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Understanding Inflation Expectations: Data, Drivers and Policy Implications

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Understanding Inflation Expectations: Data, Drivers and Policy Implications

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Abstract

We investigate inflation expectations and their measures in the context of the 2022 inflation surge in the Czech Republic. Using data and econometric analyses, we explore how inflation expectations are formed and how they may affect inflation developments. To capture the overall trend of inflation expectations in the Czech economy, we develop a Common Inflation Expectations index. Additionally, we extend the CNB's g3+ core projection model by incorporating endogenous expectation premiums that reflect elevated inflation expectations. Utilizing the Common Inflation Expectations index and the modified model, we construct a simulation that provides policy-relevant outcomes when addressing high inflation. By presenting the simulation, we emphasize the importance and relevance of our research for practical policymaking.

Abstrakt

V tomto článku zkoumáme inflační očekávání v období vzestupu inflace v České republice během roku 2022. Pomocí datových a ekonometrických analýz zkoumáme, jak jsou inflační očekávání tvořena a jaká je jejich role ve vývoji inflace. Představujeme také kompozitní index inflačních očekávání, který poskytuje ucelený náhled na vývoj inflačních očekávání v české ekonomice. Dále rozšiřujeme jádrový predikční model ČNB g3+ o endogenní inflační přirážky, abychom zachytili vývoj zvýšených inflačních očekávání. Pomocí kompozitního indexu inflačních očekávání a upraveného modelu sestavujeme simulaci, která nabízí vodítko pro měnovou politiku v prostředí vysoké inflace. Prezentováním simulace zdůrazňujeme význam a přínos našeho výzkumu pro měnověpolitické rozhodování v praxi.

JEL Codes: C32, C50, E31, E37, E50.
Keywords: Forecasting, inflation, inflation expectations, inflation expectations index, structural modelling.

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1. Introduction

Inflation targeting is a widely employed monetary policy framework among central banks in developed economies. This approach is favored because a predictable and stable low-inflation environment assists individuals and businesses in planning their activities and making decisions more effectively. The central bank's inflation target serves as the nominal anchor, establishing the foundation for the formation and guidance of inflation expectations. Furthermore, when inflation expectations are well-anchored (that is, aligned with the inflation target), policymakers can take a less aggressive stance in their response to inflationary shocks. This is because the gravity of the nominal anchor prevents medium- and long-term inflation expectations and inflation itself from deviating substantially from the inflation target (Coibion et al., 2018). Hence, the extent to which inflation expectations deviate from the central bank's inflation target can serve as a measure of the central bank's success in anchoring inflation expectations.

Weakly anchored or even de-anchored inflation expectations can spark numerous adverse effects in the economy. Such effects include increased uncertainty, overall macroeconomic and financial instability, reduced effectiveness of standard policy tools, and various redistributional effects, to name a few. Furthermore, de-anchored inflation expectations can compel the monetary authority to adopt an aggressive monetary policy approach to considerably alter monetary conditions, thereby inflicting additional (and not negligible) macroeconomic costs. These effects and considerations highlight the importance of monitoring inflation expectations as an integral part of monetary policy conduct. The Czech National Bank (CNB) is well aware of these issues and is no exception among central banks in actively addressing them.

Inflation expectations attract significant attention particularly during times of exceptionally rising prices. The recent surge in inflation in the Czech economy has raised concerns about the broader macroeconomic environment (see, for example, Franta and Vlček (2024)), including inflation expectations developments. This work provides some insights and presents various facts, conclusions, and discussions associated with inflation expectations, specifically during the past two years.

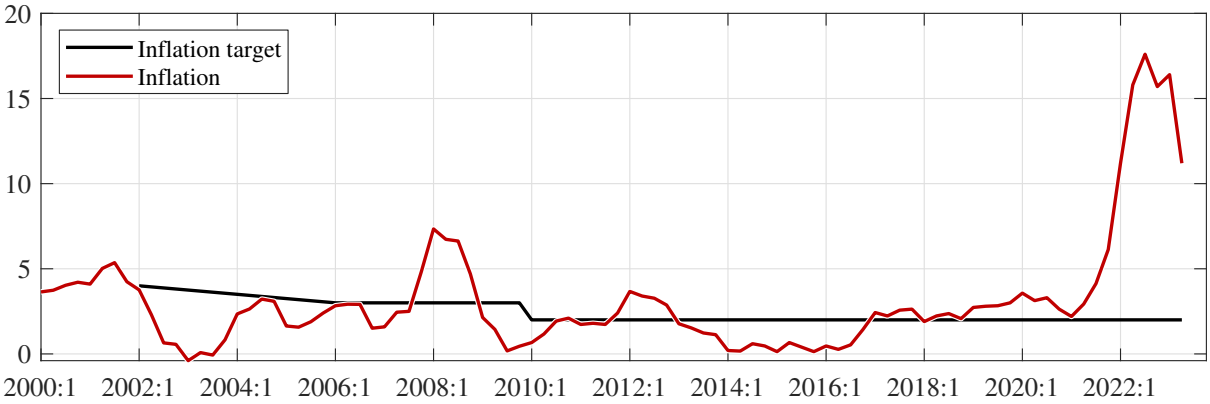
We examine inflation expectations in the Czech Republic and their repercussions for the monetary policy of the CNB. Our focus is on inflation expectations and their relation to inflation, and implications for monetary policy setting, while excluding other potential concerns such as central bank credibility. We formulate inflation expectation indices that indicate the degree of inflation expectations anchoring or portray the overall inflation expectations in the economy. The inflation expectations deviation index implies that the most recent years (2022 and 2023) in the Czech economy can be described as a period of heightened inflation expectations with an initially weak degree of anchoring. The concluding months of 2023 point to a normalization of the situation, as the degree of anchoring of inflation expectations increased. We pay particular attention to empirical analyses focused on the attributes of inflation expectations and their role in inflation dynamics. Our estimates indicate, among other things, that increased short-term inflation expectations have played a significant role in the recent inflation surge.

Furthermore, we extend the CNB's g3+ core projection structural model to accommodate heightened inflation expectations and steer an appropriate policy response. We encapsulate the effects of elevated expectations in the g3+ model via one primary and one supplementary channel, while employing a newly constructed Common Inflation Expectations (CIE) index that reflects the overall trend of inflation expectations in the Czech economy. The primary channel incorporates the impact of an inflation expectations bias affecting the expectation component in the New Keynesian

Phillips curve. The supplementary channel accounts for exchange rate dynamics in the extraordinary macroeconomic environment.

Our work contributes to the ongoing debate by presenting the CNB's experience and discussing heightened inflation expectations in the Czech economy, reflecting the recent period of extraordinary high inflation (see Figure 1). The work introduces indices of inflation expectations that are practical (and hence relatively simple and intuitive) for macroeconomic and monetary policy analysis. In addition, we demonstrate how the information conveyed by the CIE Index can be integrated into the CNB's core projection model and showcase the usefulness of model simulations in policy discussions. This way, the Czech National Bank further bolsters its transparency and high credibility.

Figure 1: CPI Inflation in the Czech Republic (YoY, in %)



Note: The inflation target is not shown prior to 2002 as the target inflation rate was defined in terms of net inflation during that time.
Source: Czech Statistical Office; Czech National Bank.

The paper is structured as follows. It begins with a description of the data. This is followed by an introduction to inflation expectations indices and various empirical analyses of inflation expectations in the context of the Czech economy. The subsequent section presents how the newly constructed CIE index is used within the g3+ model and describes the extensions of the model. The concluding section provides a summary of our key findings.

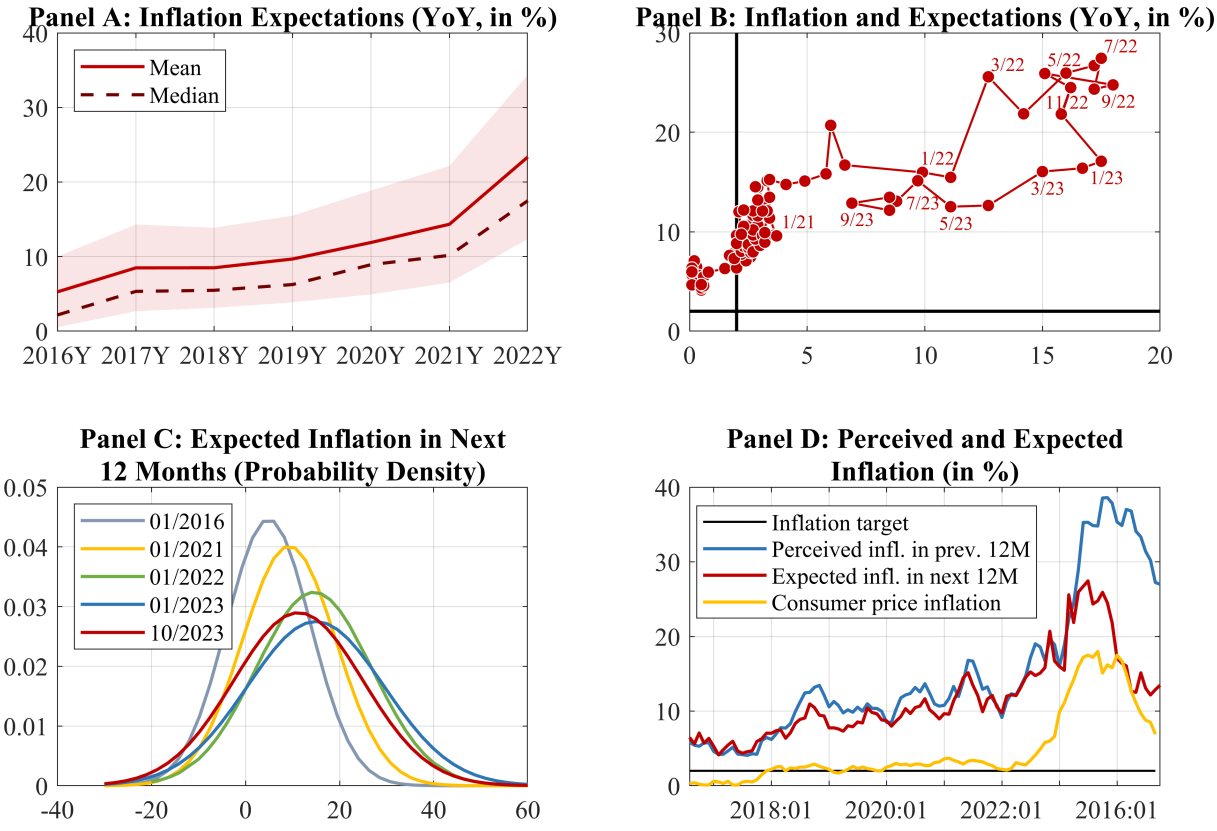
2. Development of Inflation Expectations

Inflation expectations play an important role in central banks' decision-making processes, and their effective management is a fundamental component of monetary policy. The effective guidance of expectations facilitates the smooth regulation of future inflation. Therefore, it is essential to comprehend their evolution and unique characteristics across a variety of economic agents (households, firms, and financial markets) and to extract information from multiple indicators of inflation expectations.

2.1 Households

The inflation expectations of Czech households can be described by data from the European Commission's Business and Consumer Surveys.[1] This data, available at monthly frequency, covers responses from 1,000 participants to fifteen questions regarding their perceived and expected economic developments, as well the socioeconomic attributes of the respondents. The survey questionnaire consists of a qualitative part with fixed answers and a quantitative part that asks for numerical values for perceived inflation in the past twelve months and expected consumer inflation over the next twelve months. In this paper, we focus on data from quantitative answers as they offer exact numerical information in contrast to qualitative answers.[2]

Figure 2: Inflation Expectations of Households



Note: The shaded area in Panel A corresponds to standard deviations at each time point. The horizontal and vertical axes in Panel B display the CPI and expected inflation, respectively. The solid black lines highlight 2% values reflecting the CNB's inflation target.
Source: Czech Statistical Office; European Commission's Business and Consumer Surveys.

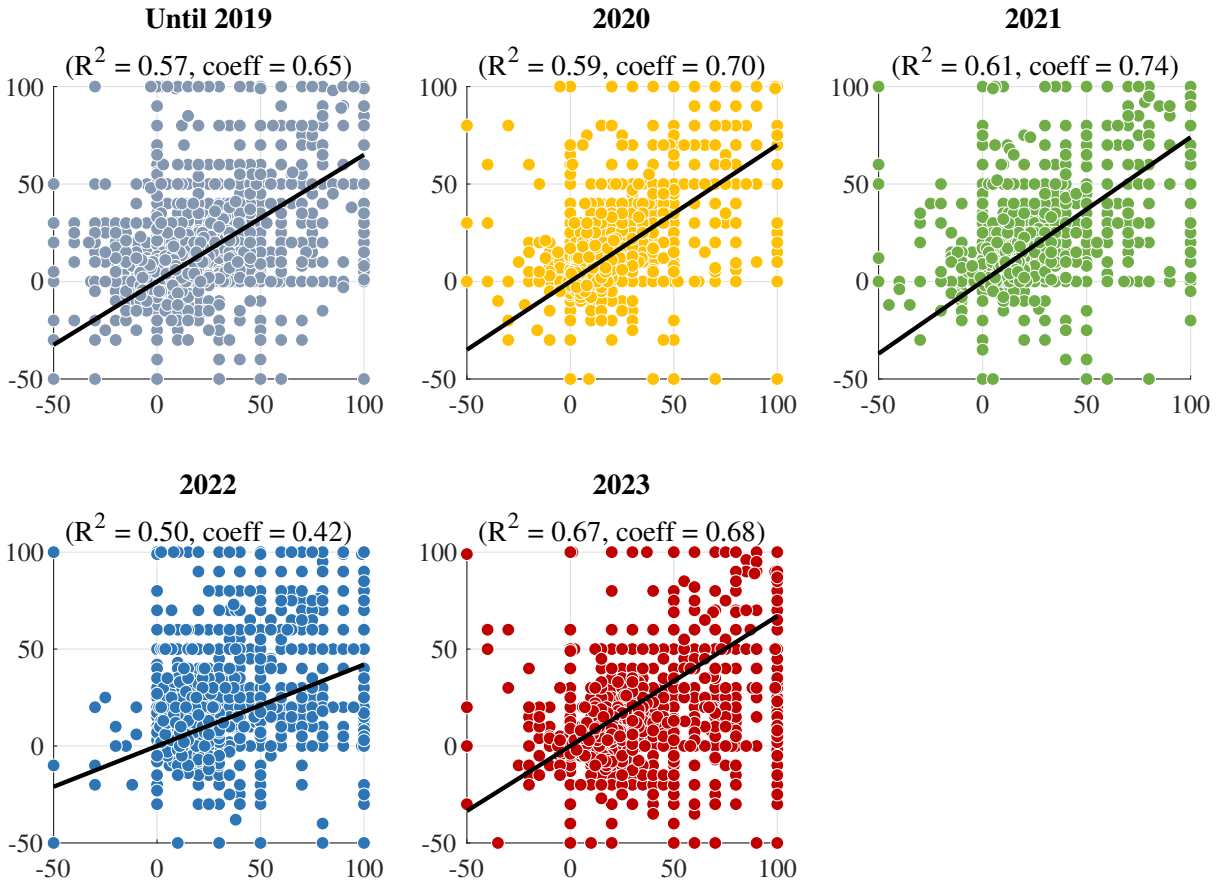
The survey data reveals that households consistently show upward bias in their one-year inflation expectations compared to the CNB's 2% inflation target. The average value hovered around 10% between 2016 and 2020, but there was a significant shift in 2021 (see Panel A in Figure 2). Notably, the median responses were consistently 4 to 5 percentage points lower than the mean value, suggesting that most respondents tended to report lower rather than higher extreme values, resulting

[1] More details can be found on the European Commission's website: https://economy-finance.ec.europa.eu/economic-forecast-and-surveys/business-and-consumer-surveys_en.
[2] In case of consumer confidence, the survey is conducted by Data Collect. The questionnaire regarding the socioeconomic status of the households interviewed and their perception of economic developments in the Czech Republic can be found here: https://economy-finance.ec.europa.eu/system/files/2022-11/questionnaires_cz_cons_cz.pdf.

in a skew towards lower figures. Panel B of Figure 2 shows a sudden surge in expectations of over 18% when headline inflation went above 10%. However, households' inflation expectations have been gradually normalizing towards their long-term average since the end of 2022. These patterns suggest short-term adaptive behavior among households, where their expectations tend to mirror current inflation developments.

Moreover, the standard deviation, a measure of the dispersion of answers, has shown a consistent increase over time. The recent surge in households' inflation expectations has not only triggered a pronounced shift in the distribution of the reported answers but has also resulted in a substantial flattening of the entire distribution (see Figure 2, Panel C). While households now anticipate higher inflation, there is an inherent increase in uncertainty regarding future developments. Despite the partial normalization of inflation expectations during 2023, their values remained high and scattered compared to historical patterns.

Figure 3: Correlation between Perceived and Expected Inflation of Households



Note: The horizontal and vertical axes display perceived and expected year–over-year CPI inflation, respectively.
Source: European Commission's Business and Consumer Surveys; authors' calculations.

From a long-term viewpoint, both perceived and expected inflation among households consistently surpass the ex-post measured reality. This holds true even during periods when inflation closely aligns with or falls below the CNB's target for a prolonged period (see Figure 2, Panel D). Despite the considerable gap between perceived and expected inflation compared to measured inflation,

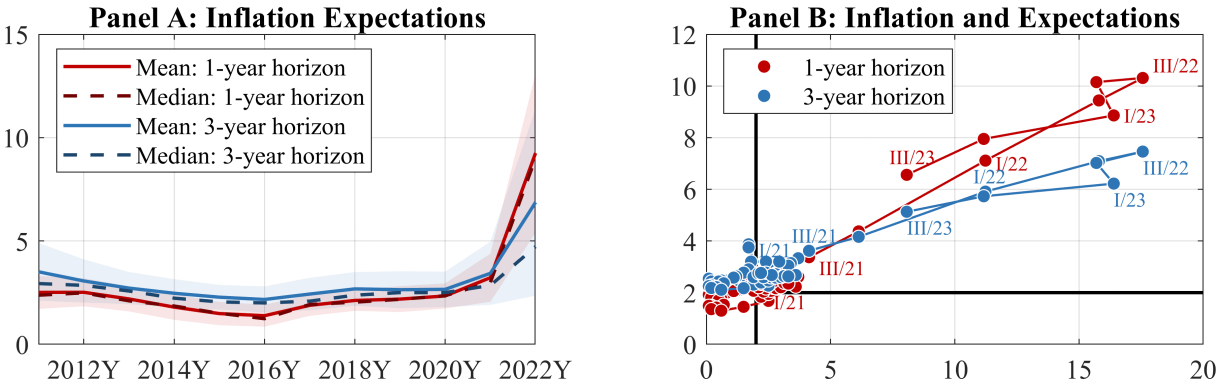
they exhibit similar trends over time.[3] This suggests that while households' perceptions reflect economic developments well, especially in terms of periods of low and high inflation, there is a notable discrepancy in magnitude compared to the actual reality.

Concerning the recent period of inflation, it appears that households perceived the rapid increase in inflation in 2022 as temporary and adjusted their inflation expectations accordingly. Following the peak of inflation in late 2022 and early 2023, the close relationship between perceived and expected inflation re-established itself in 2023. This relationship is underscored by a fairly stable correlation coefficient of around 0.7 between perceived and expected inflation, with an exception for the anomalous year of 2022, as depicted in Figure 3. The second observation from the survey reveals variations in perceived and expected inflation among households based on their socio-economic background. As the aim is not to delve into socio-economic aspects and their impact on households' inflation expectations here, readers are directed to Appendix A for a more detailed discussion on this matter.

2.2 Firms

The data on the inflation expectations of firms originate from a survey carried out jointly by the Confederation of Industry of the Czech Republic and the Czech National Bank. Around 150 firms are surveyed on a quarterly basis in contrast to the monthly statistics obtained from households and financial market analysts. We exclude the highest and lowest 5% of the values to ensure a more cohesive sample.

Figure 4: Inflation Expectations of Firms (YoY, in %)



Note: The shaded area in Panel A corresponds to standard deviations at each time point. The horizontal and vertical axes in Panel B display the CPI and expected inflation, respectively. The solid black lines highlight 2% values reflecting the CNB's inflation target.

Source: Czech Statistical Office; survey conducted by the Confederation of Industry of the Czech Republic and the CNB.

As shown in Panel A of Figure 4, firms' inflation expectations for both short and long horizons remained within the 1% to 4% range until 2021. Notably, the data reveals a consistent pattern where firms systematically anticipated higher inflation at the three-year horizon compared to the one-year horizon, with an average difference of nearly 1 percentage point. This pattern could be a reflection of firms' pricing strategies, which aim to offset current and anticipated short-term inflation pressures within future price adjustments. After the inflation surge in 2021, there was a significant rise in

[3] The seminal work by Muth (1961) outlines the basic mechanisms of expectation formation, providing insights into why such patterns might arise.

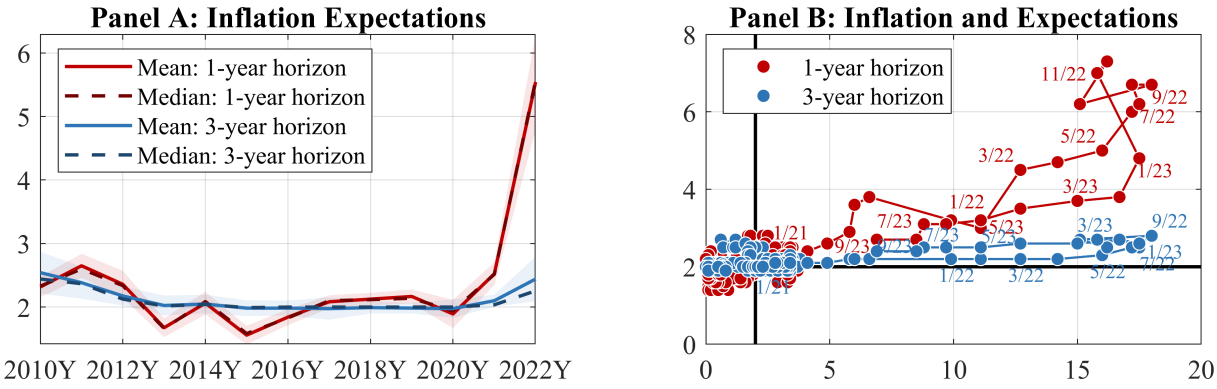
both short- and long-term expectations. At the same time, the positioning of short- and long-term inflation expectations shifted, with three-year expectations now reflecting lower values than those for the one-year horizon. In 2022, there was a noticeable increase in the dispersion of responses compared to previous years, indicating heightened uncertainty about future economic prospects. Furthermore, the mean and median values of three-year inflation expectations suggest that more extreme values are observed during high-inflation periods compared to standard times when means and medians are close to each other. This suggests that the sample exhibits more variability during times of high inflation.

In Panel B of Figure 4, the inflation expectations of firms at the one- and three-year horizon are plotted against annual headline inflation. A noteworthy surge in both expectations occurred in 2021, coinciding with headline inflation surpassing 5%. Trend inflation gained momentum in subsequent quarters, particularly at the one-year horizon, aligning with observed inflation which reached double-digit figures. This movement is considered exceptionally robust from a historical standpoint. Despite the ongoing downward trend in headline inflation, the latest data indicate that firms' expectations remain elevated. The return of these expectations to pre-2021 levels appears to be only gradual. This persistence in elevated expectations suggests that the heightened inflationary period has had a lingering impact on firms' outlook, although recent inflation figures have shown signs of moderation.

2.3 Financial Market Analysts

The inflation expectations of financial market analysts originate from the CNB's Financial Market Inflation Expectations survey.[4] The survey typically includes 16 to 18 respondents, predominantly macroeconomists affiliated with banks and other private financial institutions based in the Czech Republic. A few analysts from financial institutions located abroad also contribute to the survey results.

Figure 5: Inflation Expectations of Financial Market Analysts (YoY, in %)



Note: The shaded area in Panel A corresponds to standard deviations at each time point. The horizontal and vertical axes in Panel B display the CPI and expected inflation, respectively. The solid black lines highlight 2% values reflecting the CNB's inflation target.
Source: Czech Statistical Office; CNB's Financial Market Inflation Expectations survey.

The evolution of inflation expectations among financial market analysts in Panel A of Figure 5 offers several key and interesting insights. First, financial market analysts exhibit a high degree of

[4] The summary outcomes of the CNB's Financial Market Inflation Expectations survey can be found here.

coherence, as indicated by the consistently low standard deviations, even during high-inflation periods. This is particularly evident at the one-year horizon, suggesting that analysts may leverage analytical tools and a variety of forecasting approaches to provide a relatively consistent inflation outlook for the upcoming year. Second, three-year inflation expectations, which remained at two percent between 2012 and 2020, reflect the respondents' understanding of the central bank's policies.[5] Similar to other respondent groups, inflation expectations at the one-year horizon experienced a significant increase from 2021 onwards. At the same time, expectations at the three-year horizon also experienced a slight upward shift. Considering the well-informed status of financial market analysts about the central bank's operation, including the inflation target value, even minor changes in their long-term inflation expectations should be carefully monitored. Such changes could potentially signal a decrease in the clarity of the central bank's behavior or even a loss of credibility in its monetary policy.

Panel B of Figure 5 reveals a narrative similar to that observed in firms' inflation expectations. The graph shows inflation expectations for financial market analysts for the both the one- and three-year horizons against headline inflation. The deviations from their long-term values became more pronounced as soon as annual headline inflation hit 7%. Starting in late 2022, there has been a gradual reversal of inflation expectations among financial market analysts toward the inflation target at both horizons. However, these expectations continue to remain at high levels.

The shift in inflation expectations over the last two years, as indicated by survey results, prompts important questions about the nature of this change. What insights can we distill from this shift? Could we interpret it as inflation expectations being de-anchored from the central bank's target? Or is it a natural phenomenon that high inflation brings about an equal or even more pronounced change in inflation expectations? To answer these questions, we have to delve further beyond the descriptive data statistics.

3. Inflation Expectations Indices

To assess the degree of inflation expectations anchoring, we start by formulating an inflation expectations deviation index. We create individual indices for all economic agents covered in the surveys. These indices indicate, with some degree of uncertainty, whether or not the inflation expectations of the respective group of agents remain anchored. Inflation expectations deviation indices are further utilized in follow-up econometric analyses focusing on developments in inflation and inflation expectations as presented in Section 4.

Additionally, we aim to derive an indicator that tracks the common movements in inflation expectations across the entire economy. Given the multiple sources of inflation expectations, each reflecting the views of different economic agents, this data may have diverse implications for inflation and monetary policy responses. To eliminate potential ambiguity in the interpretation of inflation expectations data, we introduce the Common Inflation Expectations (CIE) index. This index is designed to streamline the interpretation of how inflation expectations evolve across the broader economy. Additionally, the CIE index can be useful for monitoring and disciplining model-consistent inflation expectations within our g3+ core projection model (see Section 5). It is crucial to acknowledge that while the CIE index provides a straightforward descriptive measure of the evolution of inflation expectations, it does not offer insights into the degree of inflation expectations anchoring.

[5] The downward trend in long-term expectations until 2010 can be attributed to a gradual shift in the inflation target from 6% to 2%.

3.1 Inflation Expectations Deviation Index

Inspired by the literature on central banks' credibility, we formulate an inflation expectations deviation index as the measure of the degree of anchoring. Svensson (2000) argues that high credibility is achieved when private inflation expectations align with the inflation target. Thus, if the monetary authority has an explicit inflation target, credibility and the degree of anchoring of inflation expectations can be assessed by the gap between expected inflation and the target.

However, periods of instability necessitate modifications to conventional methods. To make the concept more applicable, Cecchetti and Krause (2002) formulate a policy credibility index that measures the deviations of expected inflation from the target level set by the central bank while accounting for extreme values. According to their definition, full credibility (a high degree of inflation expectations anchoring) is achieved when expected inflation is in line with or lower than the target, decreases when inflation values are higher than the target, and completely vanishes when inflation exceeds 20 %. Recent adaptations of a similar measure of credibility include definitions of de-anchoring indices by Abib et al. (2022) and Carvalho and Nechio (2023). These adaptations set the credibility threshold to the upper level of the inflation target's tolerance band.

Periods of low- and high-inflation rates and data constraints in the Czech Republic require adjustments in formulating the inflation expectations deviation index. Some periods before 2020 were even characterised by inflation rates below the inflation target. Hence, we aim to design an inflation deviation signal accounting for deviations in both directions. Furthermore, we must deal with the limited data sources from financial markets, which prevent us from creating a measure based on forward-looking inflation expectations. In general, we define our symmetric directional inflation expectations deviation index $DevI_t$, $0 \geq DevI_t \leq 1$, as follows:

$$DevI_t = \begin{cases} 0 & \text{if} \quad \pi^{T-} < E_t[\pi_{t+s}] < \pi^{T+}; \\ 1 \quad \text{or} \quad -1 & \text{if} \quad E_t[\pi_{t+s}] > \pi^{max} \quad \text{or} \quad E_t[\pi_{t+s}] < \pi^{min} \quad \text{respectively;} \\ \dfrac{E_t[\pi_{t+s}] - \pi^{T+}}{\pi^{max} - \pi^{T+}} & \text{if} \quad \pi^{T+} \leq E_t[\pi_{t+s}] \leq \pi^{max}; \\ \dfrac{E_t[\pi_{t+s}] - \pi^{T-}}{\pi^{T-} - \pi^{min}} & \text{if} \quad \pi^{T-} \geq E_t[\pi_{t+s}] \geq \pi^{min}, \end{cases} \tag{1}$$

where, π_t is the observed year-over-year inflation rate, π^{max} and π^{min} represent the maximum and minimum thresholds, π^{T+} and π^{T-} are the upper and lower bounds, and s corresponds to the one or three-year horizon. The inflation expectations deviation index equals 0 whenever inflation expectations are close to the inflation target, that is, within the upper and lower bounds π^{T+} and π^{T-}. Values 1 and -1 resemble situations where inflation expectations are de-anchored upwards or downwards, which occurs when inflation expectations exceed the upper maximum or lower minimum limits π^{max} and π^{min}. Further, the index can take values of between 0 and 1 (-1 and 0) when inflation expectations are above (below) the lower (upper) bound but stay below (above) the upper maximum (lower minimum) boundary. We characterize such situations as a lower degree of inflation expectations anchoring. Overall, the absolute value of the deviation index $|DevI_t|$ increases with the deterioration of inflation expectations anchoring.

As the Czech economy has experienced a significant economic transition, we must take into account changes in the underlying parameters of the Czech inflation targeting regime. We also account for the systematic long-term upward shift in expectations from the inflation target for households. Given the dispersion of answers with extreme values in households' estimates of future inflation, as presented earlier, we exclude data above the 75th and below the 25th percentile to obtain a more

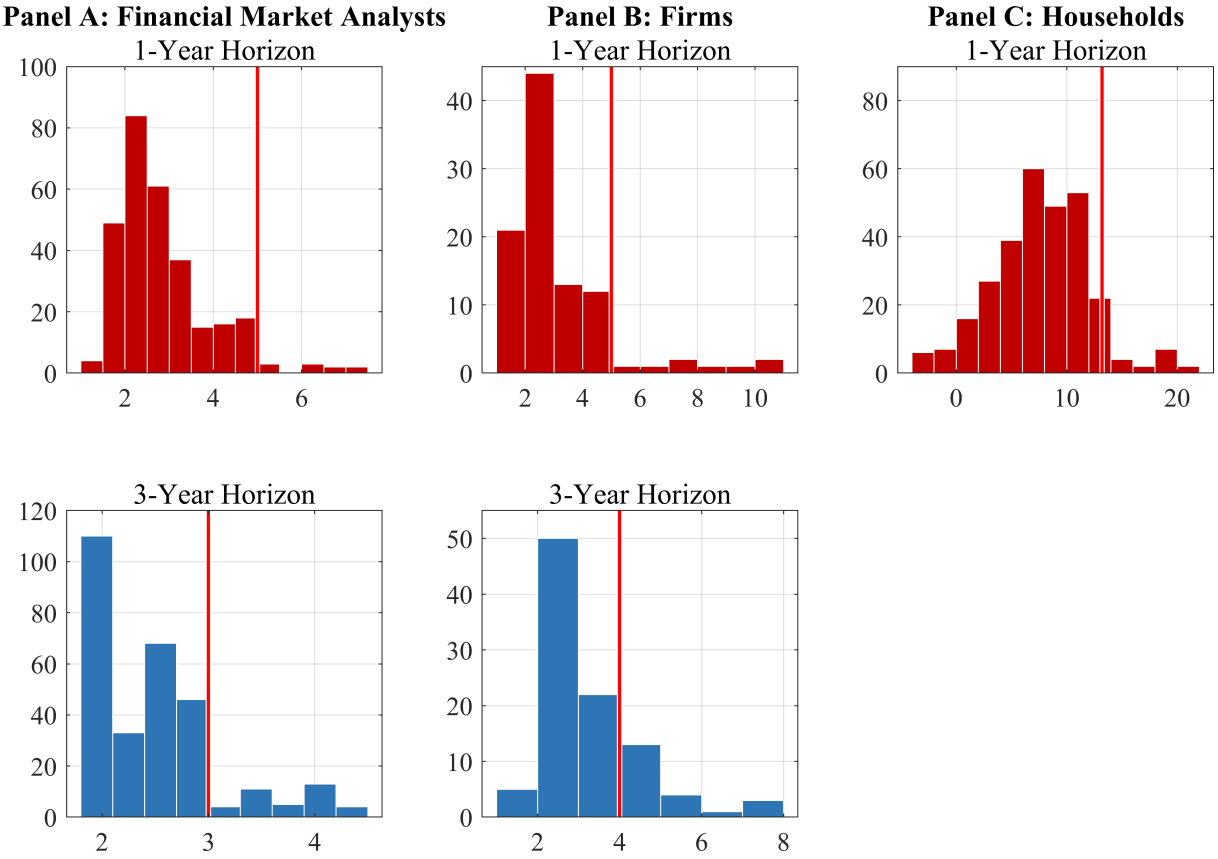
coherent sample. Ultimately, our index construction considers past changes in the setup of the inflation targeting regime parameters and households' upward bias by using mean-zero data.

Table 1: Thresholds and Bounds of Inflation Expectations Deviation Indices

	Parameter			
	π^{min}	π^{T-}	π^{T+}	π^{max}
Financial market analysts (1Y)	-3	-0.5	0.5	3
Financial market analysts (3Y)	-1	-0.3	0.3	1
Firms (1Y)	-3	-1	1	3
Firms (3Y)	-2	-1	1	2
Households (1Y)	-6.2	-4.2	4.2	6.2

Note: The abbreviations 1Y and 3Y indicate inflation expectations at the one- and three-year horizons. The numbers displayed resemble inflation expectations adjusted for the inflation target (and, in the case of households, also for the systematic long-term upward shift).

Figure 6: Distributions of Inflation Expectations and Maximum Thresholds



Note: The figures display raw data from surveys, with vertical lines demonstrating selected maximum thresholds.

Source: CNB's Financial Market Inflation Expectations survey; survey conducted by the Confederation of Industry of the Czech Republic and the CNB; European Commission's Business and Consumer Surveys.

We construct individual indices (for financial market analysts, firms, and households) based on the historical response of agents to inflation developments. The maximum and minimum thresholds,

π^{max} and π^{min}, are determined by the distribution of inflation expectation responses over several economic cycles (histogram breaks). The maximum thresholds resemble breaks between frequent and outlier observations. The minimum thresholds are then symmetric to the maximum ones. The histograms are displayed in Figure 6, and the thresholds (and tolerance bounds) are shown in Table 1.[6]

Figure 7 presents the inflation expectations deviation indices and the trajectory of inflation expectations for all agents inspected. Upon examining Panel A, we infer that the indices for financial market analysts imply a low degree of anchoring of inflation expectations at the one-year horizon in 2022. However, the recent downward trend in the index has coincided with a decrease in inflation expectations. Despite inflation expectations for the three-year horizon noticeably deviating from the 2% target since 2022, the corresponding index indicates a relatively low erosion of expectations anchoring. With a few exceptions, inflation expectations were closely aligned with the inflation target between 2012 and 2021, as indicated by the zero values of both indices.

Panel B of Figure 7 summarizes the indices for firms. The inflation expectations deviation indices suggest a possible de-anchoring of expectations in the last two years, regardless of the time horizon (three- or one-year). Even with the easing of inflationary pressures in the economy in 2023, both deviation indices remain elevated, failing to revert to pre-2021 levels. Indices for firms suggest more pronounced persistence and a lower degree of anchoring compared to those for financial market analysts. The exceptional period of escalating inflation during 2021 and 2022 drove expectations to even higher levels, particularly for the three-year horizon. It is crucial to approach these results cautiously since firms impact future prices through pricing decisions, and their inflation outlooks may reflect their intended actions.

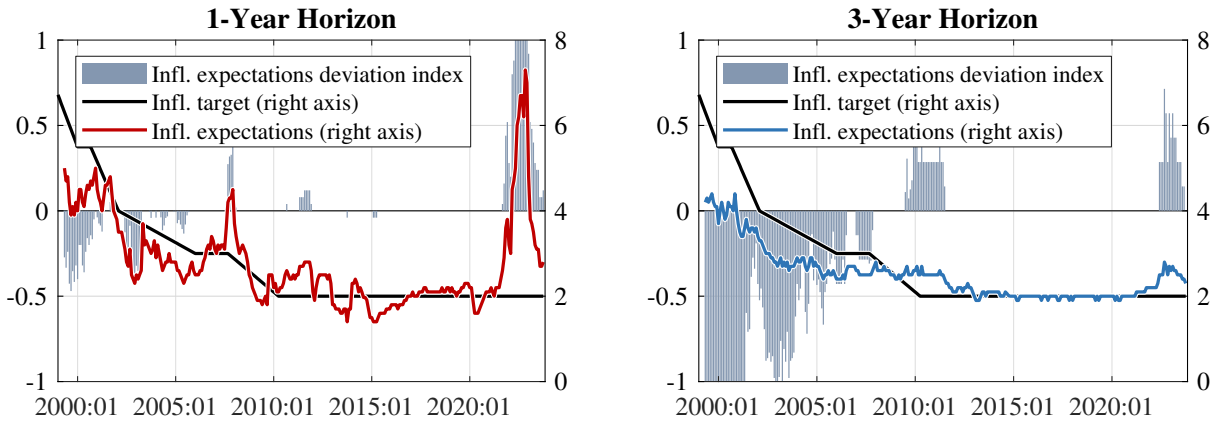
Finally, Panel C of Figure 7 highlights a notably higher level of volatility in households' inflation expectations and the corresponding deviation index compared to other agents. Similar to other groups, households' one-year inflation expectations reached potentially de-anchored levels in 2023. However, recent survey data suggest a rapid correction in the trend, indicating a swift return towards the high degree of anchoring. The heightened volatility in households' expectations underscores the dynamic nature of their outlook, and the observed correction implies a potential stabilization in response to evolving economic conditions.

In conclusion, the inflation expectations deviation indices collectively indicate a limited degree of inflation expectations anchoring across agents and horizons in the Czech economy during 2022-2023. Specifically, all indices suggest a potential de-anchoring at the one-year horizon in 2022. However, as inflation started declining, corresponding expectations also decreased concurrently at the one-year horizon. This pattern suggests a connection between recent and current price dynamics and inflation expectations, indicating the partially adaptive nature of inflation expectations over the shorter horizon. Regarding the three-year horizon, the inflation expectations deviation indices convey a generally low degree of inflation expectations anchoring, on average, over the past two years. This implies that, over the medium term, inflation expectations have exhibited a level of persistence and have not been fully anchored to the central bank's target.

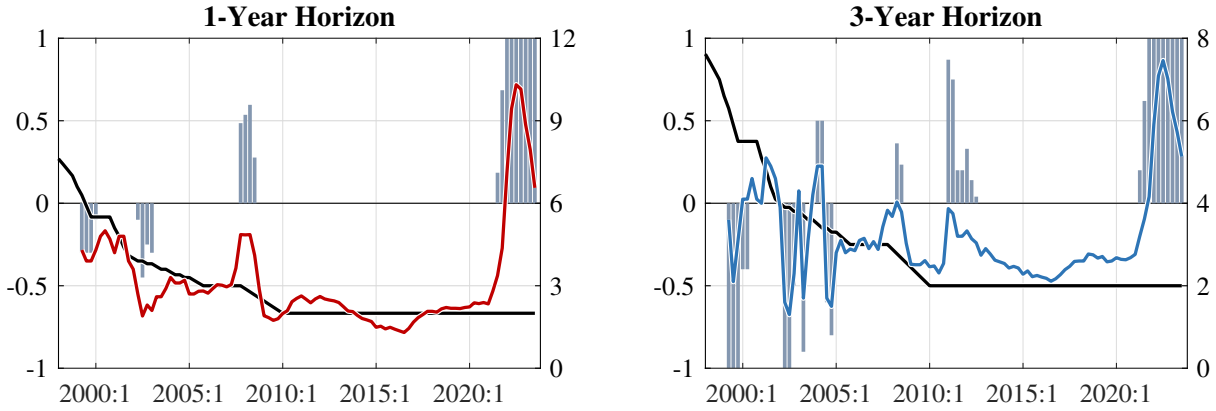
[6] For instance, inflation expectations of financial market analysts indicate a break equal to 5%. After adjusting the data for the inflation target of 2%, the maximum threshold for de-anchored expectations is set to 3%.

Figure 7: Inflation Expectations and Inflation Expectations Deviation Indices

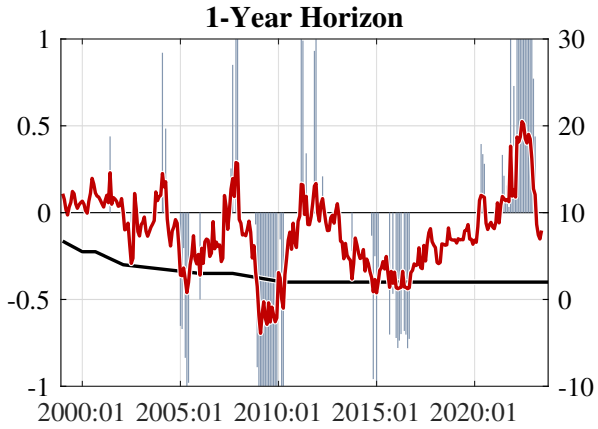
***Panel A**: Financial Market Analysts*



***Panel B**: Firms*



***Panel C**: Households*



Source: Authors' calculations.

3.2 Common Inflation Expectations Index

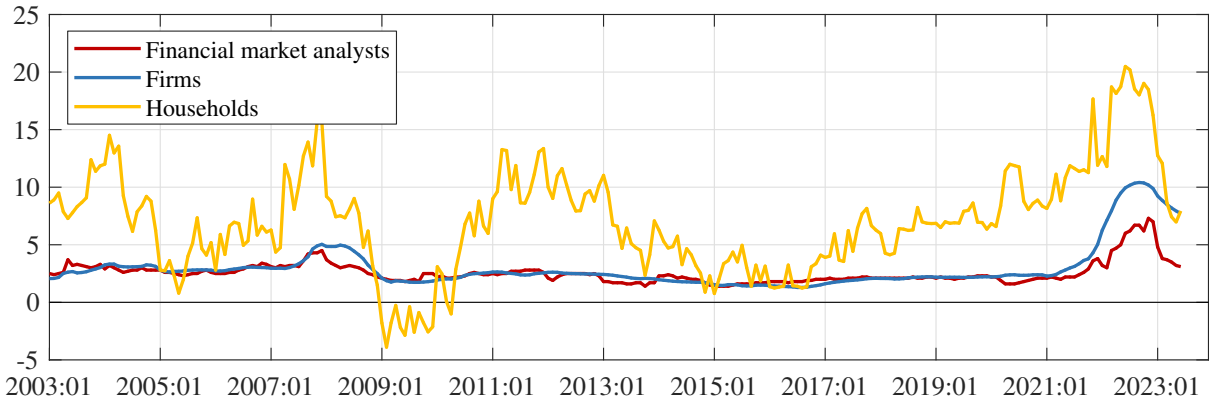
As discussed previously, there are multiple sources of inflation expectations measures. To deliver a straightforward message, we construct a single indicator called the Common Inflation Expec-

tations (CIE) index, as named by Ahn and Fulton (2020), that captures the common component of movements in inflation expectations across the economy. Ahn and Fulton (2020) constructed an economy-wide indicator of inflation expectations for the United States based on information from more than twenty variables, including surveys, market-based measures, and other inflation expectations-related data. The authors used the dynamic factor model approach to extract the central tendency from inflation expectations data as the first factor.

In our case, the dataset is much less comprehensive, primarily due to limitations stemming from less-developed Czech financial markets. For instance, we lack data based on complex financial instruments, such as Treasury Constant Maturity Securities, as in the case of the United States. Instead, we utilize surveys of inflation expectations from financial market analysts, firms, and households. For households, we employ the same procedure as mentioned above and remove the data above the 75th and below the 25th percentile.[7]

We restrict our data sources only to the surveys aimed at the one-year horizon to construct a composite index with a straightforward interpretation. As shown in Figure 8, the development of the selected inflation expectations is diverse. On one hand, expectations of firms and financial market analysts – the two agents in the economy most familiar with overall economic developments – display a strong co-movement. On the other hand, households anticipate, on average, higher inflation, and their assessment of future price changes is more volatile and noisier than the other two.

Figure 8: 1-Year Ahead Inflation Expectations (YoY, in %)



Source: CNB's Financial Market Inflation Expectations survey; survey conducted by the Confederation of Industry of the Czech Republic and the CNB; European Commission's Business and Consumer Surveys.

We employ a principal component analysis (PCA) to extract the Common Inflation Expectations index for the Czech economy. The PCA method estimates the weighting scheme for underlying time series and extracts the common movement among the considered series. The first principal component, explaining the highest share of common volatility (over 80%), is the resulting CIE index representing economy-wide inflation expectations. The index and its decomposition are presented in Figure 9 (Panel A).

[7] To check the sensitivity of the cut-off parameter, we also inspect different cut-off levels (namely 1%, 5%, 10%, 15%, and 20%). The choice of the cut-off level affects the mean of the remaining distribution, but particular series are level-shifted.

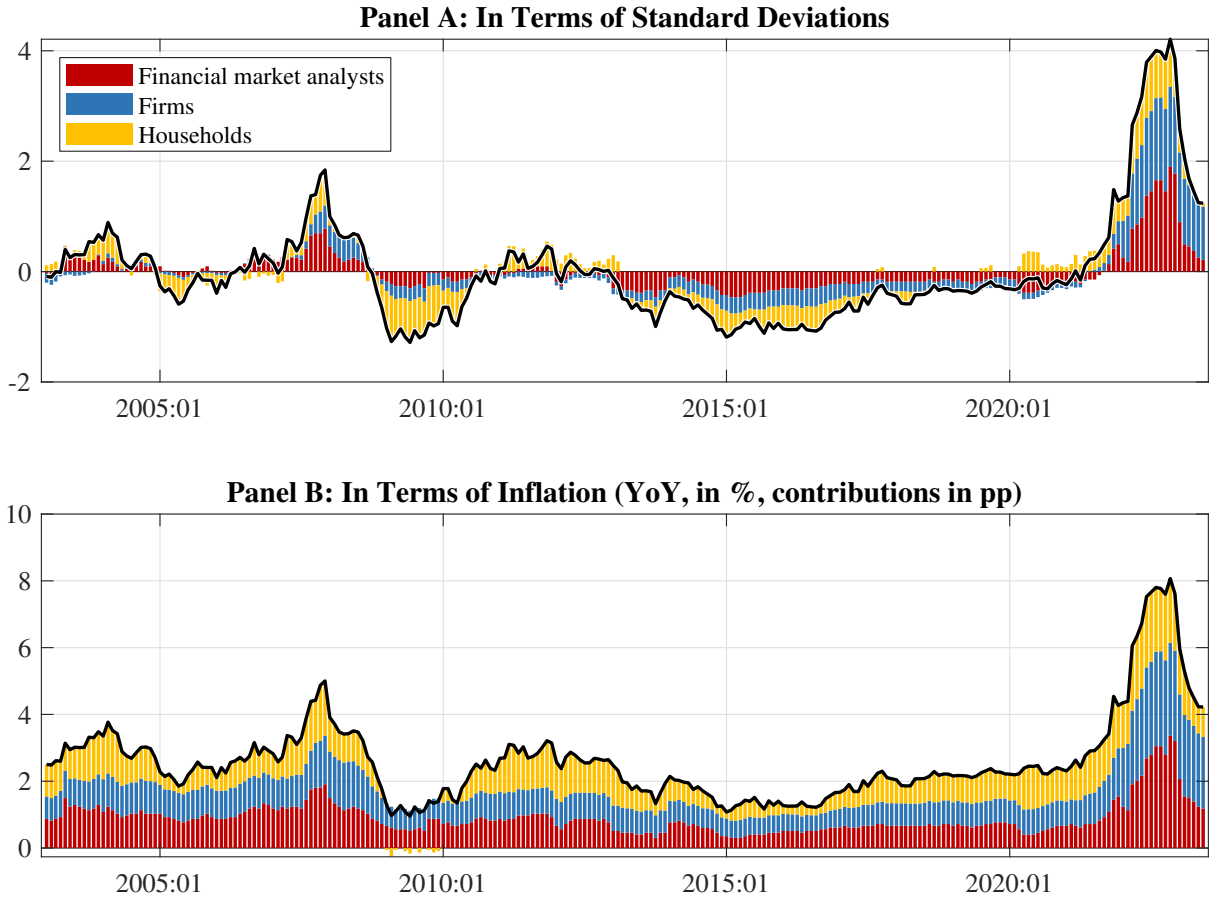
Given its construction, the metrics of the PCA-extracted CIE index are standard deviations, with zero being its sample-wide average. However, such a metric lacks practical value for daily forecasting or analytical business. To improve its applicability, we convert the CIE index into price growth terms. This conversion into an inflation-like measure is not straightforward and requires "de-standardization". First, we identify a period where the following criteria are satisfied:

(i) the period is after 2010 (since then, the CNB has pursued an inflation target of 2%);

(ii) the mean of inflation (shifted 12 months ahead) is approximately 2% (and thus corresponds with the CNB's official inflation target).

The episode satisfying these two criteria is 2010-2020, with the average inflation 12 months ahead around 2% and a standard deviation of 1.3. Second, we evaluate the mean of the CIE index over this period. As it is slightly negative (-0.4), the index is shifted up by this constant so that the resulting mean of the CIE is zero and corresponds to the 2% inflation target over the 2010-2020 period. With these parameters, we can express the CIE index in terms of inflation. Figure 9 Panel B displays the resulting CIE index in terms of the inflation measure.

Figure 9: Common Inflation Expectations (CIE) Index



Source: Authors' calculations.

The CIE index highlights various episodes in the Czech economy over the last twenty years where inflation expectations were either significantly elevated, such as in 2008 and 2022, or depressed, as

observed in 2009, in comparison to historical standards. The recent period of heightened inflation is particularly extraordinary, surpassing all previous levels, with inflation expectations reaching a peak of around 8% in the second half of 2022. The decomposition analysis reveals that expectations from all economic agents significantly contributed to the overall elevation of inflation expectations in 2022. However, the situation swiftly normalized in 2023, primarily due to a correction in household expectations, bringing general expectations closer to 4%. While firms and financial market analysts also lowered their expectations, they remain elevated. This scenario has significant implications for monetary policy, which are further discussed in detail in Section 5. The persistently elevated expectations among firms and financial market analysts indicates an ongoing challenge for monetary policymakers in managing inflation expectations and steering them towards the central bank's 2% inflation target.

4. Understanding Inflation and Inflation Expectations

Inflation expectations play a crucial role in understanding the recent inflation upsurge, and it is vital to discern any changes in the formation of these expectations over the last two years. First, we analyze the transmission from one-year inflation expectations to three-year-ahead expectations. Additionally, we examine how inflation expectations behave in both low- and high-inflation periods. Further, we explore the connection between inflation expectations and the current dynamics of inflation. Lastly, we investigate the determinants of core inflation developments through the lens of the Phillips curve. We base our econometric analyses on the inflation expectations of financial market analysts.[8]

4.1 The Pass-Through of Short- to Long-Term Inflation Expectations and the Gravity of the Central Bank Target

The prevailing perspective in the literature, as reflected in studies such as Yetman (2020) and Corsello et al. (2021), suggests that developments in medium-term inflation expectations are typically considered independent of short-term ones. In an environment with a credible central bank, long-term inflation expectations – typically in the range of 2-3 years – should align closely with the inflation target, regardless of observed inflation. This implies that the effective management of inflation expectations ensures the autonomy of expectations over longer horizons from short-term ones and prevents long-term expectations from deviating significantly from the inflation target.

However, this narrative might change in a high-inflation environment. The dynamics of expectations could be influenced differently under conditions of elevated inflation. The impact of a prolonged period of high inflation on the interplay between short- and medium-term expectations may introduce complexities that deviate from conventional understanding in a low-inflation environment.

To examine how the pass-through changes in times of high and low degrees of anchoring, we utilize the constructed inflation expectations deviation index in the form of a dummy variable. As we possess deviation indices for both horizons with different implications for the degree of inflation expectations anchoring, we run a regression on dummies related to the one- and three-year horizons, D_t^{1Y} and D_t^{3Y}. The dummies take the value of zero when the inflation expectations deviation indices

[8] It is noteworthy that we consider financial market analysts the most relevant and informed agents regarding the central bank's objectives, making their data particularly informative. Therefore, even slight shifts in financial market analysts' expectations, especially at the three-year horizon, warrant attention from central banks.

indicate the full degree of anchoring and take one otherwise. The model is expressed as follows:

$$\pi_t^{E,3Y} = \beta_0 + (\beta_1 + \beta_1^{1Y} D_t^{1Y} + \beta_1^{3Y} D_t^{3Y})\pi_t^{E,1Y} + \varepsilon_t, \tag{2}$$

where $\pi_t^{E,1Y}$ and $\pi_t^{E,3Y}$ are one- and three-year inflation expectations. The results are summarized in Table 2.

The value of parameter β_1 (see the second column in Table 2) reveals a slightly positive relation between long- and short-term inflation expectations when the expectations at both horizon are close to the inflation target. This estimated value contrasts with the prevailing view that long-term expectations should, in general, be independent of short-term ones. The value of $\beta_1 + \beta_1^{1Y}$, displayed in the fifth column, reveals that the level of elasticity is very close to the level discussed previously for a low degree of anchoring of inflation expectations at the one-year horizon. This suggests that a low degree of anchoring for short-term expectations does not significantly affect the change in the pass-through. However, once the three-year expectations become less anchored, the pass-through increases significantly. The value of the composite parameter $\beta_1 + \beta_1^{1Y} + \beta_1^{3Y}$, presented in the last column in Table 2, reveals a similar result, indicating that the low degree of anchoring in three-year inflation expectations coincides with those at the one-year horizon. In summary, a deterioration of the degree of anchoring at the long-term horizon results in a stronger transmission of changes in short-term expectations to long-term ones.

Table 2: Pass-Through of 1- to 3-Year Inflation Expectations

β_0	β_1	β_1^{1Y}	β_1^{3Y}	$\beta_1 + \beta_1^{1Y}$	$\beta_1 + \beta_1^{3Y}$	$\beta_1 + \beta_1^{1Y} + \beta_1^{3Y}$
1.84	0.14	-0.01	0.18	0.13	0.32	0.31
(0.00)	(0.00)	(0.74)	(0.00)	(0.00)	(0.00)	(0.00)

Note: Numbers in parentheses represent p-values at the 5% significance level.
Source: Authors' calculations.

Further, we test the emergence of an additional inflation premium (represented by the intercept) in an environment with a lower degree of anchoring. For this purpose, we extend the model given by Equation 2 by adding additional cross-products of dummy variables. We estimate the model with varying intercepts in addition to elasticities in the following form:

$$\pi_t^{E,3Y} = \beta_0 + \beta_0^{1Y} D_t^{1Y} + \beta_0^{3Y} D_t^{3Y} + (\beta_1 + \beta_1^{1Y} D_t^{1Y} + \beta_1^{3Y} D_t^{3Y})\pi_t^{E,1Y} + \varepsilon_t. \tag{3}$$

The estimation results, summarized in Table 3, indicate that periods with a lower degree of long-term anchoring do not bring additional premiums compared to standard times, aligning with the 2% target. Conversely, periods of less anchored inflation expectations at the one-year horizon show higher premiums, implying the formation of inflation expectations higher than 2%.

Table 3: Inflation Premiums

β_0	β_0^{1Y}	β_0^{3Y}	β_1	β_1^{1Y}	β_1^{3Y}	$\beta_0 + \beta_0^{1Y}$	$\beta_0 + \beta_0^{3Y}$	$\beta_0 + \beta_0^{1Y} + \beta_0^{3Y}$
1.43	0.76	0.06	0.31	-0.24	0.14	2.18	1.49	2.25
(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)

Note: The numbers in parentheses represent p-values at the 5% significance level.
Source: Authors' calculations.

Next, we investigate the anchoring of short- and long-term inflation expectations to the central bank's target. Our approach is inspired by Łyziak and Paloviita (2017)[9]. We employ a rolling window regression approach with a 60-month moving window on a model given in the following form:[10]

$$\pi_t^{E,iY} = \beta_0 \pi_{t+n}^{tar} + \beta_1 \pi_{t+n}^{fcast} + \beta_2 \pi_{t-1} + \varepsilon_t, \tag{4}$$

where $\pi_t^{E,iY}$ refers to inflation expectations with i being the specific type of inflation expectations – either one-year or three-years ahead, π_{t+n}^{tar} stands for the inflation target, π_{t+n}^{fcast} denotes the central bank's projections of inflation for the period $t+n$ and π_t represents the year-over-year inflation rate. The weight of the target, β_0, in Equation (4) can be understood as a measure of inflation expectations anchoring to a constant (Bomfim and Rudebusch, 2000). We set n to 12 and 36 months for the one- and three-year horizons, respectively.

The estimation results are summarized in Figure 10. The upper-left panel shows that the central bank's role in anchoring inflation expectations to the target in the formation of one-year inflation expectations has been substantially eroded during the recent inflation upsurge. However, the bank's role remains crucial for three-year expectations, as we identify negligible change in the estimated coefficients (see the lower-left panel). Furthermore, as the upper-right panel suggests, the role of lagged inflation has increased significantly in the last two years for one-year expectations. A similar conclusion can be made for three-year expectations, albeit with considerably lower magnitude. These findings highlight the complex dynamics between central bank actions, inflation expectations, and the impact of current economic conditions, particularly in the context of a high-inflation environment.

4.2 How Current Inflation Affects Inflation Expectations?

The evidence presented by Resler (1980) indicates that when a country experiences highly accelerating inflation, the nearest time periods become more important in the expectations process. Therefore, policies that can successfully lower current inflation could gain important long-run outcomes by simultaneously inducing a reduction in inflation expectations. To examine how current inflation dynamics affect inflation expectations in high and low inflation periods, we employ a quantile regression approach and estimate the model in the following form:

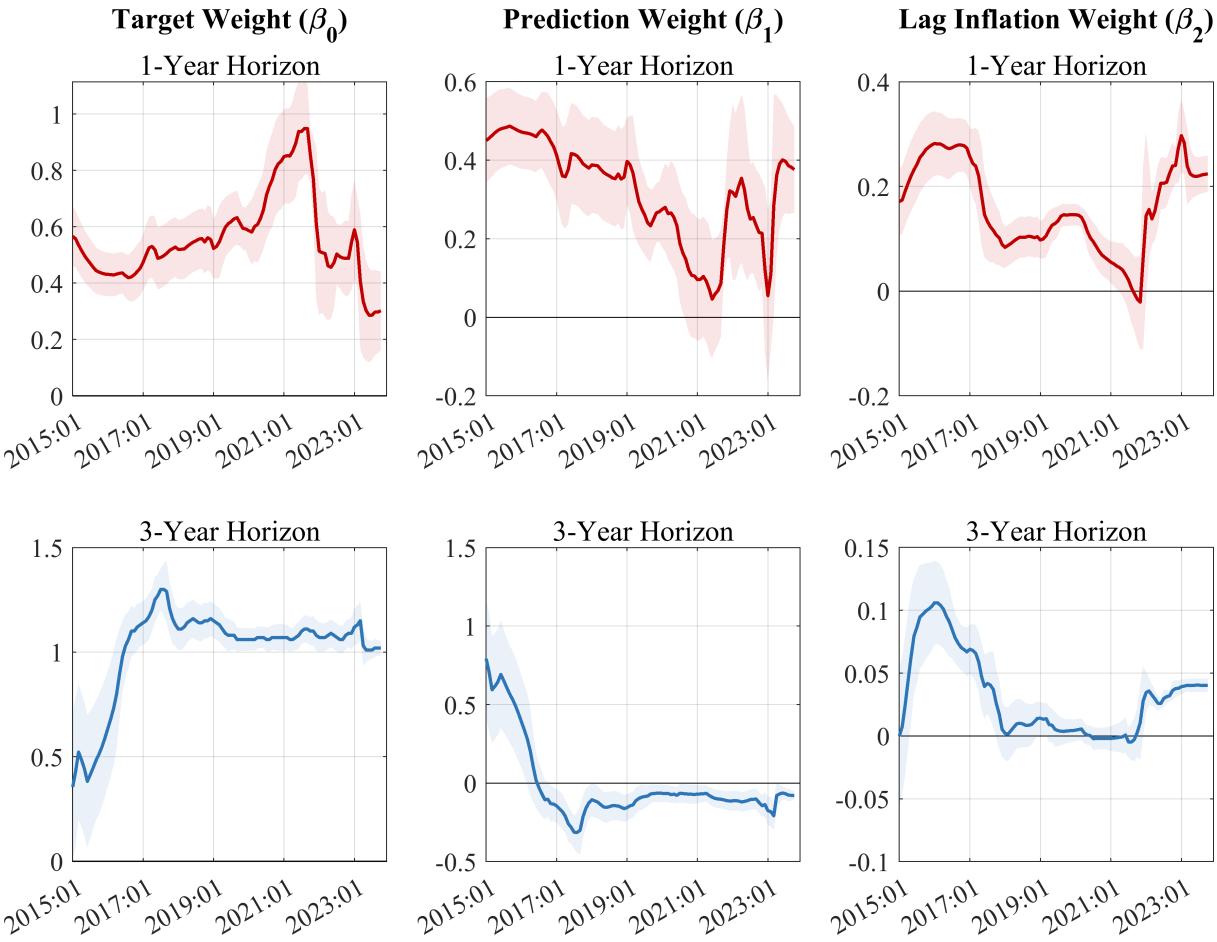
$$\pi_t^{E,iY} = \beta_0^i + \beta_1^i \pi_t + \varepsilon_t, \tag{5}$$

where inflation expectations $\pi_t^{E,iY}$ for the one- or three-year horizon are related to the year-over-year inflation rate π_t. The quantile approach is suitable as it handles heteroscedasticity present in the recent inflation data and is robust against outliers in the response variable. Also, it can discover predictive relationships between variables in case of a weak link or no link between their means. Further, the quantile regression helps to explore asymmetry in periods of high and low inflation. In our analysis, we focus on examining the changes of the elasticity, β_1, in different inflation environments rather than on its precise value. Should there be any estimation bias originating from omitted variables, we assume it to be the same over quantiles.

[9] The approaches for testing hypotheses about inflation expectations developments originate in works by Resler (1980) and Lovell (1986).

[10] We conducted various robustness checks involving different variable transformations, including diverse measures of inflation such as core inflation or monetary-policy-relevant inflation. Additionally, we explored the inclusion of lags and leads of variables to enhance the model's fit. The results remained largely consistent across these variations.

Figure 10: Anchoring of Expectations – Rolling-Window Regression

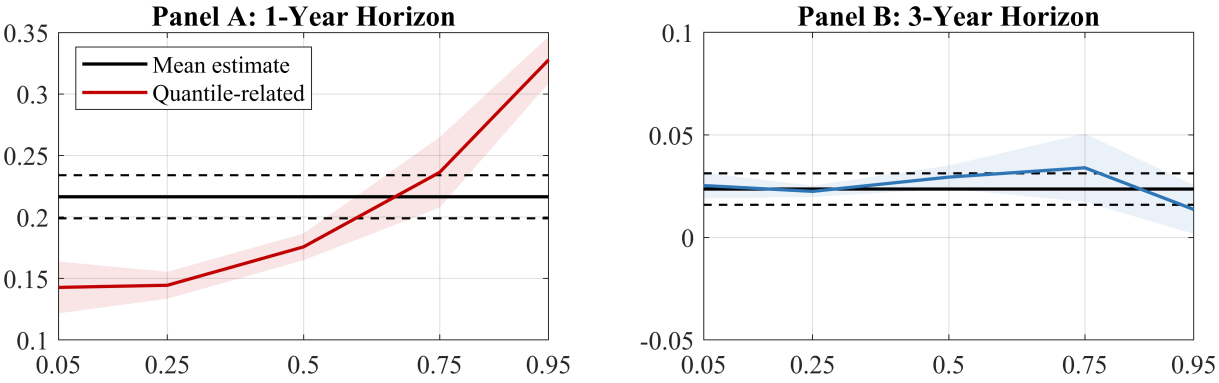


Note: The shaded areas represent a 95% confidence interval.
Source: Authors' calculations.

Compared to previous estimations, we base this analysis on the data covering the period of 2009 M1-2023 M10. The results of the estimations for one- and three-year expectations are summarized in Figure 11. Additionally, we also provide mean estimates to examine how quantile estimates behave in relation to the average ones. The mean estimates indicate the slightly positive effect of current inflation on the evolution of short-term expectations (refer to Panel A), suggesting the existence of an adaptive mechanism. In contrast, the impact of current inflation developments on three-year expectations is nearly zero (refer to Panel B).

The quantile estimates for the one-year horizon reveal that periods with elevated expectations (as indicated by higher quantiles) exhibit higher elasticity. This suggests that current inflation more strongly influences one-year expectations during these periods compared to standard ones. However, this pattern is not mirrored in long-term expectations, where there is only a negligible (almost zero) relationship between current inflation and inflation expectations, regardless of the quantiles considered. Additionally, the estimated OLS coefficient falls within the confidence intervals of the quantile regression coefficients, indicating that the quantile regression results are not statistically distinct from the OLS findings.

Figure 11: Exploring the Relationship between Inflation and Expectations – Quantile Regression



Note: The horizontal line displays quantiles. The shaded areas represent the 95% confidence interval of quantile estimates and the dashed lines represent the 95% confidence bands of the mean estimate.
Source: Authors' calculations.

4.3 Core Inflation Dynamics

Typically, core inflation tends to hover around the headline inflation target, as it is the most persistent component of inflation, reflecting the underlying economic factors and the impact of monetary policy. As it is the fundamental inflation component, central bankers pay special attention to its developments. Core inflation began to surge in mid-2021, reaching double-digit figures in summer 2022 – levels not seen in decades. Concurrently, the CNB's forecasts started to exhibit relatively high forecasting errors, consistently on the positive side. This suggested that something beyond standard economic fundamentals was propelling the increase in core inflation.

To explore the role of the factors influencing core inflation, we adopt a conventional approach and estimate the Phillips Curve (PC). Inspired by Beneš and N'Diaye (2004), we use the PC, linking the quarter-over-quarter annualized core inflation, π_t^{core}, to its lag π_{t-1}^{core}, a measure of economic slack represented by the labor utilisation composite index, $LUCI_t$[11], quarter-over-quarter annualized import price inflation excluding food and energy prices, $\pi_t^{imp,ex}$, and inflation expectations, π_t^E. The adopted PC takes the following form:

$$\pi_t^{core} = \beta_1 \pi_{t-1}^{core} + \beta_2 LUCI_t + \beta_3 \pi_t^{imp,ex} + \beta_4 \pi_t^E + \varepsilon_t. \tag{6}$$

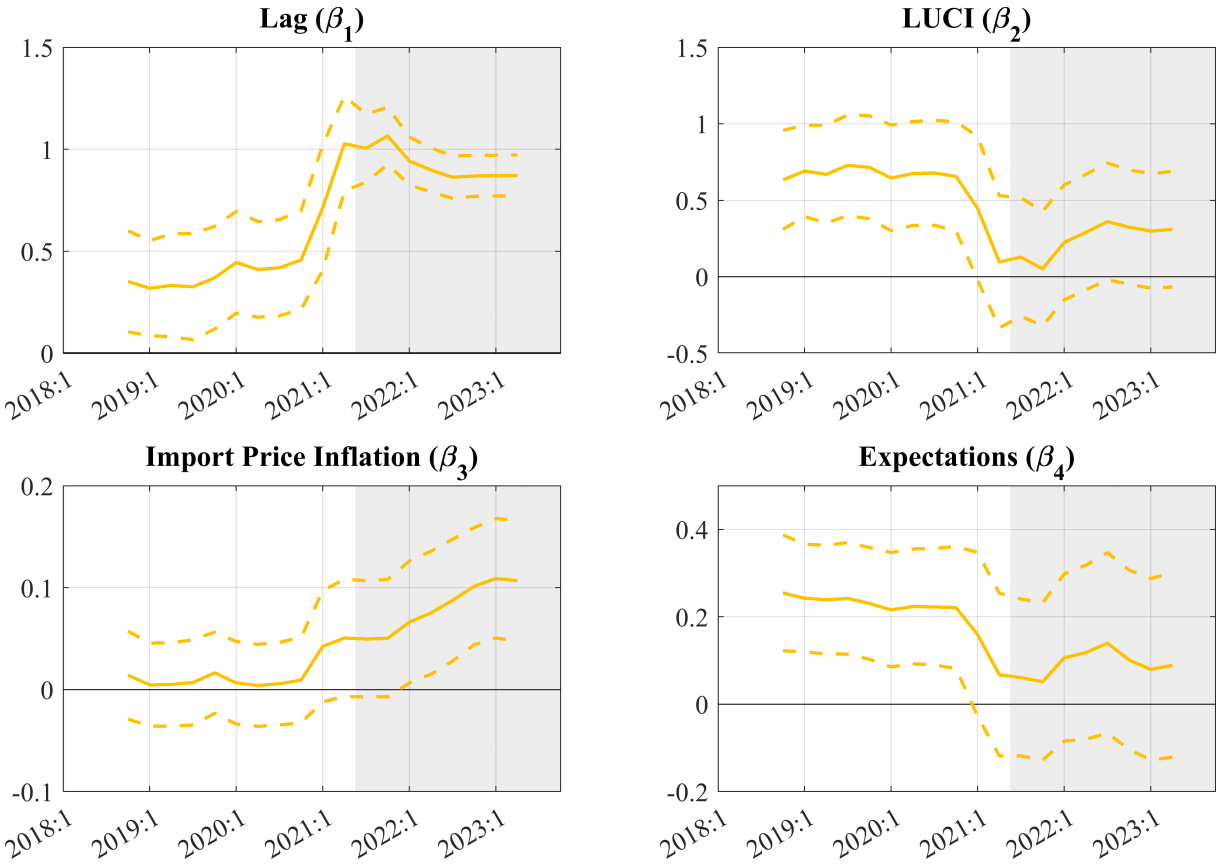
We use the inflation target as a proxy for inflation expectations. We argue that once inflation expectations are well anchored, the "target" variable within the PC should have a positive and significant coefficient, as the central bank's target anchors inflation developments. The dataset used in this exercise covers the period of 2004 Q1-2023 Q2, that is, almost twenty years. To capture the dynamics in the evolution of the individual drivers of core inflation, we apply a rolling window regression with a window of 15 years.

The estimation results, summarized in Figure 12, reveal that PC coefficients remained relatively stable until mid-2021, after which they experienced considerable changes (see the shaded area). The coefficient for lagged core inflation increased significantly and hovered around unity, suggesting a random walk process for core inflation without significant impacts from other factors. In contrast, the coefficients for the Labor Utilization Composite Index (LUCI) β_2 representing elasticity

[11] The LUCI index was presented in the Inflation Report IV/2017 (p. 39).

to economic slack, and inflation expectations elasticity β_3 decreased to zero and lost their statistical significance.

Figure 12: Estimation of the Baseline Phillips Curve



Note: The dashed lines represent the 95% confidence bands, and the shaded area highlights the period starting in mid-2021.
Source: Authors' calculations.

To assess the explanatory power of the PC, we examine its residuals in Figure 13 (yellow line). To evaluate how the PC performs in ordinary times and the extent of explanatory power missing in the recent inflation surge, we used averages of the estimated coefficients before mid-2021[12] and retrieve residuals of the PC. These residuals suggest that the specified PC fits the data reasonably well, except for the upsurge in core inflation after mid-2021.

In summary, the estimation results indicate that the components of the specified Phillips Curve model fail to provide a satisfactory explanation for the recent upsurge in core inflation. Several potential reasons for this discrepancy may be considered:

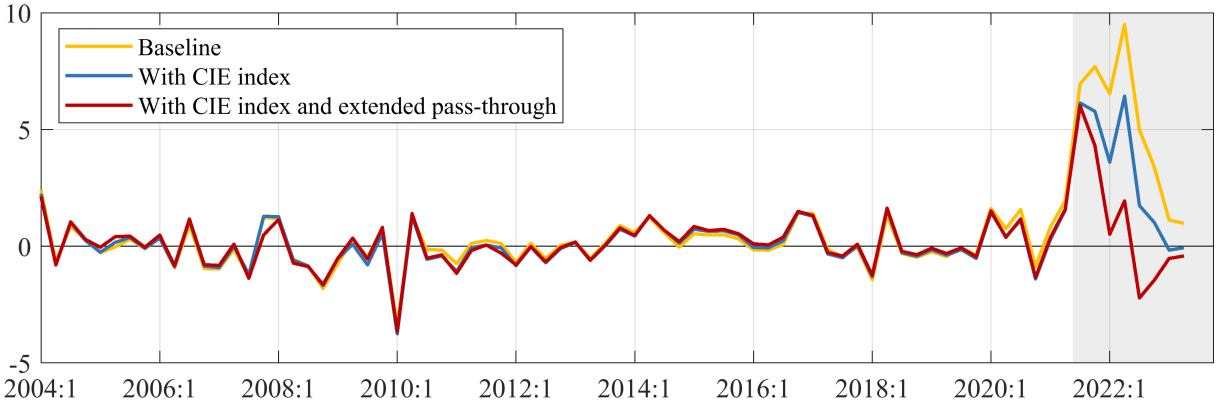
(i) omitted variable bias (for example, energy prices since an extraordinarily large energy price shock hit the domestic economy);

(ii) time varying pass-through of inflation expectations to inflation developments;

[12] The estimated coefficients proved to be relatively stable before mid-2021.

(iii) some variables might be inappropriately approximated (for example, the assumption that inflation expectations remain well anchored at the inflation target might be too strong).

Figure 13: Residuals from Estimated Phillips Curves (QoQ annualized growth rate, in %)



Note: Residuals are retrieved from PCs with fixed coefficients; the shaded area highlights the period starting mid-2021.
Source: Authors' calculations.

To check the hypotheses, we begin by examining the influence of inflation expectations within the Phillips curve. We substitute the central bank's inflation target with the CIE index (quarter-over-quarter annualized) to assess whether elevated inflation expectations contribute to explaining the recent upsurge in core inflation. The results of the estimation and the associated residuals from the PC with fixed coefficients are presented in Figures 13 and 14.

The PC model integrating the CIE index demonstrates a more accurate fit to the data compared to the original PC model, where the inflation target served as a proxy for inflation expectations. The estimated values of coefficients are very similar to the ones from the original estimation when inspecting the period before mid-2021 (see Figure 14). However, the coefficient related to inflation expectations increases after mid-2021 and remains significant, underscoring the prominent role of inflation expectations in core inflation developments. Additionally, as shown in Figure 13, replacing the inflation expectations component helps reduce the PC residuals with fixed coefficients. In certain periods, the reduction of residuals amounts to more than two percentage points.

In the next step, we also modify the strength of the pass-through of inflation expectations within the PC using the inflation expectations deviation indices presented in Subsection 3.1. We compose a single composite inflation expectations deviation index using individual indices for each group, while using the weights retrieved from the PCA when constructing the CIE index to maintain consistency. The pass-through is standard in times of anchored inflation expectations. However, once the degree of inflation expectations anchoring deteriorates, the assumed pass-through to core inflation dynamics becomes higher. Therefore, we employ the PC in the following form:

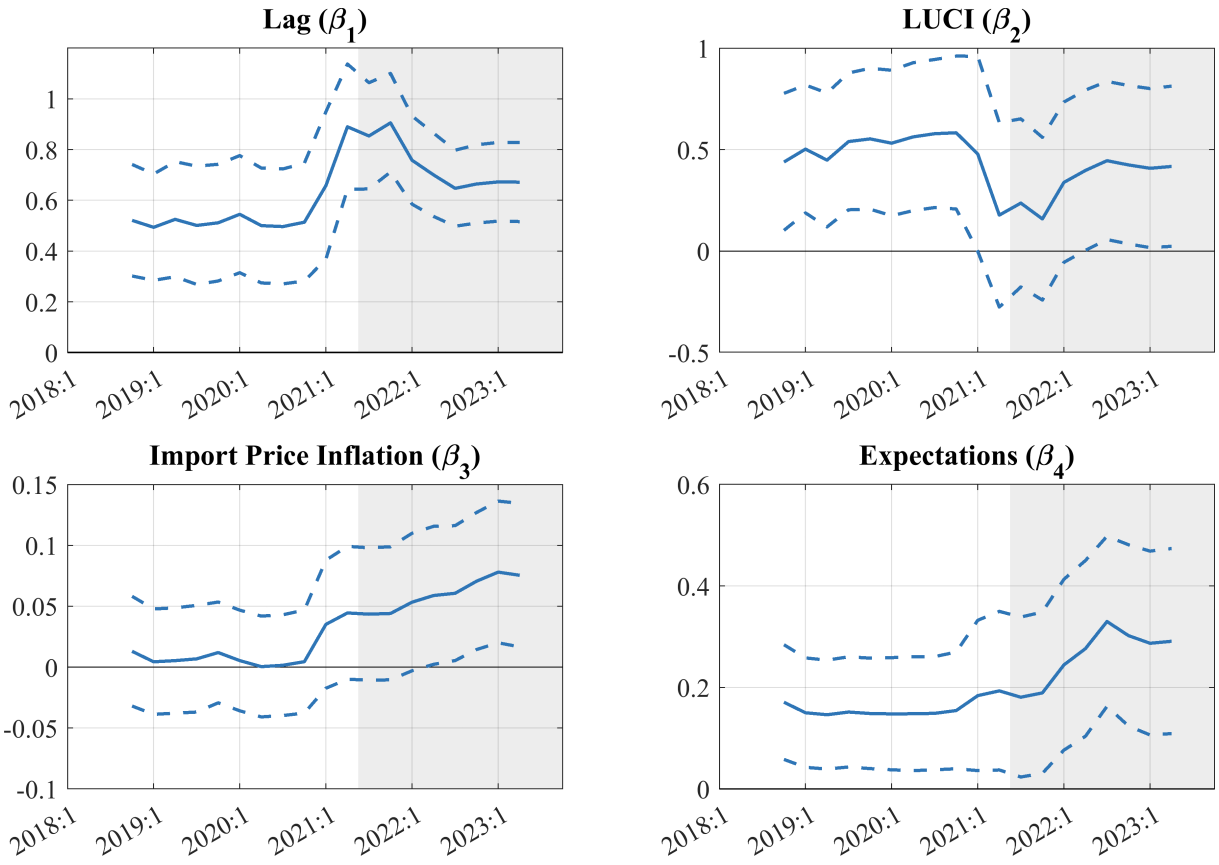
$$\pi_t^{core} = \beta_1 \pi_{t-1}^{core} + \beta_2 LUCI_t + \beta_3 \pi_t^{imp,ex} + (\beta_4 + \beta_5 DevI_t^{comp}) CIE_t, \tag{7}$$

where $DevI_t^{comp}$ stands for the composite inflation expectations deviation index as described above.

The estimated parameter values, including the residuals, are summarized in Figures 13 and 15, and show further improvement in explaining core inflation dynamics. As depicted in Figure 13,

changing the pass-through according to the assessment of the anchoring of inflation expectations further helps to eliminate the unexplained part of the core inflation dynamics. Nevertheless, there is still some part remaining on top of the inflation expectations, especially in the second half of 2021. Our expert assessment suggests that these drivers might include, for example, extraordinarily high energy prices that enter goods and services prices as costs of production.

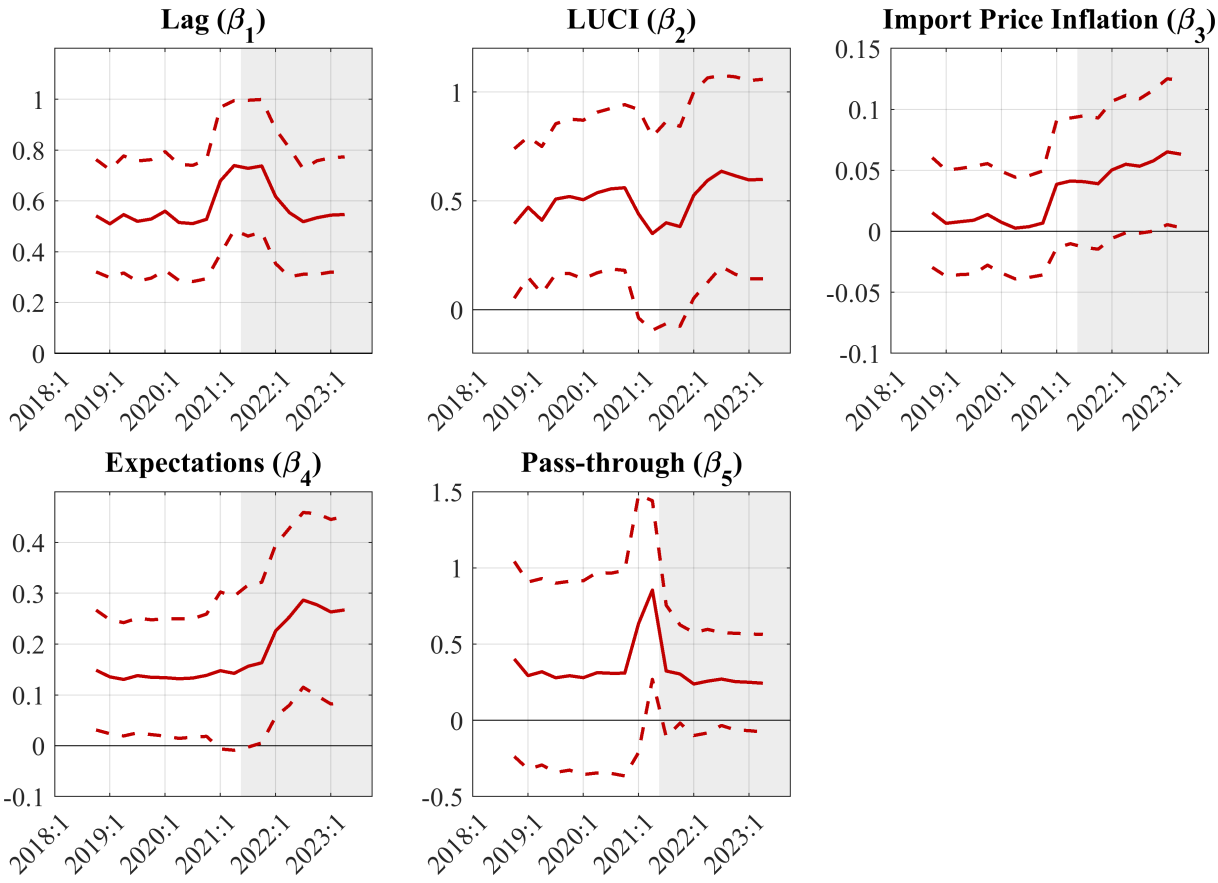
Figure 14: Estimation of the Phillips Curve with the CIE Index



Note: The dashed lines represent the 95% confidence bands, and the shaded area highlights the period starting in mid-2021.
Source: Authors' calculations.

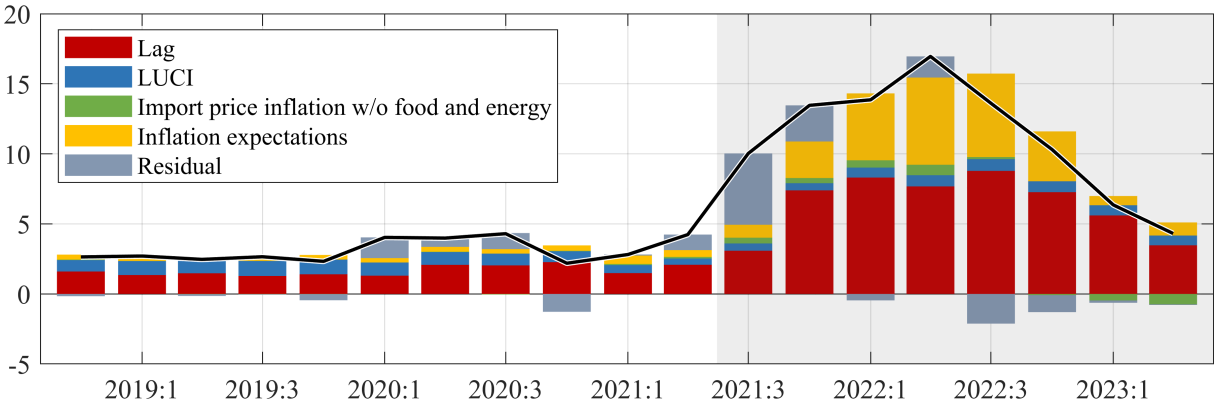
To illustrate how the PC explains the dynamics in core inflation in recent years, we compute the core inflation contributions based on the rolling-window estimation of Equation (7). Figure 16 depicts the resultant breakdown of core inflation. Historically, the dynamics of core inflation was predominantly influenced by the overheated labor market and the persistence of inflation itself, with an almost negligible impact from import prices excluding food and energy before 2021. Additionally, the contribution of inflation expectations was relatively subdued. Following the initial surge in core inflation, the influence of inflation expectations became more prominent, contributing up to nearly 40% to the overall dynamics at its peak. Furthermore, inflation persistence has markedly increased since late 2021. In recent quarters, core inflation is primarily driven by inherent factors, with relatively subdued contributions from inflation expectations compared to preceding quarters.

Figure 15: Estimation of the Phillips Curve with the CIE Index and Variable Pass-Through



Note: The dashed lines represent the 95% confidence bands, and the shaded area highlights the period starting in mid-2021.
Source: Authors' calculations.

Figure 16: Core Inflation (QoQ annualized, in %, contributions in pp)



Note: The shaded area highlights the period starting mid-2021.
Source: Authors' calculations.

In conclusion, our analyses suggest that heightened inflation expectations played a significant role in the recent surge in inflation, although they may not fully explain all variations in the data. The incorporation of the CIE index proves to be a valuable tool in enhancing our understanding of inflation dynamics. When integrated into a modified PC that allows for a more pronounced pass-through of inflation expectations, particularly during periods with a low degree of inflation expectations anchoring, the model yields minimized residuals, improving its accuracy in capturing inflation trends. This suggests that the CIE index provides a nuanced perspective on inflation expectations, offering valuable insights into the dynamics of inflation, especially during periods of economic transition or uncertainty.

5. Extending the CNB's Core Projection Model with Elevated Inflation Expectations

Using the previous outcomes, we amend the CNB's g3+ core projection model to translate the findings regarding the inflation expectations into monetary policy implications. The g3+ model, a micro-founded New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model, assumes rational expectations, meaning that model agents – households, firms, and policymakers – form expectations based on a comprehensive understanding of the economy, including the model and its parameters. However, this assumption may not always align perfectly with reality, as expectations derived from survey results might deviate from those implied by the model.[13] This might be due to limited informational resources; in some situations, agents might have incomplete knowledge about the economy and insufficient ability to understand and interpret it, for example, due to large shocks (Borgea et al., 2020). While the discrepancy between model- and data-based expectations is typically negligible in standard times, it has become more significant in the past two years due to elevated inflation, becoming increasingly relevant for policy analyses using our core forecasting model. In light of this, we modify, among others, the mechanism of forming inflation expectations in the g3+ model to bring model inflation expectations closer to survey results and to be able to assess the macroeconomic effects associated with elevated inflation expectations.

Research in the area of expectations is vast, often seeking to reconcile observed reality with various approaches to modeling expectations. Notable contributions include Sims (2003), who introduces the concept of rational inattention. Slobodyan and Wouters (2012) delve into learning mechanisms within a large New Keynesian Dynamic Stochastic General Equilibrium (NK DSGE) model. Heterogeneity in expectations is explored by De Grauwe (2011). Bertasiute et al. (2020) analyze the policy implications of behavioral expectations. Additionally, Borgea et al. (2020) implement the Markov-switching mechanism in expectations. All these studies attempt to challenge the traditional paradigm of rational expectations in DSGE model frameworks, striving to bring expectation formation closer to reality. However, from the practical standpoint of professional forecasters, these methods may be beyond the scope, as they fundamentally alter the nature of the modeling framework in use.

Nonetheless, there are practical policy-oriented papers at the intersection of elevated/de-anchored inflation expectations, offering what we consider a more plausible way of adjusting inflation expectations in the modeling framework without completely altering the underlying assumption of rational expectations. For instance, Argov et al. (2007) assume that inflation expectations are a weighted combination of forward-looking and backward-looking components. Simultaneously, they differen-

[13] The g3+ model assumes limited information rational expectations (see Brázdik et al. (2020)), but the potential discrepancy remains.

tiate between low- and high-inflationary episodes, ensuring that model inflation expectations behave differently during periods of high inflation than in standard times. Similarly, Beneš et al. (2017) implement an approach where the lack of central banks' credibility leads to de-anchored inflation expectations. Alichi et al. (2009) introduce a mechanism in which inflation expectations switch between the official inflation target and the perceived elevated inflation target. This mechanism ensures that household-formed inflation expectations deviate from those of the central bank, allowing for a more assertive policy response to bring inflation expectations (and inflation) back to the official target.

5.1 Modelling Elevated Inflation Expectations within the NKPC

Our approach is close to the one proposed by Alichi et al. (2009) and leads to a modification of the pricing equation in the model, the New Keynesian Phillips curve (NKPC). The original Phillips curve in the consumer sector in the g3+ model is formulated as follows:

$$\pi_t^N = \beta E_t(\pi_{t+1}^N) + \frac{(1-\beta\xi_C)(1-\xi_C)}{\xi_C}\mu_C mc_{C,t}^r + \varepsilon_t^C, \tag{8}$$

where π_t^N is net inflation[14] with $E_t(\pi_{t+1}^N)$ being its expected value, $mc_{C,t}^r$ represents real marginal costs in the consumer sector, β is the discount factor, ξ_C is the Calvo parameter in the consumer sector, μ_C represents a fixed markup, and ε_t^C is the price shock. Thus, inflation is determined by its forward-looking element and the pricing policy of firms up to an exogenous shock.

We modify the forward-looking component of the Phillips curve by introducing an additional element that captures the anticipated deviation of inflation from the official central bank's target. This new term influences the mechanisms for forming inflation expectations, in addition to those derived under model-based rational expectations. Importantly, it does not alter the official inflation target, indicating that the central bank's role remains consistent with the baseline model, and it remains committed to the same numerical value of the target. The modified version of Equation (8) is given as follows:

$$\pi_t^N = \beta \mathbb{E}_t(\pi_{t+1}^N \pi_{t+1}^{dev}) + \frac{(1-\beta\xi_C)(1-\xi_C)}{\xi_C}\mu_C mc_{C,t}^r + \varepsilon_t^C, \tag{9}$$

where π_{t+1}^{dev} is the anticipated deviation of inflation from the official central bank's target. It is modelled as an autoregressive process of order one, AR(1), with a component reflecting observed deviations of inflation from the target in the past:

$$\pi_t^{dev} = \left(\pi_{t-1}^{dev}\right)^{\rho_{\pi^{dev}}} \left(\frac{\pi_{t-1}^4}{\pi_{t-1}^{tar}}\right)^{\frac{1}{4}\nu_{\pi^{dev}}(1-\rho_{\pi^{dev}})} \exp\left\{\varepsilon_t^{\pi^{dev}}\right\}. \tag{10}$$

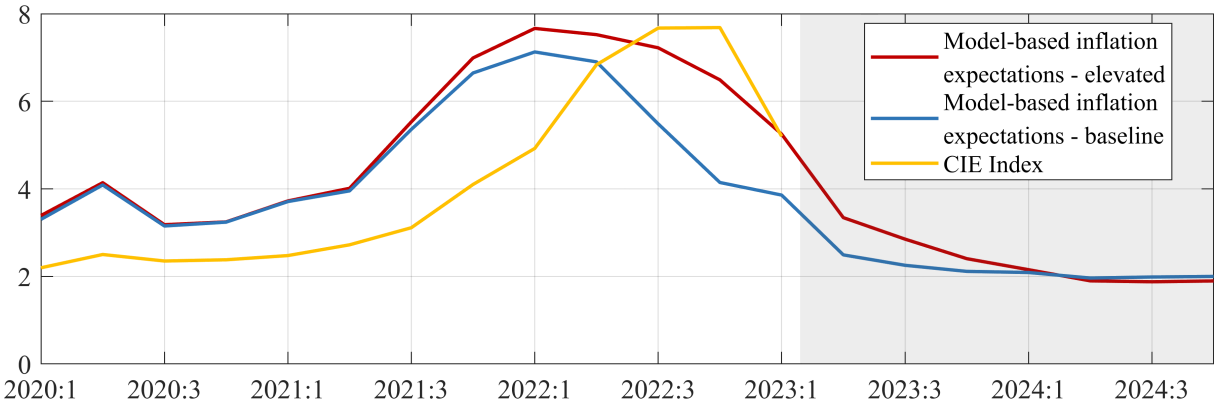
Here, π_t^4 is the year-over-year inflation rate, π_t^{tar} is the year-over-year inflation rate target, $\rho_{\pi^{dev}}$ and $\nu_{\pi^{dev}}$ are the AR parameter and the elasticity respectively, and $\varepsilon_t^{\pi^{dev}}$ is a shock. The elasticity $\nu_{\pi^{dev}} \in [0,1]$ governs the intensity of the pass-through of the observed inflation target misalignment into the expected inflation. Setting $\nu_{\pi^{dev}}$ to zero results in no endogenous mechanism of elevated inflation expectations, while keeping it at one leads to the full pass-through. We limit $\rho_{\pi^{dev}}$ to be

[14] Net inflation is calculated as the growth in prices in the unregulated part of the consumer basket adjusted for changes in indirect taxes and for the abolition of subsidies.

in interval $(0, 1)$.[15] It is important to mention that the model specification is symmetric, that is, inflation expectations are altered upwards (downwards) in cases where inflation has been above (below) the target in the past.

An appropriate calibration of the AR process in Equation (10) allows us to bring model-based inflation expectations closer to the underlying CIE index. Additionally, the introduction of an exogenous shock enables us to incorporate additional information on top of the endogenous mechanism, such as outcomes from additional analyses or expert views. Figure 17 illustrates the role of elevated inflation expectations in the modeling framework and the use of the CIE index.[16] While model-consistent inflation expectations began to increase significantly in 2021, similar to the CIE index, they already started to decrease in 2022, whereas the CIE index had yet to peak. A positive difference between the CIE index and model-consistent inflation expectations emerged, indicating the risk of elevated inflation expectations with a low degree of anchoring. The calibration of the modified model with elevated inflation expectations is chosen such that model-consistent inflation expectations align more closely with the course of the CIE index in 2022 and especially in the first quarter of 2023. In the first quarter of 2023, model-consistent inflation expectations at the one-year horizon are thus roughly 1.5 percentage points higher than in the baseline scenario.

Figure 17: Model-Based Inflation Expectations and the CIE Index (Expected Inflation at the 1-Year Horizon, YoY, in %)



Note: The shaded area depicts the forecast horizon.
Source: Authors' calculations.

The described implementation of the modified formation of inflation expectations into the model structure represents the primary mechanism through which elevated inflation expectations manifest themselves. However, additional channels and aspects can be considered when examining elevated inflation expectations and their impact on the economy (see Subsection 5.2).

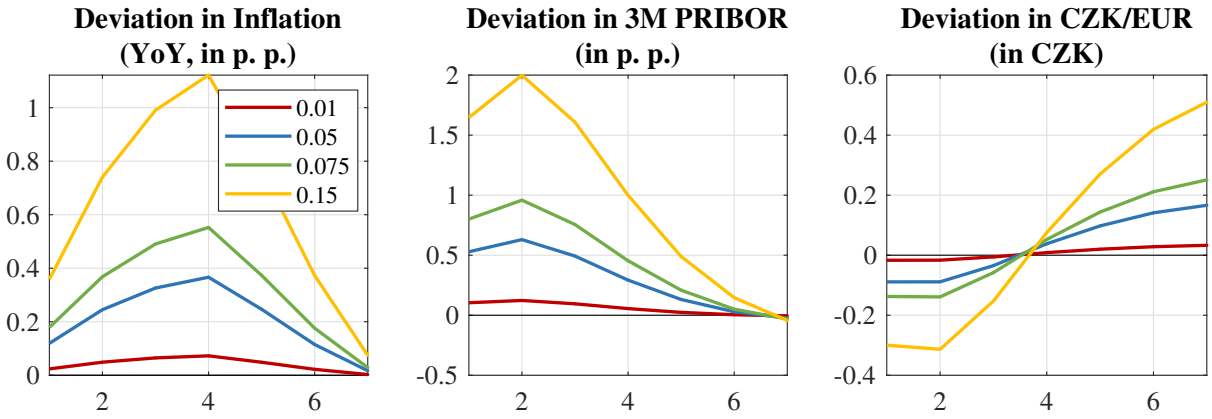
[15] Allowing $\rho_{\pi^{dev}}$ to take one would permanently enable inflation expectations to deviate from the target should there be no appropriate policy response and could indicate a long-run de-anchoring of inflation expectations. At the same time, such a setting leads to the non-stationarity of the model. We do not want to explore this ground as we are not identifying de-anchored inflation expectations in the Czech Republic but elevated ones characterised by a low degree of anchoring.

[16] It is acknowledged that inflation expectations derived from surveys differ methodologically from model-consistent ones. Surveys provide a sequence of inflation expectations for the upcoming year (without knowledge of future developments). In contrast, model-consistent inflation expectations are derived from filtering across the entire historical range using all available information. Therefore, particular focus is given to the end of history, that is, the initial condition of the forecast, and less emphasis is placed on the more distant past (as a direct comparison is challenging).

5.1.1 Simulating Impacts of Elevated Inflation Expectations

The set of simulations for different values of the elasticity $\nu_{\pi^{dev}}$ and fixed value of $\rho_{\pi^{dev}}$ in comparison to the baseline simulation in Figure 18 describes the model properties.[17] The extended model results in higher inflation expectations and, therefore, higher inflation itself. However, the impact is not as pronounced, as the central bank reacts by increasing interest rates to counter elevated inflation expectations. At the same time, higher interest rates lead to a stronger Czech currency to the euro as the interest rate differential widens. Monetary conditions are tighter; they help to tame inflation expectations and bring inflation back to the target. On top of this, Figure 18 shows the role of elasticity. As described above, the higher the elasticity, the more pronounced the pass-through of inflation expectations, and therefore, the more sizable the impact on the economy and the stronger the reaction of monetary policy through interest rates. At the same time, the stronger monetary policy response ensures that the trajectory of inflation converges to the inflation target, albeit with considerably different movement in the initial quarters.

Figure 18: Results for Extended Model with Elevated Inflation Expectations



Note: The trajectories presented above are the differences with respect to the baseline simulation without elevated inflation expectations. The simulations are based on calibration $\rho_{\pi^{dev}} = 0.5$ and different values of $\nu_{\pi^{dev}}$.
Source: Authors' calculations.

5.1.2 Inflation Dynamics: One-Off Shock vs Elevated Inflation Expectations

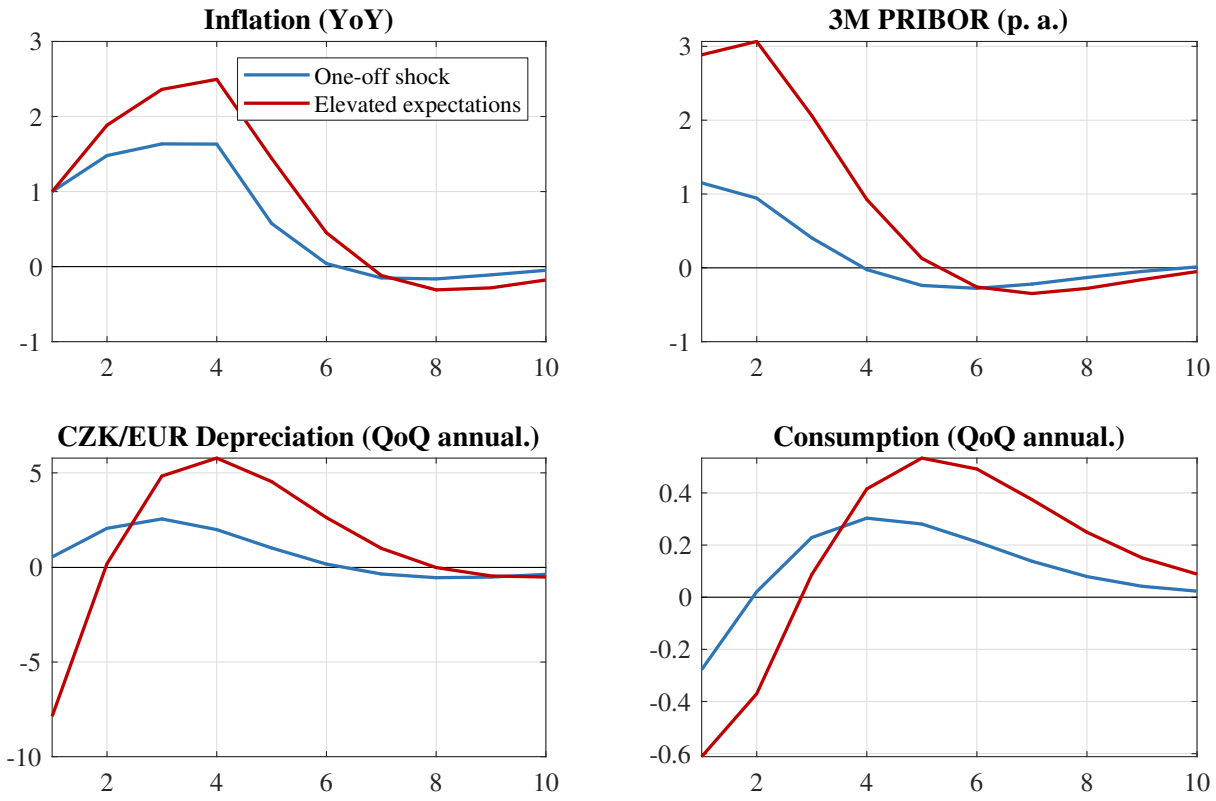
In the following exercise, we illustrate the difference between a situation where an increase in inflation results from a one-off non-persistent shock in the Phillips curve and a situation where an increase in inflation is interpreted as a manifestation of elevated inflation expectations. Figure 19 shows the responses to a one-off cost-push shock and a shock in expected inflation that both deliver a 1 pp increase in year-over-year CPI inflation on impact.

In the scenario of a cost-push shock, inflation rises as a result of an upward shift in firms' profit margins. In the periods following the shock, the impact of inflation persistence initially dominates, leading to continued slight growth in year-over-year inflation. However, the subsequent decline in

[17] Here, we do not present impulse response functions to selected shocks as the endogenous mechanism of elevated inflation expectations manifests mainly through identifying shocks in the filtering stage. In other words, the identification of the initial condition is essential for the implications at the forecast horizon. Therefore, we run the baseline scenario and then alternative scenarios with elevated inflation expectations with different parametrization and present the results in terms of deviations from the baseline. The same strategy applies to another modification of the model (see the following subsection).

profit margins, coupled with the effects of monetary tightening, eventually prevails, causing inflation to return to the target in the subsequent quarters. The monetary restriction and transmission operate through two primary channels: exchange rate appreciation and the suppression of domestic demand.

Figure 19: One-Off Cost-Push Shock vs Shock in Inflation Expectations (deviation, in %)



Note: The impulse responses presented here are based on the extended model with calibration $\rho_{\pi^{dev}} = 0.5$ and $\nu_{\pi^{dev}} = 0.1$. The responses are measured in percentage deviations from the steady state.
Source: Authors' calculations.

In the second case, following the shock in inflation expectations, the profit margin experiences an endogenously driven increase. Consequently, the subsequent decline in the profit margin back to the steady state is more gradual, maintaining year-over-year CPI inflation at higher levels compared to the cost-push shock scenario. Consequently, a more substantial monetary policy response is required to guide inflation (and expectations) back to the 2% target at the monetary policy horizon. The impact on exchange rate appreciation and the moderation of domestic demand, as reflected in households' consumption, is also more pronounced compared to the transitory price shock.

5.2 Additional Impacts via the UIP Condition

Empirical studies, such as IMF (2018), Levieuge et al. (2018), or Carrière-Swallow et al. (2021), show that high inflation and conversely inflation expectations lead to overall higher macroeconomic fragility and instability that can result in capital outflows from the economy. As a result, the exchange rate can come under pressure and ultimately weaken. Also, the exceptionality of the situation can play a role. Looking at history, Czech inflation targeting has been quite successful since the global financial crisis in 2008. The surge in inflation in the last two years could be understood as something extraordinary, putting some extra pressure on the exchange rate. Therefore, we consider the additional impact of the elevated inflation expectations on the exchange rate via the uncovered

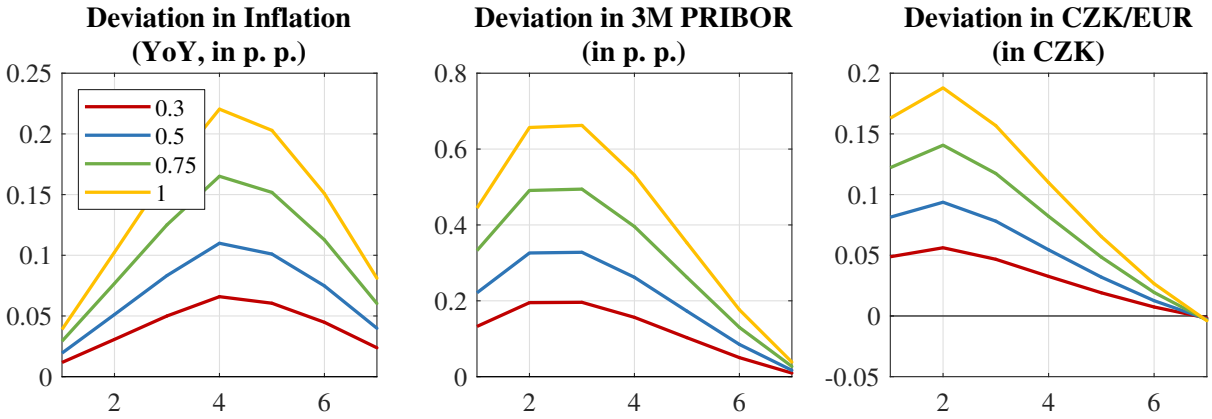
interest rate parity (UIP) condition.[18] The implemented approach has been used by Chansriniyom et al. (2020) to strengthen the feedback between elevated inflation expectations and exchange rate developments.

We add an additional risk premium term to the UIP condition that reflects perceived deviation of inflation from the target π_t^{dev}, which is weighted by the elasticity ν_{uip}. If the deviation increases (decreases), the pressure to weaken (strengthen) the exchange rate becomes stronger. Therefore, the model specification is symmetric, similar to the adjustment of the price equation. The modified UIP condition has the form:

$$\frac{i_t}{i_t^*} = \Delta s_t^{-(1-\rho_s)} \mathbb{E}_t \left(\Delta s_{t+1}\right)^{\rho_s} \left(\Delta s_{SS}\right)^{2(1-\rho_s)} \left(\pi_t^{dev}\right)^{\nu_{uip}} \kappa_t^{uip}, \tag{11}$$

where i_t and i_t^* stand for domestic and foreign nominal interest rates, Δs_t and Δs_{SS} are the depreciation of the CZK/EUR exchange rate and its steady-state rate, respectively, κ_t^{uip} includes exchange rate shocks (short- and long-term ones) and the effect of the net foreign asset position (nominal trade balance), ρ_s governs the forward-looking nature of the UIP condition and $\nu_{uip} \in [0,1]$ regulates the pass-through of elevated inflation expectations into the exchange rate developments.

Figure 20: Results for Extended Model with Elevated Inflation Expectations and Modified UIP Condition



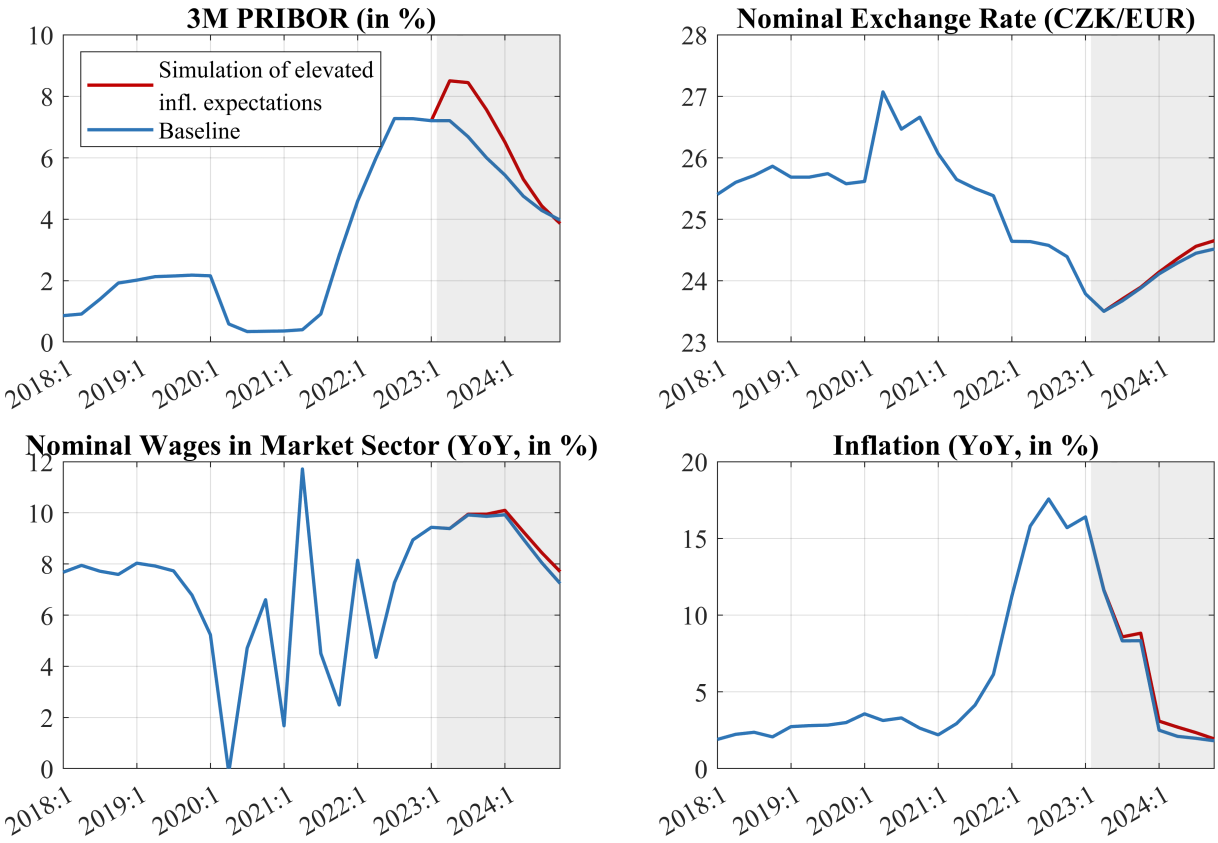
Note: The trajectories presented above are the differences with respect to the simulation with elevated inflation expectations and no change in the UIP condition. The simulations are based on calibration $\rho_{\pi^{dev}} = 0.5$, $\nu_{\pi^{dev}} = 0.1$ and different values of ν_{uip}.
Source: Authors' calculations.

Figure 20 illustrates the characteristics of the extended model with elevated inflation expectations and an additional impact through the Uncovered Interest Parity (UIP) condition, as outlined in Equation (11). An additional pro-inflationary effect arises from the latent pressure for a more pronounced weakening of the Czech koruna against the euro. However, this effect is considered in the endogenous reaction of the central bank, resulting in higher interest rates. The additional monetary policy tightening largely offsets the depreciation of the Czech koruna. The increased interest rate differential enhances the attractiveness of the koruna, preventing significant depreciation and ensuring

[18] The simulation of elevated inflation expectations without considering the additional effects via the UIP condition initially results in a stronger currency than in the baseline simulation. This is in contradiction to the empirical studies presented in the past. As discussed further, the strength of the "UIP channel" is governed by the selected parametrization and offers high flexibility in the strength of this particular effect.

the achievement of the inflation target within the monetary policy horizon. The primary impact of this channel is, therefore, evident in the central bank's response through interest rates, with other effects remaining relatively subdued. Thus, in the case of elevated inflation expectations, the policy response should be more substantial not only due to expectations themselves but also because of their implications for exchange rate depreciation.

Figure 21: Simulation of Elevated Inflation Expectations



Note: The shaded area represents the forecast horizon.
Source: Authors' calculations.

5.3 Monetary Policy Simulation

To stress the importance of the extended g3+ model with elevated inflation expectations according to the CIE index, we present a version of a monetary policy simulation from the CNB's Monetary Policy Report – Spring 2023.[19] The simulation shows the macroeconomic effects in the event of inflation tending to decline more gradually than considered in the baseline scenario due to elevated inflation expectations. The calibration of the extended model to $\rho_{\pi^{dev}} = 0.5$ and $\nu_{\pi^{dev}} = 0.072$ was chosen so that inflation expectations in the model approximate the course of the CIE index in 2022 and especially in 2023 Q1. We additionally assume that the deviation of inflation expectations from the 2% target is reflected in a deterioration in sentiment on the foreign exchange market, which increases the risk premium and exerts additional depreciation pressure on the koruna. To model this, we set the elasticity ν_{uip} to 1.[20]

[19] The original simulation can be found in the Monetary Policy Report – Spring 2023. Here, we present a simplified version of the simulation without additional assumptions related to interest rate developments.
[20] A particular calibration may reflect a specific inflationary period and may thus change over time.

Figure 21 presents the baseline forecast from the Monetary Policy Report – Spring 2023 alongside the simulation with elevated inflation expectations. Elevated inflation expectations fundamentally influence economic agents' decisions, leading to additional inflationary pressures in the economy, particularly in faster nominal wage growth. The heightened risk premium also contributes to increased depreciation pressure, resulting in a weaker koruna over the forecast horizon. In response, the central bank implements interest rate hikes. While this reaction is not entirely effective in fully offsetting the impact of elevated inflation expectations, it is adequate to bring inflation back to the target, albeit with a slight delay compared to the baseline scenario.

6. Conclusion

Inflation expectations and their steering via central banks' actions are the key to successful and efficient monetary policy operating within the inflation targeting regime and framework. The recent period of high inflation has prompted us to thoroughly examine inflation expectations, with the aim of understanding their fundamentals, development and, more importantly, discerning the implications for monetary policy decision-making. To address elevated inflation expectations, we conducted several analyses to assess the degree of inflation expectations anchoring over the last two years. Furthermore, our goal was to comprehend how inflation expectations are formed and how they contribute to inflation developments, both in high- and low-inflation environments. Additionally, we developed an economy-wide inflation expectations index (the CIE index) to provide a concise expectations indicator with a clear interpretation of the inflation expectations data. Furthermore, we adjusted our g3+ structural core projection model to endogenously incorporate elevated inflation expectations. This adjustment allowed us to offer relevant policy recommendations.

Our work yields results across multiple dimensions. The analyses revealed that different groups (households, firms, and financial markets) perceive inflation differently, leading to distinct expectation formation. This diversity contributes to uncertainties surrounding expectations. The inflation expectations deviation indices indicated periods of a low degree of short-term expectations anchoring in the last two years. This suggests that expectations, particularly in the short term, may not align closely with established targets. The findings highlighted the adaptive formation of inflation expectations in the short term, with a more pronounced inflation pass-through during high-inflation periods. This adaptive behavior underscores the responsiveness of expectations to current economic conditions. Moreover, our analysis of core inflation dynamics using the Phillips curve identified short-term inflation expectations as a primary driver behind the recent inflation surge in the Czech economy. Despite changes in short-term expectations, there are no substantial observed changes in the formation of inflation expectations over a longer horizon compared to more standard times. The construction of a simulation utilizing the g3+ extended projection model and the CIE index provided policy-relevant insights for addressing high inflation. This approach enables a more nuanced understanding of the potential effects of policy measures in the context of elevated inflation expectations.

The extension of the CNB's core projection model presented here, along with most supplementary analyses in this paper, were carried out under the assumption of linearity. Although it is recognized that inflation expectations may demonstrate non-linear behavior and exert varying elasticities on the economy in different periods, this simplification is adopted for practical usability in forecasting models and real-time policy discussions. To support this claim, we have presented one of the model simulations incorporating elevated inflation expectations. A version of this simulation was included in the Czech National Bank's Monetary Policy Report in spring 2023.

Confirming de-anchored inflation expectations robustly can be challenging. However, the emergence of elevated inflation expectations poses risks and calls for an active monetary policy response. Monitoring elevated inflation expectations at the short-term horizon is crucial, as there is a potential risk of transmission to long-term expectations without a proper policy response. Effective communication and policy actions are essential to tighten monetary conditions and bring inflation back to the target over the monetary policy horizon. Proactive measures are necessary to mitigate the impact of elevated expectations on the overall inflationary environment.

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Appendix A: Inflation Expectations and Socio-Economic Aspects

Differences in perceived and expected inflation during a period of long-term rapid price increases are linked to the socio-economic characteristics of households (see Table A1). Respondents with lower incomes, poorer education, older age and from smaller towns and villages perceive and expect significantly higher inflation – i.e., people from social groups for whom any worsening of the financial situation represents an above-average constraint and burden. Among these population groups, there is also a clearly higher variability of answers to individual questions compared to respondents from the opposite side of the demographic spectrum. Women's inflation expectations are higher than those of men. For households with higher incomes, higher education and from large cities – i.e., those socio-economic groups that are probably more easily addressed by the central bank's active communication of monetary policy – perceived inflation is, on the other hand, closer to the measured reality, and inflation expectations are also clearly lower. These differences between individual demographic groups also correspond to similar surveys conducted abroad.

Table A1: Inflation Expectations of Households and Socio-Economic Characteristics

	Perceived Inflation			**Expected Inflation**		
	Mean	**Median**	**SD**	**Mean**	**Median**	**SD**
Entire dataset	15.2	11.0	15.9	11.6	7.9	14.0
Full-time job	13.8	9.8	14.2	10.6	7.5	12.6
Part-time job	15.4	11.2	15.2	11.8	8.2	13.5
18-29 years	11.9	7.7	13.5	9.0	5.9	12.2
30-49 years	13.9	9.7	14.7	10.6	7.2	13.0
50-65 years	17.0	12.1	16.5	13.3	9.7	14.8
66+ years	18.5	13.3	17.6	13.9	9.8	15.2
Primary education	19.2	12.7	21.4	15.1	9.3	19.2
Secondary education	16.1	11.8	16.3	12.5	8.9	14.4
Tertiary education	11.7	8.2	11.1	8.6	6.3	9.7
Male	13.0	9.0	13.9	9.8	6.8	12.2
Female	17.3	12.3	17.3	13.5	9.5	15.3
Employed	15.0	11.1	14.9	11.3	8.0	13.3
Unemployed and other	18.6	13.4	18.6	14.1	9.8	16.3
Income (in CZK)						
up to 15,000	21.6	15.9	21.5	17.3	11.8	19.4
15,001-20,000	19.3	14.5	18.7	15.1	10.7	16.9
20,001-25,000	17.0	12.6	16.4	13.4	9.8	14.5
25,001-30,000	16.3	12.5	15.5	12.7	9.3	13.8
30,001-40,000	14.5	10.8	14.0	11.1	7.9	12.5
40,001-50,000	13.2	10.0	12.6	9.9	7.2	11.0
50,001+	11.4	8.0	11.5	8.3	6.2	10.0
Place of residence (inhabitants)						
up to 999	16.2	11.7	16.1	12.5	8.7	14.4
1,000-4,999	15.5	11.1	16.1	12.1	8.3	14.3
5,000-19,999	15.6	11.2	16.1	12.0	8.2	14.2
20,000-99,999	15.3	10.9	15.7	11.7	8.1	13.8
100,000+	13.7	9.2	14.6	10.2	6.9	12.8

Note: SD stands for standard deviation. The statistics presented cover the period of 2015 M08-2023 M10.

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