm. Equation (1) represents the observation equation and Equation (4) represents the transition equation. For details see Mumtaz and Zanetti (2013). We are grateful to Haroon Mumtaz for making the corresponding Matlab code available.

As an alternative to our baseline model, in a second step, we estimate a trivariate VARX model with an exogenous measure of uncertainty. In this model, the three variables of interest enter as endogenous regressors, and a proxy for expectation uncertainty – the cross-sectional dispersion of the Michigan survey – enters as an exogenous variable. This measure of disagreement ( $d_t$ ) is given by the interquartile range of inflation forecasts. We choose the lag length of the endogenous variables according to the Schwarz information criterion. Analogously to Equation (1) the VARX is given by

$$Z_t = c + \sum_{j=1}^2 \beta_j Z_{t-j} + \phi_0 d_t + e_t . \quad (5)$$

### III. RESULTS

#### A. *Volatility*

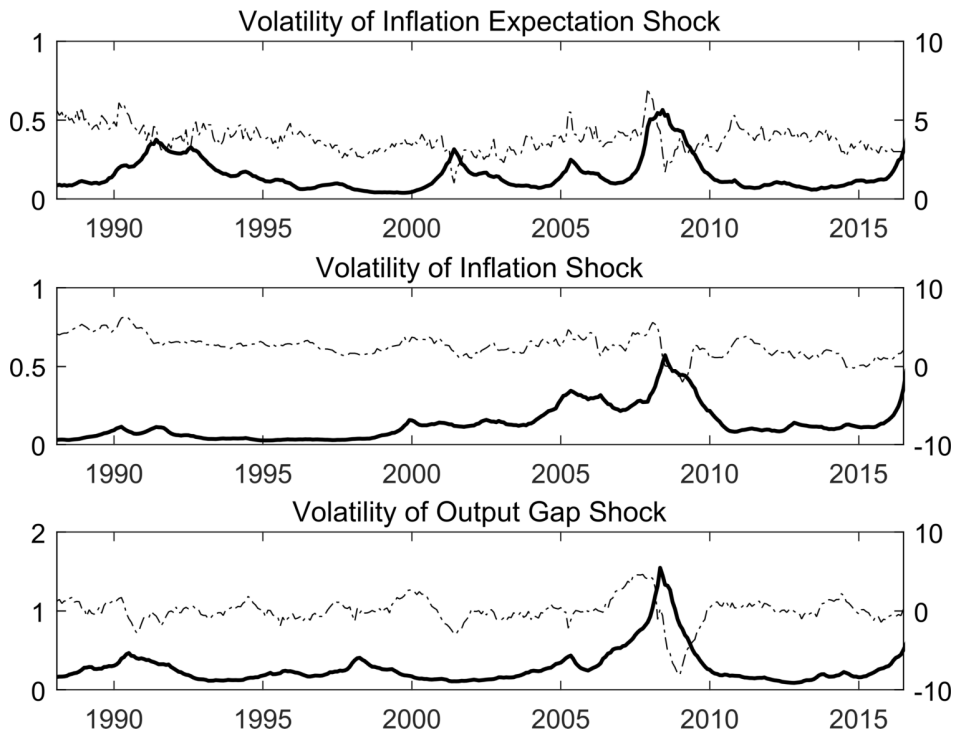
The subplots of Figure 2 illustrate the estimated volatilities of the inflation expectation shock, the inflation shock and the output gap shock. The shock to the expected inflation equation shows volatility peaks in the early 1990s after the first Gulf War, during the US recession of the early 2000s and during the recent financial crisis. The inflation shock was less volatile during the 1990s and early 2000s, but became markedly volatile during the financial and economic crisis for a period of approximately two years. The volatility of the output gap shock displays peaks in the early 1990s and in 2008. However, between 2010 and 2015 the variance was relatively low compared



to previous periods. Notably, the volatilities of all three shocks rocket upwards at the end of the observation period.

**FIGURE 2**

Estimated Standard Deviations of Shocks



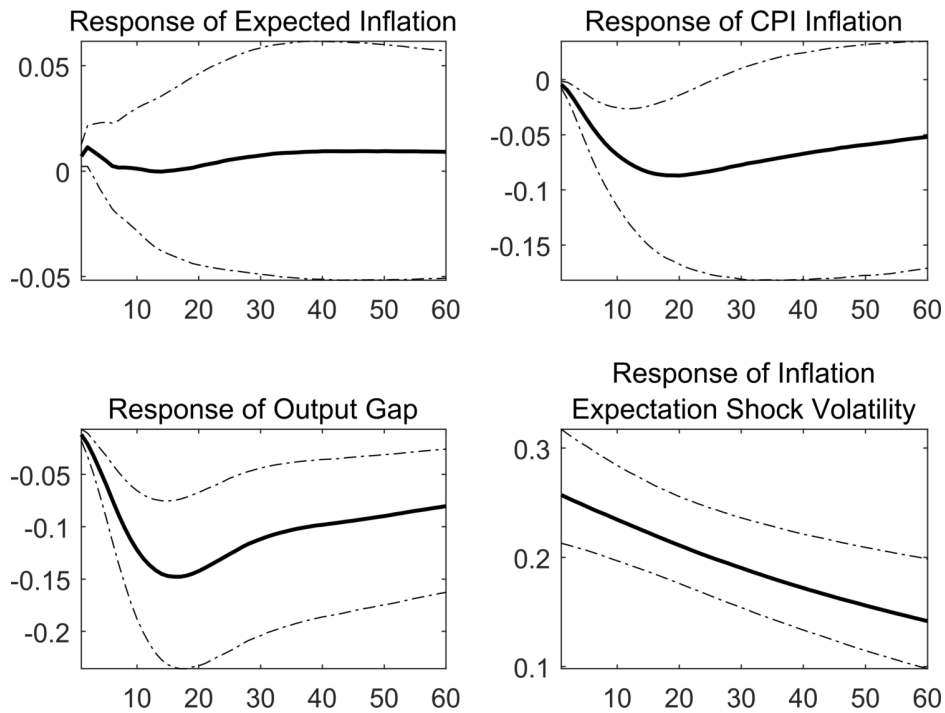
*Notes:* The bold line denotes the median of the volatility estimate of the respective shock (left axis); the dotted line denotes the time series of the corresponding level variable.

Figure 3 shows the impulse responses to an increase in the volatility of the inflation expectation shock based on the Cholesky decomposition. The response of the shocks' volatility is persistent, being still roughly half as large after 60 periods as on impact. There is only a small increase in expected inflation at the time of the shock; and in the subsequent periods the confidence bands include the zero line. CPI inflation drops only slightly on impact, but declines further during the following 15 months. Similarly, the output gap falls in response to the increase of the inflation

expectation shock volatility, with a trough occurring after 15 months. However, the decline is stronger than the decrease in inflation.

**FIGURE 3**

Impulse Responses to a Shock to the Volatility of the Inflation Expectation Shock



Notes: The solid line denotes the median response, the dashed lines indicate 68 percent confidence bands.

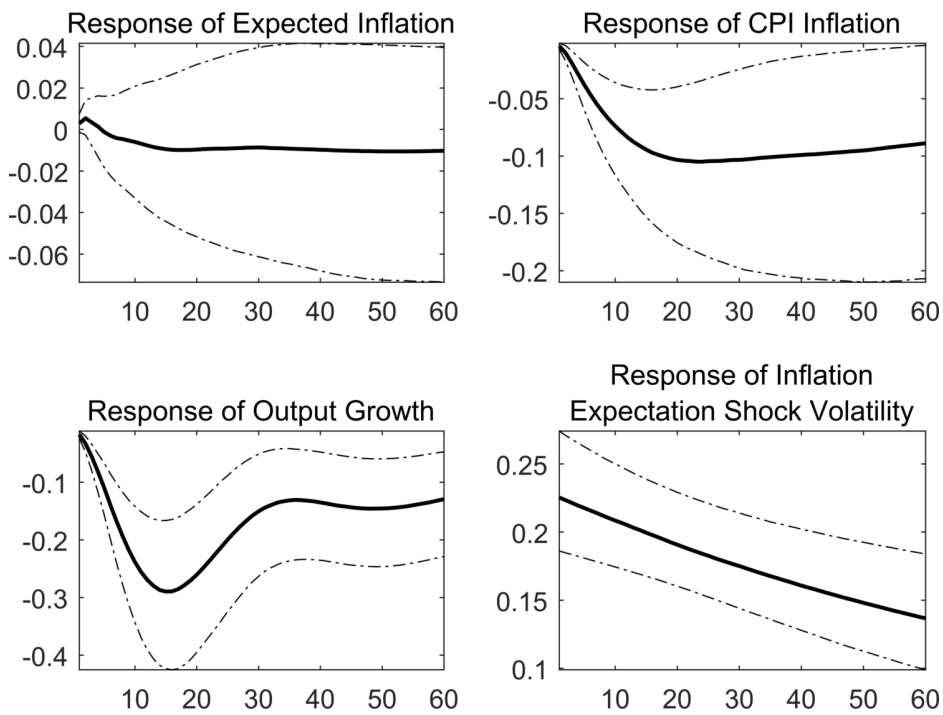
The benchmark VAR includes the output gap as an endogenous variable. However, there are some drawbacks to quantifying the unobservable output gap. In empirical estimations, the output gap is commonly calculated by a solely statistical approach, which involves filtering a time series in order to separate a cyclical component from a trend. Nevertheless, filters such as the HP filter are subject to critique (Harvey and Jaeger 1993; Cogley and Nason 1995). That is why, as a robustness check, we replace the output gap variable by output growth – a measure that has been used in other studies that analyse the relationship between uncertainty and economic variables (e.g. Grier and Perry

2000; Hartmann and Roestel 2013). Accordingly, the annual change of industrial production, the inflation rate and expected inflation are the endogenous variables of the modified VAR model.

Figure 4 displays the corresponding impulse responses.

**FIGURE 4**

Robustness Check: Impulse Responses for a VAR with Output Growth



Notes: The solid line denotes the median response, the dashed lines indicate 68 percent confidence bands.

Overall, the responses are similar to those of the benchmark VAR. On impact, expected inflation increases marginally, but the error bands remain broad. The inflation rate decreases more strongly than before, and the response is more persistent. The decline of output growth is approximately

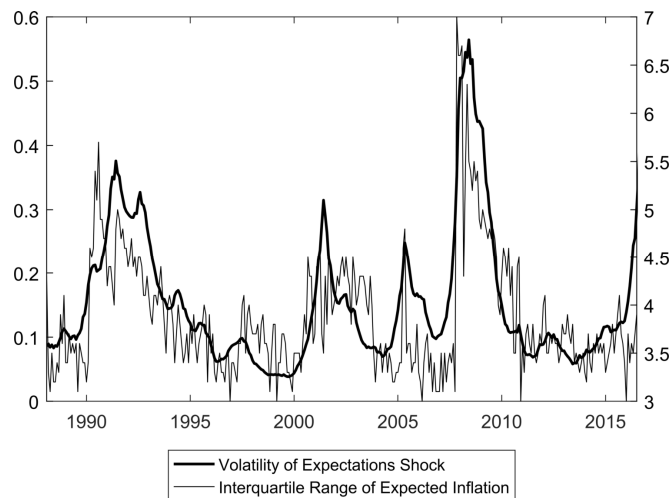
twice as large as the decrease of the output gap. The trough occurs after around 15 months, after which the response stabilises at around -0.2 percent.

### *B. Disagreement*

The alternative measure of inflation expectation uncertainty is given by the cross-sectional disagreement measure of the Michigan Survey. Figure 5 shows the volatility of the inflation expectations shock over time in comparison to the interquartile range of expected inflation. Overall, the patterns of the two series are similar. Though, in the years before the financial crisis, the disagreement between the survey respondents was low, while the volatility of the expectations shock started increasing before 2005.

**FIGURE 5**

**Uncertainty Measures: Volatility of Inflation Expectations Shock and Interquartile Range of Inflation Expectations**

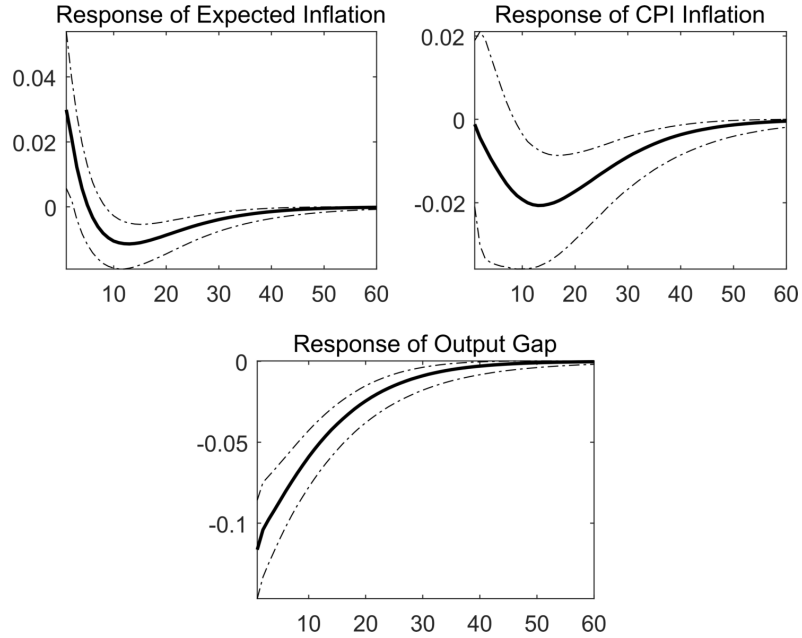


*Notes:* Axis for volatility (bold line) on the left, axis for interquartile range (thin line) on the right.

Impulse responses to a standard deviation disagreement shock from the VARX model are displayed in Figure 6. There is a small initial increase in expected inflation; after five months the response turns negative and subsequently diminishes, fading after approximately four years. The jump on impact is slightly higher than in the benchmark VAR with stochastic volatility, and the error bands are narrower. CPI inflation responds negatively to the shock, comparable to the benchmark case. However, the confidence bands indicate that the response is more imprecise on impact. After a year, the effect weakens, and after about four years, it fades. The output gap shows the strongest response to the disagreement shock, but the response is not persistent. Hence, both the model with stochastic volatility and the model with disagreement imply that inflation expectation uncertainty has contractionary effects.

**FIGURE 6**

**Impulse Responses to Disagreement Shock**



*Notes:* Disagreement is defined as the interquartile range of survey responses. The median response is denoted by the bold line, the dashed lines indicate the 68% confidence band.

**IV. CONCLUSIONS**

In the aftermath of the financial crisis, the policy rates of central banks reached the zero lower bound. Because traditional interest rate policy is no longer feasible at the zero lower bound, guidance of market expectations becomes an important instrument to affect economic conditions. However, the uncertainty that results from the zero lower bound may impinge on expectations and thus reduce the effectiveness of monetary policy. This study analyses inflation expectation uncertainty and the effect this uncertainty has on economic activity.

A VAR model with stochastic volatility in mean allows us to assess the impact of changes in the volatility of an expectation shock on inflation expectations, the inflation rate and the output gap. Our results indicate that inflation expectation uncertainty negatively affects the inflation rate and the output gap. Accordingly, expectations are an important channel through which uncertainty affects the economy. The results are robust with regard to the measure of inflation expectation uncertainty and to the measure of economic activity.

For monetary policy, in particular forward guidance, our results have important implications. Changes in inflation expectation uncertainty can have economically significant effects on inflation and real economic activity, even without substantial changes in inflation expectations. Besides focusing on stabilising the level of inflation expectations to control the future path of inflation, it is hence important to reduce the uncertainty about inflation expectations. This requires monetary authorities to better understand how expectations are formed and what the main determinants of expectation uncertainty are.

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## ABBREVIATIONS

GARCH: Generalised Autoregressive Conditional Heteroskedasticity

VAR: Vector Autoregression

NKPC: New Keynesian Phillips Curve

SPF: Survey of Professional Forecasters