Uncertainty and the Macroeconomic Effects of Monetary Policy in the Euro Area

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Abstract

This dissertation examines how uncertainty alters the transmission of monetary policy shocks to inflation and economic activity in the euro area. Using high-frequency changes in overnight index swap rates around European Central Bank announcements, the analysis estimates impulse responses under varying levels of financial market uncertainty, measured by the VSTOXX index. The results show that uncertainty amplifies the disinflationary effects of monetary policy tightening, particularly in the short to medium term. Amplification is most persistent for the part of the shock related to forward guidance and larger for the part of the shock related to stance. Regarding economic activity, the findings suggest that a policy tightening leads to a significantly larger drop in industrial production during times of heightened uncertainty. To see whether these responses are symmetric, monetary shocks are split into contractionary and expansionary shocks. Inflation responds asymmetrically: policy tightening has a stronger effect when uncertainty is high, while not significantly altering the impact of expansionary shocks. For industrial production, uncertainty amplifies both tightening and easing shocks, making the response symmetric. These findings provide new evidence on the importance of central banks to consider prevailing uncertainty when making monetary policy decisions.

Keywords: monetary policy, uncertainty, inflation, euro area, industrial production, state-dependence

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Resumo

Esta dissertação examina como a incerteza altera a transmissão de choques de política monetária para a inflação e a atividade economica na área do euro. Utilizando variações de alta frequência nas taxas de *overnight index swap* em torno dos anúncios do Banco Central Europeu, a análise estima as respostas a impulsos sob diferentes níveis de incerteza nos mercados financeiros, medida pelo índice VSTOXX. Os resultados mostram que a incerteza amplifica os efeitos desinflacionários de um aperto da política monetária, particularmente no curto e médio prazo. A amplificação é mais persistente para a parte do choque relacionada com a *forward guidance* e maior para a parte do choque relacionada com a orientação de política. No que diz respeito à atividade economica, as evidências sugerem que um aperto da política leva a uma queda significativamente maior na produção industrial em períodos de elevada incerteza. Para verificar se essas respostas são simétricas, os choques monetários são divididos em contracionistas e expansionistas. A inflação responde de forma assimétrica: o aperto da política tem um efeito mais forte quando a incerteza é alta, mas a resposta da inflação não se altera significativamente após choques expansionistas. Já para a produção industrial, a incerteza amplifica tanto o choques contracionistas como os expansionistas, tornando a resposta simétrica. As conclusões fornecem novas evidências sobre a importância de os bancos centrais considerarem a incerteza vigente ao tomar decisões de política monetária.

Palavras-chave: política monetária, incerteza, inflação, área do euro, produção industrial, dependência do estado

Título: Incerteza e os Efeitos Macroeconomicos da Política Monetária na Área do Euro

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1 Introduction

The transmission of monetary policy to inflation plays a key role in how central banks make decisions and has been a central focus in economics for a long time. Maintaining price stability is the primary objective of the European Central Bank (ECB), which relies on its ability to influence inflation and other economic variables through adjustments in policy rates (European Central Bank, 2025). However, how effective these policy changes will be might depend on the economic environment they are implemented in. One factor that may affect the transmission of monetary policy shocks to the economy is uncertainty. Studies have shown that uncertainty can significantly influence how households, firms and financial markets respond to monetary policy shock (Bloom, 2009; Pástor & Veronesi, 2012), which raises the question of whether uncertainty influences how monetary policy is transmitted through the economy.

Recently, uncertainty has been gaining a lot more attention due to high uncertainty events such as the war in Ukraine, COVID-19 and other geopolitical and economic tensions. These developments have led to new challenges to arise concerning monetary policy and raised important questions about how effectively policy can be transmitted under heightened uncertainty. Does the economy respond in the same way under circumstances of high uncertainty or does uncertainty alter the effects of monetary policy transmission? This question has become important to answer, especially if elevated uncertainty is becoming a more persistent feature in our economy. Understanding how such conditions influence the effectiveness of monetary policy has become particularly important for policymakers and central bankers since it can help them take a more informed decision and tailor their actions based on the level of uncertainty in the economy.

Along with the growing uncertainty in the economic environment, the mixed evidence on how uncertainty affects the transmission of monetary policy inspired the research in this dissertation. While some studies find that uncertainty tends to dampen the impact of policy shocks, particularly on real variables such as output and investment, others find mixed results between real variables and nominal ones. For instance, Aastveit et al. (2017) find that when uncertainty is high, monetary policy tends to have weaker effects on real variables but no meaningful effect on inflation. Furthermore, Castelnuovo and Pellegrino (2018) find that uncertainty might dampen the response of real variables but increase the effects on inflation. This raises important questions about whether the transmission of monetary policy truly weakens under uncertainty or whether the effects differ across economic channels. For central banks and policymakers, understanding this interaction is essential. Misjudging how uncertainty influences monetary policy transmission can lead to ineffective decisions or even overestimation/underestimation of policy responses under high uncertainty. It is thus important to know how the economy responds under heightened uncertainty and whether these responses vary between real and nominal variables, particularly for central banks targeting price stability in today's uncertain environment.

This dissertation investigates how uncertainty affects the transmission of monetary policy shocks to inflation in the euro area. The central question it addresses is whether heightened uncertainty amplifies or dampens the effects of monetary policy on inflation and whether these effects extend to real economic activity, as measured by industrial production.

In my analysis, I find that heightened uncertainty amplifies the disinflationary effects of monetary policy shocks, particularly in the short to medium term. This amplification lasts longer for the part of the monetary policy shock that relates to forward guidance, suggesting that markets become more sensitive to the narrative and forward guidance of the ECB when uncertainty is high. On the real side, uncertainty also strengthens the contractionary effects of monetary policy on industrial production, with firms reducing output more aggressively following policy tightening in uncertain environments. I also find that the amplification of the response of inflation to shocks is asymmetric, occurring only after contractionary shocks, whereas the amplification in industrial production is symmetric for both contractionary and expansionary shocks. Together, these findings indicate that uncertainty intensifies the overall transmission of monetary policy to both nominal and real variables, underscoring the importance of policy and communication strategies that are influenced by the prevailing level of uncertainty.

The dissertation provides several important contributions to the literature on monetary policy transmission under uncertainty. First, it offers new empirical insights about how uncertainty affects the impact of monetary policy shocks, focusing on the euro area, which has been less studied compared to the U.S.. Second, I add a communication channel dimension by breaking the event window surrounding the monetary policy shock into two separate components: the ECB’s press release window and the press conference window. Such a decomposition enables me to examine more clearly how different aspects of central bank communication help policy transmission act under uncertainty. Third, the analysis includes both inflation and industrial production in order to examine whether monetary transmission affects nominal and real variables similarly, which can shed light on whether changes in inflation are accompanied by corresponding movements in the real economy.

Finally, the empirical framework used in this research is flexible and allows for both nonlinear and asymmetric responses. In particular, the use of continuous measures of uncertainty rather than discrete regime-switching models enables the estimation of state-dependent effects. This dissertation also investigates whether the effects of uncertainty are symmetric between expansionary and contractionary policy shocks which is an aspect that most existing studies examine only for one shock direction. This allows for a deeper understanding of the complexities surrounding monetary transmission under uncertainty.

To empirically analyse these dynamics, I construct a monthly series of high-frequency monetary policy shocks derived from changes in overnight index swap (OIS) rates surrounding ECB announcements. The responses of inflation and industrial production to these shocks are estimated using the local projection method (Jordà, 2005), which allows for flexible modeling of dynamic responses without strong parametric assumptions. Uncertainty is captured by the VSTOXX index, a forward-looking measure of euro area financial market volatility, while Economic Policy Uncertainty (EPU) index is used for a robustness check.

The analysis begins by estimating the average impact of monetary policy shocks on inflation and then introduces interaction terms to capture state-dependent effects under different levels of uncertainty. After that the inflation response is decomposed based on the timing of monetary policy communication to examine whether specific ECB communication windows play a more significant role under uncertainty. Industrial production is then incorporated into the analysis to get a more complete picture of the effects of monetary policy under uncertainty. Finally, the study explores potential asymmetries in the response to contractionary versus expansionary shocks.

The rest of the dissertation is organized as follows: Chapter 2 reviews the literature on monetary policy transmission, the macroeconomic effects of uncertainty and the interaction between the two. Chapter 3 describes the data and variables used in the analysis. Chapter 4 details the empirical strategy, including model specification and interaction terms. Chapter 5 presents the core results for inflation, with extensions to industrial production. Chapter 6 reports robustness checks, and Chapter 7 concludes with a summary of findings, limitations and implications for policy and future research.

2 Literature Review

2.1 The Transmission of Monetary Policy to Inflation

How inflation responds to central bank's decisions is a key focus in macroeconomic theory and policy evaluation. The transmission of monetary policy to inflation has been at the heart of policy debate and research for decades. According to the New Keynesian framework, monetary policy influences inflation through its effect on expectations and overall demand (Woodford, 2003). When a central bank increases interest rates, demand reduces which lowers inflationary pressure over time. This happens because with higher interest rates, borrowing becomes more expensive and savings become more attractive. In turn, spending cools down, which causes demand to drop and prices to fall.

Empirical studies based on VAR models such as the one by Christiano et al. (2005) indicate that monetary policy surprises have a significant impact on inflation with a lag. While output tends to react more quickly, the inflation response unfolds more slowly and may take multiple quarters before it reaches its peak. In a previous study, Sims (1992) found that a tightening policy could initially raise inflation, a counterintuitive result later termed the "price puzzle" (Leeper et al., 1996).

To improve the estimation of inflation dynamics, Galí and Gertler (1999), incorporate forward-looking expectations and structural models based on real marginal cost. Their findings support the New Keynesian Phillips Curve, where forward-looking behavior plays a dominant role in driving inflation. The literature also highlights the role of credibility in shaping monetary policy effectiveness. A central bank that can credibly signal its intent to maintain low inflation in the future may reduce current inflation with less output reduction than otherwise required, as price-setting depends on beliefs about future economic conditions (Clarida et al., 1999).

2.2 The Macroeconomic Effect of Uncertainty

Uncertainty is an important factor when considering macroeconomic dynamics as it shapes economic behavior in various ways. Economic uncertainty can arise from multiple sources such as policy changes, geopolitical tensions, financial instability, or unexpected shocks like natural disasters and pandemics. The literature emphasizes that heightened uncertainty influences decision making of households and firms with a negative impact on economic activity. For example, Bloom (2009) found that increased volatility in stock markets led to a drop in aggregate output and employment due to a temporary pause in firms' hiring and investment behavior. Jurado et al. (2015) found similar results where they show that a spike in macroeconomic uncertainty is associated with declines in working hours, reduced hiring and lower output. These findings suggest that firms and households delay decisions when future conditions are unclear, especially those that are hard to undo.

One of the fundamental contributions to the study of uncertainty was made by Knight (1921), who distinguished between measurable risk and unmeasurable uncertainty. Knight defined uncertainty as the inability of people to predict the probability of events occurring, while risk is something that can be assigned a sensible probability distribution. For example, trying to predict whether a new technology will succeed in the market ten years from now involves a vast number of unknown factors and no reliable way to assign probabilities. On the other hand, the probability of getting a certain number when rolling a six-sided die is approximately 16.667%. The first is an example of uncertainty where the outcomes are fairly unknown and the probabilities are hard to measure. The second example is a situation involving risk, where the outcomes are known and the probabilities are well defined. This definition of uncertainty and risk laid the foundation for academic research on the behavior of economic agents in response to changes in the environment.

Financial markets are also affected by uncertainty. Pástor and Veronesi (2012) show that policy uncertainty lowers stock prices by increasing discount rates and volatility, with negative effects on investment. These effects are stronger for firms that are more sensitive to government policy. Moreover, fluctuations in firm specific uncertainty can amplify credit constraints, as higher uncertainty increases credit spreads and suppresses investment through financial frictions (Gilchrist et al., 2014). This highlights the potential role of financial frictions as a channel through which uncertainty may influence the effectiveness of monetary policy.

At the macroeconomic level, uncertainty has been shown to alter the effectiveness and transmission of monetary policy. For instance, unemployment and inflation are more sensitive to uncertainty shocks in times of recession (Caggiano et al., 2014). This suggests that inflation and unemployment are more responsive in recessions than traditional models account for and hence react more than expected during economic downturns. The authors argue that these stronger effects reflect the role of nominal rigidities and labor-market frictions, which amplify both real and nominal responses to uncertainty shocks when the economy is already weak. In a later study, Caggiano et al. (2017a) find that monetary policy tends to respond more aggressively to uncertainty shocks during recessions than in expansions, highlighting the importance of state-dependent policy behavior. They link this stronger reaction to the larger negative impact of uncertainty shocks on real activity during downturns, which results in a more forceful response to monetary policy shocks.

Also, uncertainty about future economic conditions can lead to delayed investment and dampened economic responsiveness. Bernanke (1983) argues that uncertainty creates an incentive to wait, thereby reducing immediate investment and responsiveness to economic signals. This idea is further developed in real options theory, which suggests that uncertainty increases the value of waiting before making irreversible decisions, especially in the context of investment and durable goods consumption. As Eberly (1994) and Bloom (2014) explain, purchases of durables, such as homes or cars, can often be postponed with relatively little cost. For example, households can easily delay moving or buying a car if they are uncertain about future incomes, for example the possibility of a promotion. On the other hand, nondurable goods like food and entertainment are less flexible and therefore less responsive to uncertainty shocks. This has led some to argue that monetary policy may need to be more aggressive in high uncertainty environments or accompanied by credible communication to help reduce uncertainty (Bloom, 2014).

These findings suggest that uncertainty can dampen or change the responsiveness of economic agents, particularly in investment and durable consumption. Consequently, uncertainty may change how effectively monetary policy transmits to inflation and output. This raises the question of whether uncertainty amplifies or dampens the transmission of monetary policy, which is an issue explored in the next section.

2.3 Uncertainty and the Transmission of Monetary Policy

The interaction between uncertainty and monetary policy shocks has recently been attracting growing attention from both policymakers and in the academic literature. Several theoretical models suggest that uncertainty may dampen the transmission of monetary policy, particularly due to real option effects. In models with partially irreversible investment decisions, as shown by Bloom (2009), Dixit and Pindyck (1994) and Bernanke (1983), heightened uncertainty encourages firms and households to delay spending and investment until future conditions become clearer. This cautious behavior could make economic agents less responsive to interest rate changes, thus weakening the influence of monetary policy.

Aastveit et al. (2017) provide strong empirical evidence that uncertainty dampens the transmission of monetary policy. Using structural VARs that interact contractionary monetary policy shocks with various measures of U.S. economic uncertainty, they find that GDP falls less when uncertainty is high, and that the response of investment is reduced by approximately 50% compared to low uncertainty periods. These findings are consistent with the cautiousness effects predicted by real option theory and suggest that uncertainty alters the responsiveness of key macroeconomic variables to policy changes. The authors confirm these results across different uncertainty proxies, including stock market volatility and the EPU index. By contrast, they find little difference in inflation responses across uncertainty regimes, leaving open questions about how uncertainty conditions nominal transmission.

The authors' findings contribute to a broader literature identifying uncertainty as a source of macroeconomic fluctuations. Following Bloom (2009), who found that uncertainty shocks lead to contractions in investment and employment in the U.S., studies such as Bachmann et al. (2013), Baker et al. (2016), Jurado et al. (2015), and Fernández-Villaverde et al. (2015) have shown similar contractive effects across countries and uncertainty measures.

Adding to this, Tillmann (2019) studies how monetary policy uncertainty impacts the yield curve reaction to policy shocks using local projections. He finds that when uncertainty about future policy is high, the yield curve in the U.S. does not respond as strongly to unexpected changes in the policy rate. This implies that uncertainty can mitigate the transmission of the monetary policy in financial markets and, therefore, the central bank's control over the broader financial conditions.

Castelnuovo and Pellegrino (2018) further support the view that uncertainty alters the transmission of monetary policy in the U.S., but with an important asymmetry between real and nominal variables. Using a nonlinear VAR model, they find that expansionary monetary policy shocks have milder effects on output but stronger effects on inflation when macroeconomic uncertainty is high. To explore the underlying mechanism, they estimate a medium-scale DSGE model with firm-specific capital and show that the model can replicate these asymmetric responses. Specifically, they attribute this asymmetry to a steeper Phillips curve in high uncertainty regimes than in low uncertainty regimes. Their findings suggest that uncertainty not only dampens real-side transmission, as shown by Aastveit et al. (2017), but may also amplify inflationary effects, shifting the inflation-output trade-off.

Despite these insightful contributions, there are still some gaps in the current literature. Many of the previous empirical studies, including for instance Aastveit et al. (2017) and Castelnuovo and Pellegrino (2018), are based on structural or nonlinear VARs, which come with strong assumptions about how policy effects are identified and do not always allow for differences in how the economy responds across time or under different conditions. While Aastveit et al. (2017) study how uncertainty shapes the real effects of monetary policy using structural VARs and with discrete uncertainty regimes (and use local projections only as a robustness check for the real variables), they give limited attention to how uncertainty conditions the inflation response, focusing their main and robustness analyses on real variables. Castelnuovo and Pellegrino (2018) extend this by analysing both real and nominal responses under uncertainty using a nonlinear VAR with regime-switching between high and low uncertainty states. They then estimate a DSGE model to replicate these asymmetries. However, their analysis focuses on U.S. data and models uncertainty using a discrete two-state framework. Tillmann (2019), meanwhile, uses local projections to study how monetary policy uncertainty affects financial market variables, but does not examine macroeconomic transmission channels or inflation. Also, most of the existing research is focused on the U.S. market, leaving the euro area relatively underexplored. This is important because monetary policy transmission in the euro area may differ due to institutional, structural and financial differences across the monetary union.

Building on these studies, this dissertation follows Tillmann (2019) in using local projection methods to examine whether macroeconomic uncertainty amplifies or dampens the transmission of monetary policy shocks to inflation. In contrast to most prior work, the analysis places primary emphasis on nominal outcomes in the euro area, while also considering real variables such as industrial production to better understand the full transmission of monetary policy under uncertainty and employs the VSTOXX index as a continuous measure of uncertainty. This approach allows for greater flexibility in estimating interaction effects, thereby offering new insight into how uncertainty shapes the inflationary impact of monetary policy, and allowing the analysis to also test whether these effects differ by the direction of the policy shock.

3 Data

I use monthly time-series data for the euro area in this study, which covers the period from October 2003 to October 2023. The dataset includes inflation measures, unemployment, uncertainty measures, monetary policy shocks and industrial production.

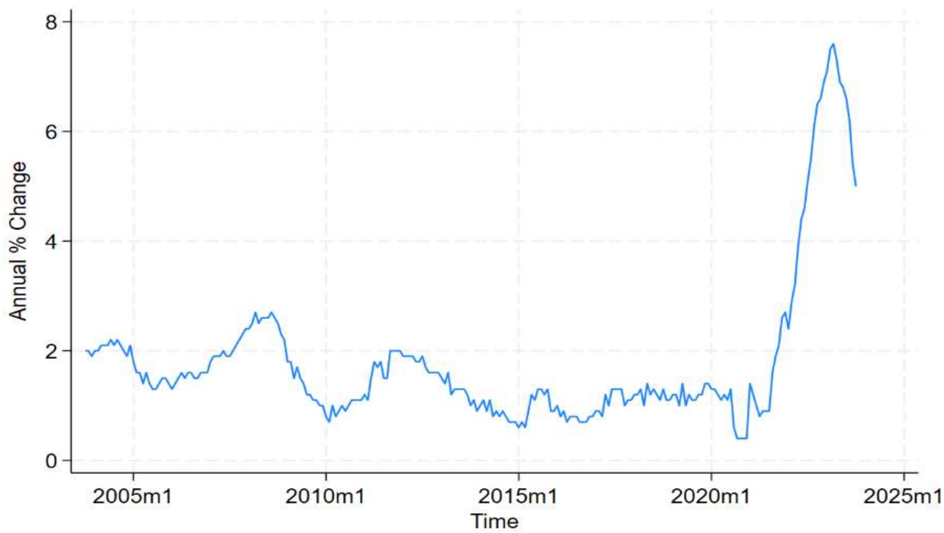
3.1 Inflation Measure

Core inflation is the main dependent variable in this study, which is used to assess the transmission of monetary policy under different levels of uncertainty. It is measured using the Harmonised Index of Consumer Prices excluding energy and unprocessed food, obtained from Eurostat (2025a). I chose core inflation rather than headline because it better reflects underlying inflationary trends relevant to monetary policy decisions by excluding the most volatile components of consumer prices, despite the target being headline inflation.

I use the series for the euro area 20 countries, which is reported as an annual rate of change at monthly frequency. As core inflation reflects broader economic developments, I do not align it with the exact dates of monetary policy announcements. Instead, I use monthly values as they better reflect the way monetary policy shocks accumulate over time. The time series for core inflation from October 2003 to October 2023 is shown in Figure 1.

Figure 1

Euro Area Core Inflation (Annual % Change)



Note: Year-over-year percentage change in core inflation for the euro area.

As shown, core inflation is fairly stable through 2004 and 2019, oscillating around 0.5% to 2.5%. However, there are two significant regime changes: sharp disinflation during the early stages of the COVID-19 pandemic in 2020 and a rapid persistent increase after the pandemic reopening and the Ukraine war starting in 2022. These large changes in the inflation process motivate the inclusion of dummy variables in the empirical model (see section 4.4).

In addition to core inflation, I also consider headline inflation in a robustness check. The headline inflation series is sourced from Eurostat (2025b) and reported as an annual rate of change. It is used to test whether the main findings hold when using the official ECB target, a broader measure of consumer prices that includes energy and food.

3.2 Unemployment

Unemployment is measured using monthly, seasonally adjusted data from Eurostat (2025d), which is expressed as the percentage of the population in the labor force that is unemployed. I use the total rate for the euro area without distinction by age or gender. This series is included as a control variable to account for cyclical labor market conditions that might affect how macroeconomic variables respond to monetary policy shocks. To ensure that the unemployment data is stationary, I take the first differences before using it in the analysis, capturing month-over-month changes in labor market slack.

3.3 Financial Uncertainty

Financial uncertainty is captured using the daily VSTOXX index obtained from Refinitiv (n.d.), which reflects implied volatility in Euro Stoxx 50 options and serves as a proxy for financial market uncertainty in the euro area. The VSTOXX index is the euro area counterpart to the U.S. VIX and serves as a forward-looking, market-based measure of uncertainty. The use of volatility-based indicators as proxies for uncertainty was popularized in research by Bloom (2009), who highlighted the role of uncertainty shocks and demonstrated the responsiveness of both realized and implied volatility measures to economic disruptions. While Basu and Bundick (2017) use the VXO index in their model, the predecessor to the VIX index, more recent empirical studies, such as Caggiano et al. (2017b), use the VIX directly. Following this, I adopt the VSTOXX as a real-time, euro area specific measure of financial uncertainty.

To align with the monthly frequency of the analysis, I aggregate the index by averaging daily values within each month. This ensures consistency across all months, regardless of whether a monetary policy announcement took place, and allows uncertainty to enter the model both directly and through its interaction with monetary policy shocks. For comparability, I standardize the monthly VSTOXX by subtracting its mean and dividing by its standard deviation.

$$\widehat{U}_t = \frac{U_t - \overline{U}}{\sigma_U}$$

Where U_t is the value of the VSTOXX uncertainty index at time t, $\overline{U}$ is its sample mean and σ_U is its standard deviation. This ensures that all interaction effects involving uncertainty are interpretable as the impact of a one standard deviation change around the average level of uncertainty.

For robustness check, I also use the Economic Policy Uncertainty Index (EPU) for Europe as an alternative measure of uncertainty. This index is obtained from the Federal Reserve Economic Data (FRED, 2025) and was originally developed by Baker et al. (2015). The data is measured at a monthly frequency and captures policy-related economic uncertainty by tracking newspaper coverage in Germany, the United Kingdom, France, Italy and Spain. Unlike the market-based VSTOXX, this index is news-based and focuses more on perceived policy uncertainty rather than financial market volatility. Using this index provides a complementary perspective to that offered by the VSTOXX by giving insight into whether the results hold under different types of uncertainty. Similar to the VSTOXX, I standardize the monthly index before using it in the analysis. See Appendix Figure A1 for a comparison of standardized VSTOXX and EPU.

3.4 Monetary Policy Shock

Monetary policy shocks are identified using high-frequency changes in OIS rates around ECB policy announcements, as provided by the EA-MPD database which was developed by Altavilla et al. (2019). For the main model, I use the change in the 6-month OIS rate measured over the ECB's monetary event window, defined as the change from 13:25–13:35 (before the press release) to the median quote between 15:40–15:50 (after the press conference). These changes are interpreted as exogenous surprises in the monetary policy stance. For each month, I assign the shock corresponding to the main policy meeting. If multiple policy announcements happen within the same month, I sum the relevant OIS changes to construct a singular monthly monetary policy shock that reflects the total surprise regarding the stance of the monetary policy during that period. Aggregating policy surprises to a monthly frequency aligns the shock series with monthly macroeconomic indicators and facilitates compatibility with local projections estimated at the same frequency. Doing this ensures consistency across months, whether or not a policy meeting occurs, while capturing the cumulative impact of all policy announcements within the month. Summing shocks within a month captures the total surprise faced by agents during that period, preserving the cumulative impact of ECB communication. If no meeting occurs in a given month, the shock is set to zero. This construction ensures a balanced monthly time series, making it suitable for local projections estimated with Newey-West standard errors. To facilitate interpretation, the monetary policy shock is also standardized by subtracting its sample mean (0.092) and dividing by its standard deviation (2.900). This transformation ensures that the estimated coefficients represent the effect of a one standard deviation increase in the shock, relative to its sample mean.

In the baseline analysis, I use the monetary event window because it captures the cumulative response of financial markets to the full communication cycle of the ECB, both the immediate policy decision and subsequent verbal communication during the press conference. To investigate the source of the transmission effect more closely, particularly under varying levels of uncertainty, I decompose this total response into two subcomponents. The press release window isolates the surprise coming from the announced policy decision, while the press conference window captures market reactions to the ECB's forward guidance, risk assessments and broader communication tone. By estimating the model separately with shocks derived from each window, I assess whether the effect of monetary policy shocks and its interaction with uncertainty is primarily driven by changes in the actual policy stance or by shifts in expectations conveyed during the press conference.

The sample period is from October 2003 to October 2023, covering a 20-year period of monetary policy shocks in the euro area. The start date was selected to provide a sufficiently long and balanced time window for the analysis and the end date is the last ECB policy announcement of the EA-MPD dataset, dated 26 October 2023.

As a robustness check, I also consider alternative maturities, more specifically the 3-month and 1-year OIS rates to test whether the results are sensitive to the definition of the policy shock. These series are standardized and treated in the same way as the 6-month OIS rate used in the main model.

3.5 Industrial Production

To complement the inflation analysis and better understand the real-side effects of monetary policy, I include industrial production as a dependent variable. The data is sourced from

Eurostat (2025c) and reflects seasonally and calendar-adjusted monthly production volume for the euro area 20 countries.

The original series is expressed as an index (2015 = 100). To make the data stationary and ensure consistency with the other macroeconomic variables, I transform the data into year-over-year growth by taking the 12-month log difference and multiplying by 100. This yields the annual percentage change in industrial production, which is then used in the local projection framework to examine the state-dependent effects of monetary policy under different levels of uncertainty.

4 Methodology

This chapter presents the methodological framework used to analyse how uncertainty influences the transmission of monetary policy shocks in the euro area, with a focus on inflation and additional analysis of industrial production. It first outlines the empirical strategy and identification approach, followed by the model specification, estimation technique and a discussion of key data properties such as stationarity and structural breaks.

4.1 Empirical Strategy

The analysis closely follows the methodology of Tillmann (2019), employing local projection techniques developed by Jordà (2005) to estimate impulse response functions (IRFs) under different levels of uncertainty. This flexible framework allows the response of inflation and industrial production to be examined both unconditionally and conditional on prevailing uncertainty, proxied by the VSTOXX index.

To ensure that the monetary policy shock is exogenous to contemporaneous macroeconomic conditions, I follow the high-frequency identification strategy developed by Gürkaynak et al. (2004) and adapted to the euro area by Altavilla et al. (2019). This strategy isolates the surprise element of monetary policy decisions by using minute by minute changes of OIS rates around the ECB announcement windows. Since financial markets react almost instantly to new information and there are no large macroeconomic data releases in these windows, the changes that are observed reflect genuine monetary policy surprises rather than reactions to other economic trends. This resolves the endogeneity concerns in lower-frequency identification strategies, where policy decisions and macroeconomic outcomes may be jointly determined or confounded by omitted variables.

4.2 Model Specification

The baseline model is designed to estimate the average dynamic response of inflation to an exogenous monetary policy shock. It controls for the direct effect of uncertainty but does not allow the transmission to vary with uncertainty. Specifically, for each forecast horizon h, the following local projection equation is estimated:

$$\pi_{t+h} = \alpha_h + \beta_h \varepsilon_t + \theta_{1,h}\varepsilon_{t-1} + \sum_{j=1}^{2} \phi_{j,h}\pi_{t-j} + \sum_{j=0}^{1} \mu_{j,h}\widehat{U}_{t-j} + \sum_{j=0}^{2} \delta_{j,h}\Delta u_{t-j} + d'_t\eta_{h,} + e_{t+h}$$

Where π_{t+h} is core inflation h periods ahead, ε_t is a standardized monetary policy shock (based on the 6-month OIS rate), $\widehat{U}_t$ is standardized uncertainty (VSTOXX), and Δu_t is the change in the unemployment rate. The vector d'_t includes dummy variables to control for the COVID crisis and the Ukraine war. Since core inflation is the dependent variable, its contemporaneous value is not included as a regressor. Instead, I include two lags of core inflation to capture its dynamic behavior without overcomplicating the model. Inflation is known to be persistent, and this is confirmed by autocorrelation analysis and autoregressive regressions (see Appendix A). Including these lags therefore helps isolate the effect of monetary policy shocks from past inflation trends. This choice of two lags for monthly macroeconomic data is consistent with Tillmann (2019), who includes two lags of control variables in a similar high-frequency identification framework.

For the monetary policy shock, I include both the contemporaneous value and one lag of the standardized 6-month OIS rate to capture the immediate and short-term effects of policy changes. Similarly, the contemporaneous and first lag of the standardized VSTOXX index are included to control for the direct effects of uncertainty on inflation. These lags capture both immediate and short-term delayed responses of inflation to financial market volatility. Changes in unemployment are included up to two lags to control for domestic demand conditions that influence inflation through the Phillips curve. The effect of labor market slack on inflation is known to be gradual and including two lags captures this delayed transmission. This model captures the average response of inflation to a monetary policy shock across all uncertainty levels.

To examine how uncertainty modifies the transmission mechanism, the baseline model is extended to include an interaction between the monetary policy shock and the level of uncertainty. This yields the following specification:

$$\pi_{t+h} = \alpha_h + \beta_h\varepsilon_t + \theta_{1,h}\varepsilon_{t-1} + \gamma_h(\varepsilon_t \cdot \widehat{U}_t) + \sum_{j=1}^{2}\phi_{j,h}\pi_{t-j} + \sum_{j=0}^{1}\mu_{j,h}\widehat{U}_{t-j} + \sum_{j=0}^{2}\delta_{j,h}\Delta u_{t-j} + d'_t\eta_{h,} + e_{t+h}$$

This model allows the impact of a monetary policy shock on inflation to depend on the amount of uncertainty through the interaction term $\varepsilon_t \cdot \widehat{U}_t$. The null hypothesis is that uncertainty does not affect the transmission of monetary policy shock, that is the interaction term is statistically insignificant ($\gamma_h = 0$). The alternative hypothesis is that uncertainty does modify the transmission, meaning that the interaction term is significantly different from zero ($\gamma_h \neq 0$).

The total effect of a monetary policy shock then consists of two components: an average (unconditional) effect, denoted by β_h , and an additional component that depends on the level of uncertainty, represented by $\gamma_h \cdot \widehat{U}_t$. The total effect is therefore captured by the following expression:

$$\frac{\partial y_{t+h}}{\partial \varepsilon_t} = \beta_h + \gamma_h \cdot \widehat{U}_t$$

Interpreting the sign of the interaction coefficient γ_h requires considering the sign of the coefficient β_h. If $\beta_h < 0$, meaning the monetary policy shock reduces inflation, then a negative γ_h implies that high uncertainty amplifies the disinflationary effect. Conversely, a positive γ_h would suggest that uncertainty dampens the transmission of the shock. If $\beta_h > 0$, the interpretation reverses, such as a negative γ_h is for dampening effects while a positive γ_h implies amplifying effects. Therefore, the interaction term gives important information regarding how uncertainty affects the efficiency of monetary policy.

Since the uncertainty variable is standardized and has a mean of 0 the β_h captured by the interaction model shows the effects when uncertainty is at its average level. To estimate the effect of monetary policy shocks under moderately high and high uncertainty, the interaction term is specified as $\varepsilon_t \cdot (\widehat{U}_t - c)$, where $\widehat{U}_t$ is the standardized VSTOXX index. By setting $c = 1$, the uncertainty carriable is re-centered around one standard deviation above the mean, allowing the coefficient β_h on the monetary policy shock to capture its effect under moderately high uncertainty. Similarly, setting $c = 2$ re-centers around two standard deviations above the mean, so β_h then reflects the effect under high uncertainty. In both cases, the interaction coefficient γ_h continues to reflect how the effect of the shock changes with each additional unit of deviation in uncertainty. The estimated IRFs from the three models with interaction terms, one under average uncertainty, one under moderately high uncertainty and one under high uncertainty, are then compared to assess whether uncertainty amplifies or dampens the inflation response.

While the main focus is on inflation, the same framework is also applied to industrial production. Including both variables makes it possible to assess whether the transmission mechanism differs between prices and real activity, and to explore whether the inflation response can be understood in light of movements in industrial production.

4.3 Estimation and Inference

Each equation is estimated separately for forecast horizons $h = 0$ to H using ordinary least squares (OLS), following the local projection method proposed by Jordà (2005). This approach flexibly estimates IRFs without imposing dynamic restrictions on the data. Because the dependent variable is defined h periods ahead, the residuals may exhibit serial correlation. To address this, standard errors are adjusted using the Newey–West correction (Newey and West, 1987), with the lag length tailored to the forecast horizon. Statistical significance, including that of the interaction term γ_h, is assessed using standard t-tests and confidence intervals.

In the baseline specification, monetary policy shocks are measured using the full monetary event window, which captures both the immediate policy decision and subsequent ECB communication. To look into the role of expectations in the transmission mechanism, separate models are estimated using shocks from the press release window and the press conference window. This decomposition provides an indirect test of whether the policy effects under uncertainty is primarily driven by actual policy decisions or by forward guidance and other form of central bank communication.

4.4 Variable Properties: Stationary and Structural Breaks

Before estimating the local projection model, I assess the time series properties of the variables used in the model, focusing on stationarity and structural breaks. Non-stationary variables can lead to spurious regression results, particularly in models using level data. The unemployment rate was found to be non-stationary based on the Augmented Dickey-Fuller (ADF) test. To avoid spurious regression and ensure valid inference, I use the first difference of unemployment, which was found to be stationary at conventional significance levels. The monetary policy shock (standardized OIS 6-month rate) and financial uncertainty (standardized VSTOXX) are found to be stationary in levels and are therefore included in the model in their standardized form.

On the other hand, ADF tests indicate mixed results for core inflation, with rejection of the unit root null at the 5% level for lag lengths ≥ 5, but not for shorter lags. This implies the series may be borderline stationary, with potential persistence or structural breaks affecting the results. While year-over-year inflation is often treated as stationary in macroeconomic applications, its persistence and sensitivity to structural changes can affect unit root test results. Keeping this in mind I include core inflation in its untransformed form, consistent with common macroeconomic practice. Visual inspection of the inflation series also suggests the presence of two structural breaks as can be seen in Figure 1 in section 3.1. The first occurs in early 2020, with a sharp decline in inflation during the onset of the COVID-19 pandemic. The second is a strong and persistent rise in inflation beginning in early 2022, following the outbreak of the Ukraine war. To control for these structural breaks, I include two dummy variables in the empirical model. The first one is from March 2020 to February 2021 and accounts for the COVID-19 pandemic. The second one is from February 2022 onward and captures the persistent inflationary effects following the outbreak of the Ukraine war.

In addition, I assess the stationarity of industrial production, which is used as a dependent variable in the complementary analysis in the Results chapter. The year-over-year growth rate, calculated using a 12-month log difference, is found to be stationary based on the ADF test and is therefore used without further transformation.

5 Results

This chapter presents the empirical results on the transmission of monetary policy shocks to core inflation and how this transmission is affected by uncertainty. Using the local projection framework, I estimate IRFs under different monetary policy communication windows and across varying levels of uncertainty. The analysis begins with the full monetary event window before looking at the transmission effects for the press release and press conference windows separately. In addition to inflation, I extend the analysis to industrial production to explore whether uncertainty also amplifies the real-side effects of monetary policy. This helps assess whether the inflation response can be linked to corresponding movements in economic activity. Finally, I test whether the responses are symmetric to contractionary shocks and expansionary shocks.

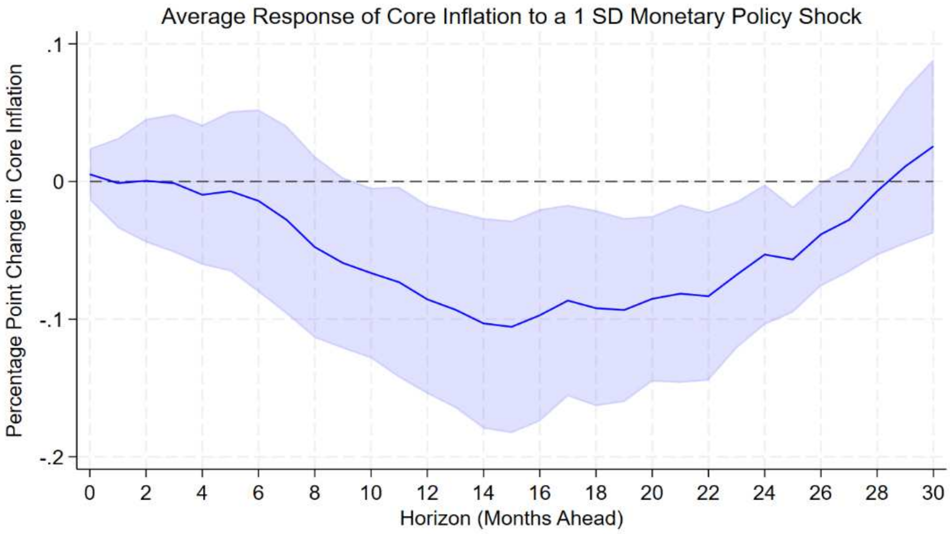
5.1 Inflation Response: Full Monetary Event Window

This section presents the baseline impulse response of core inflation to a one standard deviation monetary policy shock measured over the monetary event window, which captures the combined effect of the ECB's policy announcement and press conference. I first prresent the average effects of monetary policy shocks on inflation. After that, I analyse the role of uncertainty through an interaction term that allows the transmission of shocks to depend on the level of uncertainty.

Figure 2 shows the average impulse response of core inflation to a one standard deviation monetary policy tightening shock, measured using changes in the 6-month OIS rate.

Figure 2

Core Inflation – Impulse Response (Monetary Event Window)



Note: The response is in percentage points. Shaded area indicates the 90% confidence interval. Horizons are measured in months after the shock. The monetary policy shock is measured over the monetary event window, which includes both the press release and press conference.

The results suggest that a contractionary monetary policy shock leads to a gradual but persistent decline in core inflation. The initial response is small and statistically insignificant, with the immediate effect close to zero. However, the disinflationary effect strengthens over time, reaching its peak around month 15 where core inflation falls by approximately 0.106 percentage points after a 1 pp shock. This negative response is statistically significant at the 10% level between months 10 and 26, as the confidence bands exclude zero over this period. At several of these horizons, the response is also significant at the 5% level, as shown in Appendix Table B1. The effect then gradually fades, returning toward zero after about two and a half years.

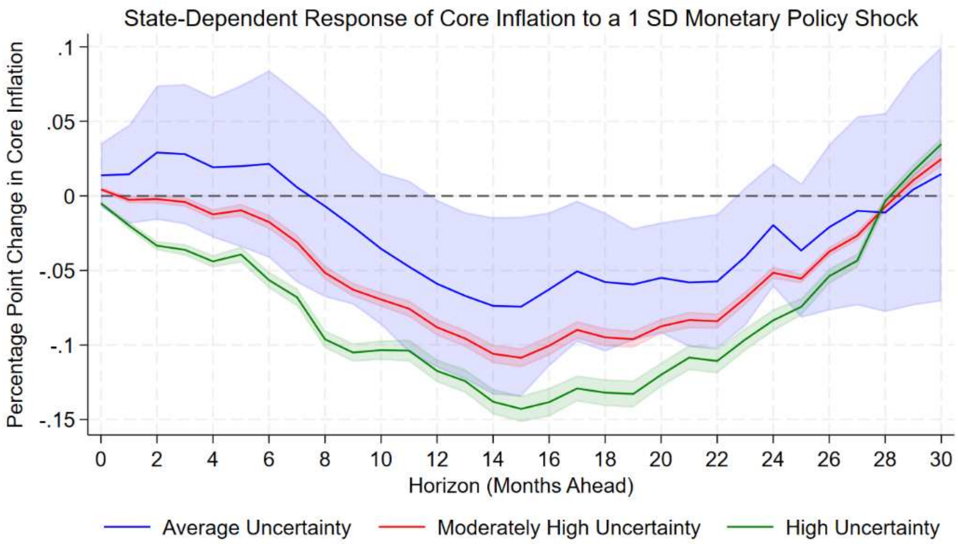
These findings are consistent with the monetary policy implications that tighter monetary policy reduces demand and puts downward pressure on inflation. The fact that the response is delayed and persistent is also in line with the recognized time lags in the transmission of monetary policy. This baseline estimate serves as the benchmark for later examining how uncertainty modifies the strength and timing of this transmission mechanism.

Building on the baseline specification, next I examine whether the effect of monetary policy on core inflation depends on the prevailing level of uncertainty. To assess how uncertainty shapes the transmission of monetary policy shocks, I use the interaction specification described in Chapter 4, estimating impulse responses under three uncertainty levels: average, moderately high (one standard deviation above the mean), and high (two standard deviations above the mean).

Figure 3 presents the estimated impulse responses of core inflation to a one standard deviation monetary policy shock under these three uncertainty regimes.

Figure 3

Core Inflation – State-Dependent Response (Monetary Event Window)



Note: The blue line shows the response of core inflation to a one standard deviation monetary policy shock under average uncertainty, with a 90% confidence band. The red and green lines show the responses when uncertainty is one or two standard deviations above its mean. The shaded areas for moderately high and high uncertainty reflect 10% confidence for clarity. Horizons are measured in months after the shock and the response is shown in percentage points. The monetary policy shock is measured over the monetary event window, which includes both the press release and press conference.

As can be seen in the figure, monetary policy shock leads to a disinflationary response across all regimes, with the magnitude of the effect becoming stronger as uncertainty increases. Under average uncertainty, core inflation declines gradually and reaches a trough of approximately -0.074 percentage points around horizon 15. When uncertainty is moderately high, the trough deepens to about –0.109 percentage points, while under high uncertainty the effect is even more pronounced, with core inflation falling by over 0.143 percentage points at its peak effect.

While the response of core inflation to a monetary policy shock is modest and statistically insignificant under average uncertainty in the short term, the effect becomes increasingly negative and faster under higher levels of uncertainty. For instance, the initial response is slightly positive at the average uncertainty level, although not statistically significant. However, with moderately high and high uncertainty, the drop in core inflation occurs immediately and the disinflationary effect becomes statistically significant at more horizons. The full IRF values at each level of uncertainty are reported in the Appendix (Table B1).

These findings suggest that uncertainty amplifies the transmission of monetary policy shocks to inflation. The interaction term confirms this amplification effect. As can be seen in Appendix Table B2, the interaction term is significantly negative at the 1%-10% level over horizons 0-10. For horizon 8, the interaction coefficient is –0.045 and statistically significant at the 5% level, suggesting that a one standard deviation increase in uncertainty amplifies the disinflationary effect of monetary policy by 0.045 percentage points at that horizon. For the other horizons, the estimates of the interaction term are mostly negative, though not statistically significant. This behavior indicates that uncertainty tends to magnify the disinflationary effect of monetary policy across most of the forecast horizon, although it is significant only in the short to medium term. This indicates that even when monetary policy has limited immediate impact under normal conditions, its transmission becomes notably more disinflationary and economically meaningful in the presence of heightened uncertainty, particularly in the short to medium term where the interaction is statistically significant.

5.2 Inflation Response: Press Release Window

Building on the results from the full monetary event window, the analysis now turns to how the transmission of monetary policy varies across different stages of central bank communication. By decomposing the policy announcement into the press release and press conference windows, it becomes possible to identify when and through which channel monetary policy affects inflation, and how this may change under different levels of uncertainty.

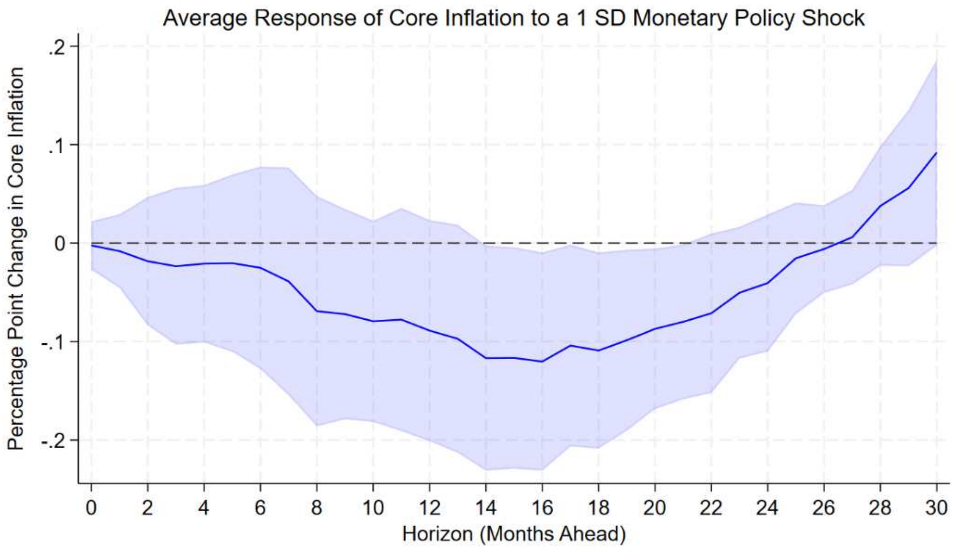
In particular, the finding that policy shocks lead to a gradual and persistent decline in core inflation, and that this effect is amplified under high uncertainty, raises the question of where in the communication sequence this transmission occurs. Does inflation respond primarily to the initial rate decision and short-term guidance, or to the expectational content and tone delivered during the press conference? Can the guidance provided by central bank communication contribute to mitigating the effects of uncertainty in the economy?

This section begins with the press release window, which captures the immediate market response to the ECB's rate decision and accompanying statement. This window is expected to reflect unexpected rate changes and short-term guidance. By isolating this stage of communication, I assess whether the average effect and the uncertainty amplification observed in the full event window are already present at the time of the announcement or whether they depend on subsequent communication during the press conference.

Figure 4 presents the average impulse response of core inflation to a one standard deviation monetary policy shock during the press release window.

Figure 4

Core Inflation – Impulse Response (Press Release Window)



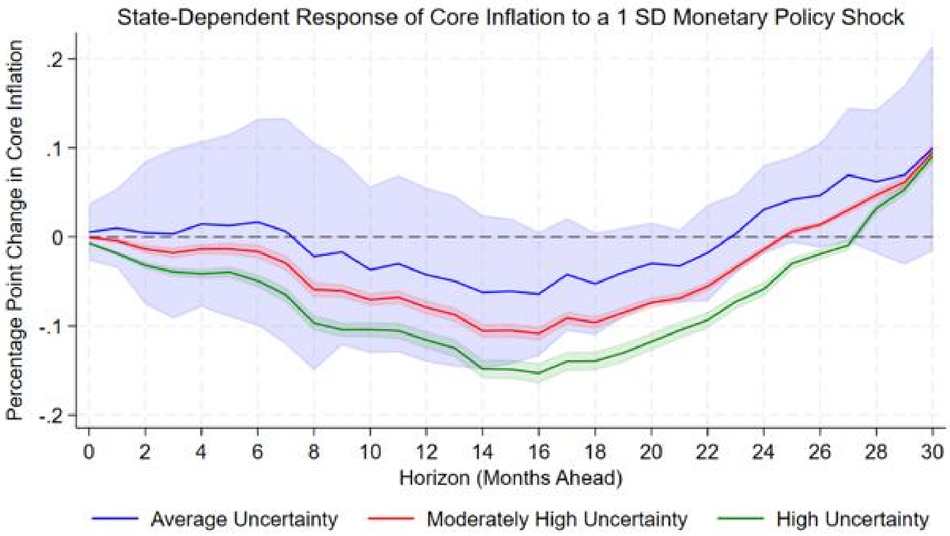
Note: The response is shown in percentage points. Shaded area indicates the 90% confidence interval. Horizons are measured in months after the shock. The monetary policy shock is measured over the press release window.

The disinflationary effect is slightly larger in magnitude than that observed in the full monetary event window, with core inflation declining by approximately 0.120 percentage points at the trough (horizon 16), compared to around 0.106 percentage points in the event window (horizon 15), after a 1 pp shock. However, the duration of statistical significance differs across the two. In the event window, the negative impact is significant at the 10% level for months 10 to 26, but in the press release window significance is limited to months 14-21 (see Appendix Table B3). Although both shocks produce a persistent disinflationary effect, the press release window exhibits a slightly larger peak effect, indicating that most of the inflation adjustment is driven by the initial policy announcement and accompanying statement, rather than the communication that follows during the press conference. However, the narrower window of statistical significance implies that the press release alone may not fully explain the persistence and robustness of the response observed in the full event window. This indicates that the post communication in the press conference may contribute modestly to the overall transmission of monetary policy to inflation.

When conditioning on uncertainty, we can see that the inflation response to monetary policy shocks differs across regimes. Figure 5 shows the impulse responses under average, moderately high, and high uncertainty.

Figure 5

Core Inflation – State-Dependent Response (Press Release Window)



Note: The blue line shows the response of core inflation to a one standard deviation monetary policy shock under average uncertainty, with a 90% confidence band. The red and green lines show the responses when uncertainty is one or two standard deviations above its mean. The shaded areas for moderately high and high uncertainty reflect 10% confidence for clarity. Horizons are measured in months after the shock and the response is shown in percentage points. The monetary policy shock is measured over the press release window.

The magnitude of the disinflationary effect increases with uncertainty, reaching approximately -0.153 percentage points under high uncertainty at horizon 16, compared to -0.064 percentage points under average uncertainty, after 1 pp shock. While the visual gap between uncertainty states is more pronounced in the press release window, the statistical significance of the amplification emerges later and is less persistent than in the full event window, with the interaction term being statistically significant at the 10% level at horizons 1, 4, 6 and 9, in this shorter window (see Appendix Table B4 for full results).

In the press release window, the disinflationary response under high uncertainty is statistically significant between horizons 14 and 16, while the response under average uncertainty is not significant at any horizon. This suggests that in the absence of heightened uncertainty, markets do not react meaningfully to the policy rate decision and accompanying statement alone. In contrast, the event window shows a more persistent and statistically robust response under both average and high uncertainty, with significance spanning horizons 12-22 and 8-20. This comparison implies that while the press release contains much of the information that shapes inflation expectations, the inflation response becomes statistically significant only under heightened uncertainty. This indicates that uncertainty has more of a role in activating the transmission within this smaller window which is less communicative and does not have the broader explanatory context provided during the press conference.

5.3 Inflation Response: Press Conference Window

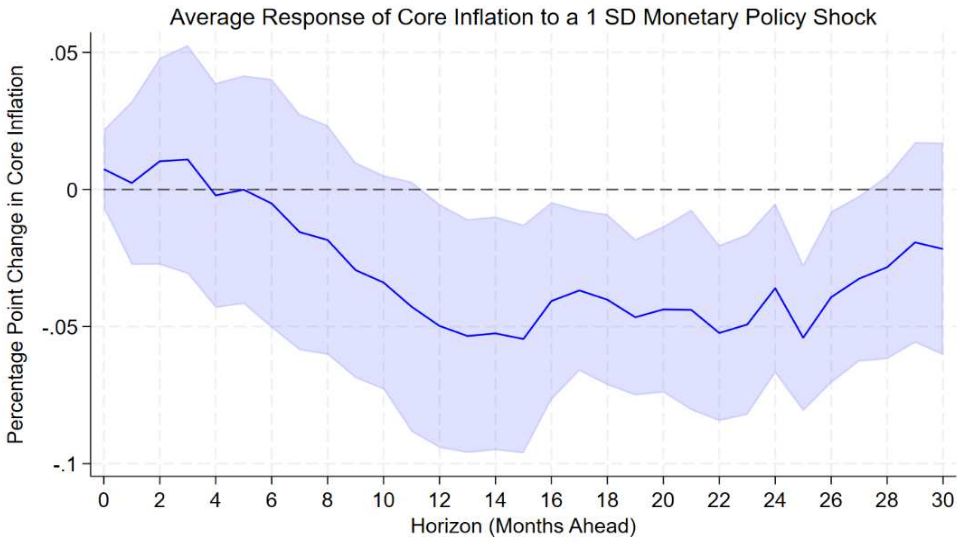
The analysis now turns to the press conference window, which captures market reactions during the explanatory stage of the monetary policy announcement. This window includes the central bank president's remarks, forecasts, risk assessments and Q&A with journalists. Unlike the press release, which conveys the policy rate decision and immediate forward guidance, the press conference is expected to reflect more qualitative and forward-looking communication, including the central bank's narrative and informational signals.

Studying this window separately allows me to assess whether monetary policy transmission also occurs through the expectations channel, and whether markets respond not just to the policy action itself, but to how it is explained. This distinction is particularly relevant under conditions of heightened uncertainty, when private agents may rely more heavily on the central bank's communication to form expectations about future policy and economic conditions.

The estimated impulse response of core inflation to a policy shock during the press conference window is shown in Figure 6.

Figure 6

Core Inflation – Impulse Response (Press Conference Window)



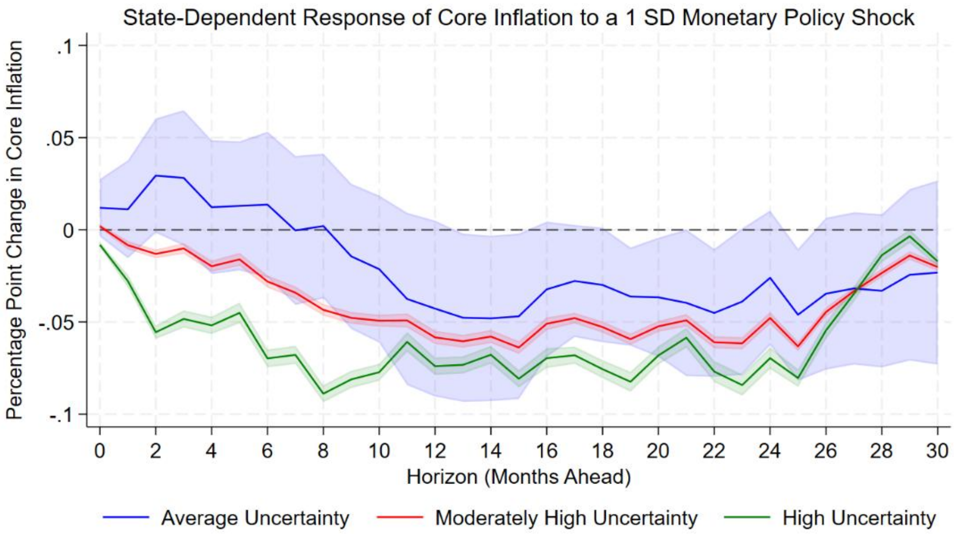
Note: The response is shown in percentage points. Shaded area indicates the 90% confidence interval. Horizons are measured in months after the shock. The monetary policy shock is measured over the press conference window, which captures market reactions to the ECB's communication during the press conference.

The disinflationary effect is more modest in magnitude than in the monetary event or press release windows, with a peak decline of approximately –0.055 percentage points occurring at horizon 15, after an initial 1 pp shock. However, the duration of the effect is relatively long as the negative response is statistically significant at the 10% level from horizons 12-27, suggesting that although the immediate impact is smaller, the response is more persistent in duration than in the press release window. This indicates that the press conference contributes to the transmission of monetary policy primarily through the extended adjustment of expectations, rather than through large initial price effects.

To examine how the inflation response to the press conference varies with uncertainty, I now turn to the state-dependent model. As can be seen in Figure 7, the inflation response to a monetary policy shock during the press conference window varies noticeably across uncertainty regimes. Under average uncertainty, the disinflationary effect is modest and statistically significant only at a few scattered horizons. In contrast, under moderately high and high uncertainty, the response becomes both stronger and more persistent, with the peak effect reaching –0.089 percentage points under high uncertainty at horizon 8 (see Appendix Table B5 for full results). Significant effects both at earlier and later horizons indicate that the influence of press conference communication becomes more apparent as uncertainty rises. This supports that uncertainty amplifies the role of expectations in the transmission of monetary policy, where markets become more responsive to forward guidance and narrative framing when the outlook is less certain.

Figure 7

Core Inflation - State-Dependent Response (Press Conference Window)



Note: The blue line shows the response of core inflation to a one standard deviation monetary policy shock under average uncertainty, with a 90% confidence band. The red and green lines show the responses when uncertainty, measured by the standardized VSTOXX index, is one or two standard deviations above its mean. The shaded areas for moderately high and high uncertainty reflect 10% confidence for clarity. Horizons are measured in months after the shock and the response is shown in percentage points. The monetary policy shock is measured over the press conference window, which captures market reactions to the ECB's communication during the press conference.

This amplification pattern is supported by the interaction term. The coefficients on the interaction term are statistically significant at horizons 2–4 and 6–9, with the strongest amplification occurring at horizon 8, where the interaction coefficient reaches –0.045 and is statistically significant at the 5% level (see Appendix Table B6). Given these findings it is clear that uncertainty enhances the transmission of monetary policy shocks delivered during the press conference, particularly in the early part of the forecast horizon, highlighting the role of expectations in shaping inflation outcomes, especially when the outlook is uncertain.

These findings directly address the question of where in the communication sequence monetary policy transmission occurs. The results show that while the policy rate decision at the press release window initiates transmission, its peak effect is larger but short-lived and statistically insignificant under average uncertainty, becoming significant only when uncertainty is moderately high or high. This suggests that transmission during this stage operates primarily through mechanical surprises tied to the policy rate decision and is limited when markets are less uncertain. In contrast, the press conference plays a more gradual but sustained role, influencing inflation more over the long run, with effects that emerge earlier in terms of statistical significance under average uncertainty, last longer and remain statistically significant even under average uncertainty. Amplification through uncertainty is also more consistent and widespread in this window, highlighting that when economic prospects are uncertain, markets rely heavily on the narrative and forward guidance delivered during the press conference to interpret the policy stance.

5.4 Real-Side Transmission: Industrial Production

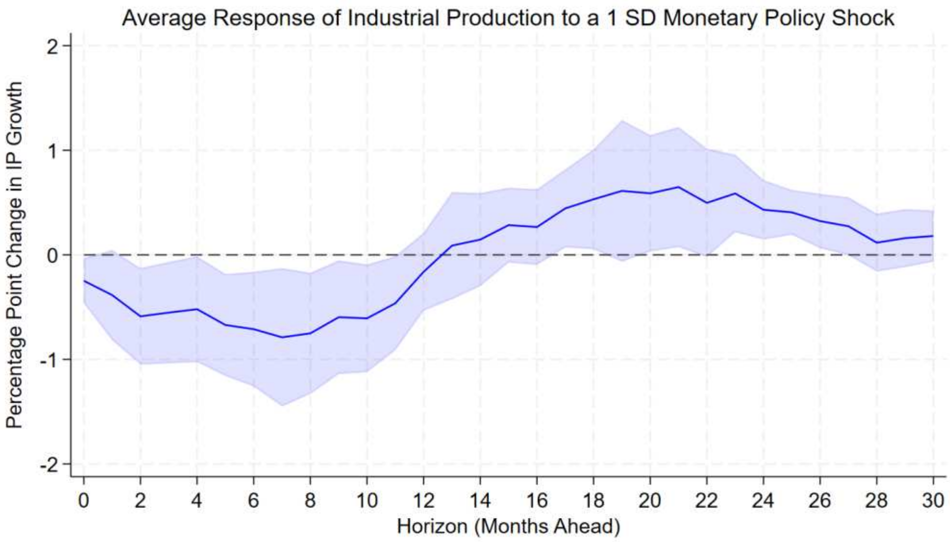
To better understand the mechanisms behind the inflation responses presented earlier, this section turns to the real side of the economy by examining the effects of monetary policy shocks on industrial production. While the earlier results showed that uncertainty amplifies the disinflationary effects of monetary policy, it remains important to explore whether similar amplification occurs on real activity and whether this might help explain the strength and persistence of the inflation response. To do so, I use the same model as before using industrial production growth as the dependent variable.

By extending the analysis to industrial production, I aim to build a more comprehensive picture of how uncertainty shapes the overall transmission of monetary policy. Specifically, I assess whether heightened uncertainty leads firms to reduce output more aggressively following a policy shock, thereby contributing to weaker price pressures and leading to a stronger disinflationary effect when uncertainty is high. As with inflation, I start by analysing the average response to a monetary policy shock before introducing uncertainty interactions to examine state-dependent dynamics.

Figure 8 shows the average response of industrial production to a one standard deviation monetary policy shock from the baseline model without the uncertainty interaction.

Figure 8

Industrial Production – Impulse Response



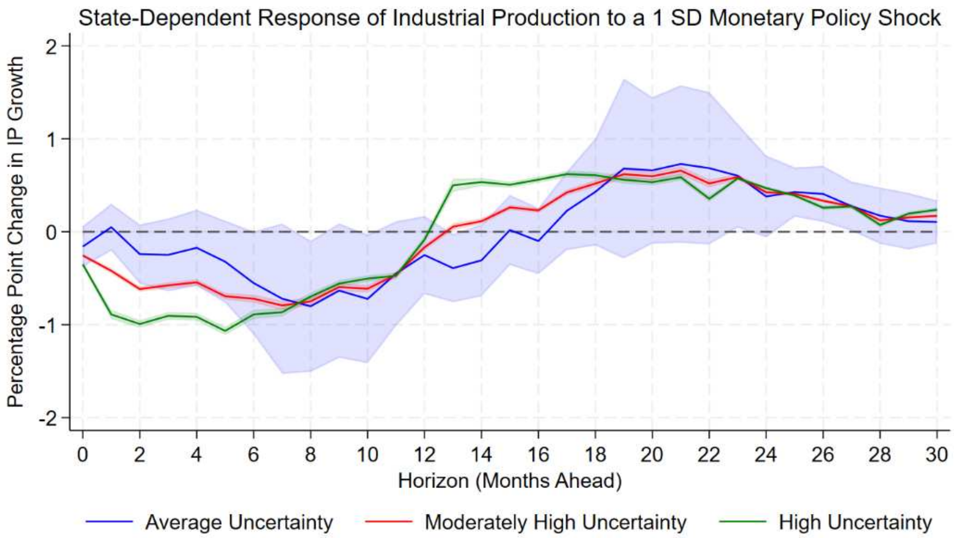
Note: The response is shown in percentage points. Shaded area indicates the 90% confidence interval. Horizons are measured in months after the shock. The monetary policy shock is measured over the monetary event window, which includes both the press release and press conference.

The response is negative and statistically significant in the short run, with industrial production growth falling sharply after the shock and reaching a trough of approximately –0.789 percentage points around horizon 7, after an initial 1 pp shock. The effect begins to fade in the medium term and industrial production returns to positive territory around horizon 13, although it is not statistically significant until horizon 17. The response peaks at 0.648 percentage points at horizon 21, which is statistically significant at the 10% level (see Appendix Table B7). The figure shows the typical hump-shaped pattern observed in empirical studies of monetary transmission, with output responding more quickly than inflation.

The response of industrial production to a monetary policy shock appears to depend substantially on the level of uncertainty in the economy. For all regimes, industrial production initially declines following a one standard deviation shock, but the magnitude, duration and timing of the rebound differ with uncertainty.

Figure 9

Industrial Production – State-Dependent Response



Note: The blue line shows the response of industrial production growth to a one standard deviation monetary policy shock under average uncertainty, with a 90% confidence band. The red and green lines show the responses when uncertainty one or two standard deviations above its mean. The shaded areas for moderately high and high uncertainty reflect 10% confidence for clarity. Horizons are measured in months after the shock and the response is shown in percentage points. The monetary policy shock is measured over the monetary event window, which includes both the press release and press conference.

As shown in Figure 9 and Appendix Table B7, under average uncertainty, industrial production reaches a trough of –0.802 percentage points at horizon 8 (statistically significant at the 10%), followed by a modest and delayed recovery. Under moderately high uncertainty, the peak decline is similar in size but more persistently significant, and the rebound begins earlier. The most pronounced effects occur under high uncertainty, where the contraction is sharp and immediate, reaching –1.067 percentage points at horizon 5 (significant at the 1% level), with statistically significant rebounds beginning at horizon 15.

The interaction terms confirm this pattern. The interaction is significantly negative at earlier horizons (1–5), indicating that uncertainty amplifies the initial contraction. The sign switches to significantly positive at horizons 14–17, indicating that recovery in industrial production is also significantly stronger under high uncertainty. The full set of coefficient estimates is reported in Appendix Table B8.

This response implies that uncertainty not only strengthens contractionary effects of monetary policy in the short run but may also heighten overall real-side volatility. Although output begins to recover in the medium term, core inflation continues to decline, suggesting a lagged nominal response relative to real activity. This is consistent with the findings of Christiano et al. (2005), who show that output responds more quickly to monetary policy shocks, while inflation reacts with a delay (in their case expansionary shocks).

Combining these results with the inflation results shown in the section earlier, these patterns help to shape a more comprehensive view of how uncertainty affects monetary policy. The results are in line with the view that uncertainty amplifies the transmission of monetary policy shocks to both the real and nominal sides of the economy, though through different mechanisms. The sharp and immediate contraction in industrial production under high uncertainty is likely to contribute to the stronger and more persistent disinflation observed across the forecast horizons when uncertainty is high. Firms seem to react more aggressively to monetary tightening in high uncertainty environments by reducing output quickly, which in turn dampens inflationary pressures at later horizons with a lag. This supports the interpretation that uncertainty creates a more adverse and fragile economic environment, in which monetary policy has a larger effect on both economic activity and price dynamics.

Industrial production appears to exhibit a structural break during the 2008-2009 global financial crisis, as can be seen in Figure B1 in the Appendix. To account for this, I run the model again including a dummy variable for the financial crisis period (defined as September 2008 to December 2009), alongside the COVID-19 and Ukraine war dummies already included in the previous specification. As shown in Appendix Tables B9-B10, the results remain highly consistent with the previous model. The timing, direction and magnitude of the responses under different uncertainty regimes, as well as the statistical significance of the interaction terms, are nearly identical to the model estimated without the crisis dummy. This similarity suggests that the amplification effect of uncertainty on the real-side transmission of monetary policy is not driven by the specific dynamics of the global financial crisis or the pandemic, but reflects a broader and more consistent transmission pattern across the sample.

5.5 Symmetry Tests for Monetary Policy Shocks

The previous sections looked into how uncertainty amplifies the effects of monetary policy shocks on inflation and industrial production. This section investigates whether these effects are symmetric across contractionary (tightening) and expansionary (easing) shocks. I test this by extending the baseline model to allow for separate interaction terms for contractionary and expansionary shocks and then I apply a Wald test to formally assess symmetry. The analysis is carried out separately for inflation and industrial production.

5.5.1 Inflation: Symmetry Test

The amplifying effect of uncertainty on the disinflationary impact of monetary policy shocks found in the earlier sections raises the question of whether this effect holds equally for contractionary and expansionary shocks, or whether the transmission is asymmetric. In other words, does uncertainty amplify the response to monetary easing in the same way it does to monetary tightening?

To examine this, the previous model is extended to include separate interaction terms for contractionary and expansionary shocks. Each interaction combines the standardized monetary policy shock, standardized uncertainty and a dummy indicating the direction of the shock. This allows me to compare how uncertainty conditions the inflation response to monetary tightening versus monetary easing.

The results, presented in Table 1, show that the interaction term for contractionary shocks is statistically significant at the 5% level across horizons 1-4 (see Appendix Table B11 for full results across all horizons), indicating that uncertainty amplifies the disinflationary effects of monetary tightening in the short to medium term. On the other hand, the interaction term for expansionary shocks is not statistically significant at any horizon, suggesting that uncertainty does not significantly alter the inflation response to monetary easing.

Table 1

Symmetry Test: Uncertainty Amplification Effects on Inflation

Horizon	Contractionary shock	Expansionary shock	Wald test p-value
1	-0.017**	-0.018	0.151
2	-0.030**	-0.033	0.024**
3	-0.038**	-0.021	0.113
4	-0.038**	-0.018	0.115

Note: "Contractionary shock" and "Expansionary shock" refer to interaction effects between monetary policy shocks and uncertainty for tightening and easing surprises. The Wald test p-value tests the null that the contractionary effect equals in magnitude and opposite in sign to the expansionary effect.

Significance levels: * = 10%, ** = 5%, *** = 1%.

To formally test whether these effects are asymmetric, I use a Wald test, which is supposed to evaluate the null hypothesis that the interaction term for a contractionary shock is equal in magnitude and opposite in sign to that for an expansionary shock. Rejection of this null indicates asymmetry between the two responses. As reported in the last column of Table 1, the Wald test rejects the null at horizon 2, implying that at this horizon the effects of uncertainty on monetary tightening and easing differ significantly.

Together, these results suggest that the effect of uncertainty on monetary policy shocks for inflation are not the same across contractionary or expansionary shocks. When the central bank imposes a monetary tightening shock, the inflation falls more under high uncertainty. However, when there is a monetary easing, inflation does not respond meaningfully less or more when uncertainty is high. This suggests that the amplifying effect of uncertainty on inflation holds only when the shock is contractionary and is therefore not symmetric.

One possible explanation for this is that under uncertainty, firms and households exhibit loss aversion which makes them react more strongly to contractionary monetary policy signals than to expansionary ones. This heightened sensitivity to signals that are negative triggers greater precautionary behavior, amplifying the disinflationary effects of tightening, whereas positive signals from easing may not trigger as strong response. However, to assess whether this asymmetry is also reflected in real economic activity, I next examine the response of industrial production to different types of monetary policy shocks under uncertainty, using the same triple interaction model having industrial production as the dependent variable.

5.5.2 Industrial Production: Symmetry Test

To check if the asymmetric effects of uncertainty seen in inflation are present in real activity as well, I estimate the extended model using industrial production as the dependent variable.

The results in Table 2 indicate that uncertainty amplifies the effects of monetary policy shocks on industrial production for both contractionary and expansionary policy shocks. Following a contractionary shock, the interaction terms are negative and statistically significant for horizons 1–7 (see Appendix Table B12 for full results), suggesting that heightened uncertainty leads to a larger decline in industrial production than under normal conditions. Likewise, the interaction terms for expansionary shocks are positive and statistically significant for horizons 4–10, indicating that uncertainty also amplifies the positive effects of easing on real activity.

Table 2

Symmetry Test: Uncertainty Amplification Effects on Industrial Production

Horizon	Contractionary shock	Expansionary shock	Wald test p-value
2	-0.715***	0.291	0.163
3	-0.775***	0.550*	0.441
4	-0.881***	0.633*	0.411
5	-0.977***	0.819*	0.635
6	-0.742***	0.955**	0.601
7	-0.520**	0.807*	0.463
8	-0.383*	0.917**	0.103
9	-0.375*	0.853*	0.223
10	-0.326	0.967*	0.106

Note: "Contractionary shock" and "Expansionary shock" refer to the estimated interaction effects between monetary policy shocks and uncertainty for tightening and easing surprises. The Wald test p-value tests the hypothesis that the interaction term for a contractionary shock is equal in size but opposite in sign to that of an expansionary shock (symmetry).

Significance levels: * = 10%, ** = 5%, *** = 1%.

This shows a different pattern than the results for the inflation, where amplification under uncertainty was only for contractionary shocks. For industrial production, the amplification appears more symmetric across the two types of policy shocks. The Wald test confirms this symmetry as it fails to reject the null hypothesis that the interaction terms are equal in magnitude but opposite in sign for most horizons. This supports that uncertainty amplifies the effects of both tightening and easing to a similar degree.

The symmetric amplification in industrial production under uncertainty may reflect the different way uncertainty interacts with real activity compared to price adjustments. Price changes tend to be slow since it is hard for firms to change prices due to costs and frictions that are associated with price adjustments, such as fixed wages and menu costs. Output and investment decisions are less constrained by these factors and may depend more directly on current financial conditions such as borrowing costs and credit availability. When uncertainty is high, the perceived cost of making the wrong decision rises, so firms may become more cautious after tightening which makes them cut back more aggressively to avoid potential losses in case conditions worsen further. Heightened uncertainty can also lead firms to move faster after easing to seize opportunities before conditions change, as uncertainty increases the risk that these gains could quickly disappear.

On the other hand, inflation shows an asymmetric response under uncertainty since price changes take longer to occur and are heavily shaped by expectations. Some models, such as Vavra (2014), predict that heightened uncertainty can increase the frequency of price changes, which aligns with the stronger price reactions to contractionary shocks observed in this dissertation. In periods of high uncertainty, loss aversion, weaker demand expectations and the fear of losing customers may encourage faster price reductions after contractionary shocks, whereas firms might hesitate to raise prices following an expansionary shock under high uncertainty due to concerns that the improved conditions may not last for long, fear of demand reversal and competitive pressures. As a result, the inflationary effect is not similarly amplified. While such models might predict smaller output effects when price adjustments are more frequent, the results here suggest that precautionary behavior and financial constraints dominate in practice, which leads to amplification in both directions for real activity.

6 Robustness Checks

This chapter reports some robustness checks to assess the stability and reliability of the main findings. Since the main focus of this dissertation is on the inflation response to monetary policy under uncertainty, the robustness checks are run for this relationship. The aim is to verify that the estimated amplification effect of uncertainty on the transmission of monetary policy is not driven by specific modeling choices, data definitions or extreme events. The checks cover other measures of uncertainty and inflation, the exclusion of event-specific dummies, variations in lag structure and other specification changes. Full regression results for the robustness specifications are reported in Appendix C.

6.1 Alternative Measure of Monetary Policy Uncertainty

The results using the EPU index are fairly similar to those obtained with the VSTOXX measure (see Table C1 and Figure C1). In both cases, moderately high and high uncertainty are associated with a larger and more persistent decline in core inflation following a monetary policy shock, suggesting that uncertainty amplifies the disinflationary effects. The interaction term is negative across most horizons and while statistical significance is stronger when using the VSTOXX, the interaction term using the EPU index is statistically significant at the 10% level at horizon 16, with a coefficient of approximately -0.075. The similarity in the results supports the robustness of the main findings to alternative measures of uncertainty.

6.2 Robustness to Event-Specific Controls

To test whether the estimated effect of uncertainty on monetary policy transmission is driven by the two structural breaks accounted for in the main model, I re-estimate the model excluding the COVID-19 dummy and the Ukraine war dummy. These dummies are included in the main model to adjust for the fact that inflation may have behaved unusually during these events due to factors unrelated to monetary policy or uncertainty. By removing the dummies, I test whether the interaction effect between uncertainty and monetary policy still holds without any special adjustment for these events. The results show that the interaction effect remains statistically significant and similar in size, even when both dummies are removed from the model. The interaction term between monetary policy shocks and uncertainty remains significantly negative across horizons 0-12 and 14, with a peak effect at horizon 8 (–0.064, significant at the 5% level). This closely mirrors the results from the main model (–0.045 at horizon 8) and suggests that the amplification effect of uncertainty is not only the result of pandemic- or war-related dynamics.

Additionally, I test the model excluding each dummy individually. When removing only the COVID dummy, the interaction effects are very similar to those in the main model, with the strongest effect at horizon 8 (–0.047, significant at the 5% level) and statistical significance at the 10% level across horizons 0-10. When removing only the Ukraine war dummy, the interaction effects become slightly stronger compared to the main model, with the strongest effect at horizon 8 (–0.064, significant at the 5% level) and statistical significance at the 10% level across horizons 0-18. These findings suggest that the results are not sensitive to the inclusion of specific event controls such as the COVID-19 and Ukraine war dummies, but instead represent a more general relationship between uncertainty and the transmission mechanism of monetary policy, which continues to hold even when the event-specific controls are removed.

I also include a dummy variable for the 2008–2009 global financial crisis to control for potential inflation dynamics specific to that period. The dummy is defined from September 2008 to December 2009, covering the collapse of Lehman Brothers and the most intense phase of the crisis. Including this dummy gives nearly the same results as the main model, with the interaction term remaining significantly negative at horizons 0-10, with a peak effect at horizon 8 (-0.042, statistically significant at the 5% level). Appendix Tables and Figures C2–C5 provide the full results.

6.3 Headline Inflaton as the Dependent Variable

Since monetary policy targets headline rather than core inflation, I re-estimate the model using headline inflation as the dependent variable to assess whether the results hold across different inflation measures. The results show that the interaction between uncertainty and monetary policy shocks remains significantly negative when headline inflation is used as the dependent variable, consistent with the findings based on core inflation. Appendix Table C6 shows that the interaction term is statistically significant at horizons 4, 6, 8 and 10, with the peak effect occurring at horizon 6 (–0.053, significant at the 5% level). These findings suggest that the amplification effect of uncertainty is not sensitive to the inflation measure used and holds for both core and headline inflation.

6.4 Robustness to Lag Structure

To ensure that the results are not sensitive to the mixed lag structure used in the main model, I run the regressions again using uniform lag lengths for all control variables. In one specification, all controls are included with one lag and in another, two lags are used for all variables. The results are similar for both versions. With one lag, the interaction term is significantly negative across horizons 0-9 at the 10% level, peaking at horizon 8 (–0.044, significant at the 5% level). With two lags, the effect remains significant at horizons 0-4 and 6-9 at the 10% level, with a peak at horizon 8 (–0.037, statistically significant at the 10% level). The estimated interaction effect between monetary policy and uncertainty remains negative and statistically significant, and the shape of the impulse responses is similar to those in the main model. These results suggest that the amplification effect of uncertainty is not sensitive to the number of lags included in the model. Appendix Tables and Figures C7–C8 provide the full results.

6.5 Alternative Monetary Policy Shocks

As a further test of robustness, I examine whether the main results are sensitive to how the monetary policy shock is measured. Instead of the 6-month OIS rate used in the main model, I estimate the model again using both a 1-year and a 3-month OIS rate as alternative shock measures.

The results using the 1-year OIS shock are similar to the findings using the 6-month OIS shock. The interaction between uncertainty and monetary policy shocks remains significantly negative across most horizons (0–12 and 14–18), with the strongest effects at horizon 8 (–0.066, significant at the 1% level). This not only confirms the presence of the amplification effect but also suggests that it may be slightly stronger when a longer-horizon policy rate is used.

On the other hand, the 3-month OIS shock yields weaker results. The interaction term is significantly negative only at horizon 6, with a peak coefficient of –0.029 (significant at the 10% level). While the sign remains negative like in the main model, the weaker statistical significance may reflect the fact that shorter-term rates capture less forward-looking monetary policy surprises.

These findings indicate that the amplification effect of uncertainty is not sensitive to the definition of the monetary policy shock and is especially robust when the shock captures forward guidance or expectations over a slightly longer horizon. Appendix Tables and Figures C9–C10 provide the full results.

7 Conclusion

This dissertation set out to examine how uncertainty alters the transmission of monetary policy shocks to core inflation in the euro area. The central research question was whether elevated uncertainty amplifies or dampens the inflationary effects of monetary policy, and whether these effects extend to real economic activity, measured by industrial production.

Using a monthly local projection framework and high-frequency monetary policy shocks derived from changes in OIS rates, the analysis provided robust evidence that uncertainty significantly influences how inflation responds to monetary policy shocks. The results show that uncertainty amplifies the disinflationary effects of monetary policy shocks, especially when looking at the short to medium term. The effect lasts longest when policy is communicated during the ECB's press conference, highlighting the crucial role of narrative and forward guidance in times of high uncertainty.

The analysis also shows that the inflation response is asymmetric, that is the amplifying effect of uncertainty only holds for contractionary shocks, while for expansionary shocks seems to be largely unaffected. This adds a new perspective to the literature. While Aastveit et al. (2017) and Castelnuovo & Pellegrino (2018) do not directly compare contractionary and expansionary shocks, their separate results hint at potential asymmetries in how inflation responds. Aastveit et al. find no effect of uncertainty on inflation following contractionary shocks, while Castelnuovo & Pellegrino report amplification for expansionary ones. My results suggest that such asymmetries exist, but in the opposite direction.

Extending the analysis to industrial production shows that uncertainty amplifies the real effects of both contractionary and expansionary shocks, with somewhat stronger statistical significance for policy tightening. This goes against the standard 'steeper Phillips curve' view, where greater price flexibility under high uncertainty should dampen real effects while making inflation respond more strongly. While less sticky prices would normally soften the impact on real variables, my results suggest that heightened uncertainty also brings in other forces that actually amplify those effects instead.

These findings suggest that the transmission of monetary policy becomes more powerful under uncertainty, but in uneven ways across nominal and real variables. For central banks, this highlights the importance of accounting for uncertainty not only in the size and timing of policy moves, but also in how policies are communicated.

While this dissertation offers important insights into the role of uncertainty in monetary policy transmission, several limitations should be noted. First, it focuses on the euro area, so the findings only apply at that level. The research does not explore how individual countries within the euro area respond to uncertainty, which could hide important differences in how monetary policy works under uncertainty across countries. Future research could explore whether the amplification effects documented here also applies to individual euro area economies or if the response is different between countries.

Second, this dissertation relies primarily on the VSTOXX index which captures market-based financial volatility and might not capture the overall geopolitical or policy related uncertainty which has become increasingly relevant in recent years. Incorporating measures of geopolitical risk or other uncertainty measures could therefore provide a richer understanding of the channels at play.

Third, the analysis centers on inflation and industrial production as the main nominal and real outcomes. Although these variables capture important transmission channels, monetary policy also affects other parts of the economy such as credit markets, employment and investment, which could help explain the responses found in this dissertation.

Finally, more research is needed to uncover the mechanisms behind the asymmetric inflation response under uncertainty. Is it driven by loss aversion, price rigidities, demand expectations, or competitive pressures? Likewise, future studies could also investigate why industrial production effects appear amplified under uncertainty and not dampened as some models would suggest. Future research could analyse whether this is because other channels such as financial constraints, credit conditions or precautionary behavior dominate during high uncertainty. Tackling these questions would help clarify why monetary policy works differently under uncertainty and could strengthen the policy relevance of future research.

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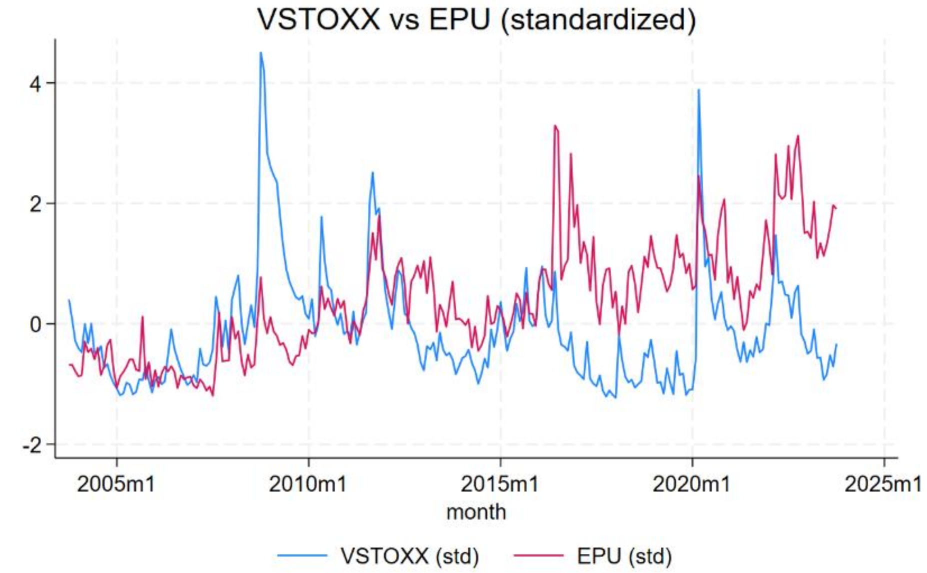
Use of AI

I would to like to acknowledge the use of AI (ChatGPT) as a supporting tool to assist me with the development of my code. Also, since English is not my first language, I used AI as a helper to improve my grammar and clarity of my written English. All ideas, analysis and conclusions presented are my own.

Appendix A. Supplementary Empirical Analyses

Figure A1

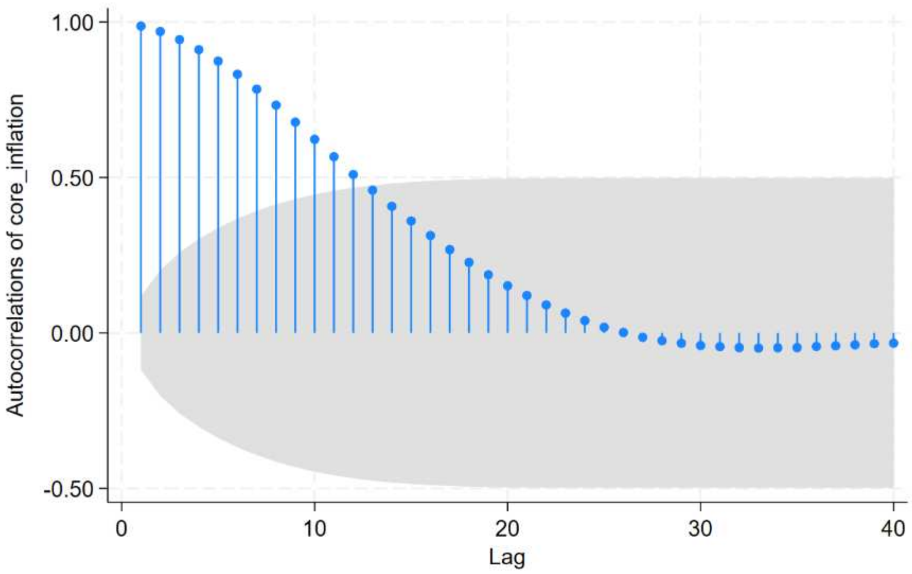
Standardized VSTOXX and European Policy Uncertainty (EPU) Indexes



Note: The blue line shows the standardized VSTOXX index and the red line shows the standardized European Policy Uncertainty (EPU) index.

Figure A2

Autocorrelation Function (ACF) of Core Inflation



Note: The figure plots autocorrelations of monthly euro area core inflation (up to 40 lags). The slow decay indicates strong persistence. Shaded areas show 95% confidence bands (Bartlett's formula).

Table A1

Autoregressive Coefficients for Core Inflation

Autocorrelation Coefficients	Core Inflation	Std. err.
AR(1)	0.986***	0.063
AR(2)	0.270***	0.088
AR(3)	-0.119	0.089
AR(4)	-0.179**	0.089
AR(5)	0.100	0.09
AR(6)	0.0864	0.09
AR(7)	-0.092	0.09
AR(8)	-0.092	0.09
AR(9)	-0.108	0.089
AR(10)	0.114	0.089

Note: Estimates from regressing core inflation on its lags (up to 10 months). Significance levels: * = 10%, ** = 5%, *** = 1%.

Appendix B. Main Results (Supplementary Tables and Figures)

Table B1

Impulse Response of Core Inflation to a 1 SD Monetary Policy Shock (Monetary Event Window)

Horizon	No interaction	Uncertainty		
		Average	Moderately high	High
0	0.005	0.014	0.004	-0.050
1	-0.001	0.014	-0.003	-0.020
2	0.001	0.029	-0.002	-0.033
3	-0.001	0.028	-0.004	-0.036
4	-0.010	0.019	-0.012	-0.044
5	-0.007	0.020	-0.010	-0.039
6	-0.014	0.021	-0.018	-0.056
7	-0.028	0.006	-0.031	-0.068
8	-0.048	-0.007	-0.052	-0.096**
9	-0.059	-0.021	-0.063*	-0.105**
10	-0.066*	-0.035	-0.069*	-0.103**
11	-0.073*	-0.047	-0.076*	-0.104*
12	-0.086**	-0.059*	-0.088**	-0.117*
13	-0.093**	-0.067**	-0.096**	-0.124**
14	-0.103**	-0.074**	-0.106**	-0.138**
15	-0.106**	-0.074**	-0.109**	-0.143**
16	-0.097**	-0.063**	-0.101*	-0.138*
17	-0.087**	-0.051*	-0.090*	-0.129*
18	-0.092**	-0.058**	-0.095**	-0.132*
19	-0.093**	-0.059***	-0.096**	-0.133*
20	-0.085**	-0.055**	-0.087**	-0.120*
21	-0.082**	-0.058**	-0.083*	-0.108
22	-0.083**	-0.057**	-0.084**	-0.111*
23	-0.068**	-0.041	-0.069*	-0.096
24	-0.053*	-0.020	-0.052	-0.083
25	-0.057**	-0.037	-0.056**	-0.074
26	-0.038*	-0.021	-0.037	-0.054
27	-0.028	-0.010	-0.027	-0.043
28	-0.007	-0.011	-0.007	-0.003
29	0.011	0.004	0.011	0.017
30	0.026	0.015	0.025	0.035

Note: The table reports estimated impulse responses of core inflation to a one standard deviation monetary policy shock across uncertainty regimes. 'No interaction' refers to the baseline model without the uncertainty interaction term. Average, moderately high, and high uncertainty correspond to the uncertainty variable centered at its mean, one standard deviation above, and two standard deviations above the mean.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Table B2

Coefficient Estimates for Interaction Term - Core Inflation (Monetary Event Window)

Horizon	Interaction	Std. err.	[90% conf. interval]	
0	-0.009*	0.005	-0.018	-0.001
1	-0.171*	0.009	-0.032	-0.002
2	-0.031***	0.011	-0.049	-0.013
3	-0.032**	0.014	-0.055	-0.009
4	-0.032**	0.013	-0.054	-0.010
5	-0.030*	0.017	-0.057	-0.002
6	-0.039**	0.016	-0.065	-0.013
7	-0.037**	0.018	-0.066	-0.007
8	-0.045**	0.019	-0.076	-0.013
9	-0.042**	0.020	-0.074	-0.010
10	-0.034*	0.019	-0.065	-0.003
11	-0.028	0.020	-0.061	0.005
12	-0.029	0.022	-0.065	0.006
13	-0.029	0.222	-0.065	0.008
14	-0.032	0.022	-0.069	0.004
15	-0.034	0.023	-0.073	0.004
16	-0.038	0.027	-0.082	0.007
17	-0.039	0.025	-0.080	0.002
18	-0.037	0.026	-0.079	0.005
19	-0.037	0.029	-0.084	0.010
20	-0.032	0.027	-0.077	0.012
21	-0.025	0.027	-0.069	0.019
22	-0.027	0.030	-0.077	0.023
23	-0.028	0.030	-0.078	0.022
24	-0.032	0.031	-0.082	0.019
25	-0.019	0.029	-0.066	0.028
26	-0.016	0.028	-0.062	0.029
27	-0.017	0.028	-0.062	0.029
28	0.004	0.025	-0.037	0.045
29	0.006	0.025	-0.036	0.048
30	0.010	0.021	-0.025	0.045

Note: This table presents the estimated coefficients for the interaction between monetary policy shocks and uncertainty. Standard errors and 90% confidence intervals are reported.
Significance levels: * = 10%, ** = 5%, *** = 1%.

Table B3

Impulse Response of Core Inflation to a 1 SD Monetary Policy Shock (Press Release Window)

Horizon	No interaction	Uncertainty		
		Average	Moderately high	High
0	-0.002	0.006	-0.001	-0.007
1	-0.008	0.010	-0.004	-0.019
2	-0.018	0.005	-0.014	-0.032
3	-0.024	0.004	-0.018	-0.039
4	-0.021	0.014	-0.014	-0.041
5	-0.020	0.013	-0.013	-0.040
6	-0.025	0.017	-0.016	-0.049
7	-0.039	0.006	-0.029	-0.065
8	-0.069	-0.022	-0.059	-0.097
9	-0.072	-0.017	-0.061	-0.104
10	-0.079	-0.037	-0.070	-0.104
11	-0.078	-0.030	-0.068	-0.105
12	-0.089	-0.043	-0.079	-0.116
13	-0.097	-0.050	-0.087	-0.125
14	-0.117*	-0.062	-0.105*	-0.148*
15	-0.117*	-0.061	-0.105*	-0.149*
16	-0.120*	-0.064	-0.109*	-0.153*
17	-0.104*	-0.042	-0.091	-0.140*
18	-0.109*	-0.053	-0.096*	-0.139
19	-0.099*	-0.040	-0.085	-0.130
20	-0.087*	-0.030	-0.074	-0.118
21	-0.080*	-0.033	-0.069	-0.105
22	-0.071	-0.018	-0.056	-0.093
23	-0.050	0.004	-0.035	-0.073
24	-0.041	0.031	-0.014	-0.059
25	-0.015	0.042	0.006	-0.030
26	-0.006	0.047	0.014	-0.019
27	0.006	0.070	0.030	-0.009
28	0.038	0.062	0.047	0.032
29	0.056	0.070	0.061	0.053
30	0.092	0.100	0.095	0.091

Note: The table reports estimated impulse responses of core inflation to a one standard deviation monetary policy shock across uncertainty regimes. 'No interaction' refers to the baseline model without the uncertainty interaction term. Average, moderately high, and high uncertainty correspond to the uncertainty variable centered at its mean, one standard deviation above, and two standard deviations above the mean.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Table B4

Coefficient Estimates for Interaction Term - Core Inflation (Press Release Window)

Horizon	Interaction	Std. err.	[90% conf. interval]	
0	-0.006	0.007	-0.018	0.005
1	-0.014*	0.008	-0.028	0.000
2	-0.018	0.129	-0.039	0.003
3	-0.021	0.014	-0.045	0.002
4	-0.028*	0.015	-0.053	-0.003
5	-0.026	0.179	-0.056	0.003
6	-0.033*	0.020	-0.066	0.000
7	-0.036	0.023	-0.073	0.002
8	-0.037	0.025	-0.079	0.004
9	-0.044*	0.026	-0.087	-0.001
10	-0.034	0.025	-0.074	0.007
11	-0.038	0.028	-0.083	0.008
12	-0.037	0.030	-0.087	0.013
13	-0.038	0.032	-0.090	0.015
14	-0.043	0.032	-0.096	0.010
15	-0.044	0.032	-0.097	0.009
16	-0.044	0.036	-0.104	0.015
17	-0.049	0.034	-0.104	0.007
18	-0.043	0.034	-0.100	0.013
19	-0.045	0.037	-0.106	0.016
20	-0.044	0.034	-0.100	0.012
21	-0.036	0.034	-0.093	0.205
22	-0.038	0.038	-0.101	0.026
23	-0.038	0.035	-0.096	0.020
24	-0.045	0.038	-0.107	0.018
25	-0.036	0.034	-0.091	0.019
26	-0.033	0.032	-0.086	0.020
27	-0.039	0.031	-0.091	0.012
28	-0.015	0.027	-0.059	0.030
29	-0.008	0.026	-0.051	0.035
30	-0.004	0.019	-0.036	0.028

Note: This table presents the estimated coefficients for the interaction between monetary policy shocks and uncertainty. Standard errors and 90% confidence intervals are reported.
Significance levels: * = 10%, ** = 5%, *** = 1%.

Table B5

Impulse Response of Core Inflation to a 1 SD Monetary Policy Shock (Press Conference Window)

Horizon	No interaction	Uncertainty		
		Average	Moderately high	High
0	0.007	0.012	0.002	-0.008
1	0.002	0.011	-0.008	-0.028
2	0.010	0.029	-0.013	-0.056*
3	0.011	0.028	-0.010	-0.048
4	-0.002	0.012	-0.020	-0.052
5	-0.000	0.013	-0.016	-0.045
6	-0.005	0.014	-0.028	-0.070*
7	-0.016	-0.000	-0.034	-0.068*
8	-0.018	0.002	-0.043*	-0.089**
9	-0.029	-0.014	-0.048*	-0.081**
10	-0.034	-0.021	-0.049*	-0.077**
11	-0.043	-0.038	-0.049	-0.061
12	-0.050*	-0.043	-0.058**	-0.074**
13	-0.053**	-0.048*	-0.060**	-0.073**
14	-0.052**	-0.048*	-0.058**	-0.068*
15	-0.055**	-0.047*	-0.064**	-0.081**
16	-0.041*	-0.032	-0.051*	-0.070
17	-0.037**	-0.028	-0.048**	-0.068*
18	-0.040**	-0.030	-0.053**	-0.076*
19	-0.047***	-0.036**	-0.059**	-0.082*
20	-0.044**	-0.037*	-0.052**	-0.068*
21	-0.044**	-0.040*	-0.049*	-0.059
22	-0.052***	-0.045**	-0.061**	-0.077*
23	-0.049**	-0.039	-0.062**	-0.084*
24	-0.036*	-0.026	-0.048*	-0.070
25	-0.054***	-0.046**	-0.063***	-0.080**
26	-0.039**	-0.035	-0.045**	-0.055
27	-0.033*	-0.032	-0.033*	-0.035
28	-0.028	-0.033	-0.023	-0.014
29	-0.019	-0.024	-0.014	-0.003
30	-0.022	-0.023	-0.020	-0.017

Note: The table reports estimated impulse responses of core inflation to a one standard deviation monetary policy shock across uncertainty regimes. 'No interaction' refers to the baseline model without the uncertainty interaction term. Average, moderately high, and high uncertainty correspond to the uncertainty variable centered at its mean, one standard deviation above, and two standard deviations above the mean.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Table B6

Coefficient Estimates for Interaction Term - Core Inflation (Press Conference Window)

Horizon	Interaction	Std. err.	[90% conf. interval]	
0	-0.010	0.006	-0.020	0.000
1	-0.019	0.013	-0.041	0.002
2	-0.042***	0.016	-0.068	-0.017
3	-0.038*	0.020	-0.072	-0.005
4	-0.032*	0.019	-0.063	-0.001
5	-0.029	0.209	-0.063	0.005
6	-0.042**	0.018	-0.071	-0.012
7	-0.034*	0.019	-0.065	-0.002
8	-0.045**	0.018	-0.075	-0.015
9	-0.033*	0.018	-0.063	-0.003
10	-0.028	0.017	-0.057	0.001
11	-0.012	0.019	-0.043	0.020
12	-0.016	0.017	-0.044	0.013
13	-0.013	0.017	-0.041	0.016
14	-0.010	0.018	-0.039	0.019
15	-0.017	0.018	-0.046	0.013
16	-0.019	0.020	-0.052	0.015
17	-0.020	0.018	-0.050	0.010
18	-0.023	0.019	-0.054	0.008
19	-0.023	0.021	-0.058	0.012
20	-0.016	0.020	-0.049	0.018
21	-0,009	0.023	-0.046	0.028
22	-0.016	0.024	-0.055	0.023
23	-0.023	0.025	-0.064	0.019
24	-0.022	0.026	-0.064	0.021
25	-0.017	0.024	-0.056	0.022
26	-0.010	0.024	-0.049	0.029
27	-0.001	0.023	-0.040	0.037
28	0.010	0.021	-0.025	0.044
29	0.010	0.022	-0.026	0.047
30	0.003	0.019	-0.028	0.034

Note: This table presents the estimated coefficients for the interaction between monetary policy shocks and uncertainty. Standard errors and 90% confidence intervals are reported.
Significance levels: * = 10%, ** = 5%, *** = 1%.

Table B7

Impulse Response of Industrial Production to a 1 SD Monetary Policy Shock

Horizon	No interaction	Uncertainty		
		Average	Moderately high	High
0	-0.248*	-0.159	-0.255*	-0.351
1	-0.385	0.049	-0.420*	-0.890**
2	-0.588**	-0.241	-0.617***	-0.993***
3	-0.552*	-0.249	-0.577**	-0.904***
4	-0.520*	-0.173	-0.544**	-0.916***
5	-0.671**	-0.322	-0.695**	-1.067***
6	-0.711**	-0.552	-0.720**	-0.889**
7	-0.789**	-0.720	-0.793**	-0.865**
8	-0.751**	-0.802*	-0.749**	-0.697**
9	-0.596*	-0.633	-0.595*	-0.558*
10	-0.607*	-0.722*	-0.613*	-0.504*
11	-0.463*	-0.450	-0.462*	-0.474*
12	-0.162	-0.251	-0.168	-0.085
13	0.088	-0.392*	0.054	0.500
14	0.146	-0.307	0.114	0.535
15	0.284	0.019	0.262	0.506*
16	0.266	-0.100	0.231	0.561**
17	0.444**	0.226	0.423*	0.621**
18	0.531*	0.430	0.519*	0.608**
19	0.612	0.680	0.620	0.559*
20	0.588*	0.661	0.597*	0.534*
21	0.648*	0.729	0.658*	0.587**
22	0.497	0.684	0.520	0.356
23	0.587***	0.603*	0.589**	0.575***
24	0.431**	0.380	0.425**	0.470***
25	0.406***	0.428***	0.409***	0.390**
26	0.323**	0.407**	0.333**	0.259
27	0.273	0.275*	0.274*	0.273
28	0.116	0.173	0.123	0.073
29	0.160	0.113	0.154	0.195
30	0.180	0.105	0.171	0.237

Note: The table reports estimated impulse responses of industrial production to a one standard deviation monetary policy shock across uncertainty regimes. 'No interaction' refers to the baseline model without the uncertainty interaction term. Average, moderately high, and high uncertainty correspond to the uncertainty variable centered at its mean, one standard deviation above, and two standard deviations above the mean.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Table B8

Coefficient Estimates for Interaction Term - Industrial Production

Horizon	Interaction	Std. err.	[90% conf. interval]	
0	-0.096	0.116	-0.287	0.095
1	-0.470**	0.201	-0.800	-0.139
2	-0.376***	0.136	-0.600	-0.152
3	-0.328***	0.122	-0.529	-0.127
4	-0.372***	0.123	-0.574	-0.169
5	-0.372***	0.127	-0.580	-0.164
6	-0.169	0.133	-0.387	0.050
7	-0.073	0.158	-0.332	0.187
8	0.053	0.143	-0.183	0.288
9	0.038	0.173	-0.246	0.322
10	0.109	0.158	-0.150	0.369
11	-0.012	0.138	-0.240	0.216
12	0.083	0.184	-0.219	0.385
13	0.446	0.295	-0.039	0.931
14	0.421***	0.155	0.167	0.675
15	0.243**	0.107	0.068	0.419
16	0.330***	0.115	0.140	0.520
17	0.197*	0.117	0.006	0.389
18	0.089	0.123	-0.112	0.291
19	-0.060	0.195	-0.381	0.260
20	-0.064	0.161	-0.329	0.202
21	-0.711	0.180	-0.367	0.225
22	-0.164	0.183	-0.466	0.137
23	-0.014	0.133	-0.233	0.205
24	0.448	0.129	-0.167	0.256
25	-0.019	0.093	-0.172	0.134
26	-0.074	0.112	-0.258	0.110
27	-0.001	0.096	-0.158	0.156
28	-0.050	0.094	-0.204	0.104
29	0.041	0.078	-0.088	0.170
30	0.066	0.081	-0.067	0.199

Note: This table presents the estimated coefficients for the interaction between monetary policy shocks and uncertainty. Standard errors and 90% confidence intervals are reported.
Significance levels: * = 10%, ** = 5%, *** = 1%.

Table B9

Impulse Response of Industrial Production to a 1 SD Monetary Policy Shock (Including Financial Crisis Dummy)

Horizon	No interaction	Uncertainty		
		Average	Moderately high	High
0	-0.261**	-0.185	-0.267*	-0.349
1	-0.403	0.015	-0.436*	-0.888**
2	-0.600**	-0.263	-0.627***	-0.991***
3	-0.560*	-0.261	-0.582**	-0.904***
4	-0.528*	-0.187	-0.551**	-0.915***
5	-0.680**	-0.340	-0.703**	-1.065***
6	-0.718**	-0.565*	-0.727**	-0.888**
7	-0.792**	-0.727	-0.796**	-0.865**
8	-0.749**	-0.799*	-0.748**	-0.697**
9	-0.600*	-0.641	-0.599*	-0.557*
10	-0.617**	-0.745*	-0.624*	-0.504*
11	-0.468*	-0.460	-0.467*	-0.474*
12	-0.152	-0.230	-0.157	-0.084
13	0.107	-0.356*	0.073	0.502
14	0.173	-0.252	0.142	0.536
15	0.317	0.092	0.298	0.504*
16	0.309	-0.007	0.278	0.563**
17	0.484**	0.309	0.467*	0.625**
18	0.573*	0.509	0.565*	0.621**
19	0.647	0.748	0.659	0.570
20	0.617*	0.717	0.630*	0.543*
21	0.667*	0.767	0.680*	0.593**
22	0.503	0.697	0.527	0.357
23	0.582***	0.594*	0.584**	0.574***
24	0.418**	0.355	0.410**	0.465***
25	0.386***	0.390**	0.387***	0.383**
26	0.286**	0.339*	0.293**	0.247
27	0.219	0.170	0.213*	0.255
28	0.055	0.056	0.055	0.054
29	0.105	0.005	0.093	0.180
30	0.134	0.011	0.119	0.228

Note: The table reports estimated impulse responses of industrial production to a one standard deviation monetary policy shock across uncertainty regimes. 'No interaction' refers to the baseline model without the uncertainty interaction term. Average, moderately high, and high uncertainty correspond to the uncertainty variable centered at its mean, one standard deviation above, and two standard deviations above the mean. Estimates are obtained from models that include a dummy for the 2008–2009 financial crisis.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Table B10

Coefficient Estimates for Interaction Term - Industrial Production (Including Financial Crisis Dummy)

Horizon	Interaction	Std. err.	[90% conf. interval]	
0	-0.082	0.128	-0.292	0.128
1	-0.451**	0.214	-0.803	-0.099
2	-0.364***	0.142	-0.598	-0.131
3	-0.321**	0.126	-0.529	-0.113
4	-0.364***	0.128	-0.575	-0.153
5	-0.363***	0.128	-0.573	-0.152
6	-0.161	0.137	-0.387	0.064
7	-0.069	0.156	-0.325	0.187
8	0.051	0.139	-0.178	0.280
9	0.042	0.168	-0.235	0.319
10	0.120	0.152	-0.129	0.370
11	-0.007	0.133	-0.226	0.212
12	0.073	0.183	-0.228	0.374
13	0.429	0.300	-0.064	0.922
14	0.394**	0.164	0.124	0.664
15	0.206*	0.109	0.026	0.386
16	0.285**	0.125	0.081	0.490
17	0.158	0.122	-0.043	0.359
18	0.056	0.121	-0.142	0.254
19	-0.089	0.190	-0.402	0.224
20	-0.087	0.157	-0.346	0.172
21	-0.087	0.178	-0.379	0.206
22	-0.170	0.182	-0.469	0.129
23	-0.010	0.133	-0.229	0.209
24	0.055	0.130	-0.159	0.269
25	-0.003	0.096	-0.161	0.154
26	-0.046	0.117	-0.238	0.147
27	0.042	0.092	-0.110	0.195
28	-0.001	0.111	-0.184	0.182
29	0.087	0.090	-0.061	0.236
30	0.109	0.089	-0.039	0.256

Note: Estimates are obtained from models including the financial crisis dummy. Standard errors and 90% confidence intervals are reported.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Table B11

***S**ymmetry Test – Core Inflation (Contractionary vs. Expansionary Shocks)*

	Contractionary shock				Expansionary shock			
Horizon	Interaction	Std. err.	[90% conf. interval]		Interaction	Std. err.	[90% conf. interval]	
0	-0.009	0.008	-0.022	0.004	-0.010	0.010	-0.027	0.007
1	-0.017**	0.008	-0.030	-0.003	-0.018	0.024	-0.057	0.021
2	-0.030**	0.014	-0.052	-0.008	-0.033	0.030	-0.082	0.016
3	-0.038**	0.015	-0.063	-0.013	-0.021	0.039	-0.085	0.043
4	-0.038**	0.019	-0.070	-0.007	-0.018	0.042	-0.087	0.050
5	-0.032	0.022	-0.068	0.005	-0.026	0.045	-0.099	0.048
6	-0.033	0.027	-0.077	0.011	-0.050	0.042	-0.119	0.019
7	-0.042	0.031	-0.093	0.009	-0.027	0.048	-0.106	0.052
8	-0.049	0.036	-0.108	0.010	-0.036	0.051	-0.119	0.048
9	-0.056	0.040	-0.122	0.009	-0.015	0.053	-0.103	0.072
10	-0.053	0.042	-0.122	0.016	0.002	0.054	-0.086	0.091
11	-0.047	0.045	-0.121	0.027	0.009	0.059	-0.088	0.105
12	-0.047	0.047	-0.125	0.030	0.005	0.057	-0.088	0.098
13	-0.046	0.049	-0.127	0.036	0.004	0.058	-0.091	0.099
14	-0.053	0.049	-0.134	0.028	0.008	0.059	-0.089	0.105
15	-0.055	0.050	-0.136	0.027	0.005	0.061	-0.096	0.106
16	-0.055	0.052	-0.141	0.031	-0.005	0.065	-0.112	0.101
17	-0.061	0.051	-0.146	0.024	0.002	0.062	-0.099	0.104
18	-0.059	0.050	-0.141	0.023	0.005	0.064	-0.100	0.110
19	-0.049	0.050	-0.132	0.033	-0.013	0.067	-0.123	0.098
20	-0.041	0.047	-0.118	0.036	-0.016	0.065	-0.124	0.091
21	-0.024	0.041	-0.092	0.044	-0.028	0.069	-0.142	0.086
22	-0.017	0.042	-0.086	0.052	-0.045	0.073	-0.165	0.074
23	-0.014	0.039	-0.078	0.051	-0.055	0.070	-0.171	0.060
24	-0.020	0.039	-0.084	0.044	-0.056	0.071	-0.172	0.061
25	-0.007	0.038	-0.069	0.055	-0.042	0.068	-0.153	0.070
26	-0.005	0.037	-0.067	0.056	-0.038	0.066	-0.146	0.070
27	-0.005	0.036	-0.064	0.054	-0.039	0.063	-0.143	0.065
28	0.022	0.034	-0.034	0.078	-0.031	0.060	-0.131	0.068
29	0.037	0.034	-0.019	0.093	-0.054	0.063	-0.157	0.050
30	0.048	0.031	-0.003	0.098	-0.063	0.058	-0.159	0.032

Note: The table reports estimates of the interaction term between monetary policy shocks and uncertainty, separately for contractionary and expansionary shocks. Standard errors and 90% confidence intervals are reported.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Table B12

Symmetry Test – Industrial Production (Contractionary vs. Expansionary Shocks)

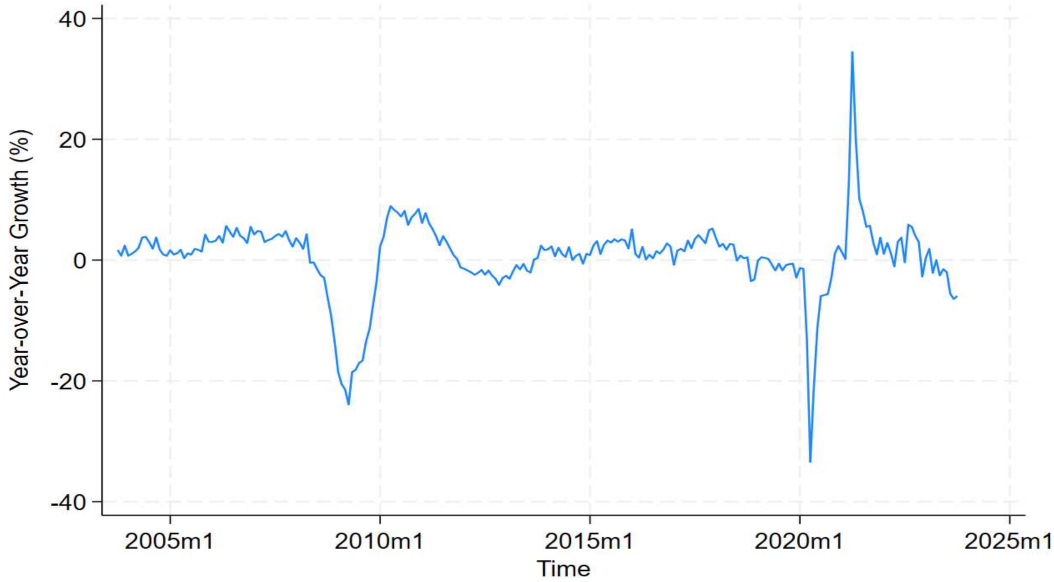
	Contractionary shock				Expansionary shock			
Horizon	Interaction	Std. err.	[90% conf. interval]		Interaction	Std. err.	[90% conf. interval]	
0	-0.112	0.176	-0.402	0.177	-0.060	0.151	-0.309	0.189
1	-0.581**	0.295	-1.066	-0.095	-0.248	0.313	-0.762	0.266
2	-0.715***	0.237	-1.104	-0.326	0.291	0.276	-0.162	0.745
3	-0.775***	0.227	-1.148	-0.402	0.550*	0.323	0.019	1.081
4	-0.881***	0.227	-1.255	-0.508	0.633*	0.367	0.030	1.235
5	-0.977***	0.251	-1.390	-0.565	0.819*	0.443	0.090	1.548
6	-0.742***	0.258	-1.166	-0.317	0.955**	0.487	0.154	1.757
7	-0.520**	0.223	-0.887	-0.153	0.807*	0.448	0.069	1.544
8	-0.383*	0.198	-0.708	-0.058	0.917**	0.413	0.239	1.596
9	-0.375*	0.217	-0.732	-0.019	0.853*	0.470	0.080	1.626
10	-0.326	0.238	-0.718	0.067	0.967*	0.505	0.136	1.798
11	-0.414	0.254	-0.831	0.003	0.782	0.503	-0.046	1.610
12	-0.288	0.285	-0.756	0.181	0.810	0.494	-0.002	1.622
13	0.145	0.372	-0.467	0.757	1.037**	0.519	0.183	1.891
14	0.296	0.308	-0.211	0.804	0.667	0.454	-0.080	1.415
15	0.286	0.293	-0.197	0.768	0.164	0.420	-0.528	0.855
16	0.563*	0.293	0.080	1.045	-0.121	0.379	-0.745	0.502
17	0.578*	0.317	0.057	1.099	-0.546	0.438	-1.266	0.174
18	0.423	0.288	-0.051	0.897	-0.567	0.462	-1.327	0.193
19	0.186	0.320	-0.340	0.711	-0.543	0.436	-1.261	0.175
20	0.136	0.304	-0.363	0.636	-0.453	0.390	-1.095	0.188
21	0.067	0.294	-0.417	0.551	-0.336	0.392	-0.980	0.309
22	-0.013	0.265	-0.449	0.423	-0.458	0.386	-1.093	0.177
23	0.021	0.241	-0.375	0.417	-0.079	0.301	-0.574	0.415
24	0.138	0.232	-0.243	0.519	-0.132	0.339	-0.689	0.425
25	0.187	0.203	-0.146	0.521	-0.422	0.276	-0.876	0.032
26	0.109	0.246	-0.296	0.514	-0.435	0.326	-0.971	0.100
27	0.092	0.231	-0.289	0.472	-0.182	0.275	-0.635	0.271
28	-0.114	0.239	-0.507	0.279	0.081	0.310	-0.429	0.590
29	-0.059	0.226	-0.431	0.313	0.242	0.318	-0.282	0.765
30	-0.016	0.228	-0.391	0.359	0.229	0.329	-0.313	0.770

Note: The table reports estimates of the interaction term between monetary policy shocks and uncertainty, separately for contractionary and expansionary shocks. Standard errors and 90% confidence intervals are reported.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Figure B1

Industrial Production in the Euro Area, Year-over-Year Growth (2003–2023)



Note: The figure shows the year-over-year growth rate of industrial production in the euro area from October 2003 to October 2023, highlighting major downturns during the global financial crisis (2008–2009), the COVID-19 pandemic (2020), and the Ukraine war (2022).

Appendix C. Robustness Checks

Table C1

Coefficient Estimates for Interaction Term - Core Inflation (EPU Index)

Horizon	Interaction	Std. err.	[90% conf. interval]	
0	0.001	0.011	-0.022	0.023
1	0.001	0.017	-0.032	0.034
2	-0.001	0.026	-0.052	0.049
3	0.004	0.030	-0.055	0.063
4	0.007	0.029	-0.049	0.064
5	-0.002	0.037	-0.075	0.071
6	-0.007	0.044	-0.093	0.079
7	-0.001	0.047	-0.093	0.091
8	-0.018	0.048	-0.113	0.077
9	-0.020	0.043	-0.105	0.065
10	-0.022	0.039	-0.098	0.055
11	-0.025	0.044	-0.112	0.061
12	-0.042	0.045	-0.131	0.047
13	-0.040	0.048	-0.134	0.053
14	-0.060	0.045	-0.148	0.028
15	-0.063	0.046	-0.153	0.028
16	-0.075*	0.046	-0.165	0.014
17	-0.059	0.040	-0.138	0.020
18	-0.066	0.041	-0.147	0.016
19	-0.066	0.042	-0.149	0.016
20	-0.051	0.040	-0.128	0.027
21	-0.052	0.040	-0.131	0.027
22	-0.043	0.046	-0.132	0.047
23	-0.034	0.042	-0.116	0.048
24	-0.045	0.050	-0.143	0.053
25	-0.019	0.039	-0.096	0.057
26	-0.014	0.031	-0.074	0.046
27	-0.009	0.029	-0.065	0.048
28	0.007	0.025	-0.043	0.056
29	0.003	0.030	-0.056	0.061
30	0.026	0.028	-0.028	0.081

Note: Estimates are based on the interaction between monetary policy shocks and the Economic Policy Uncertainty (EPU) index. Standard errors and 90% confidence intervals are reported. Significance levels: * = 10%, ** = 5%, *** = 1%.

Table C2

Coefficient Estimates for Interaction Term - Core Inflation (Excluding COVID-19 and Ukraine Dummies)

Horizon	Interaction	Std. err.	[90% conf. interval]	
0	-0.012**	0.006	-0.022	-0.002
1	-0.022**	0.011	-0.040	-0.004
2	-0.039***	0.013	-0.060	-0.017
3	-0.042**	0.017	-0.070	-0.014
4	-0.044**	0.017	-0.072	-0.016
5	-0.045**	0.022	-0.082	-0.009
6	-0.056**	0.022	-0.093	-0.020
7	-0.056**	0.025	-0.098	-0.014
8	-0.064**	0.026	-0.107	-0.020
9	-0.060**	0.027	-0.104	-0.016
10	-0.051**	0.026	-0.094	-0.009
11	-0.045*	0.027	-0.090	-0.001
12	-0.045*	0.027	-0.090	0.000
13	-0.042	0.027	-0.087	0.003
14	-0.042*	0.026	-0.084	0.000
15	-0.041	0.025	-0.082	0.001
16	-0.040	0.025	-0.081	0.001
17	-0.038	0.025	-0.079	0.002
18	-0.030	0.023	-0.068	0.008
19	-0.026	0.023	-0.064	0.012
20	-0.019	0.025	-0.060	0.022
21	-0.008	0.025	-0.049	0.033
22	-0.013	0.028	-0.059	0.034
23	-0.013	0.029	-0.062	0.035
24	-0.010	0.029	-0.058	0.037
25	0.000	0.033	-0.054	0.054
26	0.001	0.034	-0.055	0.058
27	0.006	0.035	-0.052	0.064
28	0.028	0.037	-0.033	0.089
29	0.029	0.038	-0.033	0.090
30	0.037	0.041	-0.030	0.104

Note: Estimates are obtained from models excluding the COVID-19 and Ukraine dummies. Standard errors and 90% confidence intervals are reported.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Table C3

Coefficient Estimates for Interaction Term - Core Inflation (Excluding COVID-19 Dummy)

Horizon	Interaction	Std. err.	[90% conf. interval]	
0	-0.010**	0.005	-0.018	-0.002
1	-0.018*	0.010	-0.034	-0.002
2	-0.033***	0.011	-0.051	-0.014
3	-0.034**	0.015	-0.058	-0.010
4	-0.034**	0.014	-0.058	-0.011
5	-0.033*	0.020	-0.066	-0.001
6	-0.043**	0.019	-0.073	-0.012
7	-0.040**	0.021	-0.074	-0.006
8	-0.047**	0.021	-0.081	-0.013
9	-0.043**	0.020	-0.077	-0.009
10	-0.033*	0.019	-0.065	-0.002
11	-0.027	0.020	-0.060	0.007
12	-0.027	0.021	-0.061	0.008
13	-0.024	0.021	-0.059	0.011
14	-0.026	0.021	-0.060	0.009
15	-0.025	0.022	-0.061	0.011
16	-0.026	0.022	-0.062	0.010
17	-0.024	0.022	-0.061	0.013
18	-0.018	0.022	-0.053	0.017
19	-0.015	0.022	-0.051	0.022
20	-0.008	0.025	-0.049	0.033
21	0.003	0.025	-0.038	0.044
22	-0.001	0.028	-0.047	0.045
23	-0.001	0.029	-0.048	0.047
24	0.005	0.028	-0.041	0.051
25	0.016	0.032	-0.036	0.069
26	0.019	0.033	-0.036	0.073
27	0.024	0.034	-0.032	0.080
28	0.046	0.036	-0.013	0.105
29	0.047	0.036	-0.012	0.106
30	0.053	0.041	-0.014	0.120

Note: Estimates are obtained from models excluding the COVID-19 dummy. Standard errors and 90% confidence intervals are reported.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Table C4

Coefficient Estimates for Interaction Term - Core Inflation (Excluding Ukraine Dummy)

Horizon	Interaction	Std. err.	[90% conf. interval]	
0	-0.012**	0.006	-0.022	-0.002
1	-0.022**	0.011	-0.040	-0.004
2	-0.038***	0.013	-0.060	-0.017
3	-0.042**	0.017	-0.069	-0.014
4	-0.043**	0.017	-0.071	-0.015
5	-0.044**	0.021	-0.078	-0.009
6	-0.055***	0.021	-0.090	-0.021
7	-0.055**	0.025	-0.096	-0.015
8	-0.064**	0.026	-0.107	-0.021
9	-0.062**	0.027	-0.106	-0.018
10	-0.054**	0.026	-0.098	-0.011
11	-0.049*	0.027	-0.094	-0.004
12	-0.050*	0.028	-0.096	-0.003
13	-0.048*	0.028	-0.095	-0.001
14	-0.050*	0.027	-0.094	-0.005
15	-0.050*	0.027	-0.095	-0.005
16	-0.052*	0.030	-0.102	-0.002
17	-0.052*	0.027	-0.097	-0.008
18	-0.047*	0.027	-0.092	-0.003
19	-0.045	0.029	-0.093	0.003
20	-0.040	0.027	-0.084	0.004
21	-0.032	0.027	-0.076	0.012
22	-0.033	0.030	-0.083	0.016
23	-0.034	0.030	-0.084	0.015
24	-0.040	0.031	-0.091	0.011
25	-0.027	0.029	-0.074	0.020
26	-0.025	0.028	-0.072	0.021
27	-0.026	0.029	-0.074	0.021
28	-0.006	0.026	-0.049	0.037
29	-0.004	0.026	-0.047	0.039
30	0.001	0.022	-0.035	0.037

Note: Estimates are obtained from models excluding the Ukraine dummy. Standard errors and 90% confidence intervals are reported.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Table C5

Coefficient Estimates for Interaction Term - Core Inflation (Including Financial Crisis Dummy)

Horizon	Interaction	Std. err.	[90% conf. interval]	
0	-0.009*	0.005	-0.017	-0.001
1	-0.016*	0.009	-0.031	-0.002
2	-0.030***	0.010	-0.047	-0.013
3	-0.030**	0.013	-0.051	-0.009
4	-0.029**	0.012	-0.049	-0.009
5	-0.027*	0.015	-0.052	-0.002
6	-0.036**	0.015	-0.060	-0.011
7	-0.034**	0.017	-0.062	-0.006
8	-0.042**	0.018	-0.072	-0.012
9	-0.040**	0.019	-0.071	-0.008
10	-0.032*	0.019	-0.063	-0.001
11	-0.027	0.020	-0.060	0.007
12	-0.028	0.022	-0.064	0.008
13	-0.028	0.023	-0.065	0.009
14	-0.032	0.023	-0.070	0.006
15	-0.035	0.024	-0.075	0.005
16	-0.039	0.028	-0.085	0.007
17	-0.042	0.026	-0.084	0.000
18	-0.041	0.027	-0.084	0.003
19	-0.041	0.029	-0.089	0.008
20	-0.037	0.028	-0.083	0.009
21	-0.030	0.028	-0.076	0.015
22	-0.032	0.031	-0.083	0.019
23	-0.033	0.031	-0.084	0.017
24	-0.039	0.031	-0.091	0.013
25	-0.026	0.029	-0.073	0.022
26	-0.023	0.028	-0.069	0.023
27	-0.024	0.028	-0.069	0.022
28	-0.003	0.025	-0.044	0.038
29	-0.000	0.026	-0.042	0.041
30	0.003	0.021	-0.031	0.037

Note: Estimates are obtained from models including the financial crisis dummy. Standard errors and 90% confidence intervals are reported.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Table C6

Coefficient Estimates for Interaction Term – Headline Inflation

Horizon	Interaction	Std. err.	[90% conf. interval]	
0	-0.012	0.017	-0.039	0.016
1	-0.021	0.021	-0.056	0.015
2	-0.032	0.023	-0.069	0.005
3	-0.030	0.025	-0.071	0.011
4	-0.043*	0.024	-0.082	-0.004
5	-0.041	0.026	-0.084	0.003
6	-0.053**	0.025	-0.094	-0.012
7	-0.041	0.029	-0.089	0.006
8	-0.052*	0.027	-0.096	-0.007
9	-0.044	0.030	-0.094	0.005
10	-0.044*	0.025	-0.086	-0.003
11	-0.039	0.027	-0.083	0.006
12	-0.030	0.027	-0.075	0.014
13	-0.034	0.029	-0.081	0.013
14	-0.037	0.027	-0.082	0.007
15	-0.037	0.028	-0.083	0.009
16	-0.028	0.035	-0.085	0.029
17	-0.036	0.031	-0.087	0.016
18	-0.039	0.033	-0.093	0.015
19	-0.041	0.031	-0.092	0.010
20	-0.027	0.030	-0.076	0.022
21	-0.030	0.030	-0.079	0.018
22	-0.037	0.034	-0.093	0.019
23	-0.038	0.032	-0.091	0.014
24	-0.016	0.023	-0.054	0.022
25	0.000	0.029	-0.048	0.048
26	0.009	0.031	-0.042	0.059
27	0.027	0.032	-0.026	0.079
28	0.038	0.030	-0.012	0.088
29	0.038	0.034	-0.017	0.093
30	0.037	0.036	-0.022	0.096

Note: Estimates are from models where headline inflation is used as the dependent variable. Standard errors and 90% confidence intervals are reported.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Table C7

Coefficient Estimates for Interaction Term - Core Inflation (1 Lag Specification)

Horizon	Interaction	Std. err.	[90% conf. interval]	
0	-0.009*	0.005	-0.017	0.000
1	-0.016*	0.010	-0.033	0.000
2	-0.031***	0.011	-0.048	-0.013
3	-0.032**	0.013	-0.054	-0.010
4	-0.032**	0.014	-0.054	-0.010
5	-0.031*	0.016	-0.057	-0.004
6	-0.040**	0.016	-0.066	-0.013
7	-0.037**	0.019	-0.068	-0.006
8	-0.044**	0.020	-0.077	-0.012
9	-0.041*	0.022	-0.077	-0.005
10	-0.034	0.021	-0.068	0.001
11	-0.027	0.022	-0.064	0.009
12	-0.029	0.023	-0.067	0.008
13	-0.028	0.024	-0.067	0.011
14	-0.032	0.024	-0.071	0.007
15	-0.034	0.024	-0.074	0.006
16	-0.037	0.028	-0.083	0.009
17	-0.036	0.026	-0.079	0.007
18	-0.036	0.027	-0.081	0.009
19	-0.036	0.030	-0.085	0.013
20	-0.031	0.027	-0.076	0.014
21	-0.025	0.027	-0.069	0.019
22	-0.024	0.029	-0.072	0.023
23	-0.026	0.028	-0.072	0.020
24	-0.031	0.029	-0.078	0.016
25	-0.018	0.026	-0.061	0.024
26	-0.017	0.026	-0.059	0.025
27	-0.018	0.025	-0.060	0.024
28	0.0023	0.023	-0.035	0.041
29	0.005	0.024	-0.034	0.043
30	0.008	0.019	-0.024	0.040

Note: Estimates are from a specification including only one lag of the control variables. Standard errors and 90% confidence intervals are reported.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Table C8

Coefficient Estimates for Interaction Term - Core Inflation (2 Lag Specification)

Horizon	Interaction	Std. err.	[90% conf. interval]	
0	-0.011*	0.006	-0.020	-0.008
1	-0.016*	0.010	-0.032	-0.001
2	-0.029**	0.011	-0.047	-0.010
3	-0.031**	0.014	-0.054	-0.008
4	-0.028**	0.014	-0.050	-0.006
5	-0.025	0.017	-0.054	0.003
6	-0.036**	0.016	-0.063	-0.010
7	-0.032*	0.018	-0.062	-0.002
8	-0.037*	0.019	-0.068	-0.005
9	-0.036*	0.019	-0.068	-0.005
10	-0.028	0.018	-0.058	0.002
11	-0.020	0.019	-0.052	0.011
12	-0.020	0.021	-0.055	0.014
13	-0.020	0.021	-0.054	0.014
14	-0.022	0.021	-0.056	0.012
15	-0.022	0.022	-0.059	0.015
16	-0.028	0.027	-0.072	0.016
17	-0.028	0.023	-0.066	0.011
18	-0.025	0.025	-0.066	0.016
19	-0.026	0.029	-0.073	0.022
20	-0.021	0.026	-0.064	0.022
21	-0.012	0.026	-0.055	0.031
22	-0.014	0.030	-0.065	0.036
23	-0.016	0.030	-0.065	0.033
24	-0.022	0.031	-0.073	0.029
25	-0.011	0.028	-0.057	0.036
26	-0.010	0.028	-0.056	0.037
27	-0.011	0.029	-0.059	0.036
28	0.007	0.025	-0.034	0.049
29	0.007	0.026	-0.035	0.049
30	0.009	0.021	-0.026	0.043

Note: Estimates are from a specification including two lags of the control variables. Standard errors and 90% confidence intervals are reported.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Table C9

Coefficient Estimates for Interaction Term - Core Inflation (1-Year OIS Shock)

Horizon	Interaction	Std. err.	[90% conf. interval]	
0	-0.013**	0.005	-0.022	-0.004
1	-0.025**	0.012	-0.045	-0.005
2	-0.044***	0.014	-0.067	-0.021
3	-0.049**	0.019	-0.080	-0.017
4	-0.046**	0.018	-0.076	-0.016
5	-0.044**	0.022	-0.081	-0.007
6	-0.055***	0.020	-0.088	-0.021
7	-0.054**	0.023	-0.091	-0.016
8	-0.066***	0.023	-0.104	-0.028
9	-0.059***	0.023	-0.097	-0.021
10	-0.052**	0.022	-0.088	-0.015
11	-0.041*	0.023	-0.080	-0.003
12	-0.041*	0.024	-0.081	-0.002
13	-0.040	0.025	-0.081	0.000
14	-0.043*	0.025	-0.084	-0.002
15	-0.045*	0.026	-0.087	-0.002
16	-0.050*	0.030	-0.100	-0.001
17	-0.050*	0.028	-0.095	-0.004
18	-0.051*	0.029	-0.099	-0.004
19	-0.052	0.032	-0.104	0.000
20	-0.046	0.030	-0.095	0.004
21	-0.038	0.031	-0.088	0.013
22	-0.040	0.034	-0.096	0.016
23	-0.040	0.033	-0.095	0.014
24	-0.044	0.034	-0.100	0.012
25	-0.029	0.031	-0.080	0.022
26	-0.024	0.030	-0.073	0.025
27	-0.023	0.029	-0.070	0.025
28	0.001	0.026	-0.041	0.043
29	0.004	0.027	-0.040	0.049
30	0.010	0.021	-0.025	0.045

Note: Estimates are from models where the monetary policy shock is measured using the 1-year OIS rate. Standard errors and 90% confidence intervals are reported.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Table C10

Coefficient Estimates for Interaction Term - Core Inflation (3-Month OIS Shock)

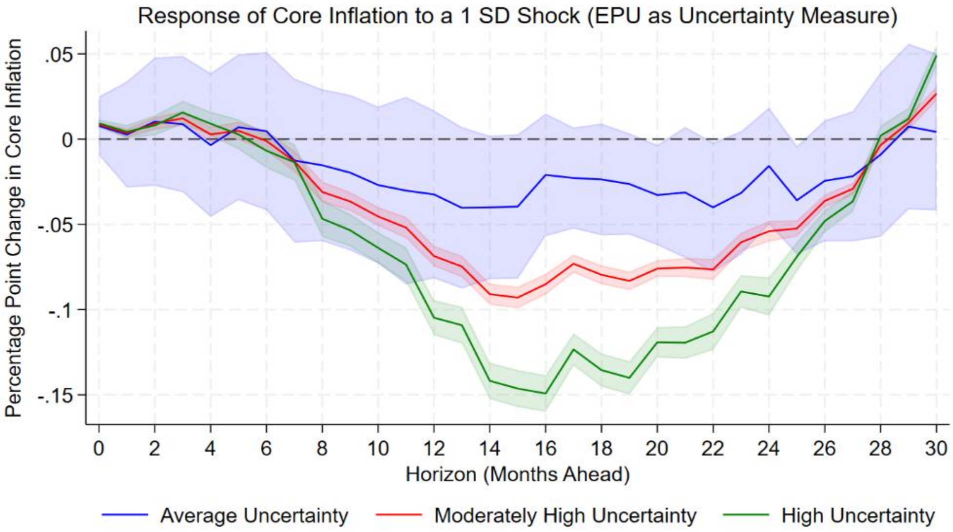
Horizon	Interaction	Std. err.	[90% conf. interval]	
0	-0.008	0.006	-0.018	0.003
1	-0.010	0.009	-0.025	0.005
2	-0.018	0.012	-0.037	0.001
3	-0.016	0.014	-0.039	0.008
4	-0.017	0.014	-0.039	0.006
5	-0.018	0.016	-0.044	0.009
6	-0.029*	0.016	-0.055	-0.026
7	-0.024	0.018	-0.054	0.005
8	-0.031	0.020	-0.064	0.002
9	-0.031	0.021	-0.065	0.003
10	-0.020	0.020	-0.054	0.013
11	-0.020	0.023	-0.057	0.017
12	-0.025	0.025	-0.066	0.017
13	-0.026	0.027	-0.070	0.018
14	-0.030	0.027	-0.075	0.014
15	-0.035	0.030	-0.084	0.014
16	-0.037	0.034	-0.092	0.019
17	-0.042	0.033	-0.096	0.012
18	-0.040	0.034	-0.096	0.017
19	-0.041	0.038	-0.103	0.021
20	-0.038	0.036	-0.097	0.021
21	-0.032	0.037	-0.092	0.029
22	-0.037	0.041	-0.104	0.030
23	-0.036	0.040	-0.102	0.029
24	-0.041	0.040	-0.107	0.025
25	-0.030	0.038	-0.092	0.033
26	-0.027	0.036	-0.086	0.033
27	-0.028	0.036	-0.088	0.031
28	-0.008	0.033	-0.063	0.047
29	-0.007	0.032	-0.059	0.045
30	-0.003	0.026	-0.045	0.039

Note: Estimates are from models where the monetary policy shock is measured using the 3-month OIS rate. Standard errors and 90% confidence intervals are reported.

Significance levels: * = 10%, ** = 5%, *** = 1%.

Figure C1

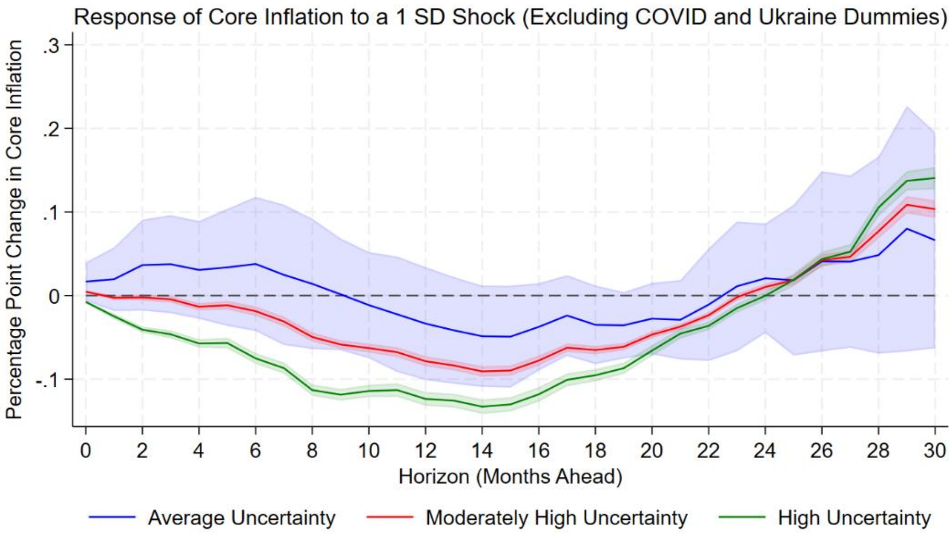
Core Inflation – Response to a 1 SD Monetary Policy Shock (EPU as Uncertainty Measure)



Note: Blue line shows the response under average uncertainty (90% confidence band). Red and green lines show responses when uncertainty, measured by the standardized EPU index, is one or two standard deviations above the mean. Horizons are measured in months and responses is shown in percentage points.

Figure C2

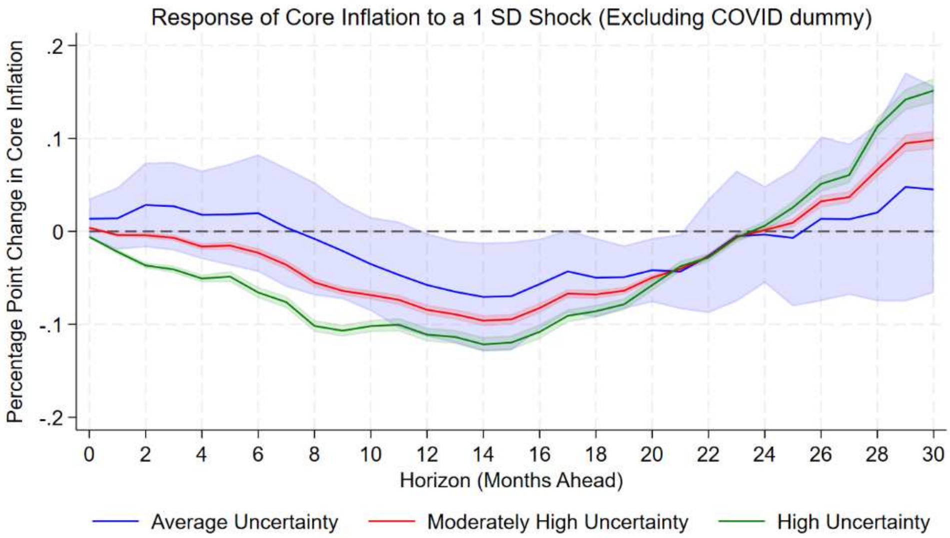
Core Inflation – Response to a 1 SD Monetary Policy Shock (Excluding COVID and Ukraine Dummies)



Note: Blue line shows the response under average uncertainty (90% confidence band). Red and green lines show responses when uncertainty, measured by the standardized VSTOXX, is one or two standard deviations above the mean. Results from models excluding COVID-19 and Ukraine war dummies.

Figure C3

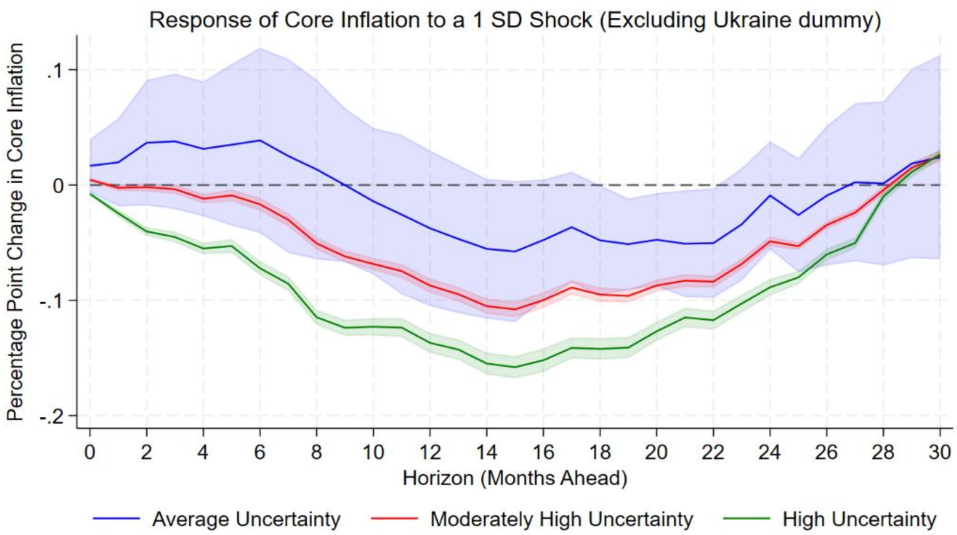
Core Inflation – Response to a 1 SD Monetary Policy Shock (Excluding COVID Dummy)



Note: Blue line shows the response under average uncertainty (90% confidence band). Red and green lines show responses when uncertainty, measured by the standardized VSTOXX, is one or two standard deviations above the mean. Results from models excluding COVID-19 dummy.

Figure C4

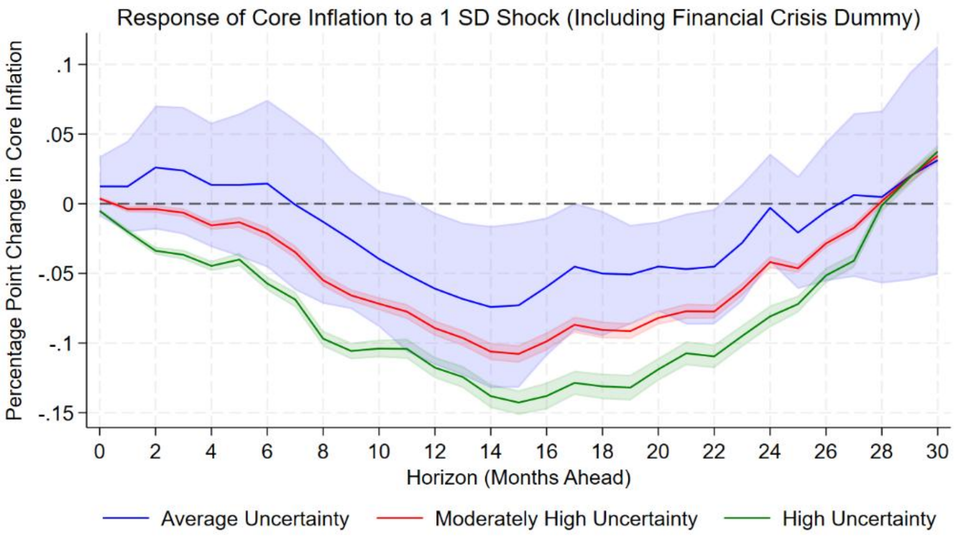
Core Inflation – Response to a 1 SD Monetary Policy Shock (Excluding Ukraine Dummy)



Note: Blue line shows the response under average uncertainty (90% confidence band). Red and green lines show responses when uncertainty, measured by the standardized VSTOXX, is one or two standard deviations above the mean. Results from models excluding Ukraine war dummy.

Figure C5

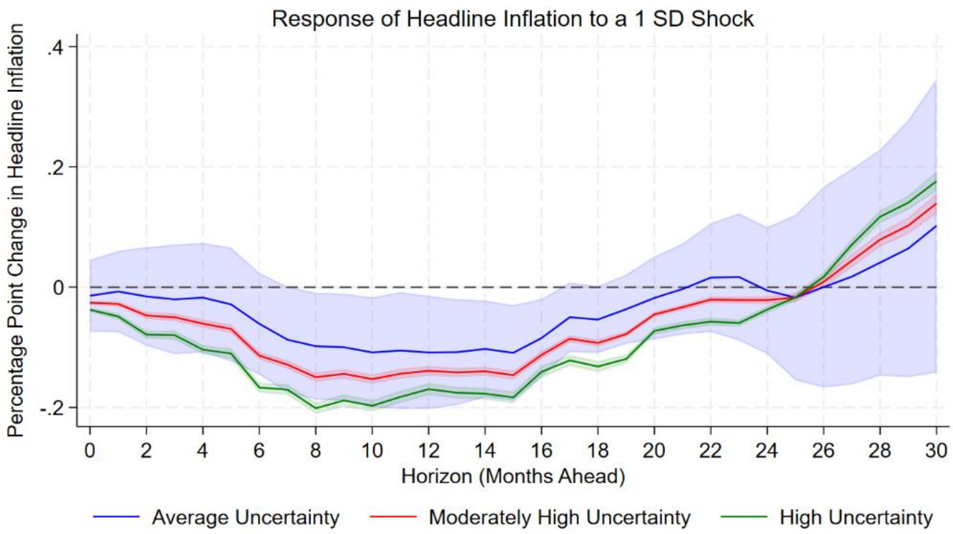
Core Inflation – Response to a 1 SD Monetary Policy Shock (Including Financial Crisis Dummy)



Note: Blue line shows the response under average uncertainty (90% confidence band). Red and green lines show responses when uncertainty, measured by the standardized VSTOXX, is one or two standard deviations above the mean. Results from models including financial crisis dummy.

Figure C6

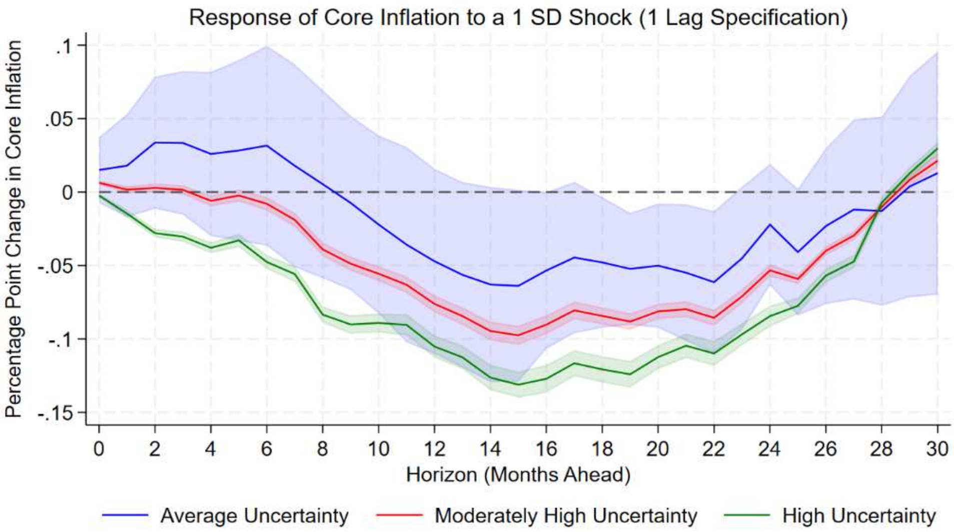
Headline Inflation – Response to a 1 SD Monetary Policy Shock



Note: Blue line shows the response under average uncertainty (90% confidence band). Red and green lines show responses when uncertainty, measured by the standardized VSTOXX, is one or two standard deviations above the mean. Results use headline inflation as the dependent variable.

Figure C7

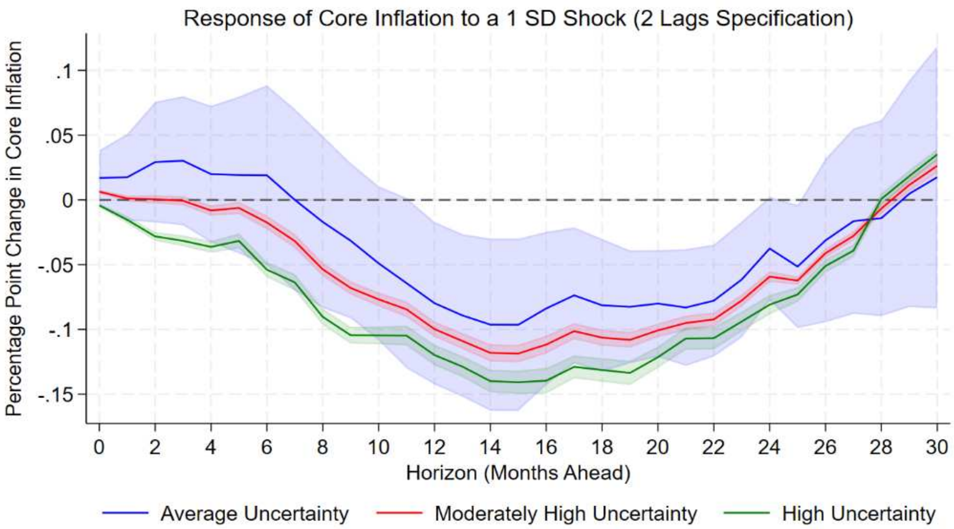
Core Inflation – Response to a 1 SD Monetary Policy Shock (1 Lag Specification)



Note: Blue line shows the response under average uncertainty (90% confidence band). Red and green lines show responses when uncertainty, measured by the standardized VSTOXX, is one or two standard deviations above the mean. Results from models estimated with 1 lag.

Figure C8

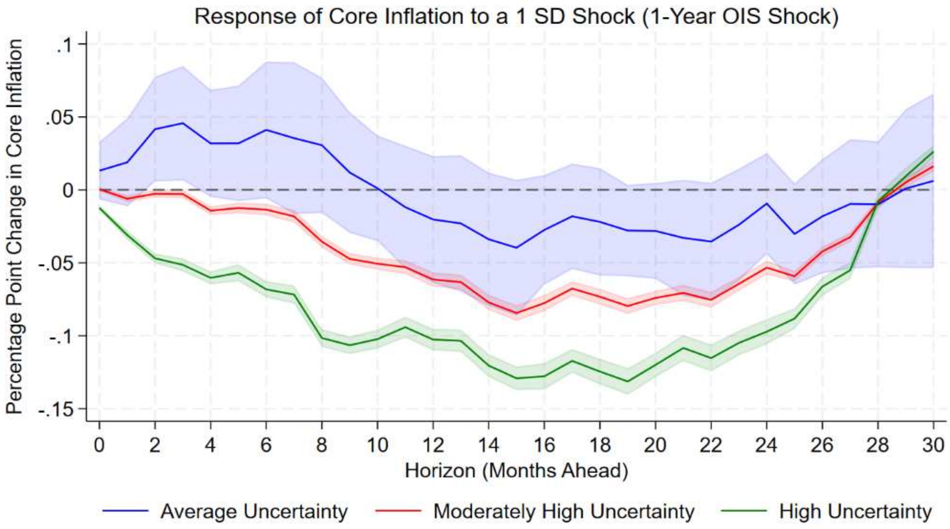
Core Inflation – Response to a 1 SD Monetary Policy Shock (2 Lag Specification)



Note: Blue line shows the response under average uncertainty (90% confidence band). Red and green lines show responses when uncertainty, measured by the standardized VSTOXX, is one or two standard deviations above the mean. Results from models estimated with 2 lags.

Figure C9

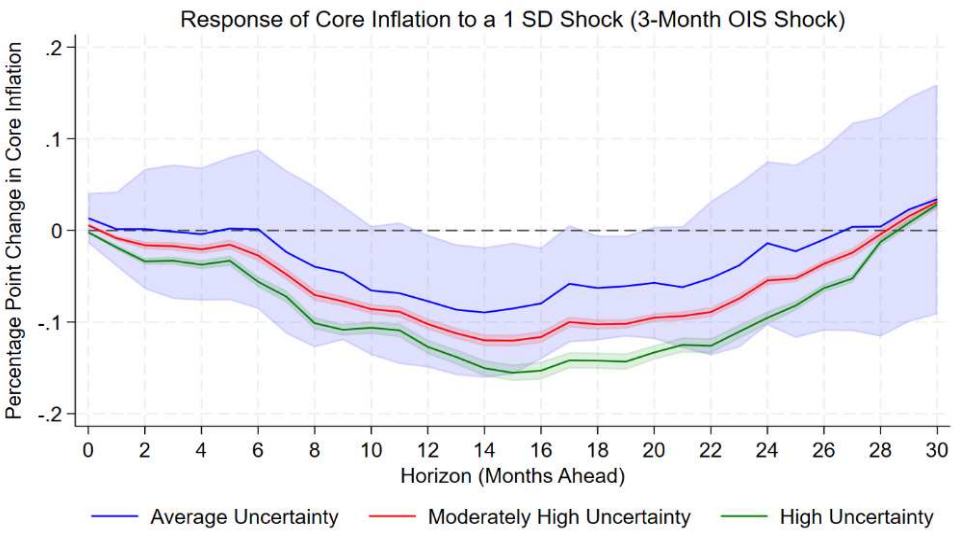
Core Inflation – Response to a 1 SD Monetary Policy Shock (1-Year OIS Shock)



Note: Blue line shows the response under average uncertainty (90% confidence band). Red and green lines show responses when uncertainty, measured by the standardized VSTOXX, is one or two standard deviations above the mean. Results use 1-year OIS shock.

Figure C10

Core Inflation – Response to a 1 SD Monetary Policy Shock (3-Month OIS Shock)



Note: Blue line shows the response under average uncertainty (90% confidence band). Red and green lines show responses when uncertainty, measured by the standardized VSTOXX, is one or two standard deviations above the mean. Results use 3-month OIS shock.