Reading between the lines - Uncovering asymmetry in the central bank loss function *

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Abstract

We depart from the common reaction function-based approach used to infer central bank preferences. Instead, we extract the tone from the textual information in the central bank communication using both a lexicon-based approach and a language model. We combine the tone with real-time information available to the monetary policy decision-maker and directly estimate the loss function. We find strong and robust evidence of asymmetry in the case of the European Central Bank during 1999-2021: the slope of the loss function was roughly three times steeper when inflation exceeded the target compared to when it was below the target. This represents a significant departure from the quadratic and symmetric monetary policy loss function typically applied in macro models.

Keywords: central bank communication, textual analysis, language models, asymmetric loss function, optimal monetary policy

JEL Codes: E31, E52, E58

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1 Introduction

Monetary policy in advanced economies is almost without an exception delegated to an independent central bank with a clearly defined mandate such as price stability. This idea is also captured in the theoretical monetary policy literature focusing on optimal policy. In this literature, it is typically assumed that central banks' preferences can be summarised through a quadratic loss function, which is U-shaped and symmetric, typically around some pre-specified inflation target, and a variable representing slack in the economy. In particular, policymakers are expected to perceive positive deviations of inflation from the target as being equally costly as negative deviations of the same magnitude. This perception arises from the Linear-Quadratic (LQ) approximation used in standard New Keynesian (NK) models to represent household, and therefore society's, welfare (see e.g. Woodford (2003), Walsh (2003) and Galí (2015)).

While quadratic loss functions are analytically tractable and mathematically convenient, they do not necessarily provide the most realistic or even theoretically the most accurate representation of central bank preferences and optimal policy. Benigno and Rossi (2021) show that a welfare-based loss function which goes beyond the second-order approximation of household welfare criteria in the basic NK model features asymmetry: a policymaker should be more concerned about output and inflation expansions than contractions. Also Yun (2005) derives optimal policy in the NK models. He shows that a central bank would have an incentive to opt for more deflationary policy when the economy exhibits initial positive price dispersion and optimal policy is based on a higher-order approximation. Yet Benigno and Rossi (2021) also suggest that asymmetry of preferences does not necessarily mean that optimal policy should have a similar bias. They show that once the non-linearity of the aggregate supply equation is taken into account in the canonical NK model, an optimal policy implies an overall expansionary bias. This underlines the fact that a reduced form estimation of the reaction function, as is usually done in the literature, does not necessarily

allow drawing direct inference on central bank preferences.[1]

In this paper, we depart from the common reaction function-based approach and aim to estimate the central bank loss function directly, following Shapiro and Wilson (2022), who apply text analysis techniques to estimate the loss function of the Federal Open Market Committee (FOMC). Contrary to the reaction function-based approaches[2], we do not have to make specific assumptions about the reaction function, its structure, stability of the economic relationships or transmission channels of monetary policy. A text mining approach also has additional advantages because the dependent variable is the tone (sentiment) proxy instead of the policy instrument itself or policy-sensitive short-term market interest rates. When approaching the zero or negative effective lower bound (ELB) and when introducing non-standard monetary policy measures, the standard policy reaction function breaks down (or alternatively, rather uncertain proxies, i.e., shadow rates, must be used). Using the tone proxy as the dependent variable, the estimation period can be extended to periods of unconventional measures in a more straightforward manner.[3]

We focus on the European Central Bank (ECB) during 1999-2021, and the possible asymmetry of the ECB's preferences. In the case of the ECB, potential asymmetry and aversion to high inflation stems directly from its definition of price stability. In 1998, price stability was defined as a *'year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2%'*. In 2003, the ECB Governing Council further clarified

[1] As emphasised by Gross and J. Hansen (2021), LQ approximation assumes away all asymmetries which can arise from curvature in household or firm decision problems. This is due to the linear approximation of the constraints and is not a general property of the nonlinear solution of the optimisation problem in the NK models.

[2] See e.g. Ruge-Murcia (2004), Kimura and Kurozumi (2007), Surico (2007), Walsh (2015), and Benchimol and Fourçans (2019).

[3] There is a separate, but related literature which focuses on strategic communication of central banks. The argument in this literature is that the central banks may have incentives not to disclose all information and communicate strategically. For instance, Kawamura et al. (2019), who study the strategic communication of the Bank of Japan, suggest that communication ambiguity increases when the economy is heading to a downturn. However, the literature on central bank communication also indicates that central banks have made great efforts to enhance clarity. In particular, the increase in central bank independence has called for accountability to the public: there has been a transition from opacity to transparency. According to international comparisons, the ECB is one of the most transparent central banks (Dincer and Eichengreen (2014), Dincer, Eichengreen, and Geraats (2022)). In particular, from early on, the ECB has been highly transparent in communicating how it assesses the economic outlook (Eijffinger and Geraats (2006)).

that *'in the pursuit of price stability it aims to maintain inflation rates below, but close to, 2% over the medium term'*. Both definitions left open the question of whether the ECB would consider inflation rates above 2% more or as equally costly as rates below 2%.[4]

We proceed in two steps. First, we apply text analysis to extract the tone, or the sentiment, from the introductory statements of the ECB's press conferences, which form the most important and formal part of the ECB's qualitative communication of its monetary policy decisions. In the second step, we estimate the parameters of the loss function directly by combining quantitative measure of sentiment to real time estimates of inflation and economic outlook, as well as financial market variables, at the time policy decisions are made. This analysis is conducted separately for the entire textual content in the introductory statements, as well as for the inflation-focusing text segments within the introductory statements. We estimate piecewise linear (V-shaped) and linear-exponential (Linex, or general U-shaped) loss functions, but we also use simple non-parametric methods.

Our sentiment analysis is based on two approaches. We start with a traditional lexicon-based, or 'bag of words', approach. This approach relies on a pre-defined list of words (dictionaries) that are associated with particular sentiments such as positive, negative or neutral. We construct a new dictionary by adjusting (through human audit) the finance-specific dictionary developed by Loughran and McDonald (2011) (L&M) to better suit the ECB's monetary policy communication. In the tailoring of the dictionary, we focus on the most frequently occurring sentiment terms and phrases in the introductory statements. We quantify the tone (net negativity) as the difference between the fraction of negative words and phrases and the fraction of positive words and phrases in each introductory statement.

[4]Prior to the strategy review of 2021, the ECB's monetary policy strategy was subject to a rather intense debate and speculation. Given the double-key formulation of price stability at the time, many researchers, journalists, and other members of the public interpreted the Governing Council's preferences as asymmetric. See e.g. Svensson (2002), Miles et al. (2017), Blanchard (2019), Reichlin et al. (2021), Mishkin (2021) and Forbes (2021). As a consequence, ECB presidents and other Governing Council members have communicated their interpretations of the definition of price stability over the years (see e.g. Appendix A). As the inflation rate fell well below 2% in the euro area, Governing Council members started emphasizing *'its commitment to symmetry'*. See the ECB's monetary policy decisions published on 25 July 2019, 30 April 2020, 29 October 2020, 4 June 2020, 10 December 2020, and 11 March 2021 (`https://www.ecb.europa.eu/press/pr/date/html/index.en.html`).

Dictionary-based approaches have the advantage of being transparent and easy to understand, but they typically ignore the context of the sentiment words, as they rely on a search of single words, or frequently recurring word combinations (n-grams). Consequently, we complement the lexicon-based approach by also using Financial BERT (FinBERT), a language model developed by Araci (2019). FinBERT is tailored for financial texts and designed for sentiment analysis. It evaluates the likelihood that the tone of the text is positive, negative, or neutral. Using FinBERT, we can compute context-aware tone indices for ECB introductory statements.

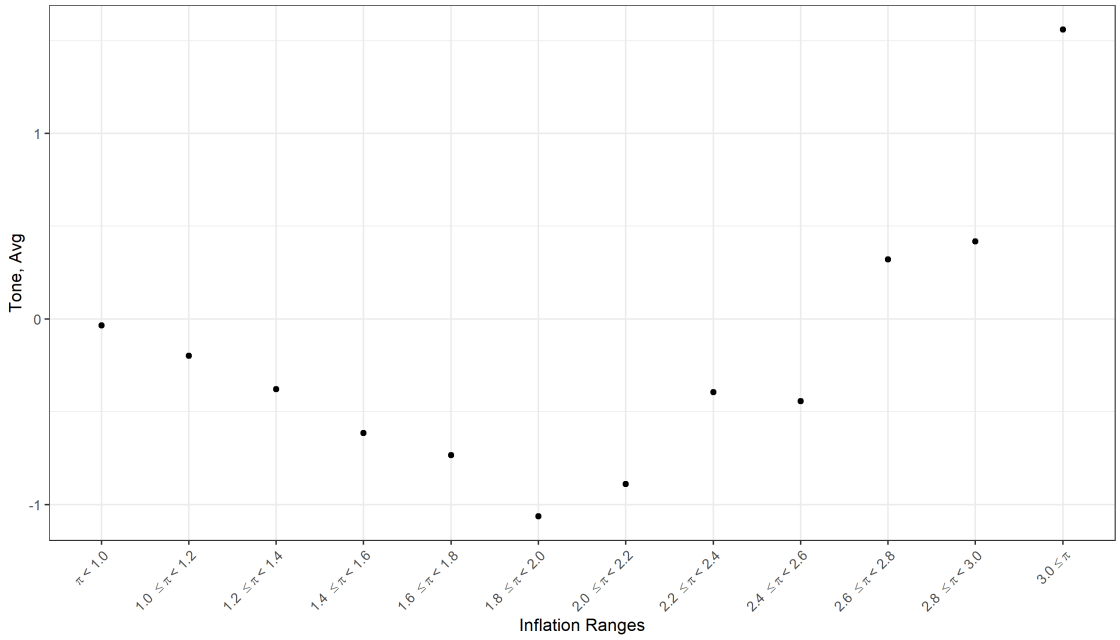

Figure 1: Non-parametric estimate of loss function. Using the inflation ranges on the x-axis, we calculate the mean tone (net negativity) in each inflation bracket and report it on the y-axis. The tone index is computed with the lexicon-based method applied to the whole introductory statement texts. Inflation is measured as the average of real-time estimates of current inflation and inflation lagged by one month.

We find strong evidence of asymmetry. Specifically, the loss function reveals a greater aversion to inflation above the inflation aim than below it. This result is illustrated in Figure 1 which shows a simple non-parametric estimate of the loss function. Our finding of asymmetric preferences is robust to the choice of control variables, to the measure of

inflation (the latest inflation observation, the average of the two latest observations, the average of current inflation and one-quarter-ahead forecast), to the choice of the text (whole introductory statements or inflation-focusing segments), to the choice of the tone measure (based on the ECB-specific dictionary or FinBERT language model; additionally we apply the Economic Outlook Index of Picault and Renault (2017)), to the choice of the loss function (piecewise linear i.e. V-shaped or a linear-exponential i.e. U-shaped) or to the choice of the data frequency (meeting based or quarterly frequency), and time periods (whole sample; excluding the ELB period; starting the sample from May 2003[5]). Moreover, our results suggest that the departure from symmetry is sizeable: the slope of the (V-shaped) loss function is roughly three times steeper when inflation is above the target than when it is below the target. Finally, we analyse separately forward-looking and backward-looking statements and find support for asymmetry in both cases.

As a part of the empirical exercise, we also estimate the *de facto* inflation target. Here the different methods give rise to slightly different results. The lexicon-based approach indicates that the *de facto* target was 1.9% or 2.0%, but the FinBERT-based estimates suggest a somewhat lower *de facto* target, perhaps 1.7% or even lower.

Our analysis is most closely related to Shapiro and Wilson (2022). However, there are some notable differences. First, given the dual mandate of the Fed, the possible asymmetry of the loss function is not the main focus in Shapiro and Wilson (2022). The paper is more geared towards estimating the Fed's *de facto* inflation target (until January 2012 the Fed had no official numerical target) and understanding its preferences with respect to developments in the real economy and financial markets. Interestingly, however, Shapiro and Wilson (2022) find some, albeit rather weak, evidence suggesting asymmetric preferences: the Fed may have been more averse to low inflation than to high inflation. Clearly, this is the opposite of what we find for the ECB. Second, our proxy for the ECB tone reflects official communication at the time of monetary policy decision making, while the tone in Shapiro and Wilson (2022),

[5]In May 2003, the Governing Council clarified its definition of price stability.

which also reflects the sentiment of policy makers in monetary policy meetings, is published with a delay. Finally, while Shapiro and Wilson (2022) apply a lexicon-based approach, we also extend our analysis by using the FinBERT language model.

We extend the literature that applies text mining techniques to analyse the ECB's communication. Many studies in this literature focus on introductory statements and Q&A sessions at the ECB's press conferences (see e.g. Ehrmann and Fratzscher (2009), Picault and Renault (2017), Schmeling and Wagner (2019), Ehrmann and Talmi (2020), Baranowski et al. (2021), Pavelkova (2022), Angino and Robitu (2023), Byrne et al. (2023b) and Klejdysz and Lumsdaine (2023))[6], but there are also papers examining other forms of ECB communication, such as speeches by the ECB President and Governing Council members, and hearings at the European Parliament (see for example Tillmann and Walter (2019), Bennani, Fanta, et al. (2020), Fraccaroli et al. (2022), Byrne et al. (2023a) and Fraccaroli et al. (2023)).[7] In addition, there are studies on the coverage of the ECB's monetary policy in print media (Berger et al. (2011)) and social media (Ehrmann and Wabitsch (2022)). Issues analysed in this literature include e.g. the semantic properties and the information content of the ECB's communication, as well as market reactions to central bank announcements. However, none of these papers study the ECB's loss function.[8]

The potential asymmetry of the ECB's monetary policy has already been subject to a few studies. Based on the traditional interest rate reaction function estimations, Hartmann and Smets (2018), Rostagno et al. (2021), Paloviita et al. (2021), and Maih et al. (2021) find some evidence of asymmetry. In particular, Hartmann and Smets (2018) find that the ECB has increased interest rates in response to high expected inflation, while decreasing interest rates in response to weak expected growth. Rostagno et al. (2021) and Paloviita et al. (2021) find that the ECB reacted more strongly to inflation above 2% than below 2%. However, they

[6]The first text analysis-based studies of the ECB introductory statements was based on human coding (Rosa and Verga (2007)).

[7]See also Marozzi (2021) for an econometric framework for nowcasting the ECB press conferences.

[8]For the vast text analysis -based literature on communication of other central banks, see for example S. Hansen and McMahon (2016), Armelius et al. (2020), Jones et al. (2020), Hubert and Labondance (2021), Gardner et al. (2022), Gorodnichenko et al. (2023), Kocherlakota (2023), and Gáti and Handlan (2024).

conclude that distinguishing this finding from symmetric policy responses around a lower inflation target is difficult. Maih et al. (2021) argue that the ECB's monetary policy was asymmetric until mid-2014, but symmetric thereafter, i.e. during the ELB period when policy was conducted through non-standard measures. While the earlier literature has analysed the potential asymmetry of the ECB's policy reactions, we investigate the potential asymmetry of its loss function. Due to factors such as the ELB, as well as possible non-linearities in economic relationships, a symmetric (asymmetric) loss function does not necessarily imply symmetric (asymmetric) policy reactions, and vice versa (see e.g. Nakov (2009), Benigno and Rossi (2021)).[9]

The rest of the paper is organised as follows. Section 2 describes methodology and data and presents the sentiment indicators. Section 3 discusses estimation of the loss functions and the results. Section 4 concludes.

2 Methodology and data

To assess the preferences of the ECB Governing Council, we extract the tone (sentiment) from the ECB's introductory statements using text analysis. These statements concisely summarise the real time economic outlook, which is then used to motivate an appropriate monetary policy stance. Unlike individual governors' speeches and other forms of the ECB's qualitative communication, however, they reflect views of all Governing Council members at the time policy decisions are made. We have gathered press conference texts from the ECB's website[10] using automated web scraping. Our sample covers the period from January 1999

[9]Using a reaction function based approach, Surico (2003) estimates a (potentially) asymmetric Linex loss function for the ECB and Surico (2007) for the Federal Reserve. The same approach is applied for Australia and New Zealand by Karagedikli and Lees (2007), and for the UK and Canada by Caglayan et al. (2016). Capistrán (2008) exploits the biases in the Federal Reserve's forecasts and links them to possible asymmetries in the Federal Reserve's preferences. All of these studies postulate that economic relationships (other than the central bank loss function, and the optimal-policy-implied reaction function) can be described by (variants of) a linearised NK model (with no ELB constraint).

[10]`https://www.ecb.europa.eu/press/pressconf/html/index.en.html`

to June 2021.[11]

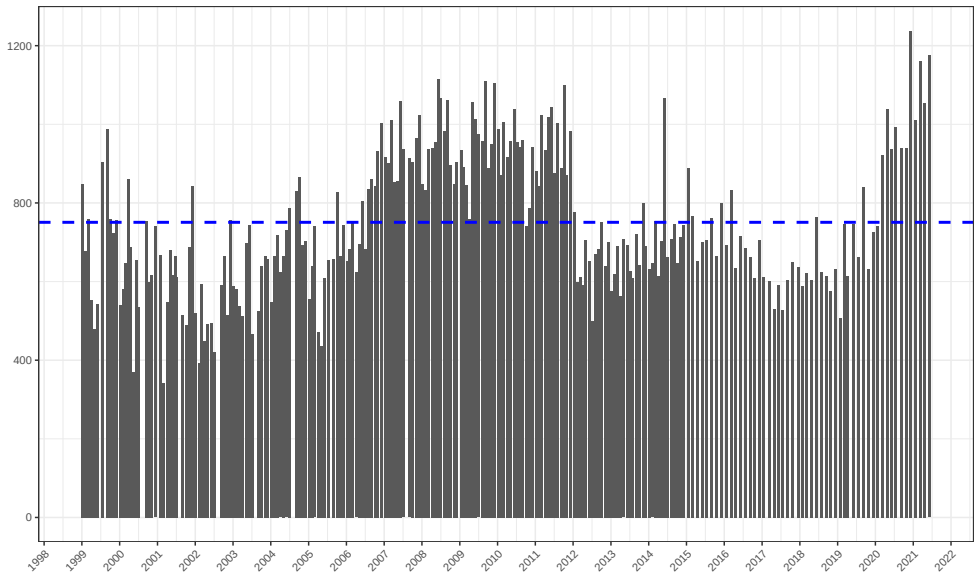

Figure 2: Number of words in each introductory statement and average of words (blue line)

We pre-process the data using common practices in text analysis. To reduce noise, we merge some common word sequences into single terms (e.g., 'european central bank', 'governing council', 'price stability', 'pass through') and delete paragraphs of less than 10 words. These short paragraphs mainly include only general expressions and thus do not concern economic analysis. We also delete first paragraphs of each introductory statement, as they represent greetings ('Ladies and gentlemen...').[12] Finally, we remove stop words. Figure 2 reports the number of words in each pre-processed introductory statement.

2.1 Topic modelling: Identifying inflation texts

Since the focus of the paper is on inflation, we pay special attention to the segments of the introductory statements which discuss inflation. To identify these segments, we apply

[11]From the beginning of the sample, until December 2014, the Governing Council had a monetary policy meeting every month, but after that the Governing Council has made monetary policy decisions eight times a year. In July 2021, the Governing Council redefined their inflation aim.

[12]The introductory statement from February 7, 2002 includes two paragraphs celebrating the 10 years of the Maastricht Treaty, while the introductory statement from October 6, 2011 includes a welcoming address by Jens Weidmann, marking the last meeting presided over by Jean-Claude Trichet. Also these segments have been removed.

topic modelling. Roughly speaking, the main idea of topic modelling is that segments of text that share the same vocabulary are likely to belong to the same topic. Specifically, we extract paragraphs from the introductory statements related to inflation using Latent Dirichlet Allocation (LDA), as introduced by Blei et al. (2003).[13] LDA is a hierarchical Bayesian model for dimensionality reduction that summarizes documents as a mixture of topics and topics as a mixture of words. The basic idea of LDA is to define a probability for each word in a corpus of being generated from a specific topic and to define each document as a distribution over a collection of topics. As a result, each word w in a document d is allocated into a topic k based on the topics present in the document. The allocation is determined by how frequently the word w appears in a particular topic k. LDA model assumes exchangeability and thus is a bag-of-words method. One benefit of using such unsupervised clustering for topic classification is the reduction in manual work as documents do not need to be read by humans. Although LDA, as a Bayesian model, requires subjective decisions when defining priors, it still reduces subjectivity compared to manual classification, as it does not predefine which words describe each topic.[14]

We set the total number of topics to 8. Figure 3 shows the topics identified by LDA, and lists the 10 most common words within each topic. We choose topics #3 and #6 as inflation texts. In both topics, 'inflation' is the second most common word. In addition, 'price stability' and 'medium term' are among the most common words and expressions in topic #3, whereas 'price' and 'hicp' are among the top 10 words in topic #6.

In our topic modelling exercise, we treat each paragraph as a separate document. LDA assigns a probability that a paragraph belongs to topic j=1,2,...,8. If the probability assigned to topic i is greater than the probability assigned to any other topic, we say that the

[13]LDA has recently become a common technique to cluster text data among authors examining central bank communication. Using LDA, Hartmann and Smets (2018) find 50 separate topics in the ECB's speeches over time, while Tobback et al. (2017) utilise LDA to extract topics in the news articles concerning the ECB's press conferences. More recently, Edison and Carcel (2020) employ LDA to the FOMC transcripts in order to examine the evolution of topics over time, whereas S. Hansen, McMahon, and Tong (2019) use LDA to identify main topics in the Bank of England's Inflation Report.

[14]We use Gibbs sampling method and set the hyperparameters α and β, controlling the distribution of topics per document, and the distribution of words per topic, to 0.05.

paragraph belongs to topic i. Figure 4 shows the share of inflation texts (i.e. paragraphs assigned to topics #3 and #6) in each introductory statement. See Appendix F for examples of introductory statements with inflation-focused paragraphs identified through topic modelling.

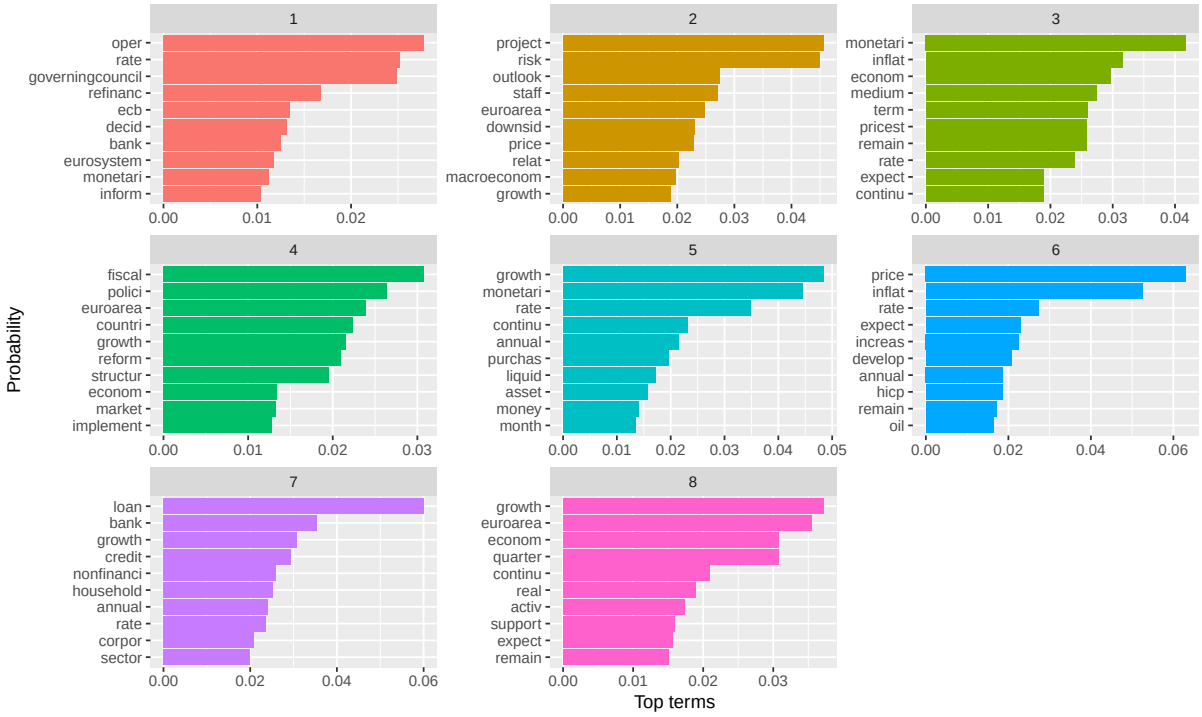

Figure 3: Topics discovered by LDA

2.2 Lexicon-based sentiment analysis

The introductory statements are carefully structured and drafted documents that use central bank specific language and expressions. Since they are largely based on repeated words and phrases from statement to statement (Klejdysz and Lumsdaine (2023)), experts and financial market participants focus on changes in individual words and expressions (Ehrmann and Talmi (2020)).[15]

[15]Issing (2019) notes that the words 'vigilant' and 'alert' are synonyms in English. However, when the word 'vigilant' was replaced with 'alert' in the introductory statement, the Governing Council was no longer 'vigilant', but 'only alert' according to some interpretations in the media.

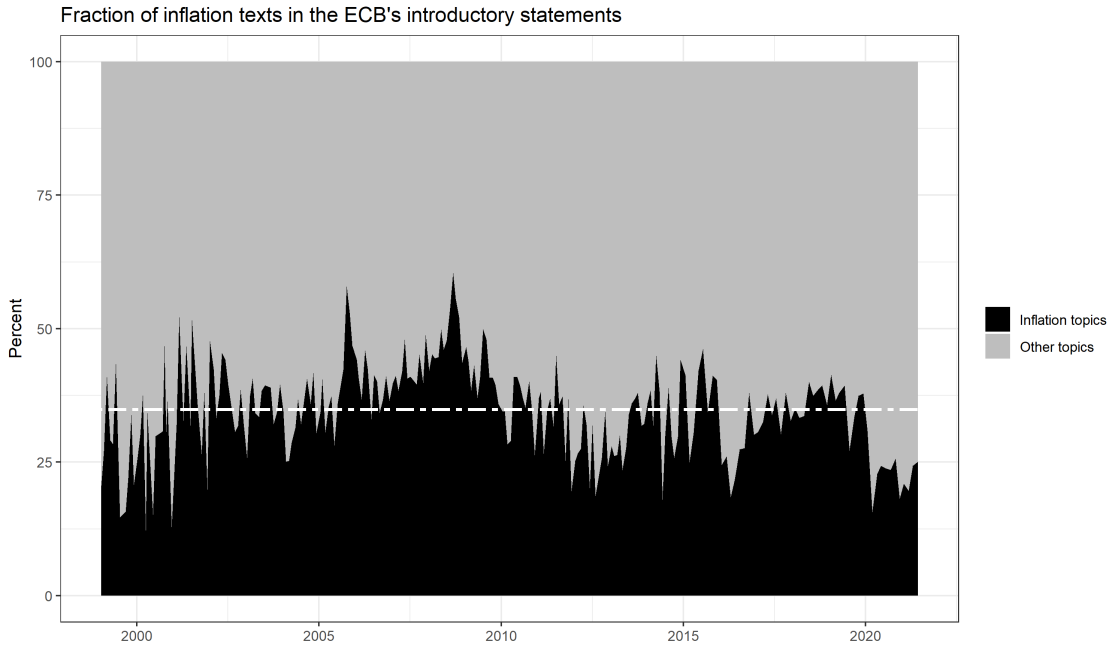

Figure 4: Fraction of inflation texts and average fraction (white)

We employ polarity classification, categorising words into three classes (negative, positive, and neutral) based on their sentiment. For this classification, we utilise the finance dictionary developed by Loughran and McDonald (2011) (L&M)[16], but with several modifications. First, recognising the use of British English in the ECB's monetary policy communication, we adapt the American English L&M (2011) dictionary accordingly. The added sentiment words with British English spelling are detailed in Appendix B, Table B.1. Secondly, we identify the most common positive and negative sentiment words in our corpus. By conducting a human audit of text segments containing these words, we remove certain sentiment words from the L&M (2011) dictionary (see Table B.2 in the Appendix B). Typically, the words we eliminate are technical terms in the ECB's communication. For instance, 'stability' and 'efficiency,' classified as positive in the L&M (2011) dictionary, and 'lag' and 'downward,' classified as negative, are reclassified as neutral. Thirdly, we compile the most common bigrams and trigrams that include at least one sentiment word from the L&M (2011) dictionary.

[16]For example Schmeling and Wagner (2019), Tillmann and Walter (2019), Baranowski et al. (2021), and Shapiro and Wilson (2022) have utilised the Loughran and McDonald (2011) dictionary to analyse central bank communication.

We classify these combinations as positive, negative, or neutral (see Tables B.3 and B.4). It is important to note that the same sentiment word may contribute to both positive and negative bigrams or trigrams, such as 'greater confidence' (positive) and 'greater uncertainty' (negative). Additionally, a sentiment word reclassified as neutral in step two may still be part of a positive or negative bigram or trigram. Fourthly, we compare the results from the dictionary-based approach to those based on the FinBERT language model[17], specifically searching for text segments where the two methods yield different outcomes. This cross-checking, along with our own reading of the texts, leads us to include additional sentiment words in the dictionary, as shown in Table B.5. Examples of these additions are positive sentiment words 'ample', 'robust,' and 'buoyant' and negative words 'disequilibrium,' 'tensions,' and 'contracted'. In particular, the word 'ample' is among the three most common positive sentiment words in our corpus.[18] See Figures D.5 and D.6 in Appendix D for lists of the most common tone words and their frequencies, and Table D.1 for information on the incidence of positive and negative tone words in the whole introductory statements and the inflation focusing segments.

Furthermore, although it is relatively complicated to account for the grammatical relations of terms in a lexicon-based classification, we still consider negations, as their impact on the overall tone may be significant. Since it is reasonable to assume that central banks do not announce good news via negative expressions combined with negations, e.g., 'confidence has not deteriorated', but instead bad news may be softened by expressing negative messages using positive words ('confidence has not improved'), we take into account only negations followed by positive words as suggested by L&M (2011). To handle negations, we treat each sentence separately. If a sentence contains a negation followed by a positive

[17]See Section 2.3 for FinBERT based analysis.

[18]In our corpus and inflation segments, 'ample' and 'robust' rank within the top five positive words, while 'tensions' is among the top four negative ones. The term 'ample' appears frequently in discussions about both the overall economy and specifically in the context of inflation, where it is commonly associated with liquidity. On the other hand, 'robust' is predominantly used in the context of the overall economy and is often linked to strong economic growth. Lastly, 'tensions' are typically mentioned in texts that focus on financial markets, particularly in discussions related to market volatility or geopolitical uncertainties.

word within three words, the sentiment of the word is reversed into negative, following the suggestion of L&M (2011). Sentences containing 'not only' and 'not least' are excluded from this step. These combined additions and changes to the L&M (2011) dictionary form our new ECB-specific dictionary, which we hope will be useful for other researchers as well.[19]

Following these modifications, we tally the occurrences of negative and positive words, bigrams, and trigrams in each introductory statement. We also conduct this counting specifically within the inflation-focusing segments within each introductory statement. In this analysis, each positive or negative bigram or trigram is treated as a single expression. Consequently, a positive (negative) bigram or trigram carries the same weight as an individual positive (negative) tone word. See Appendix F for examples of scored introductory statement texts.

We define the tone as the difference between the number of negative ($\#Neg$) and positive words ($\#Pos$), normalized by the total number of words in the introductory statement ($\#Tot$). We use the tone as a proxy for loss to measure negativity when estimating loss functions. Consequently, the measured tone index gets larger values as negative sentiment increases, corresponding to a net negativity percentage of the total corpus. More specifically, we follow Shapiro and Wilson (2022) and determine the general tone index as

$$N_t = \frac{\#Neg_t - \#Pos_t}{\#Tot_t}. \tag{1}$$

Similarly, we define the tone index for inflation texts as

$$N_t^{\pi} = \frac{\#Neg_t^{\pi} - \#Pos_t^{\pi}}{\#Tot_t^{\pi}}, \tag{2}$$

[19] A number of central bank specific dictionaries have been presented in the literature. In particular, Picault and Renault (2017) compile a lexicon to measure the sentiment of the ECB's introductory statements, Gardner et al. (2022) present a lexicon to compute a sentiment index for the FOMC, while Correa et al. (2021) develop a dictionary to gauge the sentiment in 35 central banks' financial stability reports. In addition, there are dictionaries which measure other dimensions of central bank communication, such as monetary policy stance, or the hawkish-dovish dimension (Apel and Blix Grimaldi ((2012), (2014)), Bennani and Neuenkirch (2017), Picault and Renault (2017)), and the degree of uncertainty (Cieslak et al. (2023)). In robustness checks, we apply the Economic Outlook Index of Picault and Renault (2017), to proxy the tone of the ECB's introductory statements.

where $\#Neg^{\pi}$ is the number of negative words, $\#Pos^{\pi}$ is the number of positive words, and $\#Tot^{\pi}$ is the total number of words in the inflation-focusing part of the introductory statement. Finally, the contribution of inflation texts to the general tone is

$$C_t^{\pi} = \frac{\#Neg_t^{\pi} - \#Pos_t^{\pi}}{\#Tot_t} = S_t^{\pi} \times N_t^{\pi}, \tag{3}$$

where $S_t^{\pi} = \#Tot_t^{\pi}/\#Tot_t$ is the share of the inflation texts in the introductory statement. The contribution of non-inflation texts is $C_t^{\neg\pi} = N_t - C_t^{\pi}$.

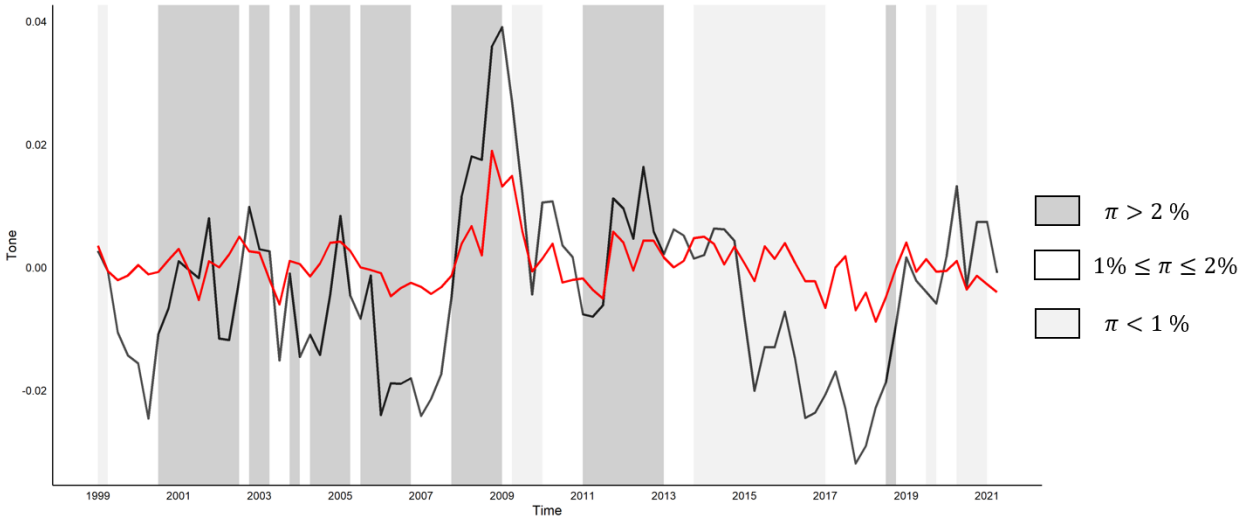

Figure 5: Quarterly whole text tone (black) and inflation text contribution (red).
Note: π denotes inflation.

Figures 5 and 6 show the evolution of the general tone, i.e. net negativity in the introductory statements of the ECB, and the tone based on inflation texts. For clarity, the tone indices have been aggregated to the quarterly level. Figures D.1 and D.2 in Appendix D show the corresponding meeting-based time series. Broadly speaking, the net negativity in the ECB's introductory statements gradually decreased in the pre-financial crisis years, and the tone was remarkably positive in 2006 and 2007. Notably, in 2007, euro area inflation was 'below, but close to, 2%', hovering between 1.5% and 2.0%. See a scored introductory statement from March 2007 in Appendix F. As expected, the financial crisis contributed to a huge increase in the net negativity. Interestingly, a close reading of the scored introductory

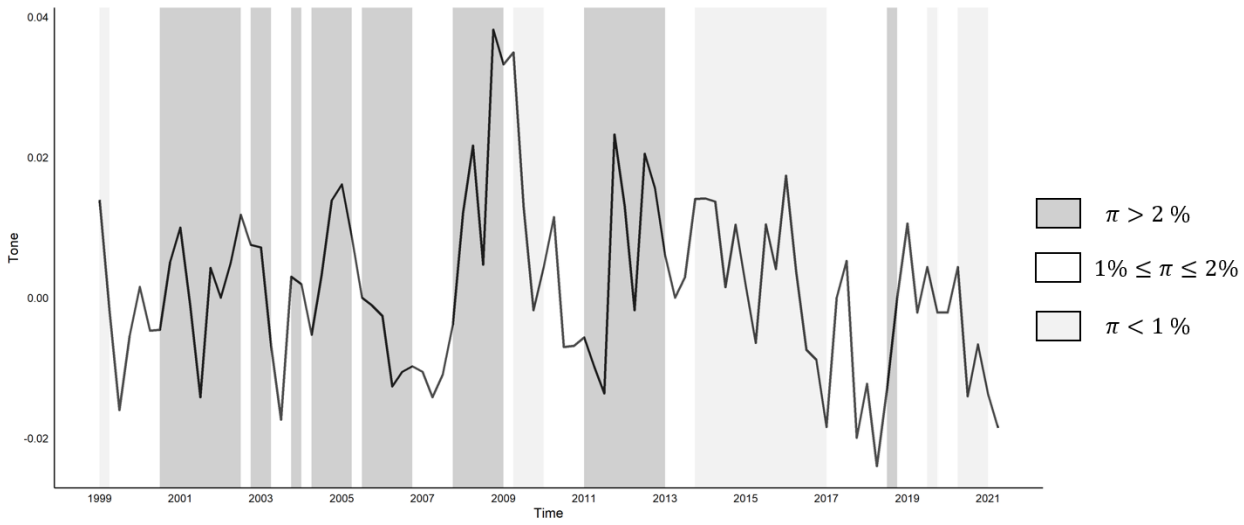

Figure 6: Quarterly inflation text tone. Note: π denotes inflation.

statement texts indicates that in the early stages of the financial crisis, the ECB's dissatisfaction stemmed largely from the high euro area inflation at the time, mainly due to soaring energy and commodity prices. See scored introductory statements from September 2008 and October 2008. When the financial crisis truly landed in the euro area, disinflation became a major cause of concern for the ECB. See scored introductory statement from May 2009. Consistent with this view, inflation texts contribute significantly to the general tone during the years 2008 and 2009 (Figure 5). In the post-financial crisis years, a gradual decrease in the net negativity is observed until 2017Q4, and it is noteworthy that the ECB was relatively content during a period of low inflation, well below 2%, in the years 2015 and 2016. Inflation texts from this period are quite terse (Figure 4), and their tone is mostly rather neutral (Figure 6). Consequently, inflation texts make only a modest contribution to the general tone (Figure 5). See scored introductory statements from April 2015 and July 2016. Towards the end of the sample, the general tone becomes more negative again, reflecting, for example, the COVID-19 pandemic. Overall, a casual inspection of Figures 5 and 6 suggests that the ECB was perhaps in general more unsatisfied when inflation was above 2% (dark grey areas) than when inflation was below 2% (white and light grey areas). See also Figure 1 in the Introduction.

2.3 Sentiment analysis with FinBERT language model

As an alternative to lexicon-based sentiment analysis, we apply *FinBERT*, short for *Financial BERT*, a language model created by Araci (2019)[20]. We employ FinBERT to generate context-aware tone indices for ECB introductory statements, as well as for text segments focusing on inflation within these statements. FinBERT has been previously utilised in central bank-related communication research by Gorodnichenko et al. (2023), among others. FinBERT is designed for sentiment analysis, predicting the classification of text in a probabilistic manner. It assesses the probability that the tone of the text is positive, negative, or neutral.

FinBERT builds on the *Bidirectional Encoder Representation model*, or *BERT* introduced by Devlin et al. (2018). BERT is bidirectional, using both the left and right sides of words to capture the context of a specific word in a sentence. The BERT model was pre-trained on the Toronto BookCorpus (800 million words) and English Wikipedia (2,500 million words). Devlin et al. (2018) introduced two BERT models: BERT-Large, with a total of 340 million parameters, and BERT-Base, with 110 million parameters. FinBERT utilises the smaller BERT-Base-Uncased model, which has 12 layers, 768 hidden units, 12 heads, and 110 million parameters (Araci (2019)). It is further pre-trained with Thomson Reuters (TRC2) financial news corpus comprising 1,800,370 news stories from January 1, 2008, to February 28, 2009, and fine-tuned with the Financial PhraseBank dataset from Malo et al. (2014), who classified English language financial news sentences into 'positive', 'negative' or 'neutral'.

For an applied researcher, perhaps one drawback of FinBERT (and other language models) is its relative opaqueness, which contrasts with the simplicity and transparency of the lexicon-based approach presented in Section 2.2. To facilitate the comparison of results from the two methods, we apply the FinBERT model at the level of individual paragraphs, so that FinBERT assigns the probability of each paragraph being positive, negative, or neutral.

[20] An alternative FinBERT model with different pre-training data has been developed by Huang et al. (2023).

Then in the scored example texts in Appendix F, one can see the probabilistic classification done by FinBERT for each paragraph, and compare it to the highlighted positive and negative tone words in the paragraph, identified by the lexicon-based method. Scored introductory statements from September 2003, October 2013 and December 2015 are examples where the differences between the two methods appear to be rather small. Conversely, scored introductory statements from July 2004, January 2009 and January 2019 are examples with more significant differences between the methods. Also, as we mentioned in Section 2.2, our reading of the scored text, and the crosschecking of the lexicon-based sentiments and the FinBERT-based classifications, prompted us to add some new words to our modified L&M (2011) dictionary.

To move from the level of individual paragraphs to the level of entire introductory statements, or inflation-specific segments with an introductory statement, we weight each paragraph according to its length. Hence the weight of paragraph i in introductory statement text t is $\omega_i = \#i/\#Tot_t$, where $\#i$ represents the number of words in paragraph i, and $\#Tot_t$ represents the total number of words in the introductory statement. Then our measure of FinBERT-based tone for introductory statement t is

$$N_t^{FB} = \sum_i \omega_i \left[Pr(Neg_i) - Pr(Pos_i)\right], \tag{4}$$

where $Pr(Neg_i)$ is the probability assigned by FinBERT that paragraph i has a negative sentiment while $Pr(Pos_i)$ is the corresponding probability that the paragraph has a positive sentiment. Likewise our measure for FinBERT-based tone in inflation-focusing segments within introductory statement t is given by

$$N_t^{FB,\pi} = \sum_{i^\pi} \omega_i^\pi \left[Pr(Neg_i^\pi) - Pr(Pos_i^\pi)\right], \tag{5}$$

with the same notation as in equation (4), but applied to paragraphs within inflation texts, identified by LDA method as explained in section 2.1.

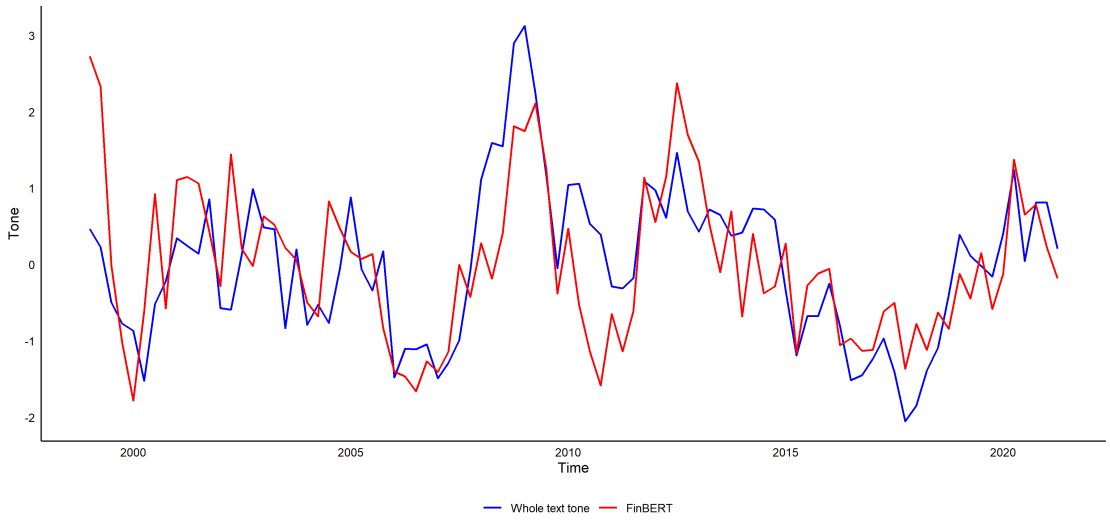

Figure 7: Quarterly whole text tone and FinBERT whole text tone

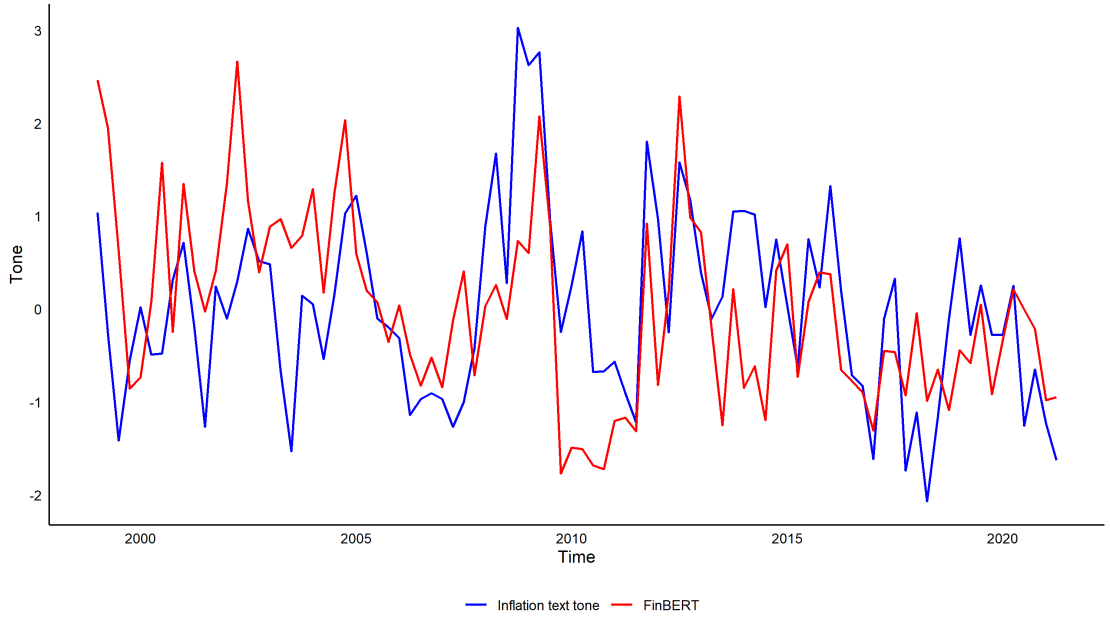

Figure 8: Quarterly inflation text tone and FinBERT inflation text tone

Figure 7 shows the FinBERT-based tone index for the whole introductory statements, together with the lexicon-based tone index for the whole texts. To facilitate comparison, both index series have been standardised, so that the standardised series have the same variance (unity) and the same mean (zero). From the figure one can see that both tone indices give a roughly similar picture of how the sentiment of ECB's introductory statements has

evolved over time. Figure 8 shows the FinBERT-based tone index and the lexicon-based tone index for the inflation texts. These series have also been similarly standardised. Here the differences between the FinBERT-based and the lexicon-based series are more marked, but the main contours are still rather similar. For clarity, the sentiment indices in Figures 7 and 8 have been aggregated to the quarterly level. The corresponding meeting-based time series are shown in Figures D.3 and D.4 in Appendix D.

3 Estimation of loss functions

We estimate the parameters of a loss function directly by linking the tone in the central bank communication to deviations of inflation from a *de facto* inflation aim. We focus on inflation as a key determinant of the loss, but we also control for measures of real time economic indicators, financial market variables and economic uncertainty measures as additional potential determinants of the loss.

In the first step, we estimate piecewise linear specifications of the loss function. While piecewise linear functions are statistically less demanding to use for capturing possible asymmetries, the caveat is that they do not allow for convexity in the preferences; the loss increases linearly with respect to a distance from, say, an inflation target. Therefore, in the second step we estimate linear-exponential (i.e., Linex) loss functions which nest both quadratic and asymmetric U-shaped preferences.

3.1 Piecewise linear loss function

Referring to Figure 1, we initially assume a V-shaped, piecewise linear loss function. This aligns with the concept that the central bank prefers to maintain inflation close to its target by minimizing the deviation between actual inflation and the targeted level, subject to some constraints and trade-offs. A V-shaped loss function is not restricted to being symmetric, unlike a quadratic loss function, which is a typical (but not necessarily the most realistic)

assumption in traditional models of central bank preferences and optimal monetary policy (see e.g. Woodford (2003), Walsh (2003), and Galí (2015)).

We begin with a short-run loss function expressed as follows:

$$L_t = |\pi_t - \pi^*| . \tag{6}$$

Hence, the central bank's loss depends on the inflation gap, defined as the difference between inflation π_t and the inflation target π^*. The loss function (6) is symmetric, indicating that the central bank equally dislikes deviations of inflation below and above the target. Following Shapiro and Wilson (2022), we approximate the central bank's loss using the tone, assuming an affine relationship between the tone and the central bank's loss function, expressed as $N = \alpha + \delta L$.[21] As previously mentioned, the tone N measures net negativity in the introductory statements of the ECB's press conferences. We relate the tone to inflation as follows:

$$N_t = \alpha + \delta |\pi_t - \pi^*| + \varepsilon_t, \tag{7}$$

where ε_t is a residual term.

Next, we split the piecewise linear loss function into two separate segments using a dummy variable. The dummy D_t is equal to zero if the real-time estimate of inflation is below the inflation aim of the central bank (i.e., when the inflation gap is negative). Conversely, the dummy D_t is equal to one if the real-time estimate of the inflation rate is above the central bank's target (i.e., when the inflation gap is positive). This leads to a more general loss function:

$$N_t = \alpha + \delta_B (\pi_t - \pi^*) (1 - D_t) + \delta_A (\pi_t - \pi^*) D_t + \varepsilon_t. \tag{8}$$

The formulation (8) allows for asymmetric central bank preferences with respect to high and

[21] Parameter α is a regression constant, but it can be thought of capturing any possible systematic direction/bias of the measured tone over the sample. Such a systematic direction in the tone could reflect e.g. long-lasting deviations of inflation from the target or other biases in communication.

low inflation. Note that a constraint on the parameters δ_B and δ_A, such that $\delta_B + \delta_A = 0$, restores the symmetric specification (7). Hence, (8) nests (7). We also add real-time explanatory variables, in addition to inflation, on the right-hand side of (8), resulting in the most general form of the loss function:

$$N_t = \alpha + \delta_B \left(\pi_t - \pi^*\right)\left(1 - D_t\right) + \delta_A \left(\pi_t - \pi^*\right) D_t + \boldsymbol{\beta'} \boldsymbol{z_t} + \varepsilon_t, \tag{9}$$

where $\boldsymbol{z_t}$ is a vector of control variables, and $\boldsymbol{\beta}$ is a vector of corresponding coefficients.

In order to measure real-time inflation observed at the time of decision-making by the Governing Council, π_t is defined as the latest monthly euro area HICP inflation rate published by Eurostat that has been available at the time of each monetary policy meeting. Typically, this refers to the flash estimate of the previous month. We evaluate the validity of our findings by using similarly real time economic indicators (euro area industrial production and unemployment rate) and financial market variables (spreads of 6-month Euribor swaps and euro area corporate bond yields over euro area government bond yields, or 'swapspread' and 'corpspread', respectively) as control variables. To proxy uncertainty, we use the Economic Policy Uncertainty (EPU) index constructed by Baker et al. (2016). The financial market variables and the uncertainty index are not available for the early part of our sample and because of this, we lose 13 out of 238 observations (i.e. Governing Council meetings) when we include them as control variables. In performing robustness checks in Section 3.3, we consider a wider set of control variables and also variables of quarterly frequency. See Appendix C for a detailed description of all the variables used and their sources.

Tables 1-4 report estimation results for the alternative sentiment indices described in Section 2. In Tables 1 and 2 the dependent variable is a lexicon-based tone, utilising whole introductory statements (Table 1), and inflation-focusing segments within the introductory statements (Table 2). In Tables 3 and 4 the dependent variable is a FinBERT-based tone, utilising whole introductory statements (Table 3), and inflation-focusing segments within the introductory statements (Table 4). As a simple symmetric benchmark, column (1) in each

of these tables reports the estimation results based on equation (7). The remaining columns display results from estimating the (potentially) asymmetric loss function of equations (8) and (9). Column (2) is a specification with no control variables (i.e. equation (8)), column (3) includes macro controls, and column (4) adds financial market variables as well as the measure of economic uncertainty.

In each specification, we estimate the *de facto* inflation target π^* by conducting a grid search for a piecewise linear Ordinary Least Squares (OLS) regression model. To obtain π^*, we first search for the best estimate by stepping through all possible values of π^* between 1% and 2.5% with a step size of 0.01 percentage points. Then we choose those specifications that minimise the sum of squared residuals (SSR) in equation (7), (8) or (9). (See Figure 9 and Figures D.14, D.16, and D.18 in Appendix D.) In Tables 1-3, the symmetric benchmark of column (1) gives a lower *de facto* target than any of the asymmetric specifications of columns (2)–(4), while in Table 4 the *de facto* target from the symmetric benchmark (1) is lower than the *de facto* target from the asymmetric specifications (2) and (3), and essentially on par with the *de facto* aim from specification (4). Notably, the *de facto* targets from all the symmetric specifications reported in Tables 1-4 are statistically significantly below 2.0%, according to a LR-test (see LR-test est vs fixed in Tables 1-4). When a FinBERT-based tone index is employed as the dependent variable (Tables 3 and 4), also the asymmetric specifications (columns (2)–(4)) give rise to *de facto* inflation target estimates which are below 2.0% in a statistically significant manner (ranging from 1.5% to 1.7% in Table 3 and from 1.0% to 1.4% in Table 4). By contrast, when the lexicon-based tone from whole introductory statements is employed, the *de facto* target π^* chosen by the SSR criterion is 2.0% in all the unrestricted, i.e., asymmetric specifications (Table 1). When the lexicon-based approach is applied to the inflation-focusing segments, the estimated *de facto* inflation target is 1.9% in all the asymmetric specifications, and this does not differ from 2.0% in a statistically significant manner (Table 2).

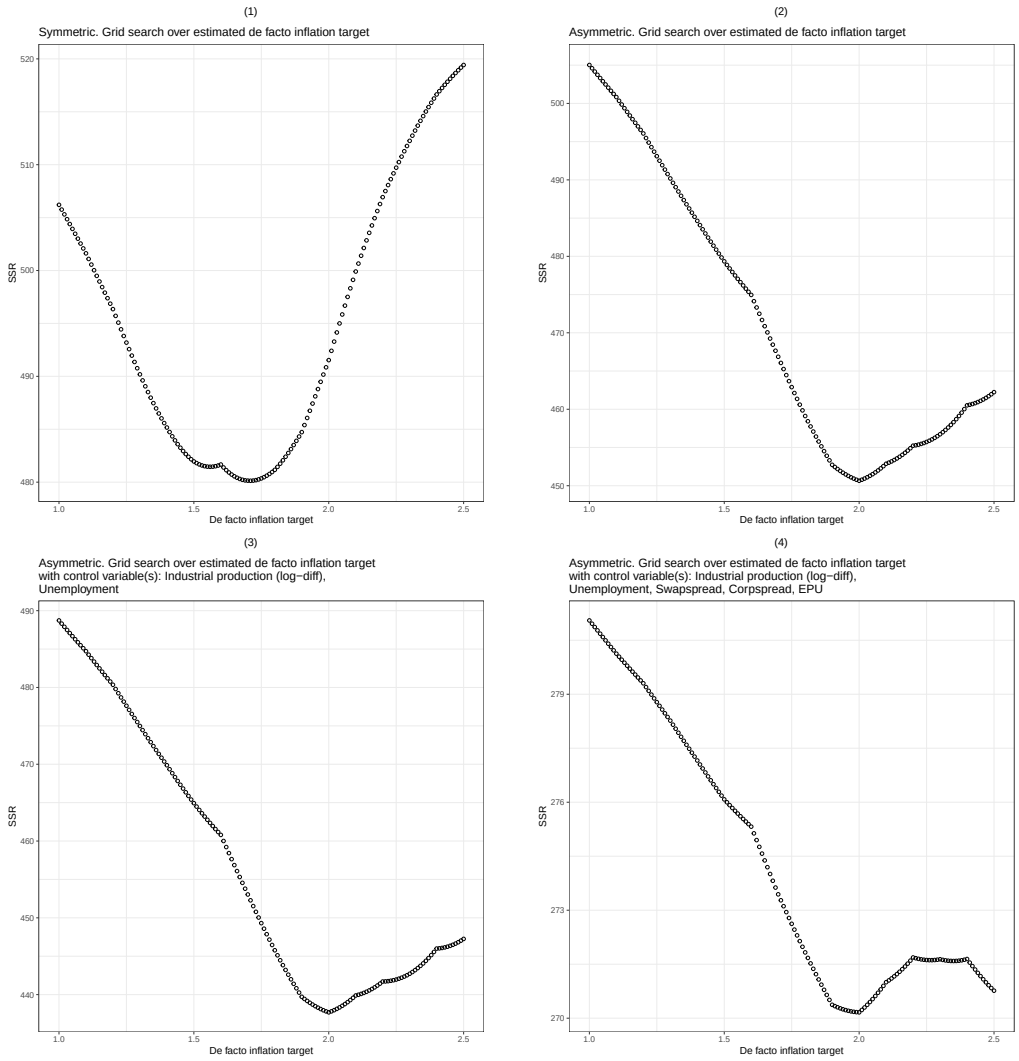

Figure 9: SSR results for columns (1) to (4) of Table 1

Table 1: Meeting based whole text tone

	Dependent variable:			
	Tone			
	Symmetric V		Asymmetric V	
	(1)	(2)	(3)	(4)
Inflation	0.771***			
Inflation below the target		−0.483***	−0.427***	−0.062
Inflation above the target		1.531***	1.579***	0.871***
Industrial production (log-diff)			−13.128**	−0.023
Unemployment			0.090	0.102
Swapspread				−0.346
Corpspread				0.761***
EPU				0.002
Constant	−0.861***	−0.876***	−1.689***	−3.083***
Observations	238	238	238	226
R^2	0.084	0.140	0.165	0.473
Adjusted R^2	0.080	0.133	0.150	0.456
Estimated inflation target	1.71	2.00	2.00	2.00
F-test symmetry p-value		6.401e-06***	2.073e-06***	6.836e-05***
LR-test p-value (asym vs. sym)		0.000***	3.731e-05***	0.001***
LR-test p-value (est vs. fixed)	0.018**	1.000	1.000	1.000
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 2: Meeting based inflation text tone

	Dependent variable:			
	Tone			
	Symmetric V		Asymmetric V	
	(1)	(2)	(3)	(4)
Inflation	0.557***			
Inflation below the target		−0.312**	−0.228	0.057
Inflation above the target		1.012***	1.088***	0.584***
Industrial production (log-diff)			−14.437***	−4.913
Unemployment			0.141**	0.378***
Swapspread				0.553**
Corpspread				0.671***
EPU				0.001
Constant	−0.198	−0.165	−1.452**	−4.463***
Observations	238	238	238	226
R^2	0.050	0.084	0.131	0.374
Adjusted R^2	0.046	0.076	0.116	0.353
Estimated inflation target	1.43	1.90	1.90	1.90
F-test symmetry p-value		0.000***	3.384e-05***	0.001***
LR-test p-value (asym vs. sym)		0.003***	0.001***	0.003***
LR-test p-value (est vs. fixed)	0.012**	0.380	0.371	0.547
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 3: Meeting based whole text FinBERT tone

	Dependent variable:			
	Tone			
	Symmetric V		Asymmetric V	
	(1)	(2)	(3)	(4)
Inflation	11.137***			
Inflation below the target		−6.210**	−4.595	−2.153
Inflation above the target		15.396***	17.306***	12.146***
Industrial production (log-diff)			−225.261**	−58.752
Unemployment			3.759***	4.433***
Swapspread				−0.232
Corpspread				9.281***
EPU				−0.014
Constant	−39.464***	−38.511***	−73.813***	−93.671***
Observations	238	238	238	226
R^2	0.055	0.068	0.124	0.300
Adjusted R^2	0.051	0.060	0.109	0.278
Estimated inflation target	1.42	1.70	1.66	1.40
F-test symmetry p-value		0.008***	0.000***	0.002***
LR-test p-value (asym vs. sym)		0.072*	0.013**	0.057*
LR-test p-value (est vs. fixed)	0.001***	0.088*	0.059*	0.024**
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 4: Meeting based inflation texts FinBERT tone

	Dependent variable:			
	Tone			
	Symmetric V		Asymmetric V	
	(1)	(2)	(3)	(4)
Inflation	11.437***			
Inflation below the target		−3.465	−2.575	−5.062
Inflation above the target		14.557***	16.046***	13.630***
Industrial production (log-diff)			−298.666*	−189.906
Unemployment			2.071	9.062***
Swapspread				25.671***
Corpspread				8.098***
EPU				−0.047
Constant	−38.297***	−36.071***	−55.892***	−123.501***
Observations	238	238	238	226
R^2	0.033	0.044	0.064	0.198
Adjusted R^2	0.029	0.036	0.047	0.172
Estimated inflation target	1.02	1.40	1.40	1.00
F-test symmetry p-value		0.033**	0.015**	0.200
LR-test p-value (asym vs. sym)		0.102	0.095*	0.593
LR-test p-value (est vs. fixed)	0.011**	0.054*	0.044**	0.089*
Note:				*p<0.1; **p<0.05; ***p<0.01

Based on the selected specifications (with π^* chosen through the SSR criterion), we report the estimation results in Tables 1-4. Using the F-test and the likelihood ratio (LR) test, we compare the empirical relevance of the unrestricted (asymmetric) and restricted (symmetric) specifications of the V-shaped loss function. In these comparisons, low p-values from the F-test and LR-test indicate that the null hypothesis of symmetry can be rejected, pointing to an asymmetric loss function. To be more specific, we test the restriction $\delta_B + \delta_A = 0$ with the F-test. The LR test pits the unrestricted asymmetric loss function (9), against the restricted symmetric loss function

$$N_t = \alpha + \delta \left| \pi_t - \pi^* \right| + \boldsymbol{\beta'} \boldsymbol{z_t} + \varepsilon_t \tag{10}$$

with the same control variables but allowing for a different estimated *de facto* inflation target π^* for the restricted and the unrestricted variant.

We get strong support for asymmetry from a vast majority of the specifications, with the tone computed a) applying the lexicon-based approach or the FinBERT language model, b) based on the entire introductory statements or the inflation-focusing text segments, and c) using different sets of control variables (Tables 1-4). First, in all specifications except one, the coefficient of inflation below the *de facto* target (π^*) is negative ($\delta_B < 0$) and the coefficient of inflation above the *de facto* target is positive ($\delta_A > 0$), consistent with a V-shaped loss function. The only exception is specification (4) in Table 2, where $\delta_A > 0$ but δ_B is essentially zero, meaning that the loss function is flat when inflation is below the *de facto* target ($\delta_B = 0.057$, which does not differ from zero in a statistically significant manner, while $\delta_A = 0.584$ differs from zero at the 1% level). Second, the slope of the right branch of the loss function is steeper than the slope of the left branch (i.e. $|\delta_A| > |\delta_B|$) in all the specifications, consistent with the notion that the ECB dislikes high inflation, above the *de facto* target, more than low inflation, below the target. Indeed, in most specifications, the absolute value of the slope is much larger above the *de facto* inflation target π^* than

below it: $|\delta_A|$ is typically roughly three times larger than $|\delta_B|$, but in some specifications it is four, five or even six times larger; furthermore — as noted above – there are specifications where the left branch is essentially flat. Third, the coefficient of inflation above the target (δ_A) is statistically significant at the 1% level in all the specifications, while the coefficient of inflation below the target (δ_B) is statistically significant in four specifications, and not significant in the remaining eight specifications. Fourth, the asymmetry of the loss function is statistically significant, according to the F-test and the LR-test, in a vast majority of the specifications. The only exception is specification (4) in Table 4, where asymmetry is not confirmed by the statistical tests. Note that the *de facto* inflation target π^* is very low (at 1.0%, i.e. at the lower bound of our grid search) in this specification (column 4 in Table 4). It is conceivable that the failure to find statistically significant support for asymmetry in this specification is related to the very low value of π^*.[22]

One may ask how the choice of the *de facto* target π^*, by the grid search, affects our results concerning the asymmetry of the loss function. To address this question, and to examine the robustness of our findings, we conduct a set of additional tests for (a)symmetry. We fix the *de facto* inflation target π^* to a given value, $\pi^* \in \{1.3, 1.4, ..., 2.0\}$, and estimate the remaining parameters of equation (9). Then we test the restriction $\delta_B + \delta_A = 0$. The p-values of the F-test, for different values of π^*, are reported in Tables 5-8. The column numbers (2), (3) and (4) in these tables refer to the specifications reported in the corresponding columns of Tables 1-4. These tables show that symmetry is rejected in all specifications when the *de facto* target $\pi^* \geq 1.6$. In many specifications, symmetry is rejected for all values of $\pi^* \in \{1.3, 1.4, ..., 2.0\}$. This is the case especially in estimations where a FinBERT-based tone is used as the dependent variable.

[22] In specification (4) of Table 4, the breakpoint of inflation that minimises SRR is 2.4%, see Figure D.18 in the Appendix. However, estimating the piece-wise linear equation (9) with $\pi^* = 2.4\%$, results in parameter estimates $\delta_B = 11.4$ and $\delta_A = -8.3$ implying an inverse V-shape, so that the putative loss function reaches its *maximum* when inflation is 2.4%. Evidently, this is not a plausible candidate for the ECB's *de facto* target. When we rule out breakpoints which give rise to an inverse V-shape, the *de facto* target that minimises SSR is 1.0%.

Table 5: Asymmetric estimations with meeting based whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	1.531***	-0.483***	6.401e-06***	1.579***	-0.427**	2.073e-06***	0.871***	-0.062	6.836e-05***
1.9	1.413***	-0.547***	6.292e-05***	1.461***	-0.493**	2.085e-05***	0.821***	-0.095	0.000***
1.8	1.271***	-0.591***	0.001***	1.323***	-0.537**	0.000***	0.750***	-0.110	0.000***
1.7	1.124***	-0.618***	0.010**	1.183***	-0.566**	0.003***	0.681***	-0.116	0.001***
1.6	0.978***	-0.627**	0.070*	1.041***	-0.576**	0.024**	0.608***	-0.110	0.004***
1.5	0.882***	-0.663**	0.259	0.948***	-0.615**	0.107	0.568***	-0.126	0.011**
1.4	0.785***	-0.685**	0.614	0.856***	-0.642**	0.312	0.524**	-0.132	0.026**
1.3	0.692***	-0.693**	0.994	0.768***	-0.660**	0.624	0.482**	-0.131	0.055*

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

Table 6: Asymmetric estimations with meeting based inflation text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	1.057***	-0.253	0.000***	1.134***	-0.169	1.310e-05***	0.593**	0.085	0.001***
1.9	1.012***	-0.312*	0.000***	1.088***	-0.228	3.384e-05***	0.584**	0.057	0.001***
1.8	0.931***	-0.352*	0.002***	1.012***	-0.269	0.000***	0.546**	0.047	0.001***
1.7	0.834***	-0.373*	0.011**	0.923***	-0.294	0.001***	0.498**	0.049	0.001***
1.6	0.734***	-0.380*	0.045**	0.828***	-0.304	0.005***	0.443**	0.065	0.002***
1.5	0.666***	-0.404*	0.139	0.764***	-0.333	0.021**	0.403*	0.077	0.004***
1.4	0.608***	-0.431*	0.327	0.711***	-0.366	0.070*	0.376*	0.083	0.007***
1.3	0.544***	-0.440*	0.582	0.652***	-0.386	0.177	0.343*	0.104	0.012**

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

Table 7: Asymmetric estimations with FinBERT meeting based whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	16.557***	-2.793	0.001***	18.571***	-0.684	2.477e-05***	10.778**	3.515	0.000***
1.9	16.624***	-4.056	0.001***	18.603***	-1.940	2.719e-05***	11.798**	2.469	6.755e-05***
1.8	16.111***	-5.161	0.002***	18.183***	-3.077	6.059e-05***	12.309***	1.494	5.144e-05***
1.7	15.396***	-6.210*	0.008***	17.639***	-4.207	0.000***	12.699***	0.427	6.581e-05***
1.6	14.378***	-7.036*	0.029**	16.730***	-5.115	0.001***	12.679***	-0.494	0.000***
1.5	13.422***	-7.874*	0.098*	15.844***	-6.041	0.005***	12.480***	-1.358	0.001***
1.4	12.282***	-8.422*	0.260	14.801***	-6.734	0.024**	12.146***	-2.153	0.002***
1.3	11.002***	-8.596*	0.503	13.621***	-7.117	0.080*	11.651***	-2.779	0.008***

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

Table 8: Asymmetric estimations with FinBERT meeting based inflation text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	8.518	5.798	0.021**	9.566	7.006	0.011**	4.726	9.644*	0.018**
1.9	10.813	4.389	0.009***	11.878	5.593	0.004***	7.489	8.416*	0.005***
1.8	12.330*	2.963	0.005***	13.467*	4.138	0.002***	9.415	7.195	0.002***
1.7	13.473*	1.380	0.005***	14.724*	2.498	0.002***	11.066*	5.744	0.002***
1.6	14.366**	-0.418	0.006***	15.702**	0.644	0.003***	12.441*	4.070	0.001***
1.5	14.796**	-2.174	0.013**	16.196**	-1.173	0.006***	13.263**	2.499	0.002***
1.4	14.557**	-3.465	0.033**	16.046**	-2.575	0.015**	13.601**	1.127	0.005***
1.3	13.770**	-4.109	0.075*	15.364**	-3.408	0.037**	13.562**	0.002	0.013**

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

The case where the tone is assessed with the FinBERT language model, utilising inflation-focusing text segments (Table 8), is somewhat different from the others. In this case, the coefficient estimate of inflation below the target (δ_B) is typically not statistically different from zero, and in many specifications the point estimate of δ_B is actually positive (whereas in a V-shaped loss function δ_B should be negative). Therefore, the results obtained from applying FinBERT to inflation texts may suggest the presence of a 'hockey stick' loss function, where the central bank is increasingly dissatisfied when inflation rises above the *de facto* target π^*, but relatively satisfied once inflation is below the target.

In summary, the analysis presented in Tables 5-8 also lends support to the notion that the loss function has been asymmetric, with the ECB displaying a stronger aversion to high inflation, above the target, compared to low inflation, below the target.

3.2 Linear exponential loss function

So far in the parametric estimations, we have assumed that the loss function has a V-shape. An alternative is to specify that the loss function is characterized by a symmetric or asymmetric U-shape. Next, we assume a linear-exponential (Linex) loss function such that

$$L_t = \frac{exp\left[\theta\left(\pi_t - \pi^*\right)\right] - \theta\left(\pi_t - \pi^*\right) - 1}{\theta^2}. \tag{11}$$

Here, the parameter θ captures potential asymmetry in preferences regarding deviations of inflation from the target. When θ is large and positive, inflation outcomes above the target are considered increasingly more costly than those below the target, while as θ approaches zero, preferences take the usual quadratic - and symmetric - form

$$L_t = (\pi_t - \pi^*)^2 . \tag{12}$$

Conversely, a negative value of θ would indicate that the central bank dislikes low inflation more than high inflation.

Once again, we proxy the central bank loss by the tone, and assume that there is an affine correspondence between the tone and the central bank's loss function such that $N = \alpha + \gamma L$. Thus, we relate the tone to inflation deviation as follows:

$$N_t = \alpha + \gamma \left[\frac{exp\left[\theta\left(\pi_t - \pi^*\right)\right] - \theta\left(\pi_t - \pi^*\right) - 1}{\theta^2} \right] + \varepsilon_t. \tag{13}$$

We also add control variables ($\boldsymbol{z_t}$), so that the general specifications we estimate can be expressed as

$$N_t = \alpha + \gamma \left[\frac{exp\left[\theta\left(\pi_t - \pi^*\right)\right] - \theta\left(\pi_t - \pi^*\right) - 1}{\theta^2} \right] + \boldsymbol{\beta' z_t} + \varepsilon_t. \tag{14}$$

The loss function (14) is estimated using maximum likelihood. However, estimating a non-linear Linex function with three interacting parameters (γ, θ and π^*) presents challenges. Since our main interest lies in studying the (a)symmetry of the loss function, we adopt an approach similar to that applied at the end of Section 3.1. We fix the *de facto* inflation target π^* to a given value, $\pi^* \in \{1.3, 1.4, ..., 2.0\}$, and estimate the remaining parameters of equation (14). Then, for each value of π^*, we examine the (a)symmetry of the loss function using a LR test. Specifically, the LR test compares the possibly asymmetric U-shaped Linex specification (14) against the corresponding symmetric U-shaped, or quadratic, specification

$$N_t = \alpha + \gamma \left(\pi_t - \pi^*\right)^2 + \boldsymbol{\beta'} \boldsymbol{z_t} + \varepsilon_t \tag{15}$$

with the same inflation target π^* and the same control variables $\boldsymbol{z_t}$.

The key results from this exercise are presented in Tables 9-11, where we report the estimated value of θ and the p-value of the LR-test for each π^*. Column numbers (2), (3) and (4) in Tables 9-11 refer to the specifications reported in the corresponding columns of Tables 1-4. Hence, column (2) represents a specification with no control variables, column (3) includes macro controls, and column (4) adds financial market variables as well as the measure of economic uncertainty.

These results are reported for the lexicon-based tone, utilising both whole introductory statements and inflation-focusing segments, as well as for the FinBERT-based tone, utilising the entire introductory statement texts. The Linex estimations do not converge when employing the FinBERT-based tone from inflation-focusing text segments as the dependent variable. One possible explanation for the failure of the Linex specification in this case is to recall the corresponding estimation results reported in Section 3.1. These results suggest a 'hockey stick' type loss function, where the central bank becomes increasingly dissatisfied if inflation rises above the target π^* but remains relatively satisfied as long as inflation remains below the target. Fitting a U-shape (considering that Linex is a generalized U-shaped function) to a 'hockey stick' pattern is challenging.

In all the specifications reported in Tables 9-11, the point estimate of θ is positive, suggesting an asymmetric loss function, with the ECB disliking high inflation (above the *de facto* inflation target) more than low inflation (below the target).[23] When the tone index is computed with the lexicon-based approach, the null hypothesis of symmetric preferences with respect to high and low inflation is rejected in all specifications as long as the *de facto* inflation target $\pi^* \geq 1.5\%$, and in many specifications, symmetry is rejected for lower values of π^* as well. When the tone for the whole introductory statements is assessed with

[23] Also the parameter γ is positive in all the specifications reported in Tables 9-11.

Table 9: Linex estimations with meeting based whole text tone for different inflation targets

	(2)		(3)		(4)	
Target	θ	LR, p-value	θ	LR, p-value	θ	LR, p-value
2	1.190	0.000***	1.264	0.000***	1.827	0.001***
1.9	1.032	0.000***	1.106	0.000***	1.642	0.001***
1.8	0.887	0.001***	0.962	0.000***	1.478	0.001***
1.7	0.752	0.002***	0.829	0.001***	1.332	0.001***
1.6	0.629	0.012**	0.707	0.004***	1.204	0.003***
1.5	0.520	0.052*	0.598	0.022**	1.093	0.007***
1.4	0.432	0.161	0.507	0.081*	1.002	0.019**
1.3	0.388	0.316	0.448	0.196	0.934	0.044**

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

Table 10: Linex estimations with meeting based inflation text for different inflation targets

	(2)		(3)		(4)	
Target	θ	LR, p-value	θ	LR, p-value	θ	LR, p-value
2	1.292	0.004***	1.436	0.001***	1.964	0.091*
1.9	1.135	0.004***	1.269	0.001***	1.773	0.047**
1.8	0.992	0.005***	1.117	0.001***	1.602	0.027**
1.7	0.863	0.010**	0.978	0.003***	1.448	0.020**
1.6	0.748	0.024**	0.853	0.006***	1.308	0.018**
1.5	0.649	0.059*	0.741	0.018**	1.182	0.022**
1.4	0.572	0.129	0.645	0.051*	1.069	0.033**
1.3	0.528	0.224	0.568	0.117	0.967	0.055*

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

Table 11: Linex estimations with meeting based FinBERT whole text for different inflation targets

	(2)		(3)		(4)	
Target	θ	LR, p-value	θ	LR, p-value	θ	LR, p-value
2	1.230	0.090*	1.520	0.034**	2.000	0.669
1.9	1.026	0.081*	1.279	0.026**	1.698	0.306
1.8	0.844	0.089*	1.068	0.026**	1.349	0.192
1.7	0.677	0.120	0.878	0.033**	1.051	0.157
1.6	0.521	0.194	0.703	0.058*	0.794	0.171
1.5	0.373	0.338	0.539	0.122	0.568	0.244
1.4	0.229	0.563	0.382	0.265	0.361	0.406
1.3	0.100	0.835	0.230	0.515	0.165	0.686

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

the FinBERT language model, symmetry is rejected in specification (2) (with no control variables) for $\pi^* \geq 1.8\%$ and in specification (3) (which includes macro control variables) for $\pi^* \geq 1.6\%$. In specification (4), which adds financial variables and the uncertainty indicator, the point estimates of θ are typically rather large, but the LR test does not reject the null hypothesis of symmetry.

In sum, the estimations using the Linex function (a generalized U-shape) also suggest that the ECB's loss function has probably been asymmetric. Hence, we obtain additional support for the notion that the ECB has been more averse to high inflation than low inflation during the first two decades of the euro area.

3.3 Robustness checks

We conduct a series of robustness checks for our main findings. The piecewise linear (V-shaped) estimation results, applying the lexicon-based tone of whole introductory statements, are reported in Appendix E.

In the first group of robustness checks, we study the sensitivity of the results to the sample period. One rather natural robustness check is to exclude the early period of common monetary policy and start the sample from May 2003, when the Governing Council clarified its definition of price stability. The results from this subsample analysis are reported in Tables E.1-E.2, and they lend support to asymmetry.

We also examine whether the asymmetry of the ECB's loss function is influenced by the ELB. Being at the ELB may have altered the ECB's communication: perhaps the ECB did not want to sound overly alarmist or negative about below-target inflation if it considered that it did not have adequate tools to rectify the situation. In Tables E.3 and E.4, we report results from estimations covering the subsample January 1999 – July 2014, thus omitting the ELB episode starting in August 2014. We find support for asymmetric policy preferences from this analysis as well, suggesting that the asymmetry result is not solely driven by the ELB.

In a related robustness check, we exclude periods during which inflation was below 0.6%. This robustness check is motivated by the observation that, according to our tone index, the ECB was relatively satisfied in 2015 and 2016, despite very low inflation. One might question whether the asymmetry result is driven by periods of exceptionally low inflation (which can also be exceptional due to, e.g., the ELB). The answer to this question is no. We find strong evidence of asymmetry even when excluding periods with inflation below 0.6% (see Tables E.5 and E.6).

In the second group of robustness checks, we explore the sensitivity of the results to the control variables and the measure of inflation. We add euro area stock market variables, including the growth rate of an aggregate stock index, the aggregate volatility of the stock market, and an aggregate P/E ratio, to the specifications reported in column (4) of the estimation tables. The stock market variables are described in Appendix C. Even with these additional control variables, the estimation results provide support for asymmetric policy preferences, as shown in Tables E.7-E.8. In another robustness check, we take a closer look at selected control variables. In our baseline, the unemployment rate, the spreads and the measure of economic uncertainty are all in levels. In robustness checks we consider specifications where these control variables appear in differences. Our results are not highly sensitive to these changes, as an asymmetric loss function is found in each case. However, there are slight differences in the estimated *de facto* inflation targets. See Tables E.9-E.12. Finally, in the estimation results reported in Tables E.13-E.14, inflation is measured as the average of the two latest real-time inflation observations instead of just the latest one. These results also are consistent with an asymmetric loss function, although there are once again slight differences in the estimated *de facto* inflation targets compared to the results from our baseline estimations.

In the third group of robustness checks, we explore the sensitivity of our results to the choice of dictionary. We recompute the lexicon-based sentiment index using the default L&M (2011) dictionary, only adding British English tone words reported in Table B.1, and

taking on board negations, but leaving out any of the modifications reported in Tables B.2-B.5 (removing and adding tone words, adding positive and negative bigrams and trigrams). Using this dictionary, we still find some support for an asymmetric loss function. However, the *de facto* inflation target is systematically estimated to be clearly above 2%, which is not very plausible (see Tables E.15-E.16). We also apply the lexicon-based Picault and Renault (2017) Economic Outlook Index to measure the tone of the ECB's introductory statements. The index is available for the period January 2006 – December 2020.[24] The estimation results are reported in Tables E.17-E.18. This analysis also lends some support to asymmetry.

In the fourth group of robustness checks, we aggregate the meeting-based sentiment indices to the quarterly level. This reduces the number of observations considerably, from 238 to 90. However, in the estimations, we can include control variables available at the quarterly frequency, notably GDP, which are not available at higher frequencies. In addition, we can use information from the Eurosystem forecasts. Estimations with quarterly data also lend support to an asymmetric loss function. The quarterly variables are described in Appendix C, and estimation results for the quarterly frequency are shown in Tables E.19-E.22. In Tables E.21 and E.22 inflation is measured as the average of inflation nowcast and one-quarter-ahead forecast[25].

In the final group of robustness checks, we address the temporal dimension of the introductory statement texts. In this exercise we use the GPT-4.0-0613 large language model. We instruct the model with a detailed prompt to categorise sentences as 'forward-looking', 'backward-looking', or 'ambiguous' based on specific keyword cues that suggest temporal focus.[26] Subsequently, we analyse the sentiment of forward- and backward-looking statements

[24] See http://cbcomindex.com/index.php.

[25] As discussed by Shapiro and Wilson (2022), using longer-term forecasts would be subject to endogeneity bias.

[26] The exact prompt is: *"Classify the following sentence from ECB introductory statements as 'forward-looking', 'backward-looking', or 'ambiguous'. Consider 'forward-looking' statements as those that discuss future economic conditions, policies, or expectations, often using keywords like 'expect', 'anticipate', 'will'. 'Backward-looking' statements should reference past data, summarize previous actions, or evaluate past and current economic conditions, with keywords like 'was', 'occurred', 'had been'. 'Ambiguous' statements are those that contain elements of both or whose intent is unclear without more context."* We set the temperature parameter to zero to ensure maximum determinism in the outputs, leveraging the model's ability to parse

in each introductory statement using our modified L&M dictionary. Interestingly, the share of sentiment words (positive plus negative) is higher in forward-looking statements than in backward-looking statements (see Table D.1). The meeting-based tones are shown in Figure D.12. The estimation results based on the backward-looking tone are displayed in Tables E.23 and E.24 and the results based on the forward-looking tone in Tables E.25 – E.28. In particular, in Tables E.27 and E.28 we use the mean of nowcast and one-quarter-ahead forecast as the measure of inflation. We get support for the asymmetry of the loss function also from this analysis. The evidence for asymmetry is stronger when using the forward-looking tone than when using the backward-looking tone.

In summary, the results from our comprehensive robustness checks reinforce our primary findings, confirming the asymmetry in the ECB's loss function.

4 Conclusions

In the optimal monetary policy literature, central bank preferences are usually cast in the form of a quadratic loss function, which is thought to approximate the welfare criteria of society, implying that the central bank considers both negative and positive deviations of inflation from its target equally costly. However, such symmetry stems from the LQ approach typically applied in theoretical literature, which effectively assumes away any asymmetries.

In this paper, we have provided robust evidence that the central bank preferences can be asymmetric. In contrast to the more common reaction function approach, which requires specific assumptions, e.g., on the structure of the economy and form of the reaction function, we have used text analysis methods to infer central bank preferences more directly. We have proxied the central bank loss function by evaluating the tone, or sentiment, in the central bank communication at the time of the monetary policy decisions and regressed it on real time inflation and several other real-time control variables available at the time of those

complex economic texts effectively. The shares of 'forward-looking', 'backward-looking', and 'ambiguous' texts in each introductory statement are shown in Figure D.11

decisions. We have also conducted a comprehensive robustness analysis. In particular, we have used both lexicon-based and language model-based text analysis methods. We have also applied topic modeling to consider only inflation-specific segments of the textual central bank communication and considered temporal dimensions of communication by analysing separately backward-looking and forward-looking statements.

Specifically, according to our results, the ECB's Governing Council has considered inflation rates above the target significantly more costly than below it during the first two decades of the euro area. While it is plausible that the ECB's aversion to high inflation originated from the double-key formulation of price stability between 1999-2021, such asymmetry of preferences also has a theoretical rationale. This is shown by Benigno and Rossi (2021) and Yun (2005), and in fact much earlier by Rogoff (1985), who suggested that in the presence of inflationary bias, society is better off by appointing an inflation-conservative central banker.

The Governing Council redefined their inflation aim in July 2021. The Governing Council stated that *'price stability is best maintained by aiming for two per cent inflation over the medium term and commitment to this target is symmetric (negative and positive deviations from this target are equally undesirable)'.* The commitment to the symmetric 2% inflation target explicitly omitted the below-2% bias related to the previous definition as well as any remaining perception of 2% constituting a ceiling for inflation. This emphasis on symmetry and a precise definition of 2% inflation target can also be interpreted as an additional buffer against disinflationary shocks, alleviating the problem of a reduced monetary policy space due to the ELB, and a low natural rate of interest at the time.

Text analysis methods, as earlier applied by Shapiro and Wilson (2022) to study the Fed, have proved a useful and quite powerful tool to estimate the central bank loss function. In future work, it would be interesting to extend this approach to other inflation-targeting central banks with possibly differing targets and mandates, and also to study whether the new strategy represents a significant change to the ECB's preferences and monetary policy relative to the old one as time goes by.

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Appendices

A ECB texts

Table A.1: ECB on price stability and symmetry

Speaker	Date	Quote
Duisenberg	Paris, 11 October 1999	"Some observers have criticised the strategy as "asymmetric". In other words, they argue that the Eurosystem is more concerned about inflation than it is about deflation. In their view, such asymmetry will impose a drag on the overall performance of the euro area economy as a whole because monetary policy will be overly restrictive on average, and risks triggering a damaging deflationary spiral in some circumstances. These assertions are often based on the perceived lack of a quantitative lower bound to the definition of price stability, which is contrasted with a clear upper bound of 2%. I reject this criticism. The use of the word "increases" in the definition imposes a floor of at least zero for the lower bound. ... This clearly demonstrates that **we are certainly not asymmetric in the sense that we would be more concerned about inflation than deflation.** These are largely technical issues. Let me state categorically, as I have often done in the past, that neither prolonged inflation nor prolonged deflation in the euro area would be deemed by the Governing Council to be consistent with the maintenance of price stability."
Trichet	Wyoming, 27 August 2010	"Let me now turn to central banks. Their role as anchors of stability is all the more important in times of deleveraging. A credible, medium-term orientation on price stability is the best contribution that central banks can make toward sustainable, stable growth. A credible commitment to price stability anchors inflation expectations, depresses inflation risk premia and contributes to keeping longer-term interest rates low, thus helping to contain the costs of servicing public and private debts. **Such a commitment to price stability must be symmetric, ruling out both inflation and deflation.**"
Draghi	Frankfurt am Main, 10 March 2016	"What I can say, however, is that our mandate is defined as reaching an inflation rate which is close to 2% but below 2% in the medium term. Which means that we'll have to define the medium term in a way that, if the inflation rate was for a long time below 2%, it will be above 2% for some time. The key point is that **the Governing Council is symmetric in the definition of the objective of price stability over the medium term.**"

ECB on price stability and symmetry

Speaker	Date	Quote
Draghi	Vienna, 2 June 2016	"However, while **our mandate is symmetric, and our commitment to our mandate is symmetric**, there is an asymmetry in the tools we can use to achieve it, which stems from the existence of a lower bound for interest rates."
Draghi	Vienna, 2 June 2016	Question in Q&A session: The first question is about the ECB's objective. The close, but below, 2% is no longer in the monetary policy decision; it's in your introductory statement but not in the decision, so does that mean something? Can we expect the ECB to rephrase, redefine its policy objective? "On the other point: no, there isn't any change really. In fact, it's true it's not there in the first page; it's in the fourth page, it's just what it is. But we had a discussion about symmetry and there is a sense in the Governing Council that there should be a reflection on the objective: namely is it is close to but below 2%, or, should we move to another objective? There were different Governing Council members suggesting that we should carry out a reflection on this. Now, it's an important change so we just want to think about it seriously. In the meantime, however, the main thing in this introductory statement is that the Governing Council – I think I have said this many times, but now it's in the introductory statement – reaffirmed its **commitment to symmetry around the inflation aim**, which in a sense is 1.9 – it's close to, but below, 2%. At the same time, we say we don't like the current inflation. So, there is no question about accepting lower inflation as we are seeing today. These two things must be read together. The bottom line of the discussion that I reported to you before is that we don't like what we see on the inflation front. The symmetry means basically that there is no cap, or 2% cap, and that inflation can deviate on both sides. We don't accept permanently lower inflation rates. **Symmetry means that the Governing Council will act with the same determination whether inflation is above or below the inflation aim.** I think that's important to read in the full context."
Lagarde	Frankfurt am Main, 12 December 2019	"In any case, the Governing Council continues to stand ready to adjust all of its instruments, as appropriate, to ensure that inflation moves towards its aim in a sustained manner, in line with its **commitment to symmetry**."
Lagarde	Frankfurt am Main, 13 September 2020	"In the current environment of elevated uncertainty, the Governing Council will carefully assess incoming information, including developments in the exchange rate, with regard to its implications for the medium-term inflation outlook. It continues to stand ready to adjust all of its instruments, as appropriate, to ensure that inflation moves towards its aim in a sustained manner, in line with its **commitment to symmetry**."

B Modifications to L&M dictionary

Table B.1: Positive and negative British English sentiment words added to L&M (2011) dictionary

Added positive words	**Added negative words**
favourable	criticise
favourably	criticised
favoured	criticises
favouring	criticising
favourite	destabilisation
favourites	destablise
honour	destabilised
honourable	destabilising
honoured	disfavour
honouring	disfavoured
honours	disfavouring
revolutionise	disfavours
revolutionised	dishonour
revolutionises	dishonourable
revolutionising	dishonourably
stabilisation	dishonoured
stabilisations	dishounouring
stabilise	dishonours
stabilised	mischaracterisation
stabilises	misdemeanour
stabilising	misdemeanours
	penalise
	penalised
	penalises
	penalising
	rationalisation
	rationalisations
	rationalise
	rationalised
	rationalises
	rationalising
	scrutinise
	scrutinised
	scrutinises
	scrutinising
	unauthorised
	undercapitalised
	underutilisation
	underutilised
	unfavourability
	unfavourable
	unfavourably
	unlicenced
	unstabilised

Table B.2: Positive and negative words in L&M (2011) dictionary that we classify as neutral

Positive in L&M dictionary	**Negative in L&M dictionary**
conclusive	argue
despite	argue
ease	argued
easier	argument
easiest	arguments
easily	concern
easiness	concerned
easing	concernful
efficiencies	concerning
efficiency	concerningly
efficient	concernment
efficiently	concerns
exceptional	corrected
exceptionally	correcting
great	correction
greater	corrections
greatest	correctly
greatly	correctness
greatness	corrects
highest	crucial
leading	cut
stabilisation	decline
stabilisations	declined
stabilise	declines
stabilised	declining
stabiliser	downward
stabilises	exploit
stabilising	exploitation
stability	exploitations
stabilization	exploitative
stabilize	exploited
stabilized	exploiting
stabilizer	exploits
stabilizes	lag
stabilizing	lagged
stable	lagging
strong	lags
stronger	late
strongest	lie
strongly	recall
	recalled
	recalling
	recalls
	restate
	restated
	restatement
	restatements
	restates
	restructure
	restructured
	restructures
	restructuring
	restructurings
	solvencies
	solvency
	solvent
	unemployed
	unemployment
	volatile
	volatilities
	volatility

Table B.3: Bigram modifications to the L&M (2011) dictionary

Positive	**Negative**	**Neutral**
greater confidence	greater uncertainty	countries concerned
great opportunity	stronger passthrough	far concerned
great opportunities	not corrected	less concern
greater spending	great concern	not concern
greater choice	stronger protracted	counterbalance concerns
greater dynamism	strong concern	dampen concerns
greater stability	inconsistent progress	progress fiscal
great potential	insufficient progress	business efficiency
greater success	dampen strength	parties concerned
great contribution	dampen improvement	improve functioning
strong growth	exceptional challenges	achieve growth-friendly
stronger growth	less favourable	reducing vulnerabilities
strong economic	high unemployment	persistent strong
strong uniform		persistently strong
recover strongly		
progress correction		
unemployment fallen		
unemployment declines		
unemployment decreased		

Table B.4: Trigram modifications to the L&M (2011) dictionary

Positive	**Negative**	**Neutral**
gained business restructuring	greater currently expected	not cause concern
greater business efficiency	greater currently assumed	not give cause concern
greater corporate efficiency	disorderly correction global imbalances	not give rise concerns
greater price competitiveness	stronger expected slowdown	not dampened strength
strong uniform recovery	without undue delay	improve capital solvency
accumulated ongoing strong	unemployment remains high	exploited make faster progress
improve resolution nonperforming	high structural unemployment	
price stability risk low	unemployment euro area remains high	
price stability risk decrease	price stability risk high	
gain business restructuring	price stability risk increase	

Table B.5: Positive and negative sentiment words added to L&M (2011) dictionary

Added positive words	**Added negative words**
ample	disequilibrium
amply	disequilibria
buoyant	tension
buoyantly	tensions
dynamic	contracted
dynamically	
robust	
robustly	
benefits	

C Description of the data

In compiling the data, efforts have been made to replicate the real-time data available to the ECB Governing Council at each monetary policy meeting.

The inflation variable used in the meeting-based analysis ('meeting-based inflation variable') is the latest monthly year-on-year rate of change (%) of the euro area overall Harmonised Index of Consumer Prices (HICP) publicly recorded by Eurostat. The data sources used for the compilation of the variable are (i) vintages of the time series ICP.M.U2.N. 000000.4.ANR extracted from the ECB's Statistical Data Warehouse (SDW) database, and (ii) Eurostat's HICP press releases, which can be found at `https://ec.europa.eu/eurostat/web/hicp/publications`. As an alternative meeting-based inflation variable, an average of the two latest monthly year-on-year inflation rate observations has been calculated for each meeting, instead of just the latest one.

In constructing the meeting-based inflation variables, an observation has been assumed to be known at the time of a monetary policy meeting if it has been published on the day prior to the meeting at the latest. In most cases, the latest monthly observation known at the time of a meeting has been for the month $t_m - 1$, preceding the meeting held at month t_m. Eurostat has published its monthly flash estimate of euro area inflation since 5 November 2001, with the first flash observation being in October 2001. Prior to the first flash estimate, the monthly observation for $t_m - 1$ was known during only four meetings: on 30 March 2000, 19 October 2000, 21 June 2001, and 30 August 2001. During the meeting on 4 February 1999, the latest monthly observation known was for $t_m - 3$. In all other cases before the first flash, the meeting-based inflation variable consists of the monthly observation for $t_m - 2$. In the flash era, the preceding month's flash for $t_m - 1$ wasn't known during only three monetary policy meetings: on 3 January 2002, 3 February 2005, and 2 February 2006. In these three cases, the meeting-based inflation variable consists of the observation for $t_m - 2$. The first monetary policy meeting of the ECB Governing Council took place on 7 January 1999.

The quarterly inflation variable used in the quarterly analysis is the nowcast of the year-

on-year rate of change (%) of the euro area overall HICP, made by the Eurosystem/ECB staff in each quarter since the beginning of 1999. The forecast vintages are extracted from the time series MPD.Q.U2.HIC.A.XXX.0000 of the ECB's public Macroeconomic Projection Database (MPD) in the SDW, where 'XXX' signifies each forecast round (e.g. 'A14' refers to the Autumn 2014 Broad Macroeconomic Projection Exercise conducted by the Eurosystem and ECB staff, etc.). The specific publication dates of the inflation rate nowcasts play no role in the quarterly analysis, as each nowcast is deemed to be a single data point, paired with the corresponding quarterly sum of meeting-level tones.

The real-time control variables (i.e. other variables than those related to the tone or inflation) have also been compiled in two alternative ways. On one hand, the value of each control variable used in the meeting-based analysis ('meeting-based control variables') can be either the last observation or a transformation of the last observation(s) of the original published time series (which are described below), using the latest vintage that has been publicly available at the time of a monetary policy meeting. We assume that a vintage of the original data is known at the time of a meeting if it has been published no later than the day before the meeting.

On the other hand, the control variables used in the quarterly analysis ('quarterly control variables') are aggregated to a quarterly level from the original time series of daily or monthly frequency (which are described below). For the stock market data of daily frequency, for which the closing value of a day is observed late during the same day, the observation of a quarterly control variable for the quarter t_q (for which the nowcast is made) is the arithmetic mean of that same quarter t_q. For original data of monthly frequency, the observation of a quarterly control variable for the quarter t_q is the arithmetic mean of monthly observations from the previous quarter $t_q - 1$, calculated using the most recent vintage available, which is published no later than the last day of the quarter t_q.

The GDP growth and unemployment rates used as quarterly control variables in the quarterly analysis are nowcasts or one-quarter-ahead forecasts made by the Eurosystem/ECB

staff in each quarter since the beginning of 1999. The rates are the year-on-year rate of change (%) of the euro area GDP volume and the level of the euro area unemployment rate (as a % of labour force), respectively. The forecast vintages are extracted from the time series MPD.Q.U2.YER.A.XXX.0000 and MPD.Q.U2.URX.F.XXX.0000, respectively, from the ECB's public MPD database in the SDW, following a similar approach to the quarterly inflation variable described above.

The original published data used to calculate control variables other than quarterly nowcasts or forecasts are the following.

The monthly industrial production index for the euro area recorded by Eurostat covers all industries except construction. The time series is seasonally and calendar adjusted. Real-time vintages have been compiled from the time series RTD.M.S0.Y.I-XCONS.X in the ECB's RTD database in the SDW. For vintages published before 2001, data were extracted from the ECB's Monthly Bulletins, available at `https://www.ecb.europa.eu/pub/economic-bulletin/mb/html/index.en.html`.

The monthly euro area unemployment rate, i.e. seasonally and calendar adjusted percentage of labour force, is also recorded by Eurostat. Real-time vintages have been compiled from the time series RTD.M.S0.S.L-UNETO.F in the RTD database, and for vintages published prior to 2001, from the ECB's Monthly Bulletins (see details above).

The swap spread is the monthly average of the difference between 6-month Euribor swaps and euro area benchmark bonds of a 10-year maturity, calculated by the ECB. The source is the time series FM.B.U2.EUR.4F.SP.SW-6E-BB-10Y.SPR in the ECB's FM database in the SDW.

The corporate yield spread is the monthly average of the difference between 7 to 10-year euro area corporate bond yields and 7 to 10-year euro area government bond yields, calculated by the ECB. The source is the time series FM.M.U2.EUR.4F.SP.MLEC8JE-MLDD710E.SPRE in the FM database.

The monthly Economic Policy Uncertainty (EPU) Index for Europe, constructed by

Baker et al. (2016), can be retrieved from `https://www.policyuncertainty.com/europe_monthly.html`.

The daily closing observations for stock market data have been retrieved from Bloomberg. The EURO STOXX Index is a subset of the STOXX Europe 600 Index. The volatility measure used is the EURO STOXX 50 volatility. And the PE ratio of the MSCI EMU Index (USD) is adjusted to take into account only positive earnings per share. The three Bloomberg tickers (and their more detailed properties) are SXXE Index, V2X Index, and MXEM Index (INDX-ADJ-POSITIVE-PE), respectively.

D Figures and tables

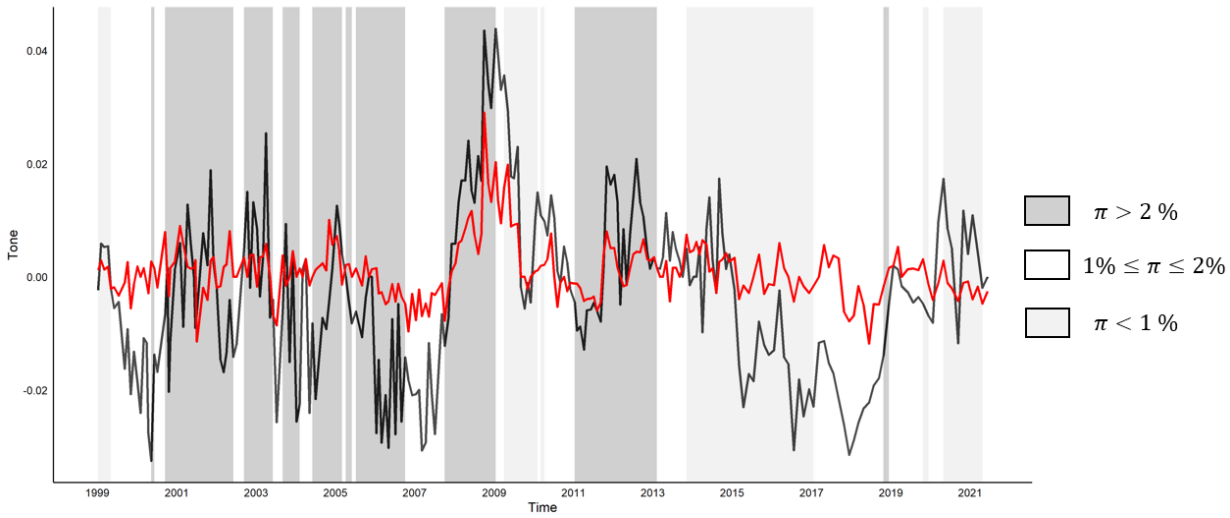

Figure D.1: Meeting based whole text tone (black) and inflation text contribution (red)
Note: π denotes inflation.

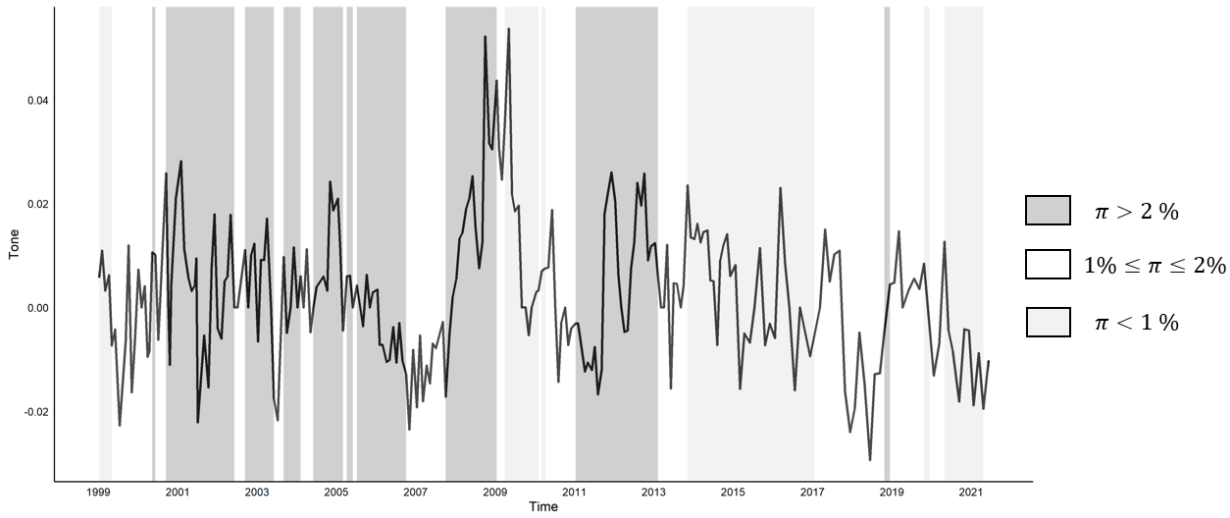

Figure D.2: Meeting based inflation text tone
Note: π denotes inflation.

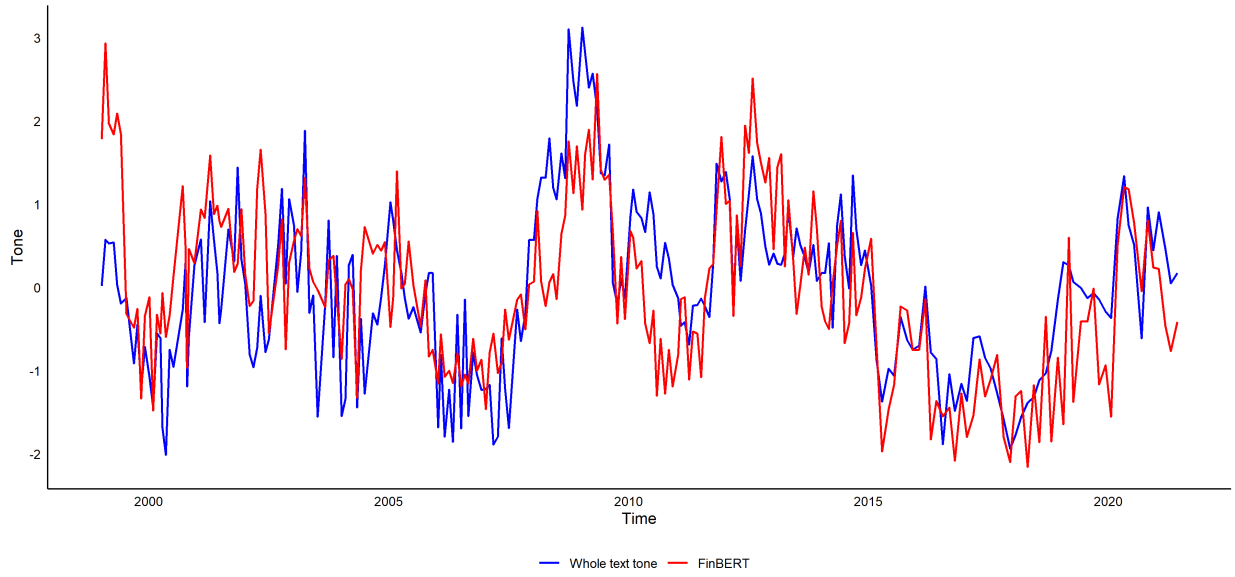

Figure D.3: Meeting based whole text tone and FinBERT whole text tone

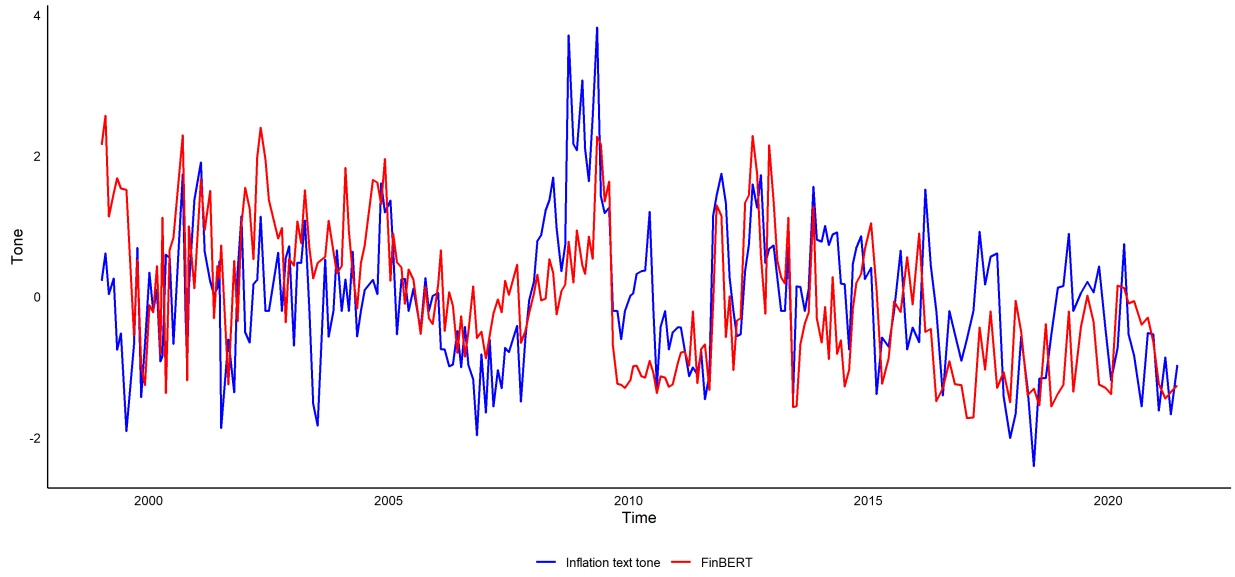

Figure D.4: Meeting based inflation text tone and FinBERT inflation text tone

Table D.1: Share of sentiment words

Text	**Share of positive words**	**Share of negative words**	**Sentiment words / all words**
Whole texts	51.926%	48.074%	4.243%
Inflation texts	43.022%	56.978%	2.361%
Forward-looking	53.911%	46.089%	4.723%
Backward-looking	46.892%	53.108%	3.503%
Ambiguous tense	49.632%	50.368%	4.157%

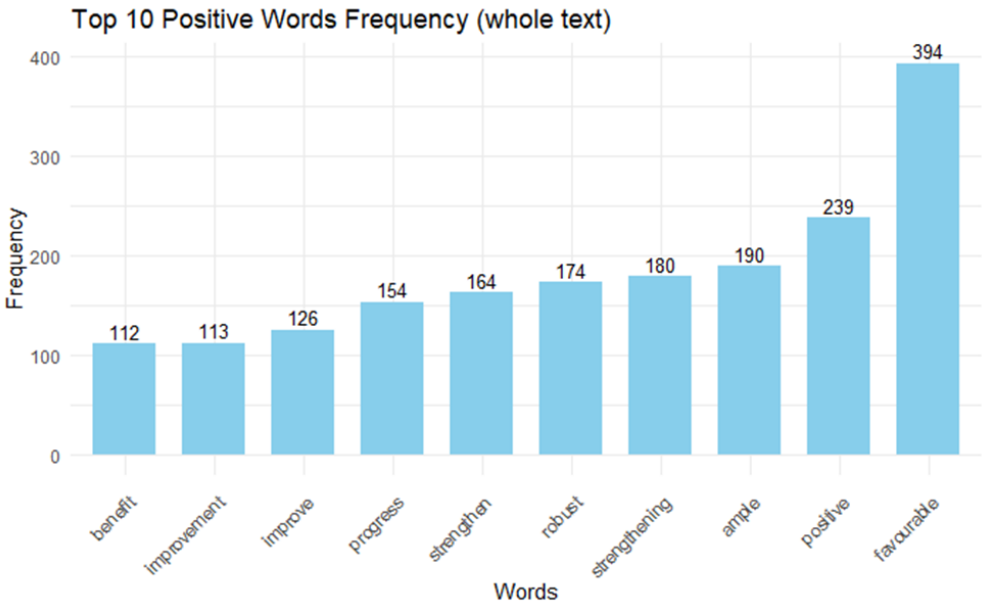

Figure D.5: Top 10 positive sentiment words in whole introductory statement texts

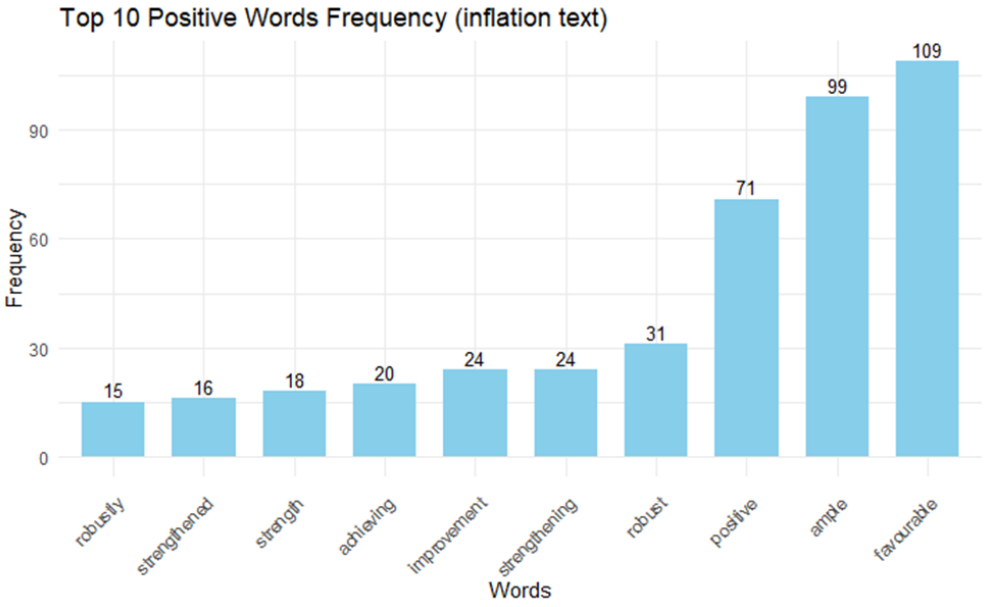

Figure D.6: Top 10 positive sentiment words in inflation texts

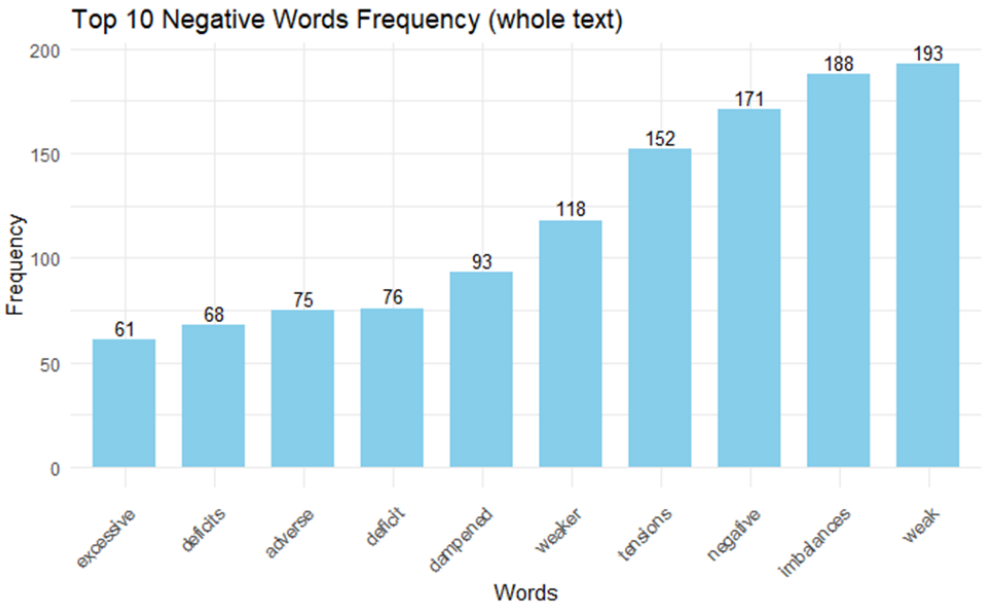

Figure D.7: Top 10 negative sentiment words in whole introductory statement texts

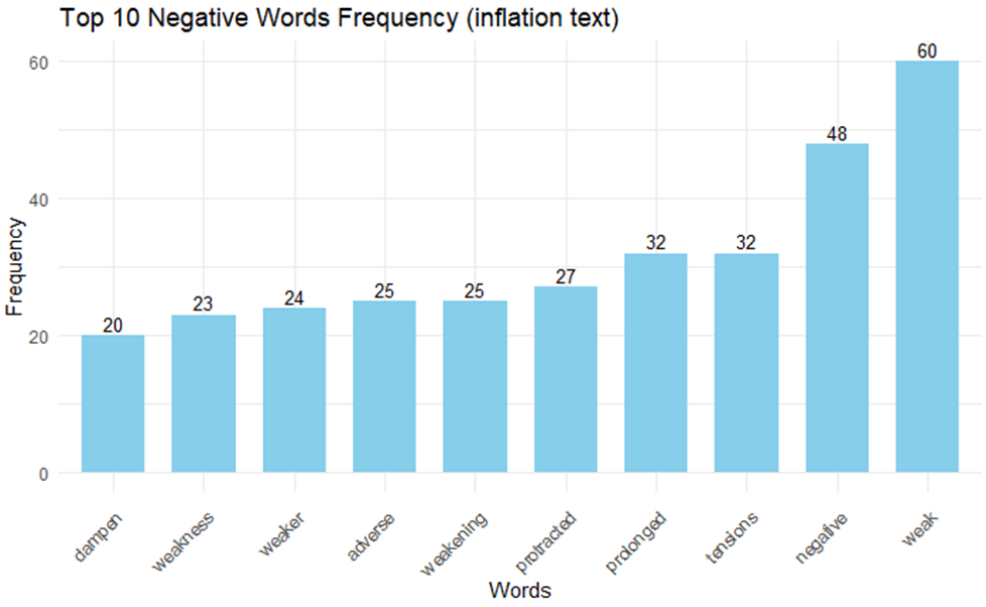

Figure D.8: Top 10 negative sentiment words in inflation texts

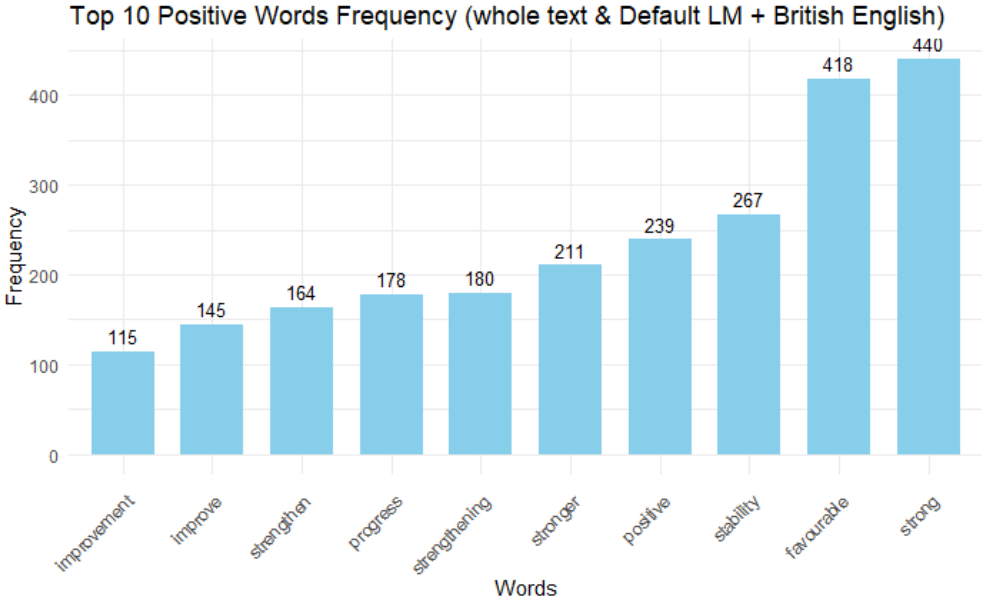

Figure D.9: Top 10 positive words from default L&M plus British English tone

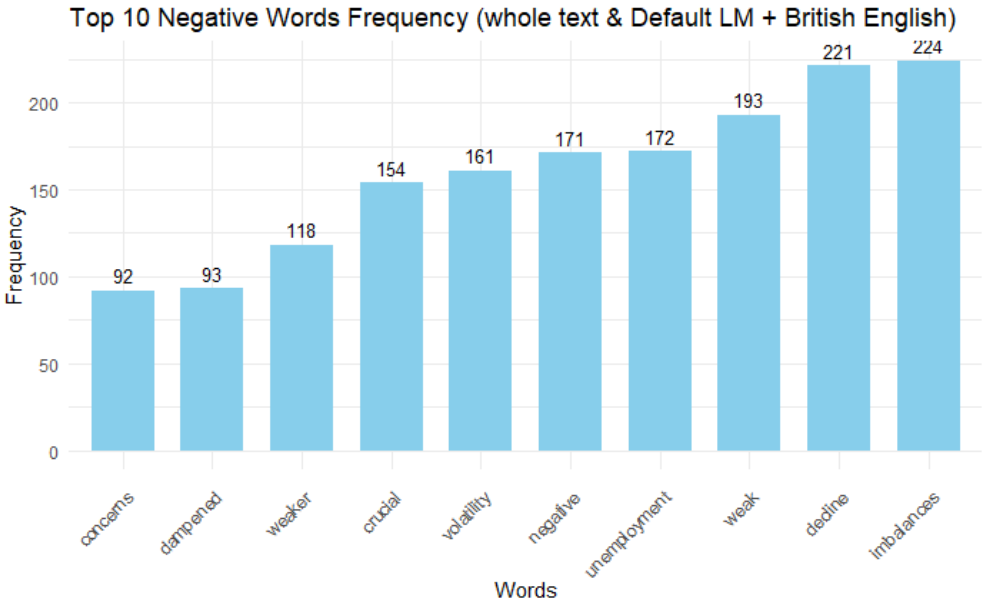

Figure D.10: Top 10 negative words from default L&M plus British English tone

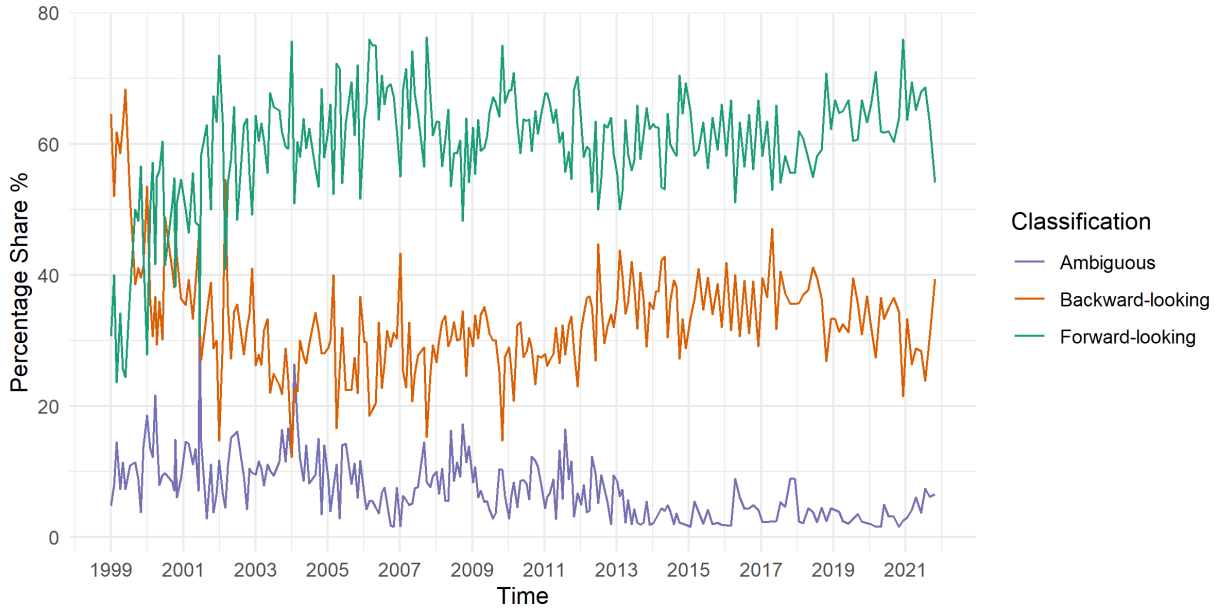

Figure D.11: The share of forward-looking, backward-looking, and ambiguous sentences

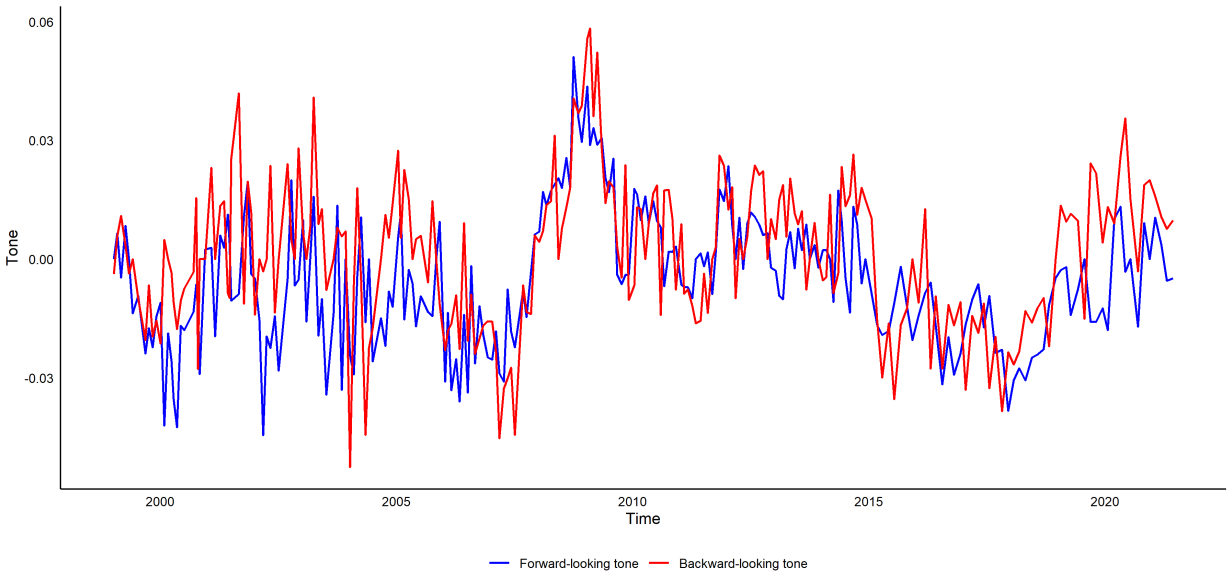

Figure D.12: Meeting based forward- and backward-looking tones

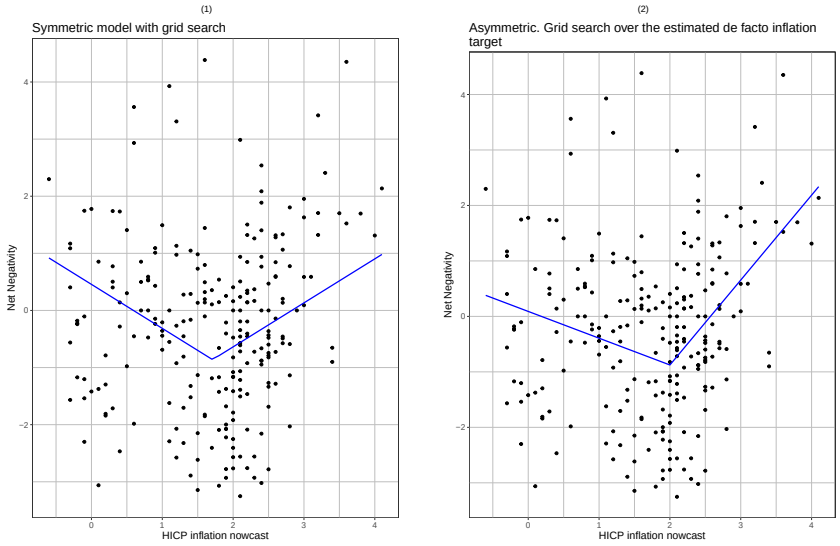

Figure D.13: V results for columns (1) and (2) of Table 1

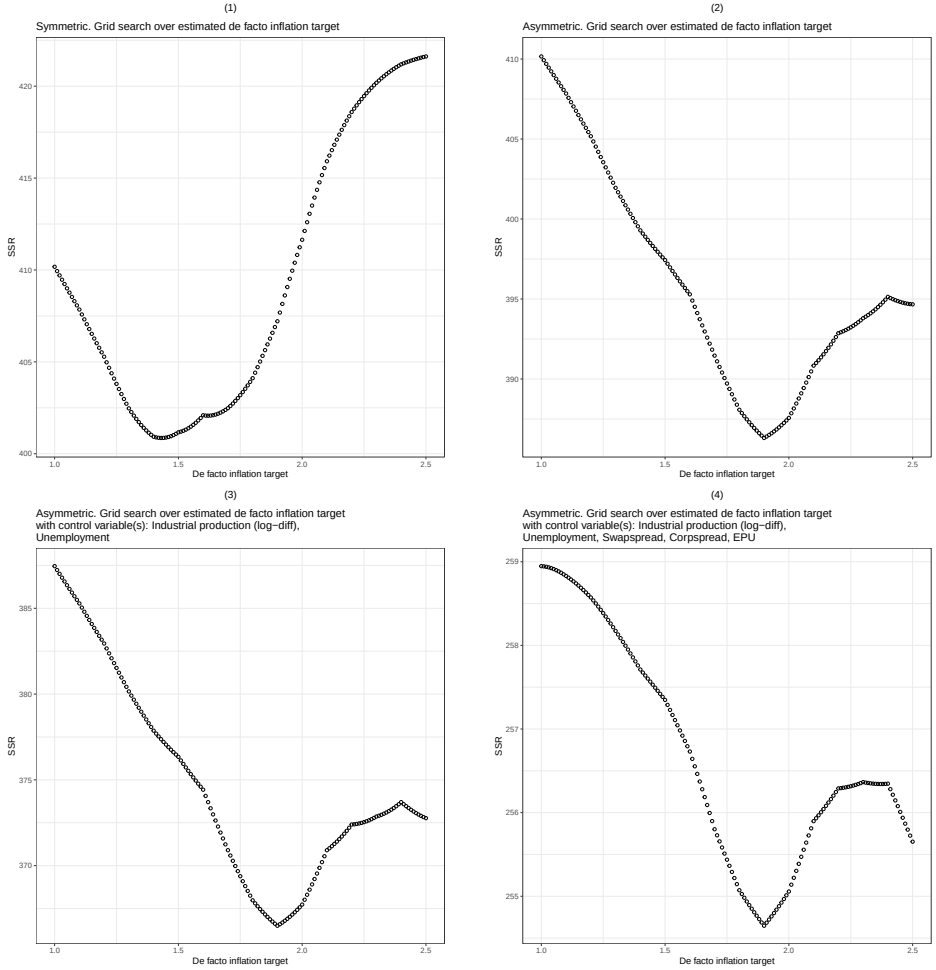

Figure D.14: The sums of squared residuals (SSR) for columns (1) to (4) of Table 2

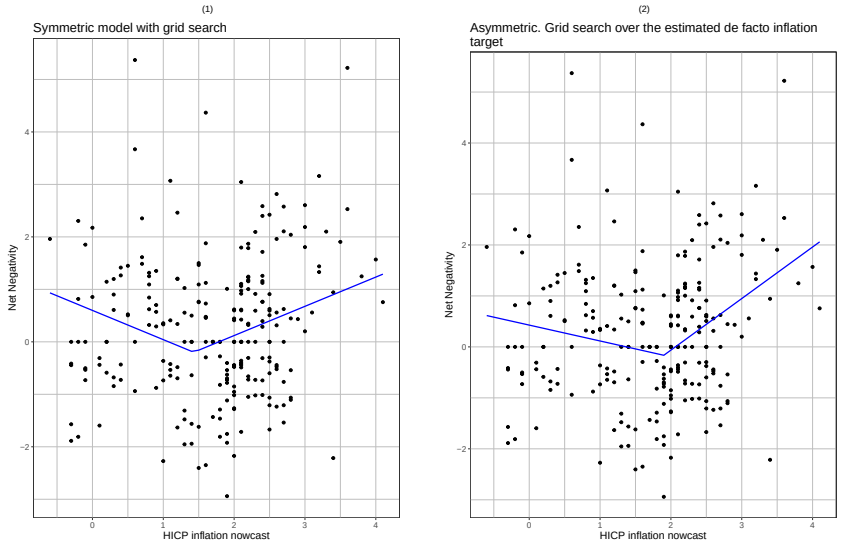

Figure D.15: V results for columns (1) and (2) of Table 2

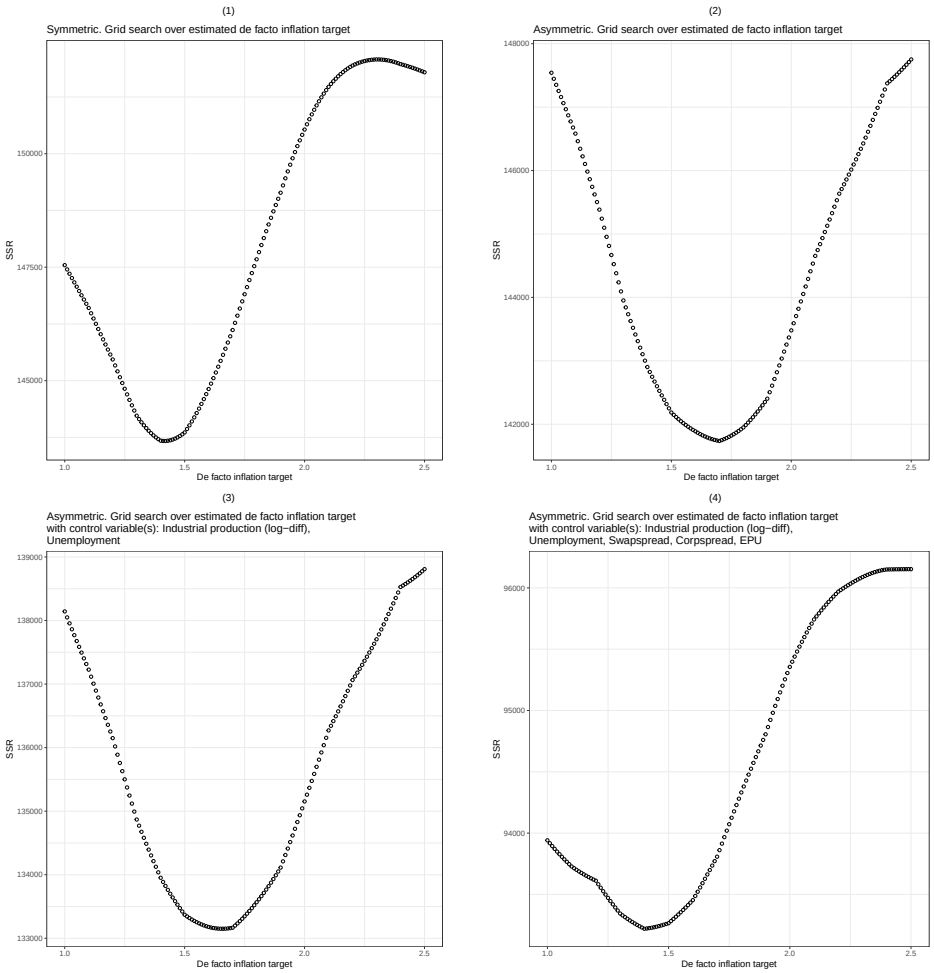

Figure D.16: The sums of squared residuals (SSR) for columns columns (1) to (4) of Table 3

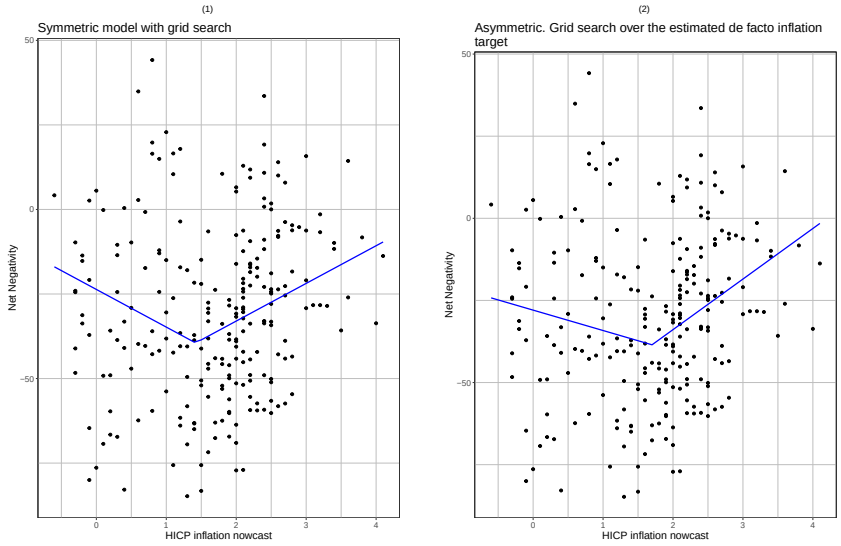

Figure D.17: V results for columns (1) and (2) of Table 3

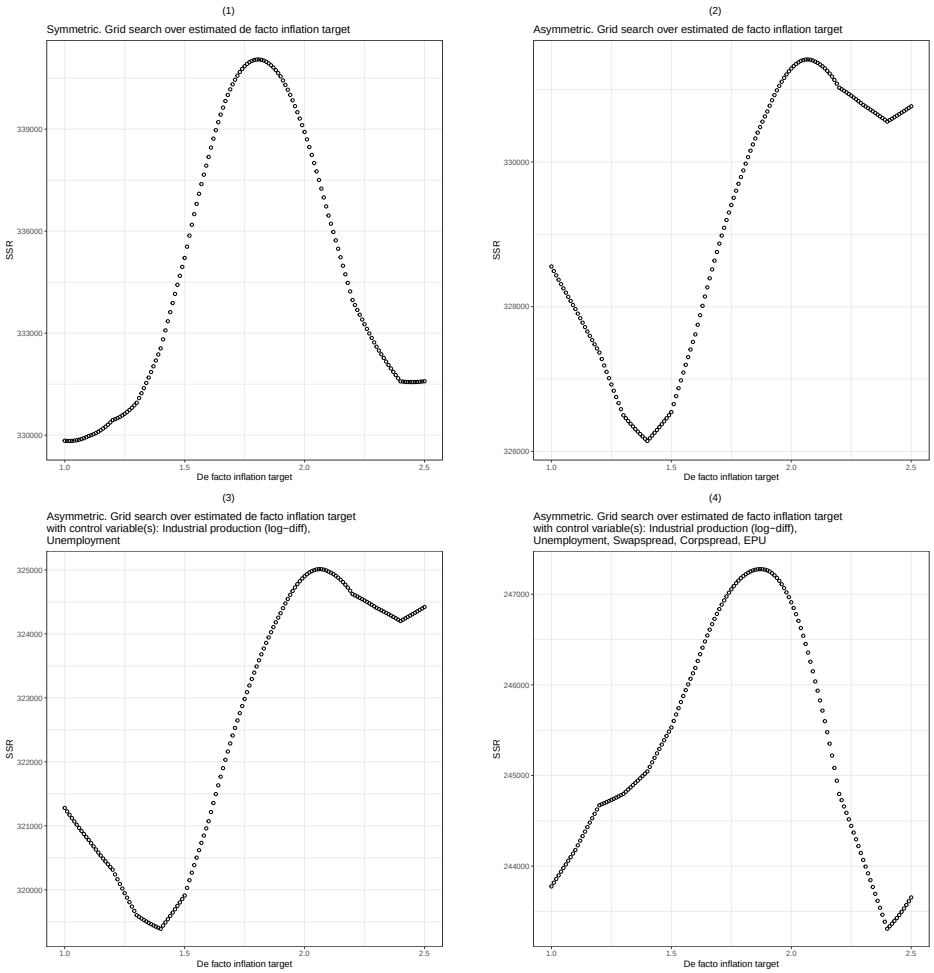

Figure D.18: The sums of squared residuals (SSR) for columns (1) to (4) of Table 4

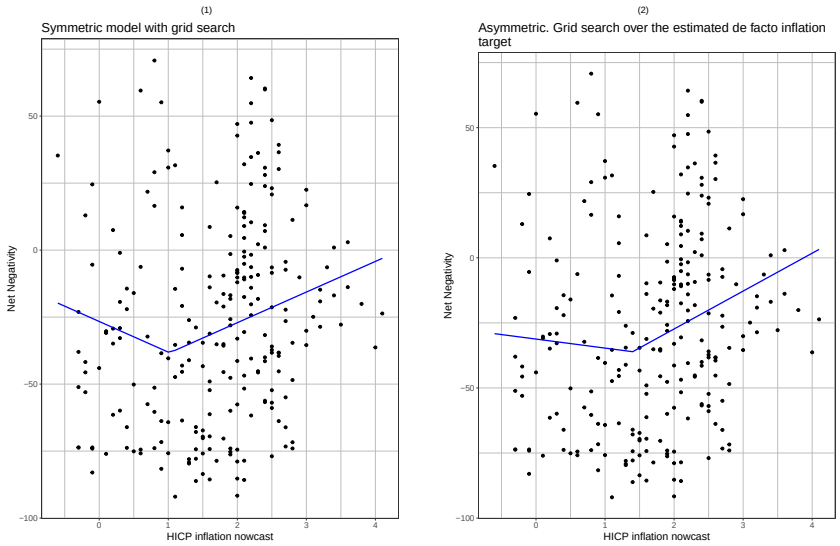

Figure D.19: V results for columns (1) and (2) of Table 4

E Robustness checks for piecewise linear estimations

E.1 Data restricted to start from May 2003

Table E.1: Meeting based whole text tone

	Dependent variable:			
	Tone			
	Symmetric V		Asymmetric V	
	(1)	(2)	(3)	(4)
Inflation	0.728***			
Inflation below the target		−0.369***	−0.287**	−0.028
Inflation above the target		2.139***	2.335***	1.626***
Industrial production (log-diff)			−13.535**	−1.230
Unemployment			0.151**	0.101
Swapspread				−0.562*
Corpspread				0.700***
EPU				−0.0005
Constant	−0.801***	−0.787***	−2.141***	−2.642***
Observations	188	188	188	188
R^2	0.082	0.172	0.213	0.511
Adjusted R^2	0.077	0.163	0.196	0.492
Estimated inflation target	1.76	2.26	2.30	2.50
F-test symmetry p-value		8.598e-08***	5.712e-09***	4.678e-06***
LR-test p-value (asym vs. sym)		9.617e-06***	1.037e-06***	8.418e-05***
LR-test p-value (est vs. fixed)	0.073*	0.185	0.076*	0.066*
Note:				*p<0.1; **p<0.05; ***p<0.01

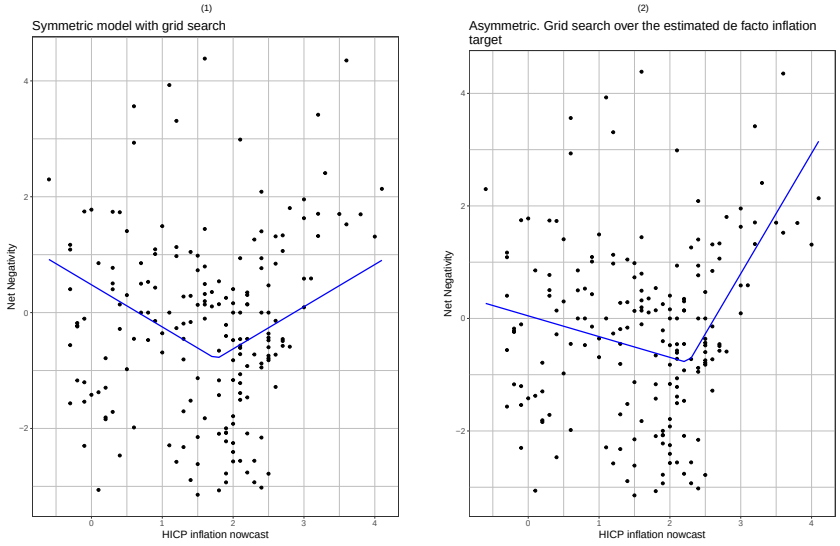

Figure E.1: V results for columns (1) and (2) of Table E.1

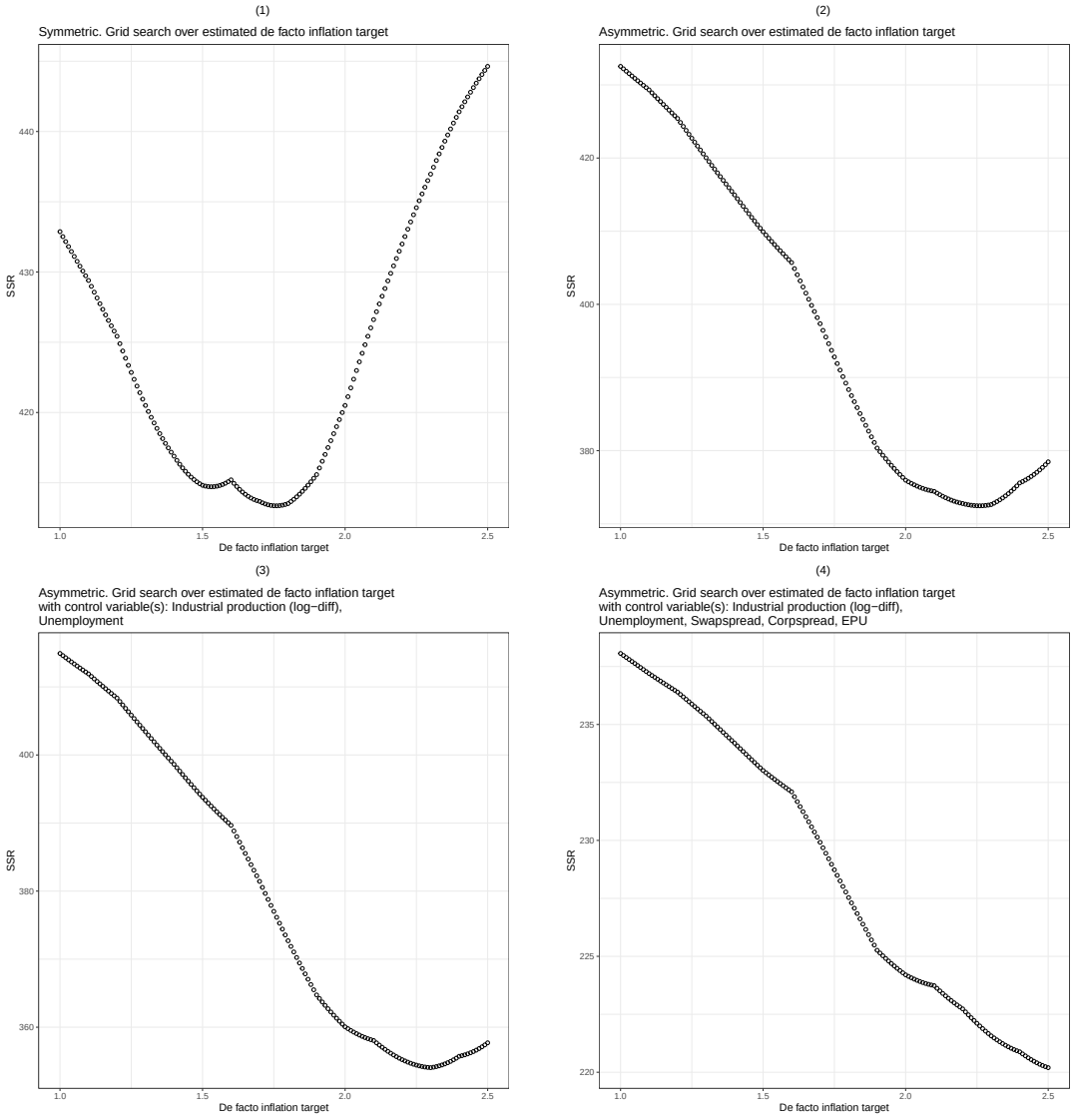

Figure E.2: The sums of squared residuals (SSR) for columns (1) to (4) of Table E.1

Table E.2: Asymmetric estimations with meeting based whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	1.692***	-0.493**	5.495e-06***	1.756***	-0.436**	1.084e-06***	0.995***	-0.133	9.819e-05***
1.9	1.538***	-0.542**	5.284e-05***	1.596***	-0.485**	1.208e-05***	0.911***	-0.158	0.000***
1.8	1.365***	-0.570**	0.001***	1.423***	-0.514**	0.000***	0.810***	-0.162	0.001***
1.7	1.194***	-0.583**	0.006***	1.257***	-0.528**	0.002***	0.714***	-0.155	0.003***
1.6	1.030***	-0.578**	0.039**	1.095***	-0.524*	0.012**	0.623***	-0.139	0.010***
1.5	0.929***	-0.607**	0.139	0.994***	-0.556*	0.053*	0.574**	-0.149	0.023**
1.4	0.829***	-0.624**	0.354	0.896***	-0.576*	0.162	0.523**	-0.149	0.050**
1.3	0.733***	-0.630*	0.652	0.805***	-0.589*	0.362	0.474**	-0.143	0.092*

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

E.2 Omitting the ELB episode

Table E.3: Meeting based whole text tone

	Dependent variable:			
	Tone			
	Symmetric V		Asymmetric V	
	(1)	(2)	(3)	(4)
Inflation	1.268***			
Inflation below the target		−1.067***	−0.857***	−0.160
Inflation above the target		1.535***	1.599***	1.439***
Industrial production (log-diff)			−30.452***	7.754
Unemployment			0.136*	0.352***
Swapspread				0.600**
Corpspread				0.758***
EPU				0.009***
Constant	−0.888***	−0.878***	−2.103***	−5.884***
Observations	182	182	182	170
R^2	0.200	0.209	0.250	0.610
Adjusted R^2	0.196	0.200	0.233	0.594
Estimated inflation target	1.90	2.00	2.00	2.50
F-test symmetry p-value		0.062*	0.007***	2.308e-05***
LR-test p-value (asym vs. sym)		0.161	0.028**	0.016**
LR-test p-value (est vs. fixed)	0.206	1.000	1.000	0.324
Note:				*p<0.1; **p<0.05; ***p<0.01

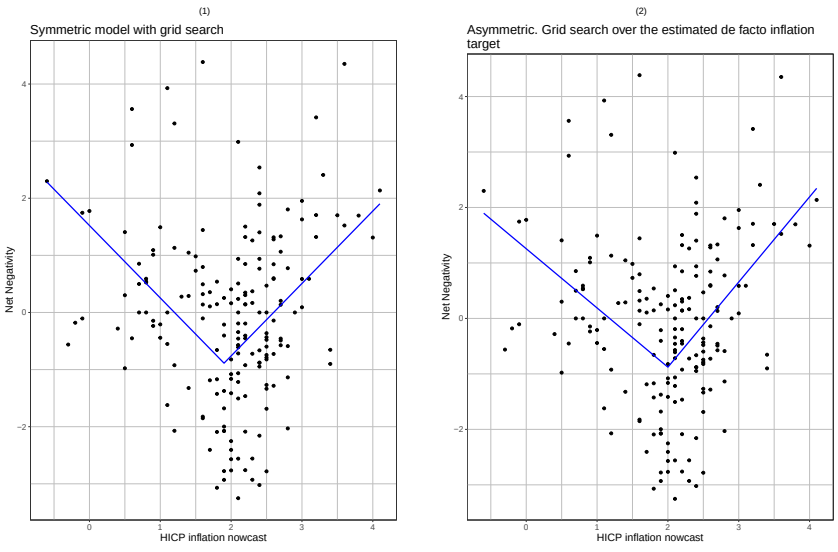

Figure E.3: V results for columns (1) and (2) of Table E.3

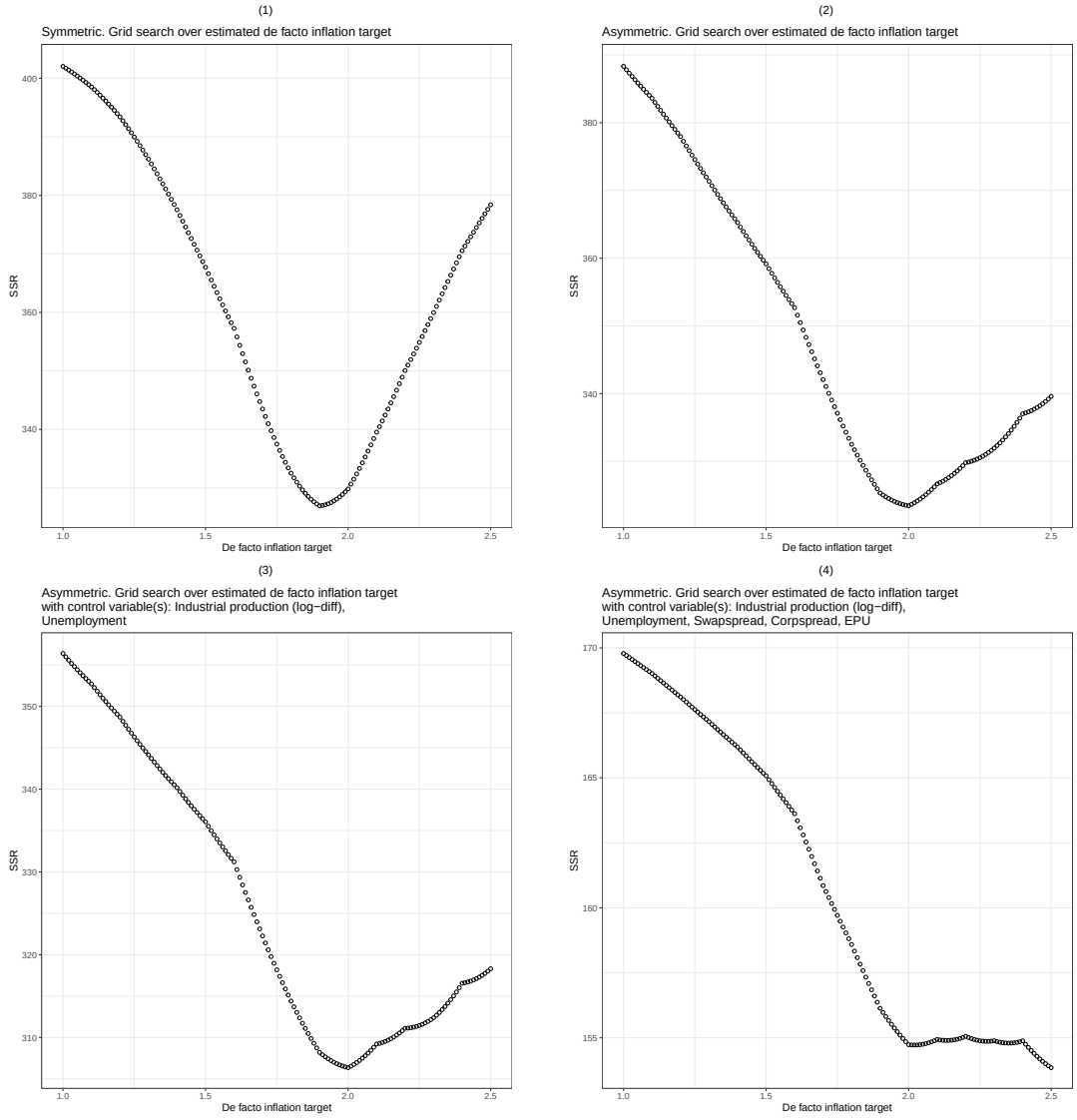

Figure E.4: The sums of squared residuals (SSR) for columns (1) to (4) of Table E.3

Table E.4: Asymmetric estimations with meeting based whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	1.535***	-1.067***	0.062*	1.599***	-0.857***	0.007***	0.932***	-0.404*	0.024**
1.9	1.408***	-1.179***	0.346	1.477***	-0.961***	0.056*	0.846***	-0.431*	0.078*
1.8	1.258***	-1.260***	0.991	1.342***	-1.032***	0.251	0.755***	-0.423	0.168
1.7	1.102***	-1.317***	0.391	1.211***	-1.079***	0.632	0.680***	-0.405	0.267
1.6	0.942***	-1.340***	0.130	1.073***	-1.097***	0.931	0.597***	-0.354	0.343
1.5	0.840***	-1.414***	0.040**	0.993***	-1.174***	0.547	0.552**	-0.344	0.437
1.4	0.739***	-1.478***	0.015**	0.918***	-1.252***	0.294	0.515**	-0.340	0.532
1.3	0.640**	-1.526***	0.008***	0.844***	-1.329***	0.158	0.480**	-0.333	0.620

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

E.3 Omitting the periods when inflation is below 0.6%

Table E.5: Meeting based whole text tone

	Dependent variable:			
	Tone			
	Symmetric V	Asymmetric V		
	(1)	(2)	(3)	(4)
Inflation	1.571***			
Inflation below the target		−1.398***	−1.065***	−0.474*
Inflation above the target		1.642***	1.664***	0.964***
Industrial production (log-diff)			−32.641***	−2.279
Unemployment			0.165**	0.299***
Swapspread				0.213
Corpspread				0.805***
EPU				0.003*
Constant	−1.167***	−1.137***	−2.579***	−5.097***
Observations	202	202	202	190
R^2	0.201	0.203	0.256	0.550
Adjusted R^2	0.197	0.195	0.241	0.532
Estimated inflation target	1.87	1.90	1.90	1.91
F-test symmetry p-value		0.375	0.039**	0.049**
LR-test p-value (asym vs. sym)		0.432	0.083*	0.090*
LR-test p-value (est vs. fixed)	0.019**	0.224	0.422	0.639
Note:				*p<0.1; **p<0.05; ***p<0.01

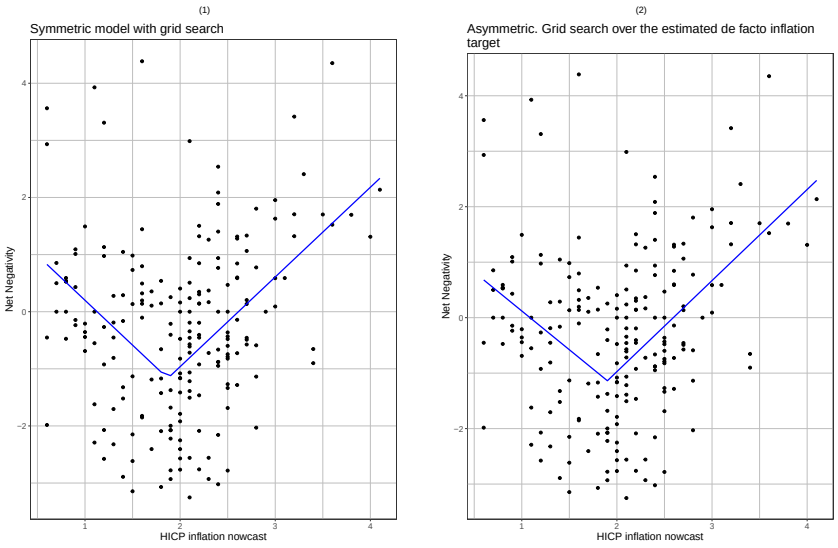

Figure E.5: V results for columns (1) and (2) of Table E.5

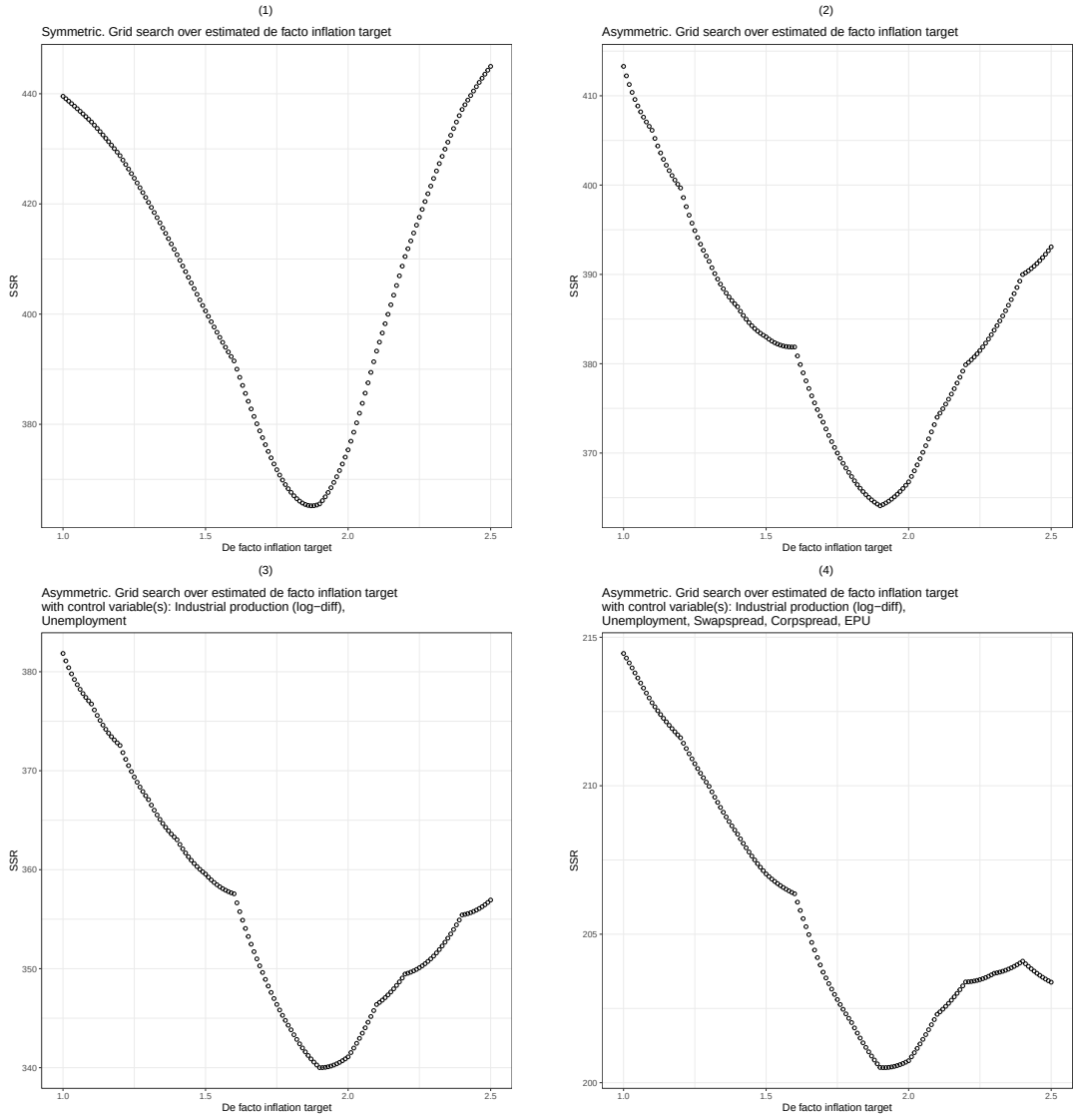

Figure E.6: The sums of squared residuals (SSR) for columns (1) to (4) of Table E.5

Table E.6: Asymmetric estimations with meeting based whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	1.730***	-1.148***	0.032**	1.757***	-0.840**	0.001***	1.008***	-0.365	0.008***
1.9	1.642***	-1.398***	0.375	1.664***	-1.065***	0.039**	0.958***	-0.484	0.059*
1.8	1.521***	-1.634***	0.699	1.545***	-1.264***	0.361	0.882***	-0.563	0.236
1.7	1.384***	-1.861***	0.140	1.417***	-1.447***	0.931	0.808***	-0.629	0.550
1.6	1.224***	-2.049***	0.026**	1.265***	-1.578***	0.421	0.715***	-0.630	0.804
1.5	1.137***	-2.434***	0.003***	1.180***	-1.893***	0.116	0.673***	-0.752	0.841
1.4	1.042***	-2.865***	0.000***	1.091***	-2.235***	0.035**	0.623***	-0.842	0.639
1.3	0.940***	-3.359***	0.000***	1.001***	-2.627***	0.014**	0.570***	-0.894	0.567

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

E.4 Including stock market variables

Table E.7: Meeting based whole text tone

	Dependent variable:			
	Tone			
	Symmetric V	Asymmetric V		
	(1)	(2)	(3)	(4)
Inflation	0.771***			
Inflation below the target		−0.483***	−0.427***	−0.069
Inflation above the target		1.531***	1.579***	1.285***
Industrial production (log-diff)			−13.128**	−0.553
Unemployment			0.090	0.149
Swapspread				−0.164
Corpspread				0.512***
PE ratio (log)				−1.159***
EURO STOXX (log-diff)				2.036
EURO STOXX volatility (log)				0.776**
EPU				0.001
Constant	−0.861***	−0.876***	−1.689***	−2.163
Observations	238	238	238	226
R^2	0.084	0.140	0.165	0.497
Adjusted R^2	0.080	0.133	0.150	0.474
Estimated inflation target	1.71	2.00	2.00	2.50
F-test symmetry p-value		6.401e-06***	2.073e-06***	0.000***
LR-test p-value (asym vs. sym)		0.000***	3.731e-05***	0.003***
LR-test p-value (est vs. fixed)	0.018**	1.000	1.000	0.282
Note:				*p<0.1; **p<0.05; ***p<0.01

Table E.8: Asymmetric estimations with meeting based whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	1.531***	-0.483***	6.401e-06***	1.579***	-0.427**	2.073e-06***	0.810***	-0.184	0.004***
1.9	1.413***	-0.547***	6.292e-05***	1.461***	-0.493**	2.085e-05***	0.741***	-0.206	0.010**
1.8	1.271***	-0.591***	0.001***	1.323***	-0.537**	0.000***	0.656***	-0.210	0.027**
1.7	1.124***	-0.618***	0.010**	1.183***	-0.566**	0.003***	0.574**	-0.202	0.059*
1.6	0.978***	-0.627**	0.070*	1.041***	-0.576**	0.024**	0.491**	-0.182	0.112
1.5	0.882***	-0.663**	0.259	0.948***	-0.615**	0.107	0.442*	-0.180	0.176
1.4	0.785***	-0.685**	0.614	0.856***	-0.642**	0.312	0.392*	-0.169	0.256
1.3	0.692***	-0.693**	0.994	0.768***	-0.660**	0.624	0.343*	-0.151	0.337

Note: $^{*}p < 0.1;^{**} p < 0.05;^{***} p < 0.01$

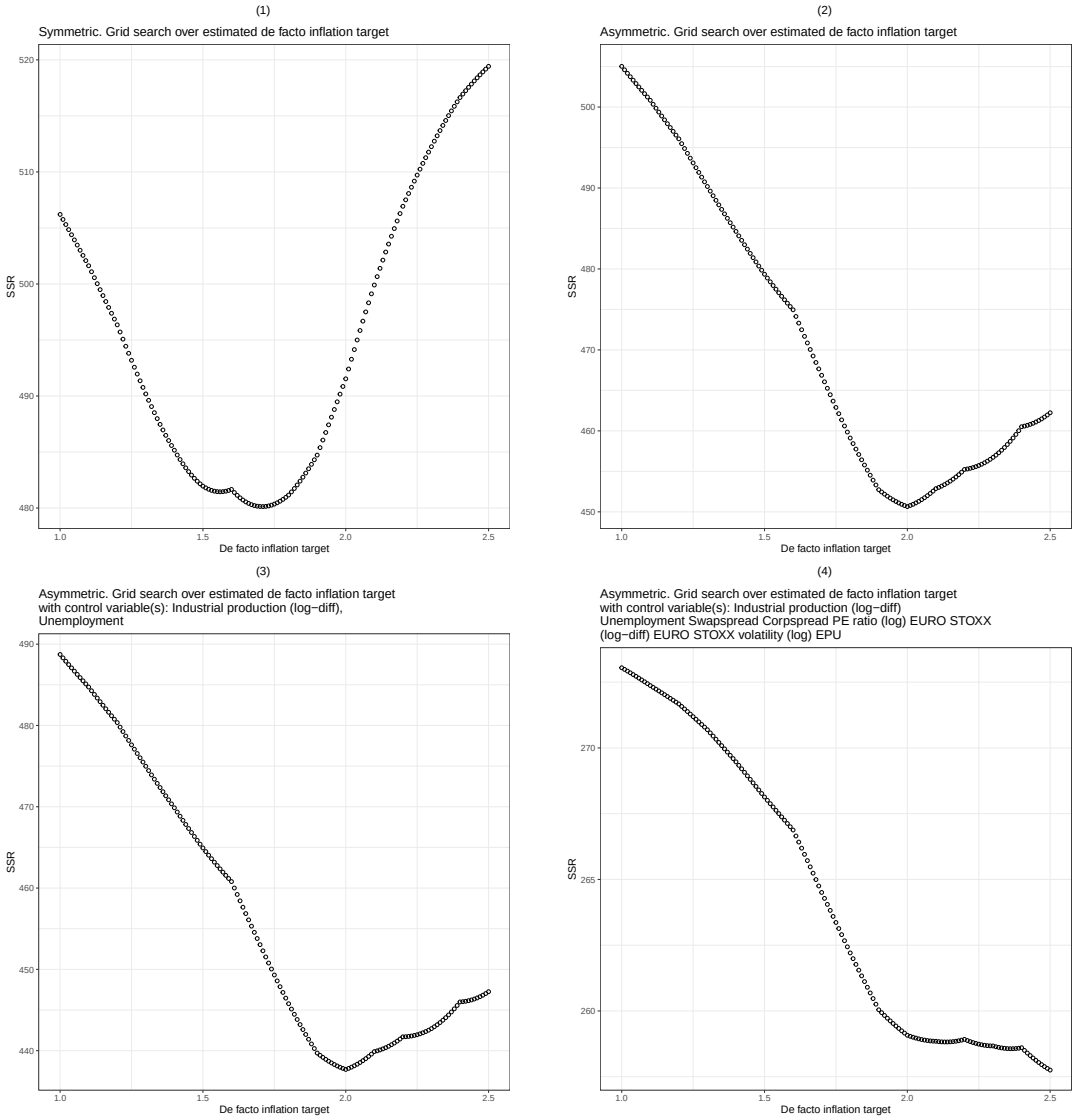

Figure E.7: The sums of squared residuals (SSR) for columns (1) to (4) of Table E.7

E.5 Differenced unemployment and financial data

Table E.9: Meeting based whole text tone

	Dependent variable:			
	Tone			
	Symmetric V		Asymmetric V	
	(1)	(2)	(3)	(4)
Inflation	0.771***			
Inflation below the target		−0.483***	−0.266**	−0.204*
Inflation above the target		1.531***	1.609***	1.659***
Industrial production (log-diff)			−8.354	−7.587
Unemployment (diff)			10.863***	11.501***
Swapspread (diff)				0.313
Corpspread (diff)				0.309
EPU (log-diff)				0.051
Constant	−0.861***	−0.876***	−0.726***	−0.648***
Observations	238	238	238	225
R^2	0.084	0.140	0.371	0.383
Adjusted R^2	0.080	0.133	0.360	0.363
Estimated inflation target	1.71	2.00	2.15	2.25
F-test symmetry p-value		6.401e-06***	4.606e-09***	2.649e-08***
LR-test p-value (asym vs. sym)		0.000***	1.170e-06***	2.947e-06***
LR-test p-value (est vs. fixed)	0.018**	1.000	0.514	0.356
Note:				*p<0.1; **p<0.05; ***p<0.01

Table E.10: Asymmetric estimations with meeting based whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	1.531***	-0.483***	6.401e-06***	1.431***	-0.343**	6.915e-08***	1.346***	-0.314*	9.080e-07***
1.9	1.413***	-0.547***	6.292e-05***	1.311***	-0.391**	1.037e-06***	1.228***	-0.356**	9.238e-06***
1.8	1.271***	-0.591***	0.001***	1.177***	-0.423**	2.355e-05***	1.097***	-0.382**	0.000***
1.7	1.124***	-0.618***	0.010**	1.041***	-0.438**	0.000***	0.965***	-0.391*	0.001***
1.6	0.978***	-0.627**	0.070*	0.904***	-0.432**	0.005***	0.835***	-0.383*	0.010**
1.5	0.882***	-0.663**	0.259	0.810***	-0.447*	0.032**	0.750***	-0.397*	0.045**
1.4	0.785***	-0.685**	0.614	0.718***	-0.448*	0.121	0.669***	-0.401*	0.138
1.3	0.692***	-0.693**	0.994	0.636***	-0.441*	0.288	0.597***	-0.400	0.297

Note: $^{*}p < 0.1;^{**} p < 0.05;^{***} p < 0.01$

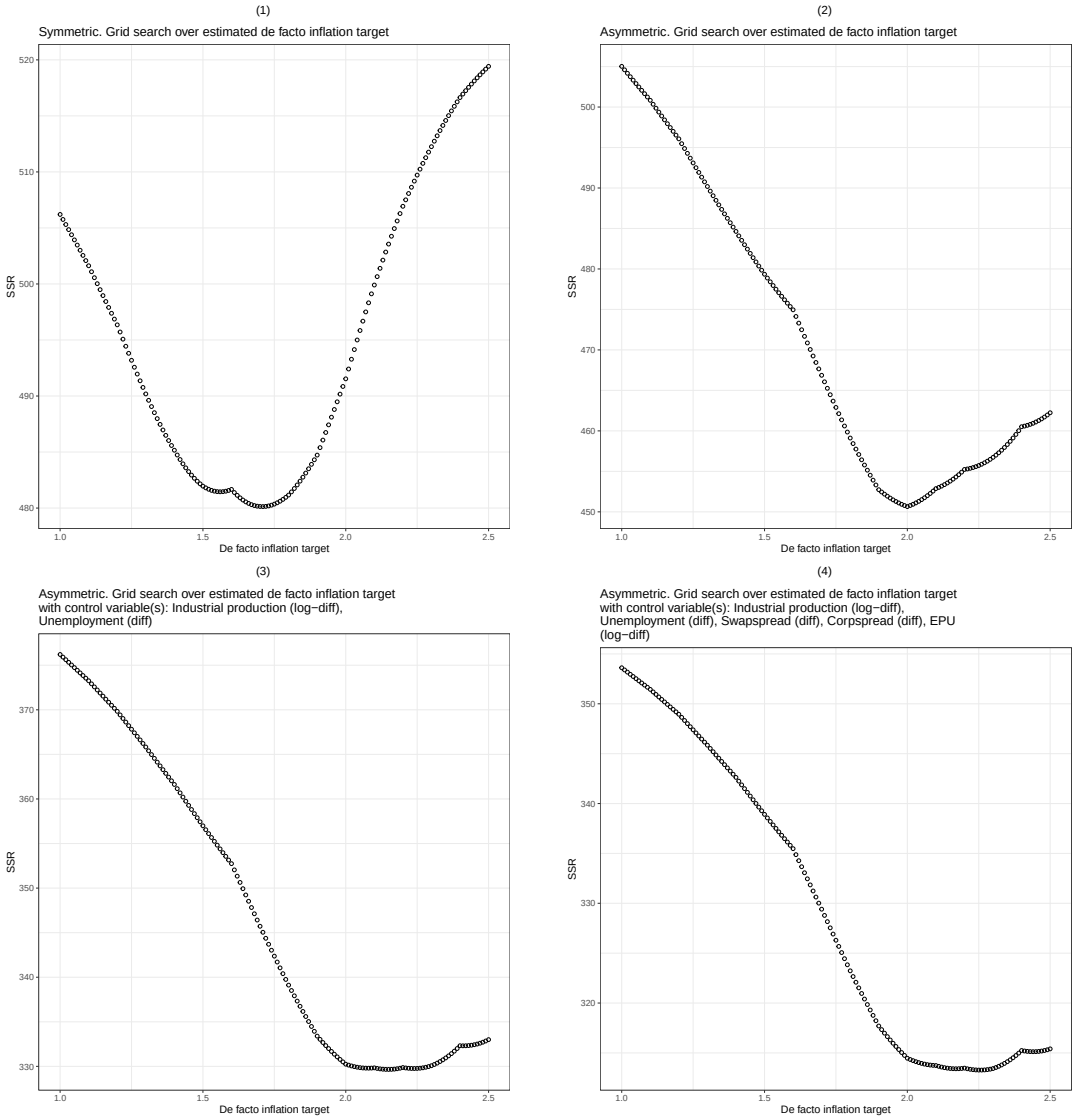

Figure E.8: The sums of squared residuals (SSR) for columns (1) to (4) of Table E.9

E.6 Unemployment in differences and financial data in levels

Table E.11: Meeting based whole text tone

	Dependent variable:			
	Tone			
	Symmetric V		Asymmetric V	
	(1)	(2)	(3)	(4)
Inflation	0.771***			
Inflation below the target		−0.483***	−0.266**	0.041
Inflation above the target		1.531***	1.609***	1.429***
Industrial production (log-diff)			−8.354	−0.146
Unemployment (diff)			10.863***	5.826***
Swapspread				−0.469***
Corpspread				0.549***
EPU				0.001
Constant	−0.861***	−0.876***	−0.726***	−1.648***
Observations	238	238	238	226
R^2	0.084	0.140	0.371	0.510
Adjusted R^2	0.080	0.133	0.360	0.495
Estimated inflation target	1.71	2.00	2.15	2.50
F-test symmetry p-value		6.401e-06***	4.606e-09***	2.606e-06***
LR-test p-value (asym vs. sym)		0.000***	1.170e-06***	0.000***
LR-test p-value (est vs. fixed)	0.018**	1.000	0.514	0.689
Note:				*p<0.1; **p<0.05; ***p<0.01

Table E.12: Asymmetric estimations with meeting based whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	1.531***	-0.483***	6.401e-06***	1.431***	-0.343**	6.915e-08***	0.964***	-0.095	7.333e-06***
1.9	1.413***	-0.547***	6.292e-05***	1.311***	-0.391**	1.037e-06***	0.897***	-0.124	2.044e-05***
1.8	1.271***	-0.591***	0.001***	1.177***	-0.423**	2.355e-05***	0.815***	-0.139	8.632e-05***
1.7	1.124***	-0.618***	0.010**	1.041***	-0.438**	0.000***	0.734***	-0.144	0.000***
1.6	0.978***	-0.627**	0.070*	0.904***	-0.432**	0.005***	0.650***	-0.135	0.002***
1.5	0.882***	-0.663**	0.259	0.810***	-0.447*	0.032**	0.602***	-0.148	0.005***
1.4	0.785***	-0.685**	0.614	0.718***	-0.448*	0.121	0.550***	-0.150	0.015**
1.3	0.692***	-0.693**	0.994	0.636***	-0.441*	0.288	0.503***	-0.148	0.036**

Note: $^{*}p < 0.1;^{**} p < 0.05;^{***} p < 0.01$

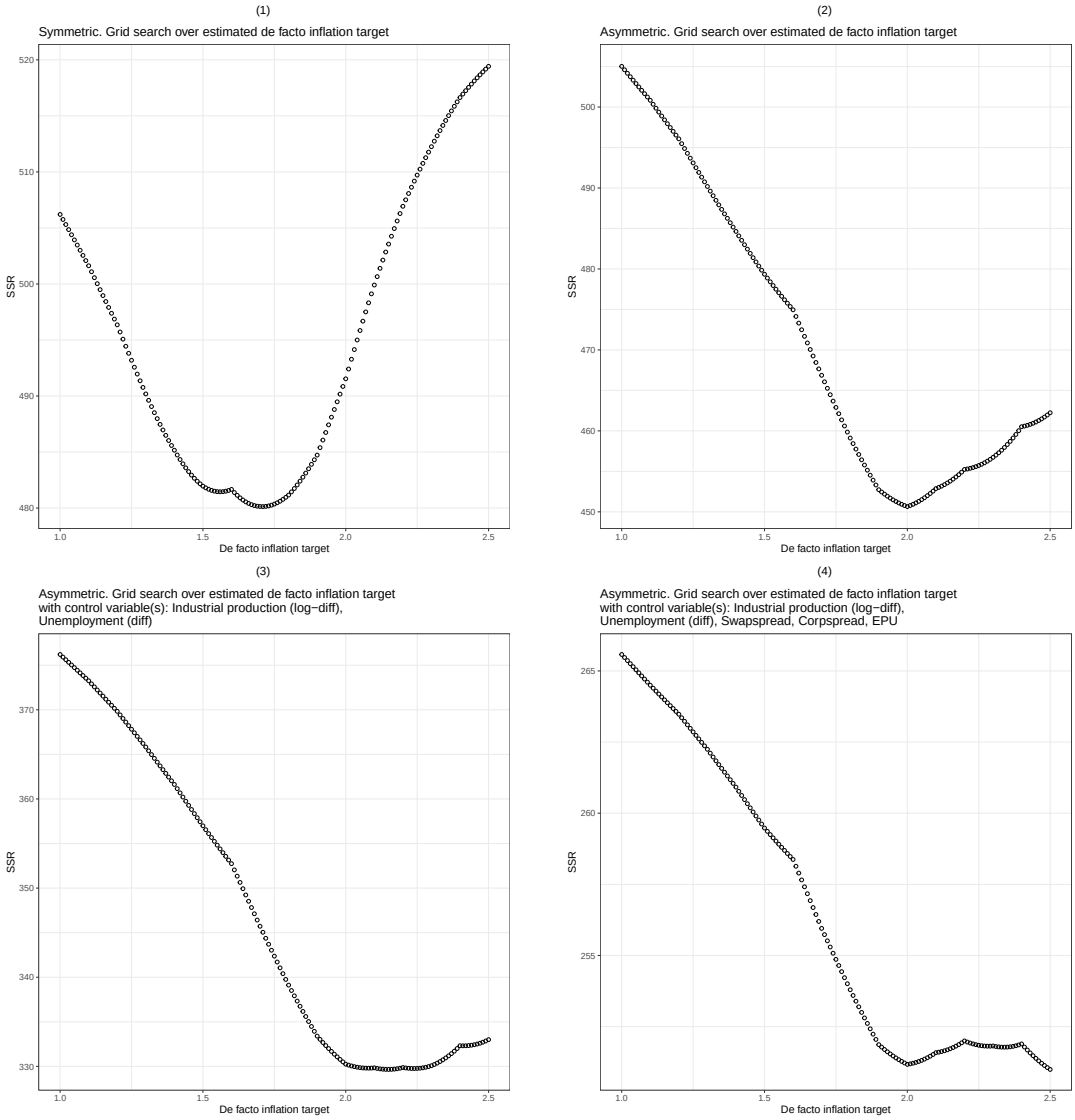

Figure E.9: The sums of squared residuals (SSR) for columns (1) to (4) of Table E.11

E.7 Inflation measured as the average of latest two observations

Table E.13: Meeting based whole text tone

	Dependent variable:			
	Tone			
	Symmetric V		Asymmetric V	
	(1)	(2)	(3)	(4)
Inflation	0.810***			
Inflation below the target		−0.419***	−0.357**	0.083
Inflation above the target		1.728***	1.780***	1.384***
Industrial production (log-diff)			−12.863**	0.465
Unemployment			0.105	0.125
Swapspread				−0.354
Corpspread				0.751***
EPU				0.002
Constant	−0.900***	−0.859***	−1.810***	−3.088***
Observations	237	237	237	226
R^2	0.085	0.156	0.182	0.479
Adjusted R^2	0.081	0.149	0.168	0.462
Estimated inflation target	1.62	2.05	2.05	2.50
F-test symmetry p-value		1.047e-07***	2.671e-08***	1.017e-05***
LR-test p-value (asym vs. sym)		1.295e-05***	4.703e-06***	0.000***
LR-test p-value (est vs. fixed)	0.005***	0.653	0.624	0.343
Note:				*p<0.1; **p<0.05; ***p<0.01

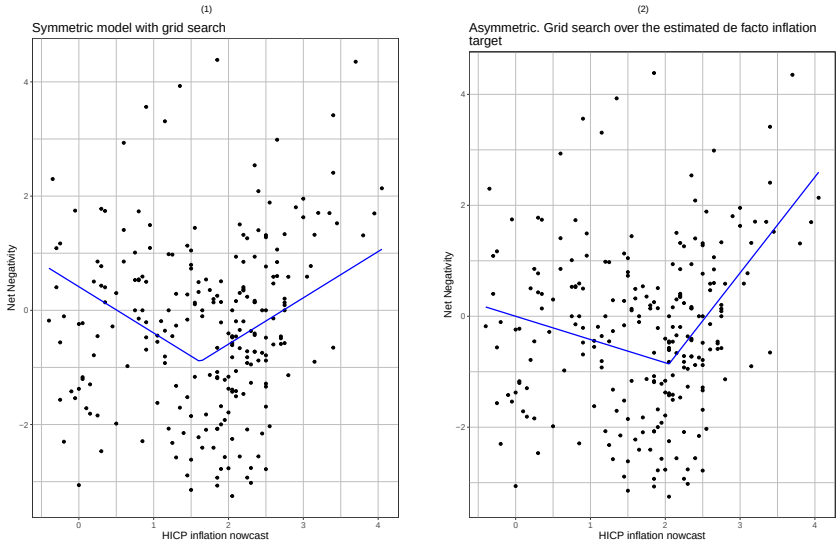

Figure E.10: V results for columns (1) and (2) of Table E.13

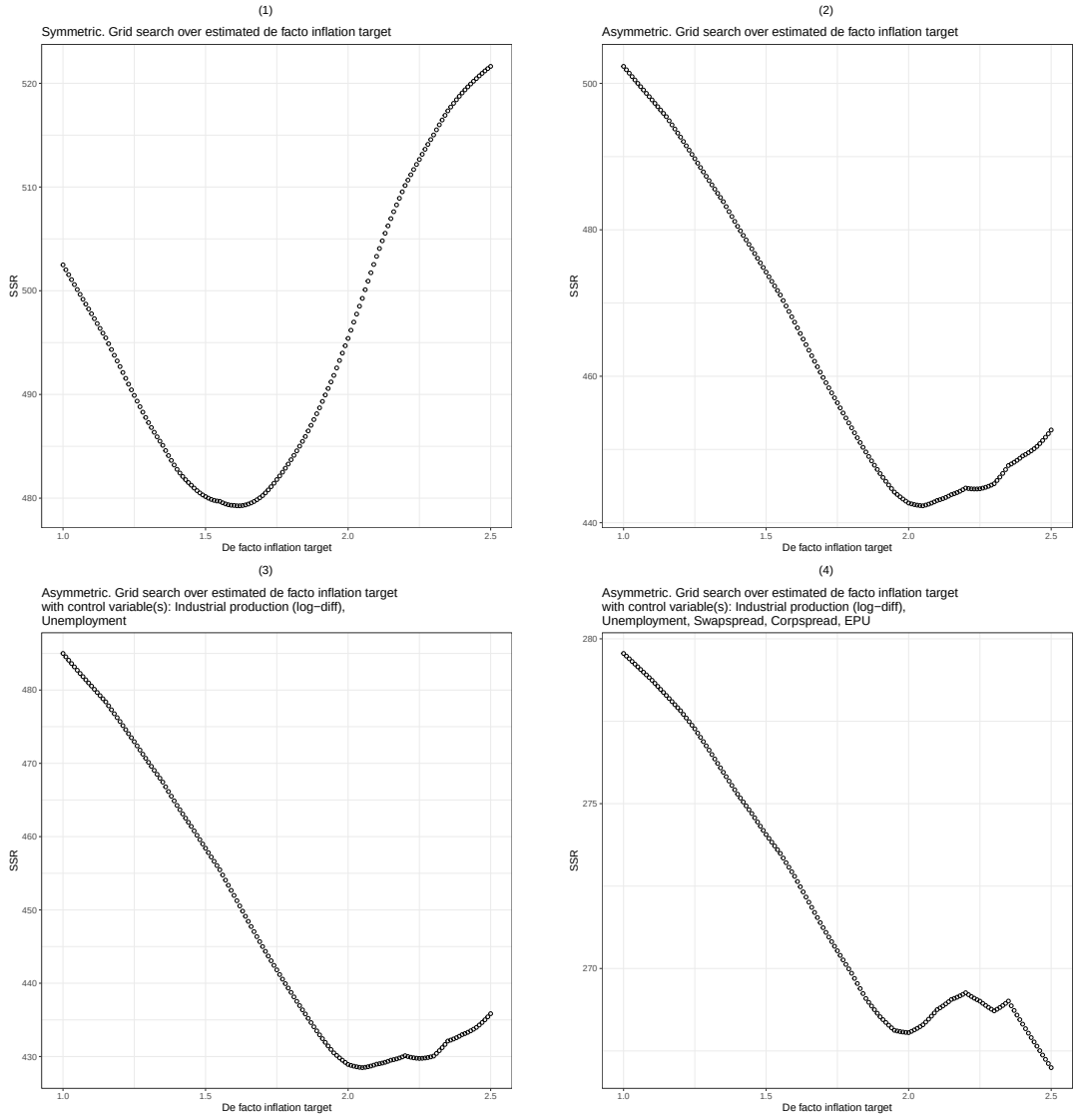

Figure E.11: The sums of squared residuals (SSR) for columns (1) to (4) of Table E.13

Table E.14: Asymmetric estimations with meeting based whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	1.665***	-0.454**	2.964e-07***	1.715***	-0.392**	7.828e-08***	0.925***	-0.046	2.196e-05***
1.9	1.514***	-0.507***	4.627e-06***	1.562***	-0.447**	1.293e-06***	0.860***	-0.073	4.879e-05***
1.8	1.365***	-0.553***	8.993e-05***	1.419***	-0.494**	2.415e-05***	0.789***	-0.090	0.000***
1.7	1.225***	-0.590***	0.001***	1.286***	-0.533**	0.000***	0.724***	-0.102	0.000***
1.6	1.085***	-0.611**	0.015**	1.154***	-0.557**	0.004***	0.658***	-0.105	0.002***
1.5	0.960***	-0.626**	0.089*	1.035***	-0.576**	0.028**	0.604***	-0.109	0.005***
1.4	0.856***	-0.643**	0.291	0.936***	-0.600**	0.115	0.556***	-0.114	0.013**
1.3	0.755***	-0.644**	0.602	0.839***	-0.611*	0.305	0.507**	-0.106	0.030**

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

E.8 Default L&M (2011) dictionary augmented with British English words

Table E.15: Meeting based whole text tone

	Dependent variable:			
	Tone			
	Symmetric V	Asymmetric V		
	(1)	(2)	(3)	(4)
Inflation	0.713***			
Inflation below the target		−0.485***	−0.485***	−0.140
Inflation above the target		1.544***	1.502***	0.842**
Industrial production (log-diff)			−13.837**	−0.342
Unemployment			−0.002	−0.007
Swapspread				−0.373
Corpspread				0.760***
EPU				0.002
Constant	−0.507***	−0.515***	−0.496	−1.865**
Observations	238	238	238	226
R^2	0.081	0.100	0.119	0.422
Adjusted R^2	0.077	0.092	0.104	0.403
Estimated inflation target	1.90	2.27	2.25	2.50
F-test symmetry p-value		0.001***	0.001***	0.041**
LR-test p-value (asym vs. sym)		0.025**	0.039**	0.135
LR-test p-value (est vs. fixed)	0.326	0.523	0.687	0.297
Note:				*p<0.1; **p<0.05; ***p<0.01

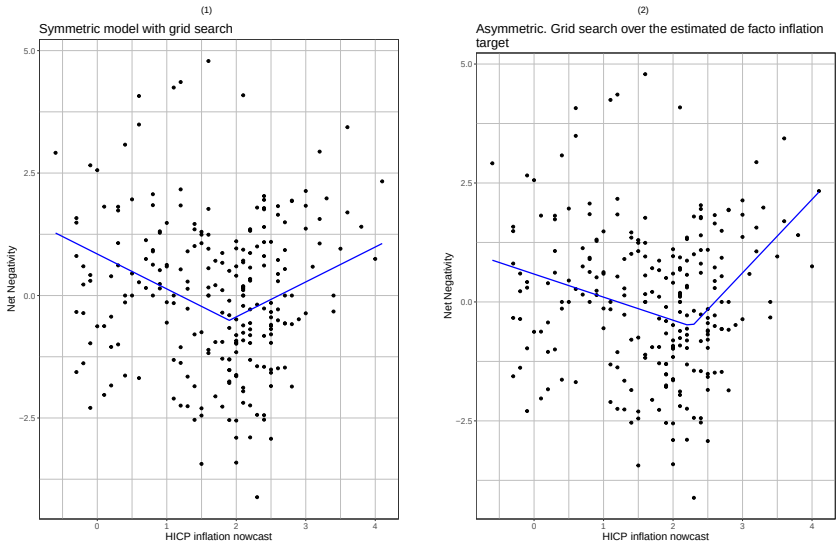

Figure E.12: V results for columns (1) and (2) of Table E.15

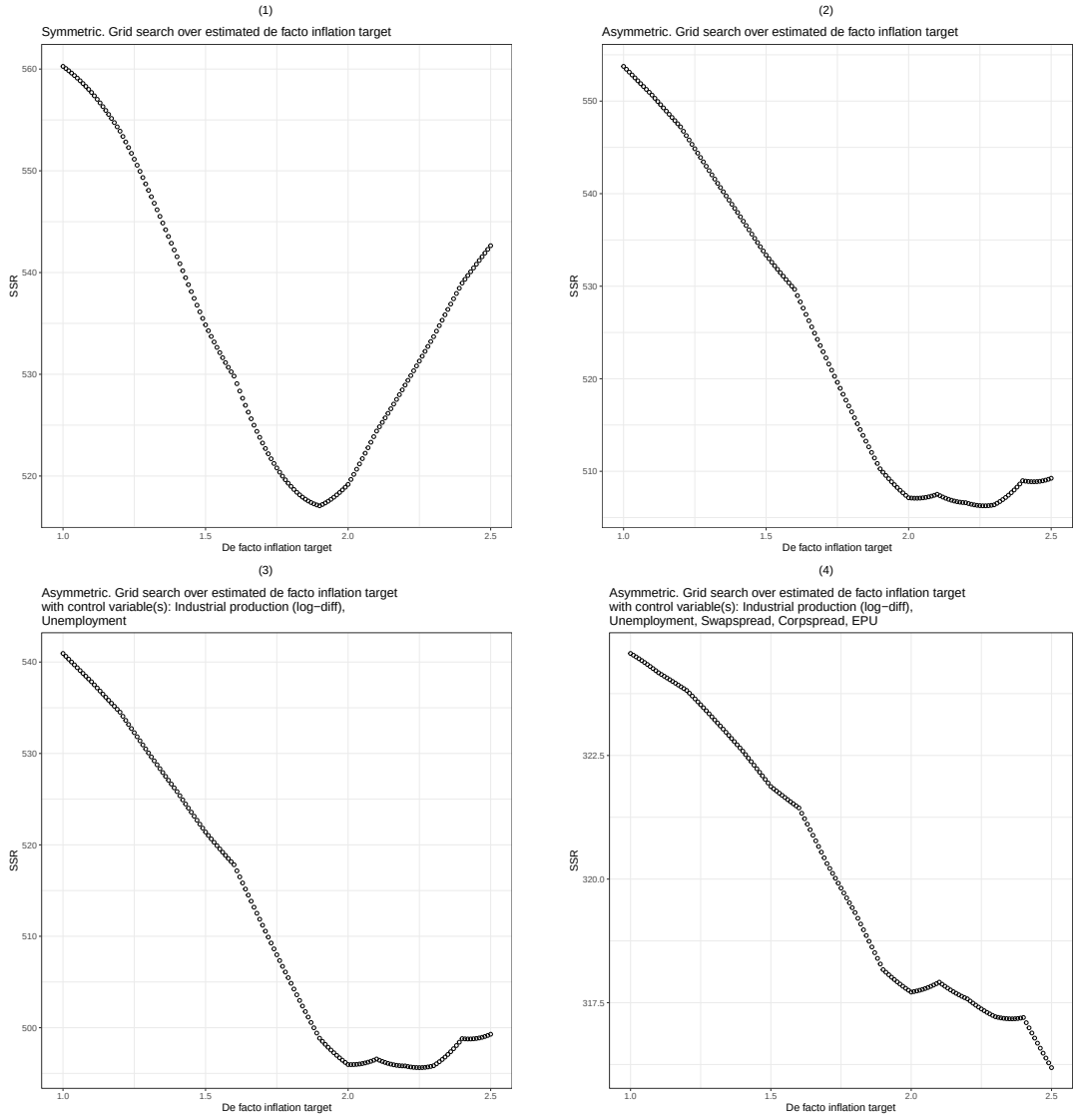

Figure E.13: The sums of squared residuals (SSR) for columns (1) to (4) of Table E.15

Table E.16: Asymmetric estimations with meeting based whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	1.180***	-0.611***	0.019**	1.170***	-0.612***	0.028**	0.468*	-0.221	0.254
1.9	1.059***	-0.660***	0.078*	1.051***	-0.663***	0.103	0.420	-0.239	0.374
1.8	0.921***	-0.690***	0.282	0.916***	-0.692***	0.327	0.356	-0.241	0.555
1.7	0.787***	-0.708***	0.703	0.785***	-0.709***	0.733	0.301	-0.240	0.746
1.6	0.653**	-0.707***	0.791	0.653**	-0.709***	0.799	0.243	-0.228	0.935
1.5	0.565**	-0.731***	0.418	0.568**	-0.734***	0.447	0.213	-0.234	0.909
1.4	0.474*	-0.737**	0.212	0.480*	-0.743**	0.239	0.175	-0.225	0.790
1.3	0.389*	-0.731**	0.121	0.399*	-0.743**	0.138	0.140	-0.212	0.715

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

E.9 Picault & Renault (2017) measure of economic outlook

Table E.17: Meeting based whole text tone

	Dependent variable:			
	Tone			
	Symmetric V		Asymmetric V	
	(1)	(2)	(3)	(4)
Inflation	7.008***			
Inflation below the target		−6.190**	−3.866	−2.597
Inflation above the target		9.468**	12.348***	5.826**
Industrial production (log-diff)			−137.838	6.427
Unemployment			5.103***	3.198**
Swapspread				−11.524**
Corpspread				7.524***
EPU				0.036*
Constant	−8.845***	−9.115***	−56.593***	−61.989***
Observations	155	155	155	155
R^2	0.046	0.049	0.209	0.482
Adjusted R^2	0.039	0.037	0.187	0.457
Estimated inflation target	1.80	1.90	1.90	1.72
F-test symmetry p-value		0.353	0.013**	0.231
LR-test p-value (asym vs. sym)		0.456	0.054*	0.456
LR-test p-value (est vs. fixed)	0.241	0.451	0.702	0.800
Note:				*p<0.1; **p<0.05; ***p<0.01

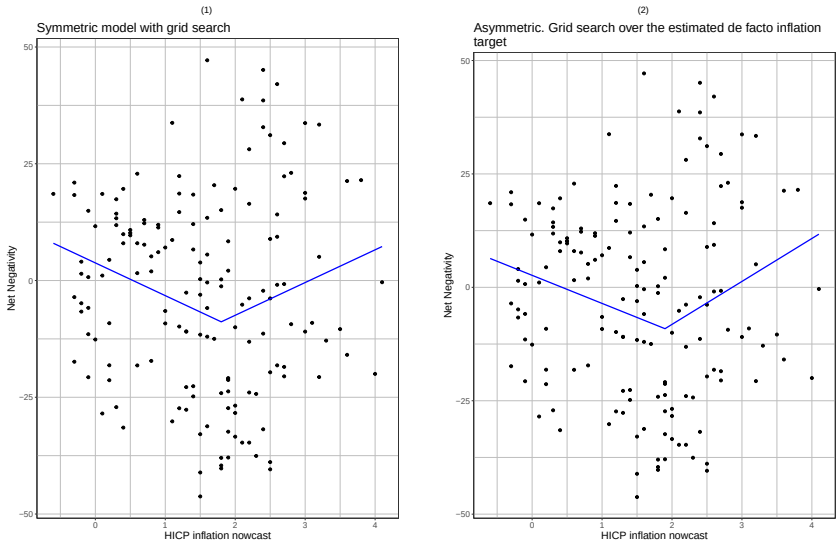

Figure E.14: V results for columns (1) and (2) of Table E.17

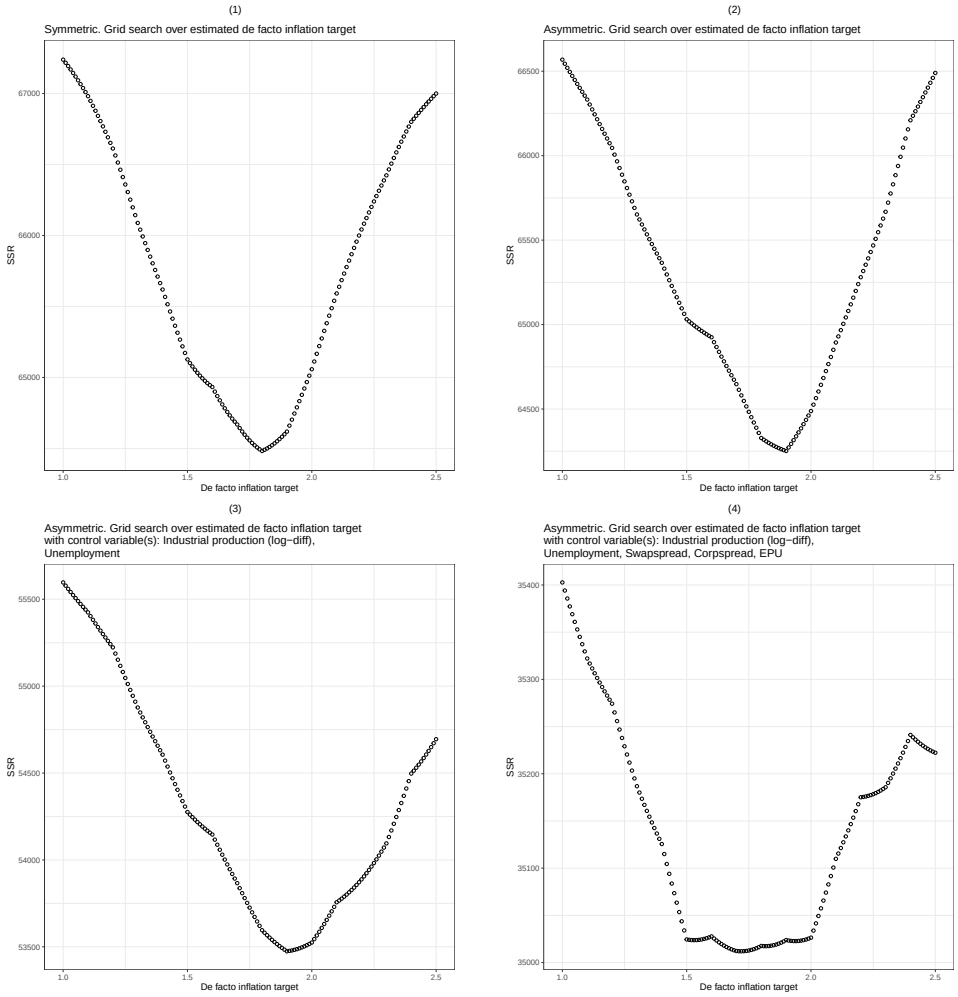

Figure E.15: The sums of squared residuals (SSR) for columns (1) to (4) of Table E.17

Table E.18: Asymmetric estimations with meeting based whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	9.970*	-5.605*	0.248	13.238**	-3.398	0.007***	7.011*	-1.856	0.094*
1.9	9.468*	-6.190*	0.353	12.348**	-3.866	0.013**	6.501*	-2.090	0.128
1.8	8.613*	-6.600*	0.547	11.400**	-4.259	0.028**	6.095*	-2.358	0.177
1.7	7.542*	-6.816*	0.822	10.398**	-4.546	0.062*	5.750*	-2.650	0.248
1.6	6.552	-6.985*	0.891	9.396**	-4.747	0.130	5.342*	-2.884	0.353
1.5	5.920	-7.403*	0.637	8.715**	-5.170	0.245	5.049*	-3.227	0.491
1.4	5.087	-7.536*	0.444	7.888**	-5.360	0.414	4.571	-3.339	0.648
1.3	4.373	-7.697*	0.316	7.194**	-5.608	0.619	4.218	-3.561	0.814

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

E.10 Quarterly piecewise estimations

Table E.19: Quarterly data and whole text tone

	Dependent variable:			
	Tone			
	Symmetric V	Asymmetric V		
	(1)	(2)	(3)	(4)
Inflation	0.776^{***}			
Inflation below the target		-0.526^{**}	0.203	0.195
Inflation above the target		1.355^{***}	1.818^{***}	1.042^{*}
GDP growth			-0.222^{***}	-0.148^{***}
Unemployment			0.151	0.099
Swapspread				−0.497
Corpspread				0.007^{***}
EPU				−0.001
Constant	-0.938^{***}	-0.954^{***}	-1.525^{*}	-2.111^{*}
Observations	90	90	90	86
R^2	0.091	0.130	0.297	0.578
Adjusted R^2	0.081	0.110	0.264	0.540
Estimated inflation target	1.64	1.87	2.36	2.50
F-test symmetry p-value		0.016^{**}	0.000^{***}	0.018^{**}
LR-test p-value (asym vs. sym)		0.047^{**}	0.001^{***}	0.014^{**}
LR-test p-value (est vs. fixed)	0.042^{**}	0.484	0.436	0.253
Note:				*p<0.1; **p<0.05; ***p<0.01

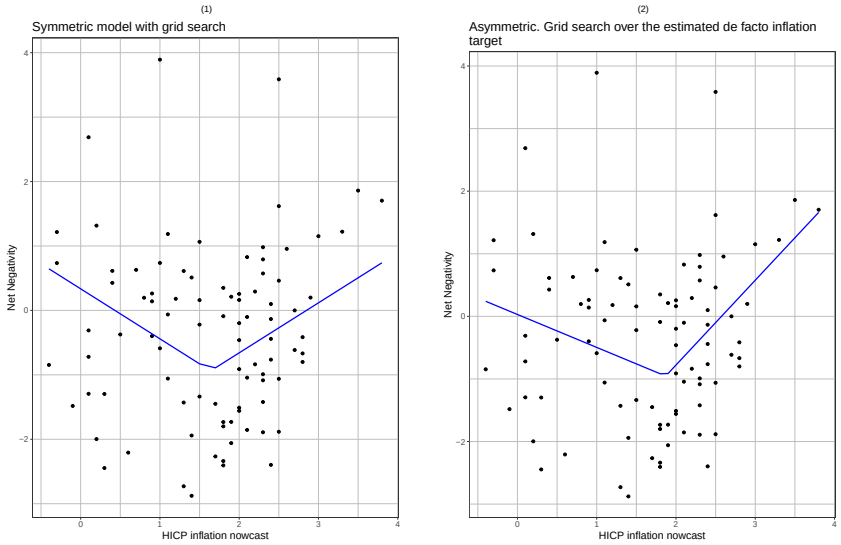

Figure E.16: V results for columns (1) and (2) of Table E.19

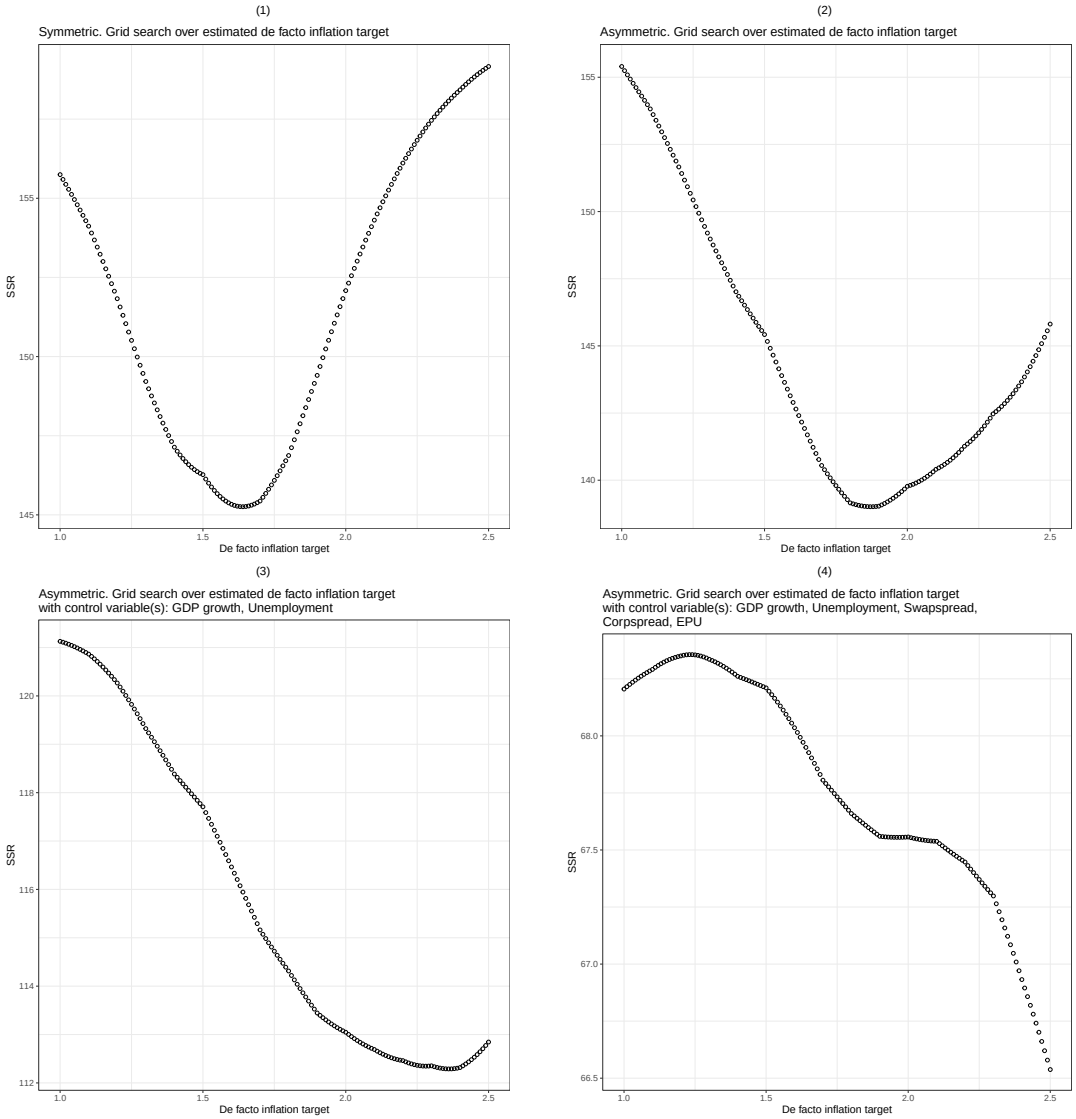

Figure E.17: The sums of squared residuals (SSR) for columns (1) to (4) of Table E.19

Table E.20: Asymmetric estimations with quarterly whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	1.471***	-0.427*	0.007***	1.346***	0.065	0.000***	0.590	0.165	0.020**
1.9	1.385***	-0.504*	0.013**	1.253***	0.023	0.000***	0.566	0.146	0.019**
1.8	1.276***	-0.571*	0.031**	1.145**	-0.002	0.001***	0.528	0.138	0.021**
1.7	1.160**	-0.630*	0.085*	1.058**	-0.022	0.001***	0.490	0.140	0.026**
1.6	1.021**	-0.661*	0.226	0.951**	-0.010	0.003***	0.435	0.165	0.032**
1.5	0.873**	-0.664*	0.478	0.844**	0.025	0.007***	0.383	0.201	0.038**
1.4	0.771**	-0.690*	0.788	0.778**	0.036	0.015**	0.362	0.213	0.047**
1.3	0.662*	-0.689	0.933	0.701**	0.083	0.024**	0.327	0.255	0.054*

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

E.11 Quarterly estimations, with inflation measured as the average of the current quarter and one-quarter-ahead forecast

Table E.21: Quarterly data and whole text

	Dependent variable:			
	Tone			
	Symmetric V		Asymmetric V	
	(1)	(2)	(3)	(4)
Inflation	0.898***			
Inflation below the target		−0.673***	0.179	0.197
Inflation above the target		1.319***	1.988***	1.303**
GDP growth			−0.220***	−0.147***
Unemployment			0.145	0.096
Swapspread				−0.535
Corpspread				0.007***
EPU				−0.001
Constant	−0.990***	−0.986***	−1.467*	−2.101*
Observations	90	90	90	86
R^2	0.103	0.121	0.279	0.580
Adjusted R^2	0.093	0.101	0.245	0.543
Estimated inflation target	1.61	1.79	2.35	2.50
F-test symmetry p-value		0.072*	0.001***	0.014**
LR-test p-value (asym vs. sym)		0.173	0.006***	0.012**
LR-test p-value (est vs. fixed)	0.024**	0.213	0.224	0.139
Note:				*p<0.1; **p<0.05; ***p<0.01

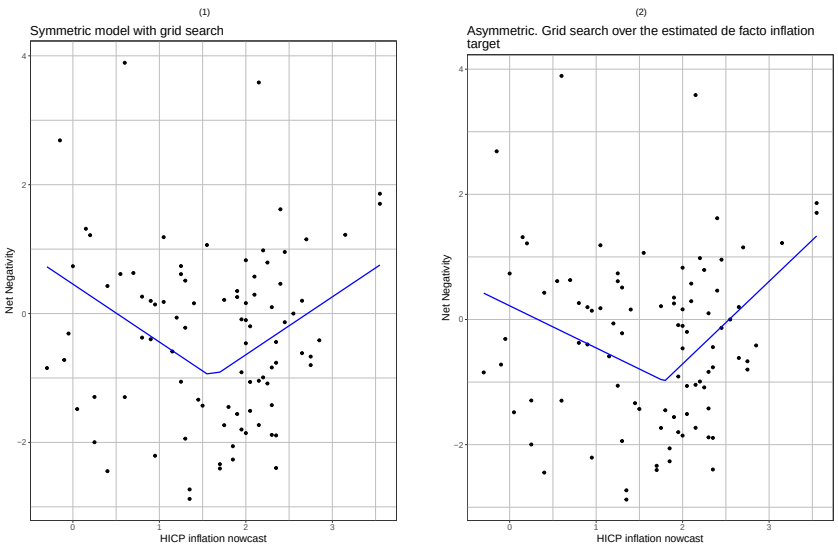

Figure E.18: V results for columns (1) and (2) of Table E.21

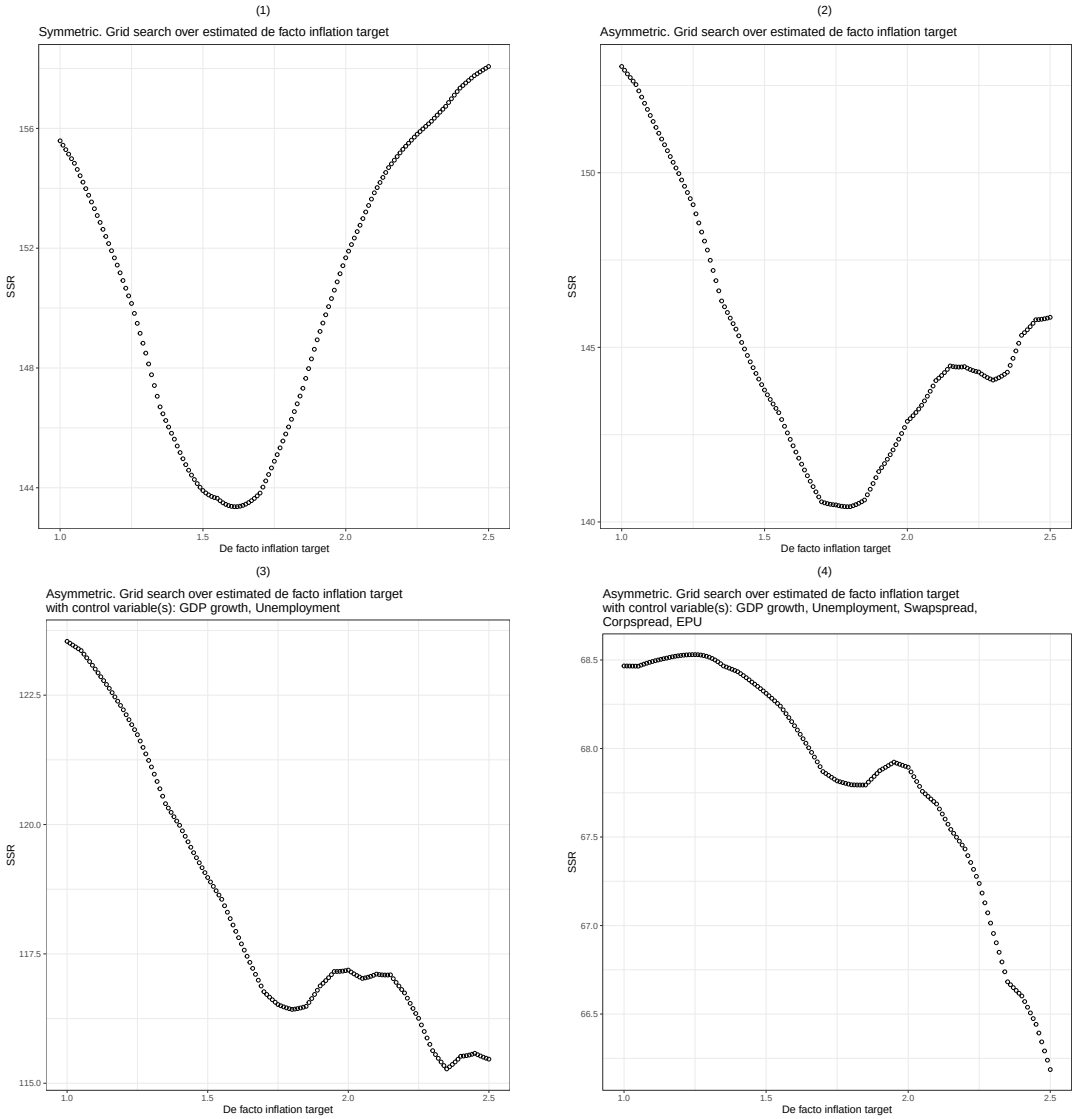

Figure E.19: The sums of squared residuals (SSR) for columns (1) to (4) of Table E.21

Table E.22: Asymmetric estimations with quarterly whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	1.456**	-0.462*	0.023**	1.367**	0.060	0.001***	0.605	0.202	0.027**
1.9	1.394**	-0.558*	0.035**	1.307**	-0.005	0.001***	0.587	0.182	0.024**
1.8	1.328**	-0.664*	0.066*	1.266**	-0.080	0.002***	0.584	0.153	0.023**
1.7	1.227**	-0.755**	0.160	1.186**	-0.134	0.004***	0.553	0.141	0.026**
1.6	1.091**	-0.818**	0.394	1.075**	-0.152	0.009***	0.490	0.163	0.032**
1.5	0.951**	-0.864**	0.780	0.968**	-0.156	0.022**	0.435	0.192	0.040**
1.4	0.817*	-0.895*	0.808	0.869**	-0.147	0.047**	0.389	0.227	0.049**
1.3	0.682*	-0.897*	0.520	0.773**	-0.111	0.080*	0.344	0.281	0.055*

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

E.12 Backward-looking meeting based tone

Table E.23: Meeting based whole text tone

	Dependent variable:			
	Tone			
	Symmetric V	Asymmetric V		
	(1)	(2)	(3)	(4)
Inflation	0.694***			
Inflation below the target		−0.519***	−0.493**	−0.061
Inflation above the target		1.153***	1.171***	0.517*
Industrial production (log-diff)			−19.175**	−6.211
Unemployment			0.031	0.131
Swapspread				−0.010
Corpspread				0.777***
EPU				0.003
Constant	−0.402**	−0.439**	−0.716	−3.043**
Observations	238	238	238	226
R^2	0.045	0.061	0.087	0.282
Adjusted R^2	0.041	0.053	0.071	0.259
Estimated inflation target	1.74	1.90	1.90	1.90
F-test symmetry p-value		0.023**	0.020**	0.095*
LR-test p-value (asym vs. sym)		0.042**	0.036**	0.176
LR-test p-value (est vs. fixed)	0.073*	0.400	0.373	0.534
Note:				*p<0.1; **p<0.05; ***p<0.01

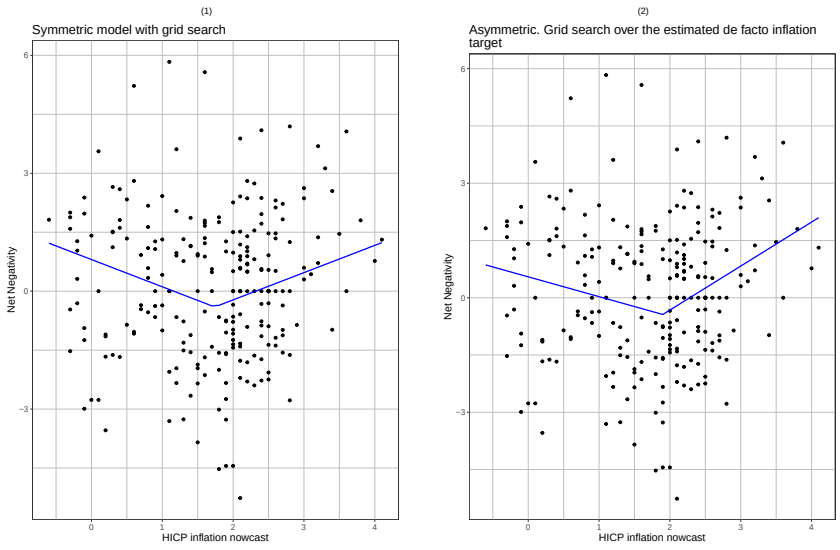

Figure E.20: V results for columns (1) and (2) of Table E.23

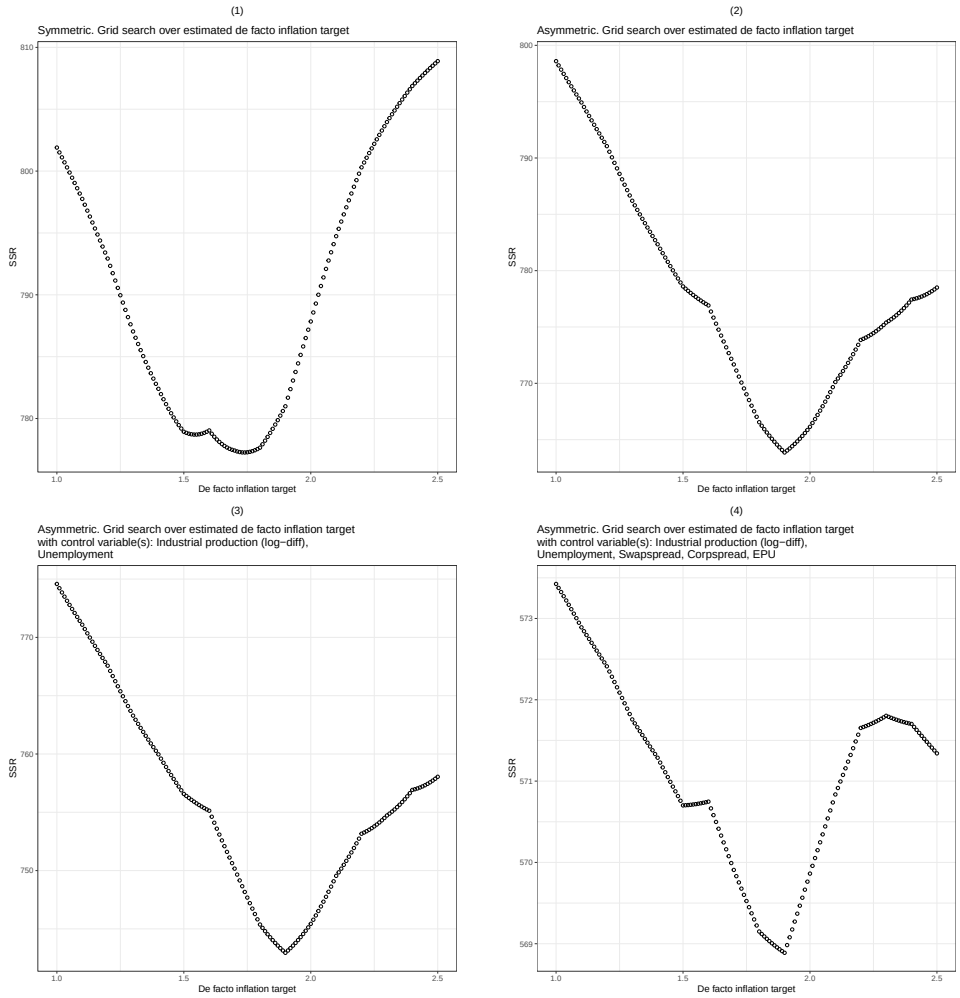

Figure E.21: The sums of squared residuals (SSR) for columns (1) to (4) of Table E.23

Table E.24: Asymmetric estimations with meeting based whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	1.207***	-0.444*	0.010**	1.224***	-0.416*	0.009***	0.506	-0.021	0.095*
1.9	1.153***	-0.519**	0.023**	1.171***	-0.493*	0.020**	0.517	-0.061	0.095*
1.8	1.052***	-0.570**	0.066*	1.075***	-0.545*	0.056*	0.483	-0.078	0.120
1.7	0.933***	-0.600**	0.188	0.961***	-0.576*	0.151	0.436	-0.081	0.159
1.6	0.815**	-0.618*	0.424	0.847**	-0.594*	0.338	0.387	-0.075	0.208
1.5	0.748**	-0.670*	0.752	0.783**	-0.649*	0.612	0.374	-0.098	0.267
1.4	0.666**	-0.699*	0.896	0.706**	-0.683*	0.934	0.341	-0.099	0.337
1.3	0.589**	-0.721*	0.618	0.634**	-0.715*	0.771	0.313	-0.100	0.414

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

E.13 Forward-looking meeting based tone

Table E.25: Meeting based whole text tone

	Dependent variable:			
	Tone			
	Symmetric V		Asymmetric V	
	(1)	(2)	(3)	(4)
Inflation	0.963***			
Inflation below the target		−0.594***	−0.511***	−0.176
Inflation above the target		2.034***	2.119***	1.337***
Industrial production (log-diff)			−11.350*	2.245
Unemployment			0.129*	0.057
Swapspread				−0.699**
Corpspread				0.765***
EPU				0.001
Constant	−1.244***	−1.260***	−2.418***	−3.018***
Observations	238	238	238	226
R^2	0.107	0.186	0.208	0.494
Adjusted R^2	0.103	0.179	0.195	0.477
Estimated inflation target	1.72	2.05	2.06	2.06
F-test symmetry p-value		4.497e-08***	6.347e-09***	6.183e-07***
LR-test p-value (asym vs. sym)		2.491e-06***	5.120e-07***	3.349e-05***
LR-test p-value (est vs. fixed)	0.017**	0.649	0.610	0.727
Note:				*p<0.1; **p<0.05; ***p<0.01

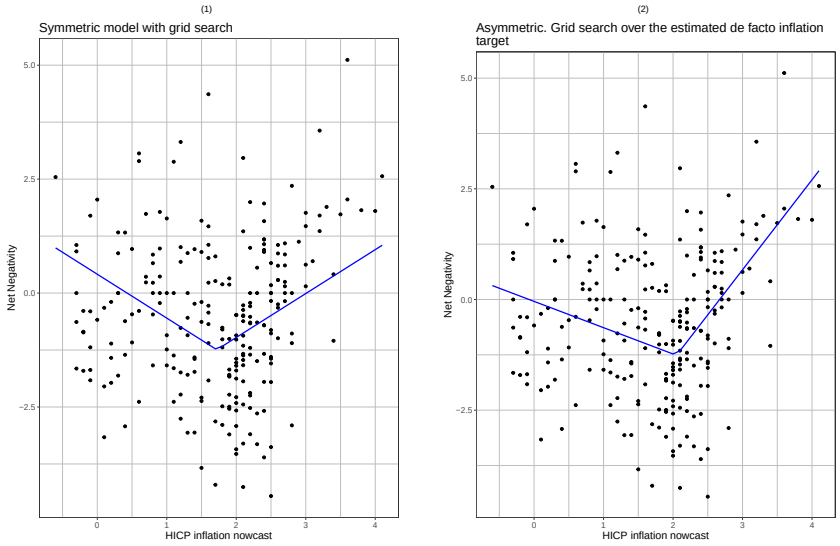

Figure E.22: V results for columns (1) and (2) of Table E.25

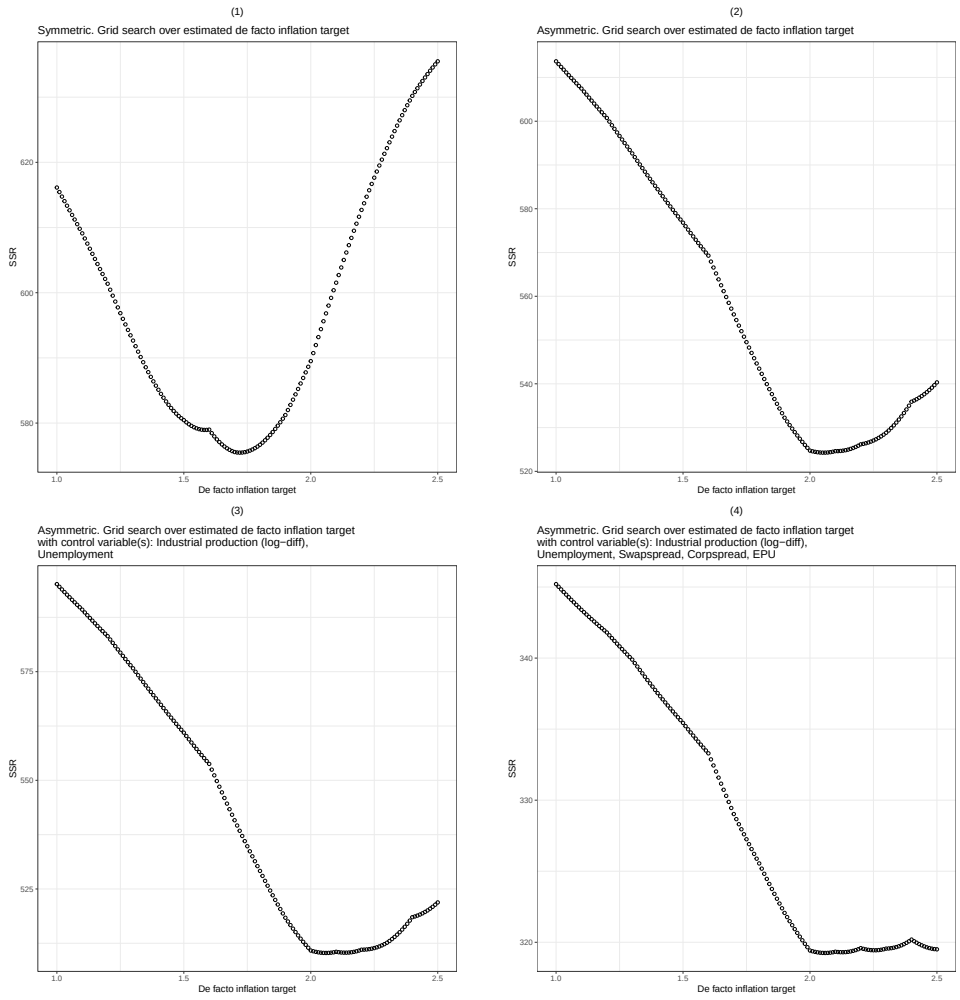

Figure E.23: The sums of squared residuals (SSR) for columns (1) to (4) of Table E.25

Table E.26: Asymmetric estimations with meeting based whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	1.951***	-0.632***	1.746e-07***	2.019***	-0.558***	3.251e-08***	1.281***	-0.203	1.324e-06***
1.9	1.769***	-0.698***	5.523e-06***	1.836***	-0.625***	1.091e-06***	1.169***	-0.237	8.701e-06***
1.8	1.582***	-0.748***	0.000***	1.653***	-0.675***	3.762e-05***	1.060***	-0.260	6.393e-05***
1.7	1.397***	-0.781***	0.004***	1.476***	-0.709***	0.001***	0.959***	-0.274	0.000***
1.6	1.208***	-0.785***	0.046**	1.293***	-0.717***	0.011**	0.849***	-0.267	0.002***
1.5	1.083***	-0.824***	0.224	1.171***	-0.759***	0.069*	0.783***	-0.287	0.009***
1.4	0.967***	-0.855***	0.611	1.060***	-0.795**	0.254	0.723***	-0.305	0.032**
1.3	0.854***	-0.870**	0.943	0.952***	-0.819**	0.583	0.662***	-0.312	0.084*

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

E.14 Quarterly estimations, with inflation measured as the average of the current quarter and one-quarter-ahead forecast and forward-looking tone

Table E.27: Quarterly data and whole text

	Dependent variable:			
	Tone			
	Symmetric V		Asymmetric V	
	(1)	(2)	(3)	(4)
Inflation	1.054***			
Inflation below the target		−0.739***	0.113	0.113
Inflation above the target		1.702***	2.609***	1.925***
GDP growth			−0.202***	−0.108**
Unemployment			0.194*	0.054
Swapspread				−0.952**
Corpspread				0.007***
EPU				−0.002
Constant	−1.336***	−1.322***	−2.259**	−2.189*
Observations	90	90	90	86
R^2	0.128	0.162	0.282	0.624
Adjusted R^2	0.119	0.143	0.248	0.591
Estimated inflation target	1.63	1.85	2.35	2.50
F-test symmetry p-value		0.014**	5.020e-05***	0.001***
LR-test p-value (asym vs. sym)		0.060*	0.002***	0.002***
LR-test p-value (est vs. fixed)	0.015**	0.314	0.233	0.063*
Note:				*p<0.1; **p<0.05; ***p<0.01

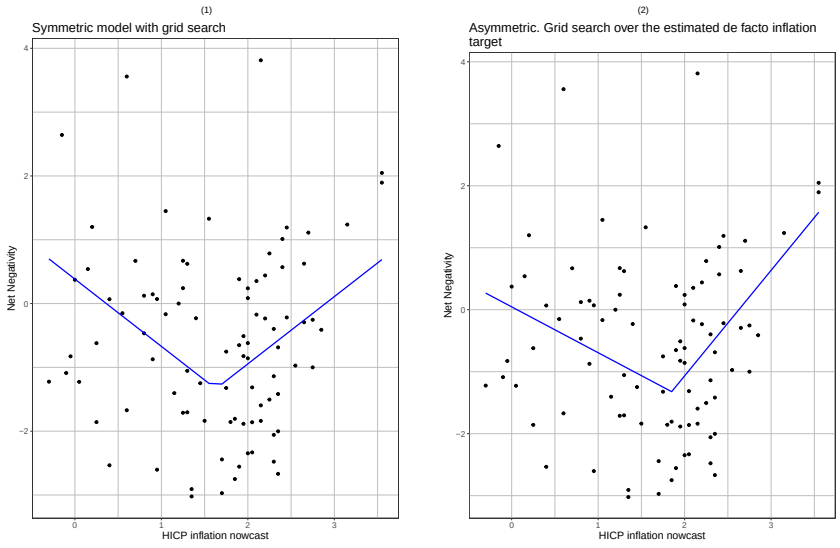

Figure E.24: V results for columns (1) and (2) of Table E.27

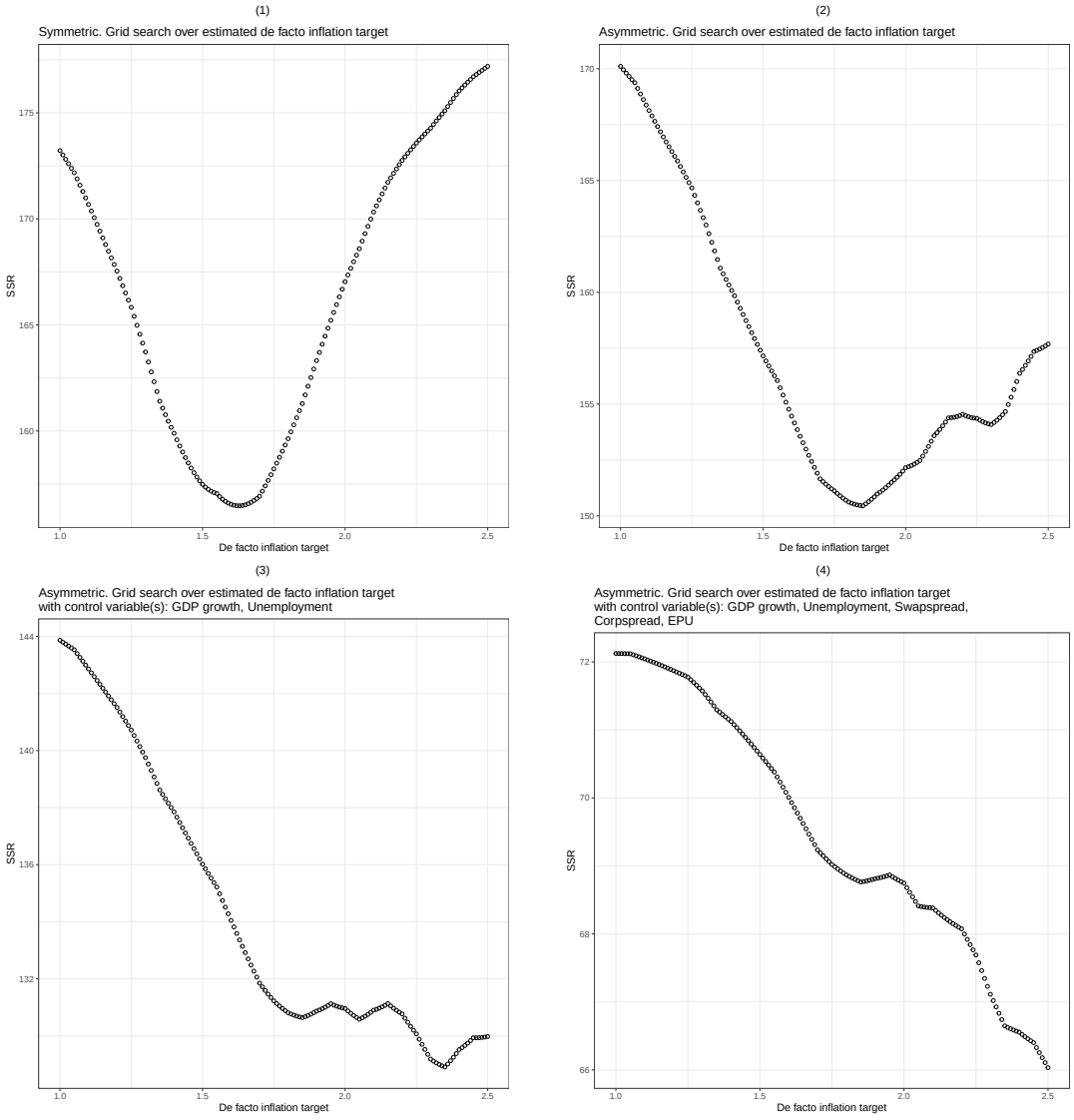

Figure E.25: The sums of squared residuals (SSR) for columns (1) to (4) of Table E.27

Table E.28: Asymmetric estimations with quarterly whole text for different inflation targets

	(2)			(3)			(4)		
Target	Above	Below	F-test, p-value	Above	Below	F-test, p-value	Above	Below	F-test, p-value
2	1.863***	-0.572*	0.004***	1.823***	-0.080	0.000***	0.990**	0.034	0.006***
1.9	1.751***	-0.679**	0.009***	1.713***	-0.164	0.000***	0.932**	-0.005	0.007***
1.8	1.637***	-0.793**	0.025**	1.623***	-0.251	0.001***	0.886**	-0.047	0.010**
1.7	1.492***	-0.890**	0.086*	1.499***	-0.316	0.002***	0.818**	-0.072	0.018**
1.6	1.316***	-0.957**	0.282	1.347***	-0.341	0.008***	0.722*	-0.063	0.033**
1.5	1.139**	-1.001**	0.673	1.199***	-0.347	0.024**	0.634*	-0.041	0.056*
1.4	0.975**	-1.030**	0.869	1.065**	-0.338	0.061*	0.559*	-0.013	0.086*
1.3	0.815**	-1.031*	0.539	0.943**	-0.302	0.115	0.490	0.033	0.115

Note: $^{*}p < 0.1;^{**}p < 0.05;^{***}p < 0.01$

F Scored Introductory Statements

See separate PDF-file ***'Scored introductory statements'***.