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# The Power of Words: Central Bank Green Communication and Performance of Energy Sectors

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## Abstract

This paper investigates the effect of climate- and energy-related (green) communication by the European Central Bank (ECB) on the performance of renewable and fossil-based energy sectors. Using a sentence-embedding natural language processing method, we identify 247 ECB speeches from 2015 to 2024 that explicitly reference both climate and energy themes, categorize them, and compute a green score for each. The analysis reveals prominent topics of climate and financial risk, and monetary policy and economic conditions, along with consistently positive and trust-related emotional cues. We then use high-frequency identification to estimate the effect of ECB green speeches on the return differential between the green and the brown energy sectors. The results show that such ECB communication positively and significantly affects sectoral relative returns, highlighting the communicative role of the ECB in influencing the relative performance of green and brown energy sectors. The results remain robust across a series of sensitivity analyses. The effect does not change significantly with respect to the outbreak of the Russian–Ukrainian war or the ECB communication topics.

**Keywords:** central bank communication, ECB green speeches, text analysis, high-frequency identification, energy sectors.

**JEL Codes:** E44, E52, E58, G14, Q43

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# 1 Introduction

Climate change represents one of the most pressing and complex challenges globally. Within this global context, the European Union (EU) faces unique vulnerabilities and responsibilities. Over the last decade, the EU has positioned itself as a global leader in climate policy. The EU has committed to reducing greenhouse gas emissions by at least 55% by 2030 and to achieving net-zero emissions by 2050 under the European Green Deal ([European Commission, 2019](#)). These goals require not only environmental and industrial reforms, but also a deep transformation of the entire economy, including how it is financed and governed. As such, the green transition has become a central theme in macroeconomic strategy and financial stability.

As the green transition reshapes economic priorities, central banks have begun to take a more active role in climate policy initiatives. An expanding body of research and institutional communication acknowledges that climate change and the transition to a low-carbon economy pose significant risks to price stability and the financial system ([Battiston et al., 2017](#); [Bolton et al., 2020](#)). These risks are both physical, stemming from climate-related damages, and transitional, arising from shifts in regulation, technology, and investor reactions. In response, central banks progressively incorporate climate-related considerations into their policy framework.

The European Central Bank (ECB) has been at the forefront of integrating climate-related considerations into central banking practices. In its 2021 monetary policy strategy review, the ECB formally acknowledges the importance of addressing climate change in the implementation of monetary policy and the maintenance of financial stability ([European Central Bank, 2021b,a](#)). The ECB has launched a unified climate change center, introduced climate-related disclosure requirements into its collateral framework, and adjusted its corporate bond purchases based on climate-related criteria. More broadly, climate change has become a recurring theme

in official ECB speeches, press conferences, and public engagements, reflecting both a normative commitment and recognition of the macro-financial relevance of the issue.

Within the broader climate-related agenda, energy issues play a central and increasingly prominent role. Energy consumption is not only the largest contributor to carbon emissions in Europe, but also one of the most strategically sensitive policy challenges ([International Energy Agency, 2025a](#)). Shocks to energy prices, whether driven by global markets, supply chain constraints, or geopolitical events such as the Russian–Ukrainian war, have direct implications for inflation, economic activity, and financial stability ([Lagarde, 2024](#)). At the same time, the transition to renewable energy, investment in clean infrastructure, and the phasing out of fossil fuels are reshaping the long-term outlook for both economic growth and environmental sustainability ([International Energy Agency, 2025b](#)). In this context, when ECB policymakers speak about energy issues, they often implicitly convey their views on the climate transition, policy risk, and capital flows.

This paper is motivated by the growing relevance of climate-related risks and energy dynamics in central bank policy. Climate change has emerged as a systemic risk to long-term economic resilience and financial stability, prompting central banks to reconsider their role in supporting the green transition ([Dikau and Volz, 2021](#); [European Central Bank, 2021b](#); [Joëts et al., 2023](#)). The European dependence on fossil fuels, together with the commitment to decarbonization, especially in the wake of the Russian–Ukrainian war, has made energy issues central to macroeconomic uncertainty and policy response ([Schnabel, 2022](#)). While a growing body of literature explores the impact of monetary policy on green finance, relatively little attention has been paid to the communicative role of the ECB in shaping market sentiment toward environmental goals ([Ebeling, 2024](#); [Neszveda and Siket, 2025](#)). In particular, to the best of our knowledge, no study has examined the impact of climate- and energy-related (green) ECB speeches on European energy markets. This paper addresses the gap in the

literature by analyzing the financial impact of ECB communication on climate and energy issues.

We use a sentence-embedding method to identify ECB green speeches over the period 2015–2024. We identify 247 climate-related ECB speeches that mention the term “energy” and compute a green score for each speech. Using natural language processing techniques, we categorize the speeches into two topics: climate and financial risk, and monetary policy and economic conditions. The two strongest emotions expressed across the topics are trust and positivity. Using high-frequency identification (event study methodology), we provide evidence that the green score of ECB communication positively and significantly affects the return differential between the green and brown energy sectors. The findings remain consistent across various robustness analyses. Furthermore, this effect is not affected by the outbreak of the Russian–Ukrainian war or the ECB communication topics.

This paper contributes to the literature in several ways. First, it contributes to the growing body of literature on climate-related communication by central banks ([Arseneau et al., 2022](#); [Campiglio et al., 2025](#); [Feldkircher and Teliha, 2024](#); [Zhang et al., 2025](#)). Second, it narrows the focus to the ECB, one of the most vocal and institutionally committed central banks in integrating climate-related considerations into its policy framework ([European Central Bank, 2021b,a](#); [Schnabel, 2022](#)). Finally, while previous studies have assessed the general climate-related tone of ECB communication ([Ebeling, 2024](#); [Deyris, 2023](#); [Joëts et al., 2023](#); [Neszveda and Siket, 2025](#)), this research contributes by isolating speeches that explicitly mention the term “energy”, a domain central to the green transition and a major factor in both climate risk and economic opportunity. This focus enables a more targeted investigation into how market participants respond to climate- and energy-related discourse.

In addition to the conceptual contributions, this study provides valuable empirical insights. It links the textual analysis of ECB speeches with financial market data, providing empirical evidence of the relationship between green communication and

return differential between renewable and fossil energy sectors ([Bauer et al., 2025](#); [Ebeling, 2024](#)). Furthermore, this paper provides empirical evidence in support of signaling theory, reinforcing the view that market participants extract meaningful information from the public communication of authoritative institutions ([Spence, 1978](#)). This study also evaluates the impact of one of the biggest recent shocks on this relationship: the Russian–Ukrainian war.

The rest of this paper is structured as follows. Section 2 outlines the key events in ECB green communication while Section 3 presents the literature review. Section 4 discusses the data and Section 5 presents the empirical methodology. Section 6 discusses the results and Section 7 concludes this paper.

## 2 Key events in ECB green communication

The evolution of the ECB green communication can be contextualized through several pivotal events.

The negotiations of the *Paris Agreement* concluded in 2015 ([United Nations Framework Convention on Climate Change \(UNFCCC\), 2015](#)) and was signed in 2016. The agreement marked a turning point in global climate governance and catalyzed a shift in expectations for central bank involvement in sustainability. This has led to an increasing adoption of supervisory tools by central banks to address climate-related financial risks ([Schoenmaker and McKechnie, 2024](#)).

The launch of the *Network for Greening the Financial System* (NGFS) in December 2017 formalized the involvement of central banks and supervisors in climate risk assessment, with the ECB joining in April 2018. Since then, the ECB has increasingly incorporated sustainability issues into its communication on financial stability and risk, in line with its mandate. Research suggests that broader mandates are associated with greater adoption of climate-related financial policies ([D’Orazio and Popoyan, 2023](#)).

A major leadership transition took place at the ECB in November 2019, when Christine Lagarde became its president. She publicly positioned climate action as a strategic priority, marking a decisive shift in both rhetoric and policy emphasis toward the green transition, including energy system decarbonization ([Deyris, 2023](#)).

The COVID-19 outbreak, declared a pandemic by the World Health Organization in March 2020 ([Ghebreyesus, 2020](#)), disrupted global economies but also triggered a policy rethink. In response, the ECB emphasized the importance of “building back greener” and increasingly highlighted the role of green investment and renewable energy in the recovery ([Hepburn et al., 2020](#)).

In July 2021, the *ECB Strategy Review* officially included the assessment of climate change in the strategic agenda of the ECB, communicating its commitment to sustainability more firmly ([Deyris, 2023](#); [European Central Bank, 2021b](#); [Eliet-Doillet and Maino, 2022](#)). This new climate strategy explicitly addressed energy transition challenges and committed to adapting monetary policy operations, such as collateral frameworks and asset purchases, to mitigate climate-related risks. Since the strategy review, the ECB has maintained its focus on climate-related risks in its policy agenda.

The *Russian–Ukrainian war*, which began in February 2022, added new urgency and complexity to the green transition narrative of the ECB. The conflict exposed the EU energy dependence on fossil fuels, and elevated climate and energy security on the agenda. ECB communication increasingly linked inflation risks to energy shocks and sustainability efforts to the pursuit of strategic autonomy ([Falkner, 2023](#)).

These events outline a trajectory in which the energy-related communication of the ECB has intensified, broadened, and grown more strategic in response to both internal policy shifts and external systemic or geopolitical shocks.

### 3 Literature review and hypothesis development

#### 3.1 Central bank communication and financial markets

Central bank communication has emerged as a key component of monetary policy, especially following the introduction of unconventional measures such as forward guidance. A substantial body of research demonstrates that the tone, timing, and content of central bank statements have a significant impact on financial markets, including asset prices, risk premia, and investor expectations (among others, [Bauer et al., 2025](#); [Rostagno et al., 2025](#); [Swanson, 2021](#)).

Empirical evidence shows that markets respond not only to policy rate decisions but also to the interpretative framing conveyed in press conferences and other communications. For example, [Altavilla et al. \(2019\)](#) decompose the effects of ECB policy communication on the yield curve into four distinct components: policy target, timing, forward guidance, and quantitative easing.

The effectiveness of communication depends equally on its content and its delivery, that is, on what is said and how it is expressed. [Parle \(2022\)](#) shows that, even in the absence of policy changes, linguistic tone and sentiment can significantly influence investor reactions. [Gorodnichenko et al. \(2023\)](#) extend this insight to non-verbal elements. Shifts in vocal tone during central bank press conferences significantly affect equity returns, revealing a new dimension of monetary signaling.

The institutional design of central banks can also shape the tone and the content of their communication. Analyzing speeches from the ECB and the Federal Reserve (Fed), [Bohl et al. \(2023\)](#) find that central bank mandates influence the sentiment expressed in speeches. Unemployment expectations are the key drivers of tone in Fed speeches whereas inflation expectations shape the tone of ECB speeches.

Speaker identity is also a relevant factor in shaping the impact of central bank communication. [Gertler and Horvath \(2018\)](#) examine the intermeeting communication



of ECB Governing Council members and find that markets react more strongly to messages from key committee members. At the same time, [Gnan and Rieder \(2023\)](#) show that breaches of the ECB quiet period can trigger market reactions twice as large as those following regular intermeeting communications, highlighting the importance of timing and perceived credibility.

The effects of communication extend beyond traditional financial variables. [Anastasiou et al. \(2023\)](#) show that negative tones in ECB communication significantly discourage firms from borrowing from banks, showing that central bank narratives can influence credit access and real economic behavior. Recent studies also examine how ECB communication influences bond markets and investor positioning. [Neugebauer et al. \(2024\)](#) find that different communication formats, such as press releases, speeches, and blog posts, can have various effects on sovereign spreads, particularly when delivered by influential figures.

In summary, central bank communication has become a powerful policy tool, with its market impact depending on tone, content, timing, speaker, and institutional context. As interpretive signals become increasingly influential, understanding their dynamics is essential for effective monetary policy and financial stability.

Although the literature on climate-related central bank communication is scarce, it is expanding rapidly. There is increasing evidence that such discourse, especially from the ECB, can influence investor reactions, portfolio reallocation, and asset prices. The emerging body of work highlights that green communication is not merely symbolic but it is increasingly recognized as a relevant dimension of monetary policy signaling.

[Neszveda and Siket \(2025\)](#) construct a green sentiment index for ECB speeches and demonstrate that markets respond differently to the environmental tone of central bank messaging. Firms with stronger environmental performance tend to benefit from green-leaning speeches while more polluting firms experience negative returns. This suggests that climate-related language from central banks influences investor expectations and may contribute to market-based discipline in corporate sustainability

performance. In line with these results, [Ebeling \(2024\)](#) shows that climate-themed communication by the ECB can trigger measurable portfolio shifts toward greener assets. His topic modeling analysis finds that speeches emphasizing green finance and monetary policy instruments, rather than risk narratives, tend to elicit stronger financial market responses.

At the global level, [Campiglio et al. \(2025\)](#) provide one of the most comprehensive analyses of central bank climate communication. Analyzing more than 32,000 speeches, they classify green discourse into two broad themes: green finance and climate-related financial risks. Their analysis reveals that institutional features, such as the presence of explicit sustainability mandates and membership in networks like the Network for Greening the Financial System (NGFS), are strong predictors of the frequency and scope of climate communication. Similarly, [Arseneau et al. \(2022\)](#) emphasize that the mandate structure critically determines not only how often central banks communicate about climate issues, but also how they frame them, whether as a financial stability concern, a macroeconomic risk, or a developmental objective.

With a focus on the ECB, [Deyris \(2023\)](#) traces the institutional evolution of green communication over the past decade, highlighting a shift from rhetorical acknowledgment to strategic engagement. By combining analyses of speeches, parliamentary hearings, and stakeholder interviews, [Deyris \(2023\)](#) documents a growing alignment between the climate discourse of the ECB and broader societal expectations. This alignment is shaped in part by political pressures and reputational incentives.

Overall, the emerging literature suggests that green communication, especially from the ECB, has become an important component of the financial market information set. While the literature on climate-related monetary policy is still less mature than that on conventional policy signaling, the evidence increasingly shows that climate-oriented messages from central banks are priced by investors, shape expectations, and may redirect capital flows in support of the energy transition. The ECB stands out as

an active and influential institution, both in terms of its volume of climate-related messaging and its tangible impact on sustainable finance dynamics.

### **3.2 Central banks and the energy transition**

Central banks are now regarded not only as guardians of price and financial stability but also as key supporters of the transition to a low-carbon economy. Although traditionally constrained by narrow mandates, many central banks are actively exploring both policy tools and communication strategies to support green finance and clean energy investments ([Campiglio et al., 2025](#); [D’Orazio and Popoyan, 2023](#); [Monnin, 2018](#)).

Unconventional monetary policy can be an effective tool to support the green transition. [Zaghini \(2024\)](#) finds that the ECB Pandemic Emergency Purchase Program effectively supports firms in financing climate-friendly investments in the bond market. [Ferrari and Nispi Landi \(2023\)](#) show that green-targeted quantitative easing effectively reduces emissions and supports the transition to a carbon-free economy. At the same time, [Gordo et al. \(2024\)](#) find that monetary policy has exerted only a limited overall effect on renewable energy stocks since the implementation of quantitative easing.

In parallel, central banks are deploying macroprudential tools, climate stress tests, and disclosure frameworks, although their integration into core monetary operations remains limited ([Campiglio et al., 2025](#)). [D’Orazio and Popoyan \(2023\)](#) find that broader monetary mandates are significantly associated with greater adoption of climate-related financial policies while more integrated financial stability governance is not.

Monetary policy can influence renewable energy development even in emerging markets. [Razmi et al. \(2021\)](#) show that money supply shocks significantly influence renewable energy generation in Iran. This suggests that tighter monetary conditions could hamper green infrastructure development in capital-intensive sectors.

Theoretical contributions highlight the need for the structural adaptation of climate-related monetary policy. [Batten et al. \(2016\)](#) advocate for revising macro-financial models and inflation-targeting frameworks to incorporate climate-related transition and physical risks. Similarly, [Battiston et al. \(2017\)](#) argue that early and stable policy messaging, especially regarding transition costs, carbon exposure, and financial system resilience, can reduce the risk of a disorderly transition.

Alongside operational tools, policy communication is becoming an increasingly important instrument through which central banks can influence market expectations and support the green transition. For instance, [Eliet-Doillet and Maino \(2022\)](#) show that the ECB 2021 Strategy Review announcements ([European Central Bank, 2021b,a](#)) significantly lowered yields and increased green bond issuance in the euro area, particularly among seasoned issuers. [Joëts et al. \(2023\)](#) provide evidence that ECB communication plays a central role in guiding market expectations and supporting the green transition.

The literature highlights the influence of central banks in facilitating the integration of climate considerations into financial markets. It also underscores the need for transparent standards to manage climate-related financial risks and limit greenwashing in sustainable energy finance. [Monnin \(2018\)](#) argues that central banks should actively assess and mitigate climate-related financial risks. This includes using capital requirements and adjusting asset purchase frameworks to support the low-carbon transition while maintaining financial system stability. The literature demonstrates that central banks have both the policy tools and the communicative influence necessary to support the energy transition. Through asset purchases, regulation, or communication, central bank interventions can shape investor expectations and help direct capital toward cleaner energy systems.

This paper relates to the growing body of literature on climate-related communication by central banks ([Arseneau et al., 2022](#); [Campiglio et al., 2025](#); [Feldkircher and Teliha, 2024](#); [Zhang et al., 2025](#)). It contributes to the literature by focusing on the impact of

green communication on the return differential between the renewable and the fossil energy sectors. This paper also studies the impact of heightened uncertainty, such as that following the onset of the Russian Ukrainian war, on green communication by the ECB.

### **3.3 Hypothesis development**

Signaling theory ([Spence, 1978](#)) addresses situations of asymmetric information, where one party possesses relevant knowledge that the other lacks. To overcome such information gaps, the informed party engages in signaling by sending observable and credible cues that convey their private information. For a signal to be effective, it must be both costly to mimic for lower-quality agents and interpretable by the receiver as indicative of the underlying trait or intention.

In the policy context, signaling theory explains how public institutions convey non-observable intentions or assessments to market participants. In particular, this paper uses signaling theory as a theoretical foundation to understand how green communication by the ECB influences investor reactions. The ECB, as an authoritative and well-informed actor, uses speeches and public statements to signal its views on climate risk, the green transition, and future policy directions.

These communications serve as informational cues that financial markets interpret as signals of long-term macro-financial risks, institutional priorities, and regulatory guidance. Specifically, speeches with a stronger climate-related emphasis, particularly those explicitly referencing the energy sector, can be seen as signaling increased central bank commitment to decarbonization and support for sustainable finance.

Based on the signaling theory and the literature that demonstrates the significant effects of central bank communication on financial markets, we formulate the first hypothesis.

H1: ECB speeches with a stronger green tone have a positive effect on the relative performance of the green and the brown energy sector returns.

Several studies suggest that central bank communication may have amplified effects during periods of heightened uncertainty (Coenen et al., 2017; Gardner et al., 2022), such as following the outbreak of the Russian–Ukrainian war. However, whether this amplifying effect extends to climate-related communication, particularly when it intersects with strategic sectors such as energy, remains an open question. In any case, in line with prior evidence, we formulate our second hypothesis.

H2: The positive impact of ECB green speeches on the relative performance of green versus brown energy sector returns intensifies following the onset of the Russian–Ukrainian war.

## 4 Data

### 4.1 Data sources

We use data from various sources in our empirical analysis. The ECB speeches are retrieved from its official website, which provides all official speeches by the President, Vice-President, and Board members. Such speeches are publicly available for download and include the date, speaker, title, subtitle, and content.

We draw on financial return data from two sector-specific stock indices to construct a return differential metric based on the closing prices of the indices. Since we analyze the impact of ECB speeches, we focus on European stock indices. As a renewable energy index, the FR Europe Renewable Energy Index is used, capturing the performance of European companies classified under GICS (Global Industry Classification Standard) Industry Code 5020, which includes firms focused on renewable electricity generation and sustainable energy technologies. This index reflects broad exposure to the European

clean energy sector. For a robustness check, this index is replaced with a narrower sub-industry index under GICS code 502010, which isolates firms more specifically involved in renewable electricity. It excludes broader utilities and focuses exclusively on firms whose primary business is generating energy from renewable sources such as solar, wind, or hydro.

As a brown energy index, in line with [Bauer et al. \(2025\)](#), the STOXX Europe 600 Oil and Gas Index is used, which tracks the performance of the oil and gas sector within the STOXX Europe 600 family. Specifically, it includes major European companies engaged in oil exploration, production, refining, and related services. As such, it serves as a proxy for carbon-intensive brown energy investments.

To control for market trends in the robustness analysis, we use market returns based on the MSCI Europe Index. It is a broad stock market index designed to measure the performance of large- and mid-cap equities across 15 developed European countries. All the indices are retrieved from the Refinitiv Eikon database.

## **4.2 Measuring ECB green communication with an energy focus**

To capture the green sentiments in the ECB speeches, we compare two methods: a more traditional dictionary-based approach ([Arseneau et al., 2022](#); [Campiglio et al., 2025](#); [Ebeling, 2024](#); [Neszveda and Siket, 2025](#)) and a more recent sentence-embedding method, specifically the Sentence-BERT model ([Reimers and Gurevych, 2019](#)). The goal is to evaluate which technique more effectively captures the green content of central bank communications. Across both methods, we apply the following approach. First, we compute the green scores of all speeches in the database. Then, we filter for those that specifically contain the word “energy”, given the central role of energy in the green transition. The energy sector is both the largest contributor to greenhouse gas emissions and the primary target of decarbonization policies, making it a central theme in climate mitigation strategies (International Energy Agency, 2021; European

Commission, 2020). By first computing the green score of the speeches and then filtering for those that explicitly mention the word “energy”, we ensure that the analysis focuses on climate communication related to this strategic sector. For brevity, we refer to such communication as green communication.

The dictionary-based method operates on the premise of detecting literal keywords. It uses a curated list of climate-related expressions compiled from existing literature ([Campiglio et al., 2025](#); [Ebeling, 2024](#)), supplemented with manual additions to include ECB specific terms. For example, the expression “global warming” is often referred to as “global heating” in these speeches and so the latter was added to the keyword list. Table [A.1](#) shows the full list of such curated expressions.

In the literature on climate-related communication, climate themes are often treated separately from energy topics. In particular, any dictionary entries containing the word “energy” are excluded. For each speech, the green score is calculated as the ratio of climate-related word occurrences to the total word count and then normalized across all speeches. This method is commonly used in the literature for its transparency and replicability although it is inherently limited in capturing context, paraphrasing, or semantic subtlety. Since we are specifically interested in the effects on energy markets, we filter for speeches that contain the word “energy”.

The sentence-embedding method uses a pre-trained sentence transformer model from the Sentence Transformers library ([Reimers and Gurevych, 2019](#)). This model embeds both the text and the reference terms in a shared vector space, enabling the similarity between a speech and the reference climate lexicon to be measured using cosine similarity. The reference set of phrases is the same as [Neszveda and Siket \(2025\)](#) use and consists of a limited set of words related to the topic, specifically: green, climate change, climate risk, climate-related, emission, global warming, environmental, carbon, ecological, and ESG (environmental, social, and governance). We use this smaller set of words intentionally to minimize false positives. Each speech is converted into a dense vector and its green score is computed based on the similarity to the average embedding



of the reference green terms. As before, we filter for speeches that specifically mention the word “energy”.

The Sentence-BERT model measures semantic similarity between texts using cosine similarity. It ranges from -1 (completely dissimilar) to +1 (identical in meaning). Nevertheless, in practical applications involving complex and multi-topic texts, such as ECB speeches, most similarity scores range between 0 and 0.5. This is because even speeches that reference energy and climate topics often do so briefly or in conjunction with broader themes such as inflation, financial stability, or monetary policy. As a result, the semantic overlap with the climate-specific reference embeddings tends to be moderate rather than high. Moreover, cosine similarity scores close to 1 are rare in natural language processing unless texts are nearly identical. Since this analysis already filters for energy-related content, most irrelevant or unrelated speeches are excluded, resulting in a narrower range of moderately relevant scores. Thus, scores between 0.1 and 0.5 likely reflect partial alignment with climate discourse, capturing speeches that acknowledge the energy transition or sustainability, even if they are not entirely focused on these topics.

Figures 1 and 2 present the evolution of the monthly average green score identified by the two methods and highlight various events discussed in Section 2. The dictionary-based method exhibits a highly skewed distribution, with a substantial percentage of speeches assigned the default score of -1. This flat distribution implies that many speeches do not match any of the fixed terms in the dictionary, despite likely containing semantically related content. Consequently, the method underestimates the variation of ECB green communication over time.

The embedding-based method yields a smoother and more continuous range of green scores over the years, capturing meaningful fluctuations that align with known events such as the European Green Deal ([European Commission, 2019](#)), the COVID-19 pandemic ([Ghebreyesus, 2020](#)), and the ECB Strategy Review ([European Central Bank, 2021b](#)). This method appears to be more sensitive to the underlying semantics of each

speech, reflecting variations even when explicit keywords are absent. Moreover, unlike the dictionary-based method, it does not reduce informative speeches to “non-green” simply because of linguistic diversity or paraphrasing.

To highlight the differences between the two methods, we consider a specific example. We compile the speeches that were given a score of -1 based on the dictionary-based method. Then, we use the sentence-embedding method to compute the green score for these speeches. We obtain a score greater than 0.1. We also manually examine these speeches. For example, in a speech by Lagarde on 24 May, 2023, the following phrase has been said: “threat of a changing climate”. Since this sentence does not use “climate change” but instead uses “changing climate”, it is filtered out as non-green in the dictionary-based method. However, the sentence-embedding method, which can recognize semantic similarities rather than exact keyword matches, correctly assigns a green score higher than 0. Therefore, based on these considerations, we continue our analysis using the sentence-embedding method.

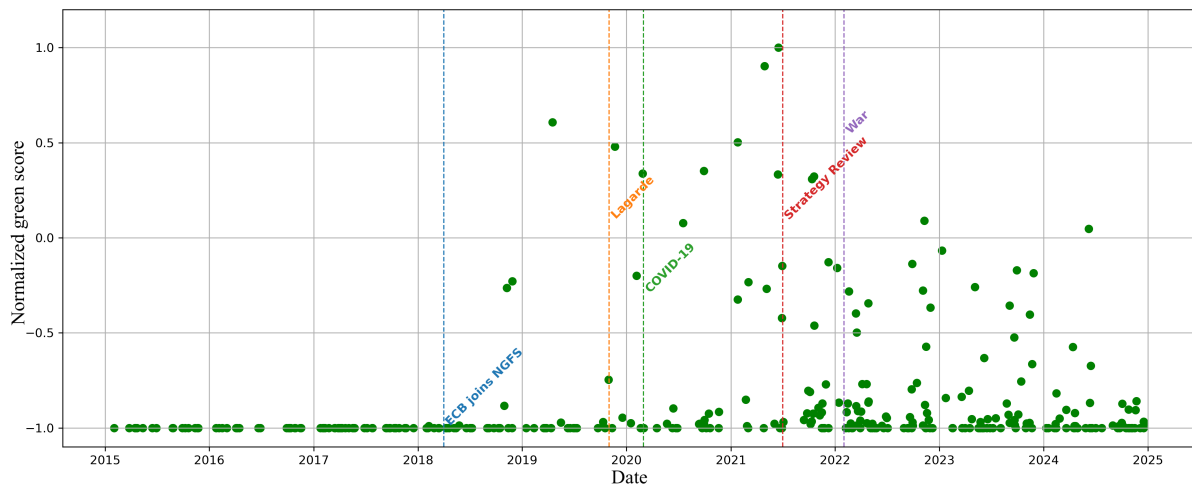
From Figure 2, it is evident that, prior to 2019, average green scores were consistently low, indicating that while energy-related topics were discussed, the framing was less explicitly aligned with climate transition goals. The first major shift occurred in late 2019, coinciding with Christine Lagarde’s appointment as ECB President. Lagarde has frequently emphasized the role of the ECB in facilitating the green transition (Lagarde, 2021), and this leadership change has appeared to coincide with an increase in the average green tone of energy-related speeches. This date also coincides with the launch of the European Green Deal, a strategy aimed at achieving climate neutrality in the European Union by 2050 (European Commission, 2019).

The upward trend intensified in 2020 and 2021, with notable peaks around the ECB Strategy Review, when climate considerations were explicitly included in its strategic agenda in July 2021. These institutional milestones signaled the intention of the ECB to more systematically consider climate change in its monetary policy framework, supervisory activities, and risk assessments (European Central Bank,

2021b,a). Green scores were also slightly elevated during the COVID-19 pandemic period, reflecting broader policy debates on green recovery and sustainable fiscal and monetary coordination (Hepburn et al., 2020).

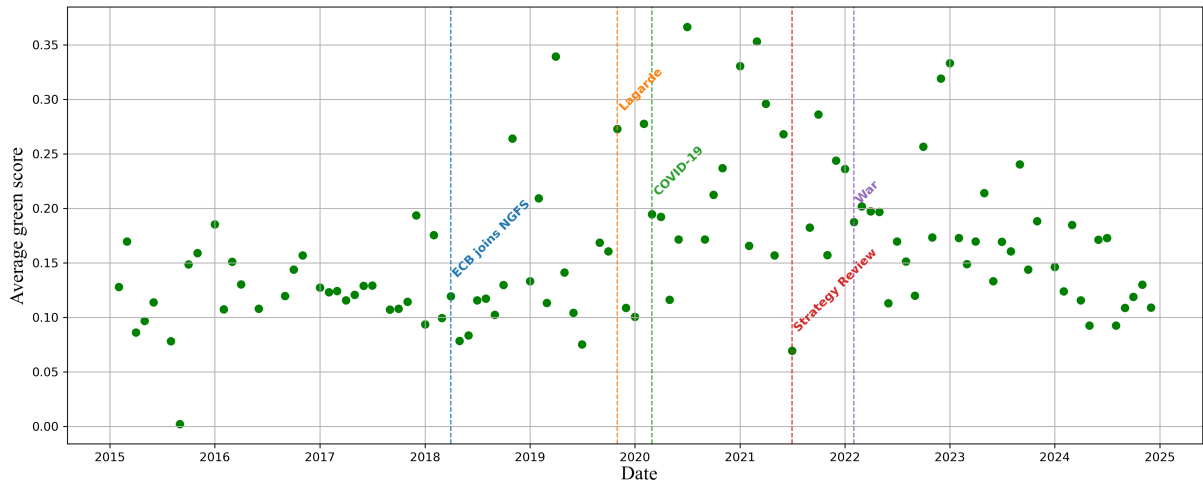
A significant geopolitical shock, the start of the Russian–Ukrainian war in February 2022, apparently did not produce a major upward spike in green speech content. This is arguably because ECB discourse shifted toward energy security and inflation dynamics, emphasizing near-term stabilization rather than long-term decarbonization. As noted by Bauer et al. (2025), periods of macro financial stress, such as the aftermath of the Russian–Ukrainian war, tended to shift central bank attention toward immediate stabilization objectives. Thus, this reprioritization may help explain the observed relative flattening in green communication scores since 2022.

**Figure 1: Monthly average green score of ECB speeches mentioning the word “energy”, based on the dictionary-based method**



*Note:* Key events are highlighted for validation.

**Figure 2: Monthly average green score of ECB speeches mentioning the word “energy”, based on the S-BERT method**



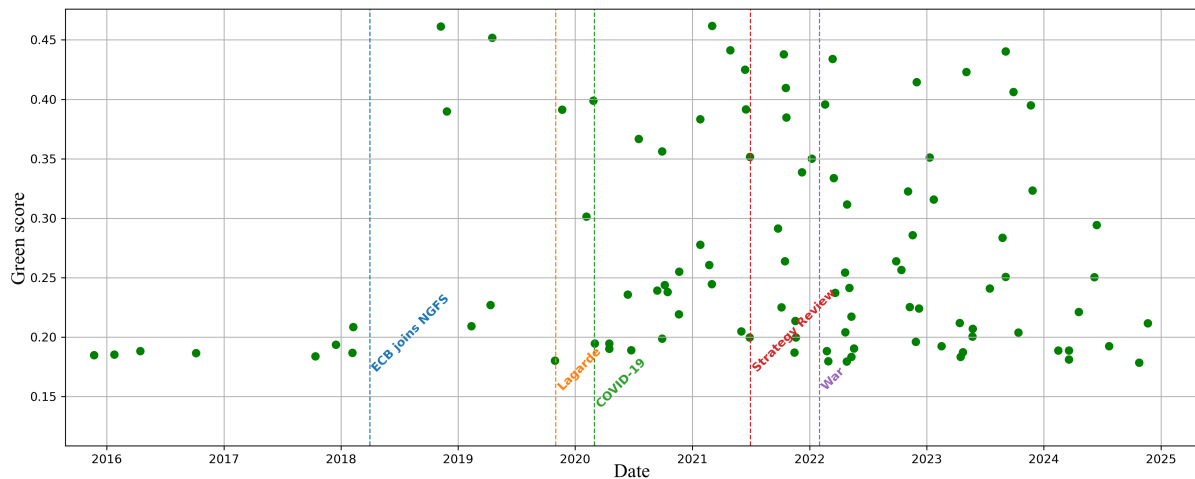
*Note:* Key events are highlighted for validation.

In Figure 3, we plot the top 100 green scores for ECB speeches mentioning the word “energy”. We can observe a clustering of green scores between 2020 and 2022, reaffirming that this was a period of climate-intense communication. Speeches surrounding the ECB Strategy Review are particularly well represented. In Figure 2, which plots monthly averages, green scores for ECB speeches are particularly high since the start of the Russian–Ukrainian war. However, when focusing on the top 100 speeches in Figure 3, the green scores of several individual speeches around the outbreak of the war stand out for their elevated green content. This suggests that the broader communication of the ECB during this period was dominated by themes such as energy security, inflation dynamics, and macro-financial stability, which is understandable given the geopolitical shock. At the same time, the ECB also issued specific speeches with a pronounced green orientation within the energy context.

The energy-related speeches may reflect strategic efforts to reassert the relevance of climate goals even amid crisis, consistent with the view that green monetary policy can support resilience and the long-term energy transition (Batten et al., 2016). This lends support to recent empirical findings suggesting that climate communication by central banks displays strategic and temporal variation (Arseneau et al., 2022). In 2022

and 2023, the ECB continued to deliver high green-scored speeches related to energy, reflecting its ongoing commitment to green agendas.

**Figure 3: Top 100 green scores for ECB speeches mentioning the word “energy”**



*Note:* Key events are highlighted for validation.

### 4.3 Topic modeling and emotion analysis

To ensure the analysis focuses on ECB speeches that meaningfully engage with green themes in the context of energy, a green score threshold of 0.1 is applied. This threshold is based on a combination of the empirical distribution and the semantic interpretation of cosine similarity scores generated by the sentence transformer model. Speeches clustered below 0.1 suggest minimal semantic alignment with the green reference vector.

#### 4.3.1 Topic modeling

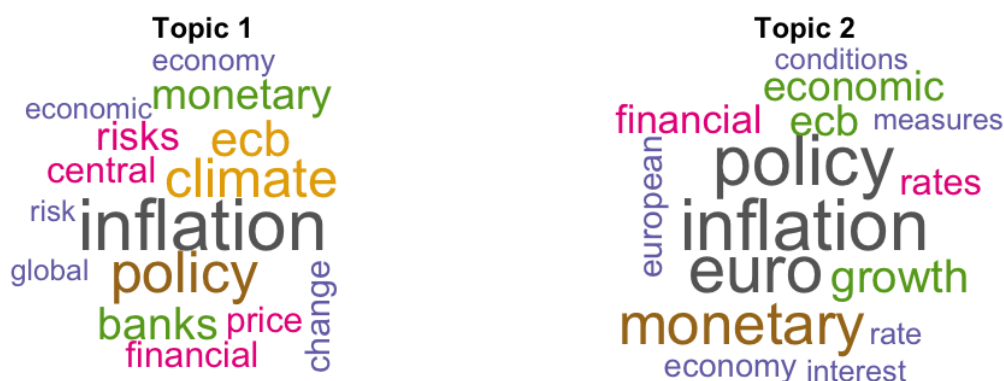
To further characterize the thematic structure of climate-related ECB speeches mentioning energy, this study employs Latent Dirichlet Allocation (LDA), a widely used unsupervised topic modeling technique. The LDA model assumes that each document is a mixture of topics, and each topic is a distribution over words (Blei et al., 2003). When applied to green central bank communication, the LDA model can reveal

underlying thematic structures, an approach previously employed in related research (Arseneau et al., 2022; Campiglio et al., 2025; Ebeling, 2024).

Figure 4 displays word clouds for the two topics identified from the filtered speeches. Both include overlapping macroeconomic and policy terms, but they differ in focus. Topic 1 centers on terms such as “climate,” “financial,” “risks,” “central banks,” and “price,” suggesting a discourse related to the intersection of environmental risks and financial system stability. This theme aligns with the evolving narrative on how climate change can pose a systemic financial risk, particularly in the banking sector. It reflects concerns about how climate factors influence risk assessments, prudential regulation, and financial market dynamics, aligning with the work of the ECB on climate stress testing. We name this group *“climate and financial risk.”*

Topic 2 emphasizes macro-financial and monetary themes, as reflected by terms such as “monetary,” “policy,” “euro,” “growth,” and “inflation.” This topic appears to capture ECB communication on how climate and energy issues intersect with monetary transmission, inflation dynamics, and macroeconomic conditions. In this case, climate discourse is embedded in broader economic outlooks, such as how the energy transition affects inflation expectations, growth projections, and monetary accommodation strategies. We label this group *“monetary policy and economic conditions.”* While both topics feature the term “inflation,” Topic 1 emphasizes climate risk and financial structure, whereas Topic 2 situates climate discourse within conventional macroeconomic policy framework. This categorization aligns with the previous literature on climate-related ECB communication (Ebeling, 2024).

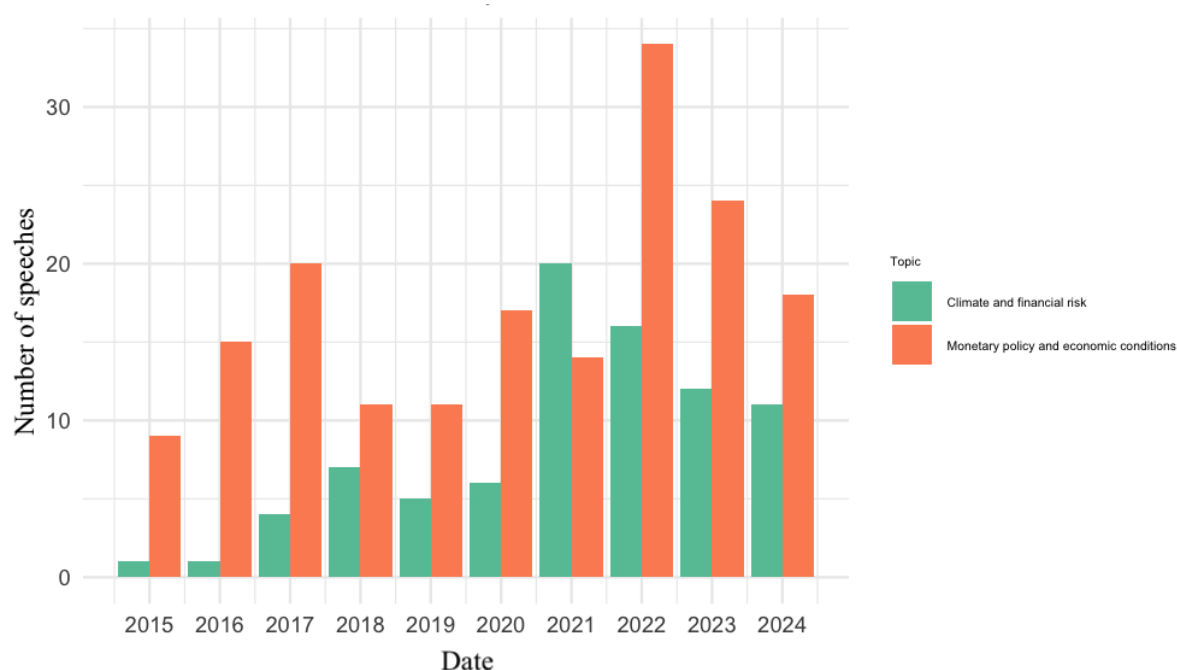
**Figure 4: Word clouds of the two dominant topics identified in ECB speeches**



*Note:* Using LDA techniques, two main groups are identified in ECB speeches. This figure shows the top 15 words used in each group.

Figure 5 contains a bar chart, which visualizes the annual evolution of ECB speeches categorized under the two green topics: “climate and financial risk” (Topic 1) and “monetary policy and economic conditions” (Topic 2). The latter topic emerges as the dominant one over the former across most years, reflecting the consistent emphasis of the ECB on integrating climate concerns within the broader macroeconomic framework. Notably, the peak in 2022 for “monetary policy and economic conditions” aligns with a period of heightened inflation and energy market disruptions related to the geopolitical aftermath of the Russian–Ukrainian war. This suggests a stronger focus on climate discourse framed through economic resilience and policy measures. At the same time, the steady rise and relative persistence of “climate and financial risk” speeches, particularly in 2020 and 2021, indicate growing institutional recognition of climate change as an independent source of systemic financial risk. This increase likely reflects the strategic shift of the ECB following the 2021 climate action plan and the integration of this agenda into monetary policy strategy reviews. Yet, the divergence in 2022 and 2023 may indicate a temporary prioritization of traditional economic stability concerns amid the crisis, while the sustained presence of climate-related risk discourse suggests its permanent role in ECB communication.

**Figure 5: Evolution of topics in ECB green communication**



*Note:* The identified topics are assigned to their respective speech and are counted for each year.

In Figure 6, the scatter plot highlights the five highest green scores for ECB speeches per year, providing insights into the evolving thematic focus of the ECB communication. Before 2020, the most green-intensive ECB speeches were primarily associated with the topic of monetary policy and economic conditions. This suggests that during this period, climate and energy issues were often embedded in discussions about inflation or macroeconomic stability. Such an approach reflects a more conventional framing of energy as a driver of economic indicators rather than as a sustainability concern.

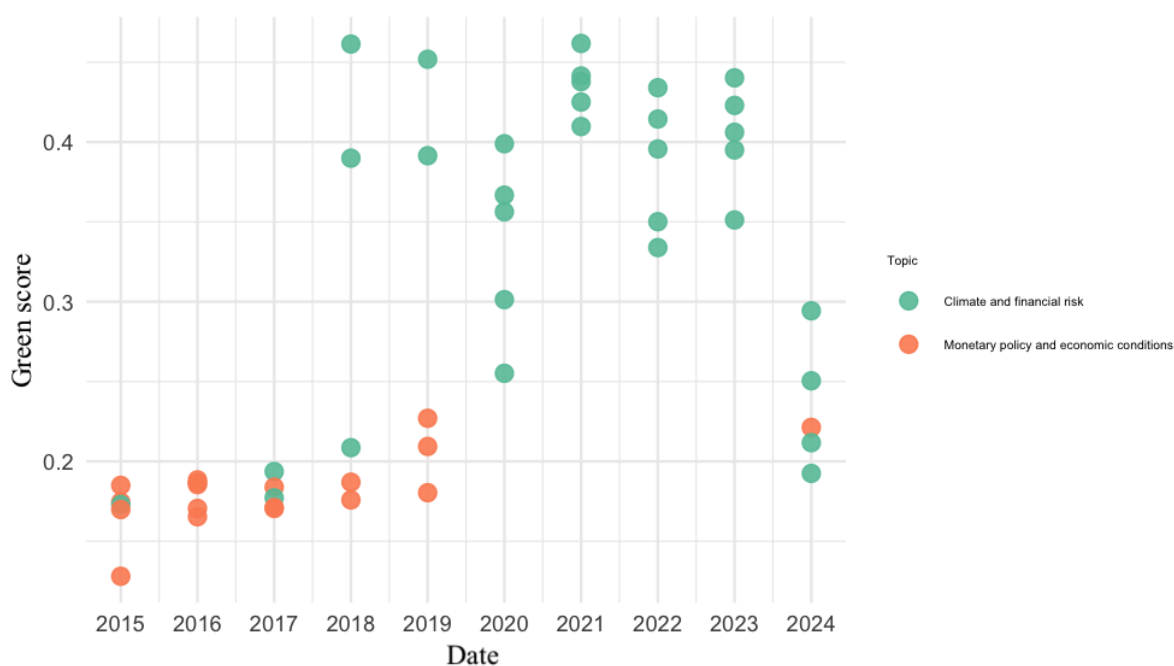
Since 2020, there has been a notable shift in the focus of the topic. The majority of green-intensive ECB speeches have been associated with the topic of climate and financial risk. This aligns with a broader institutional pivot around the time of the ECB 2021 climate action plan and it has become pronounced following the onset of the Russian–Ukrainian war in February 2022. While the monthly averages suggest that the war did not lead to a sustained spike in climate-related discourse, Figure 6 shows that several individual speeches contained relatively high green content following the onset of the war. These likely reflect ECB interventions focused on energy security, transition



investment, and systemic climate-related financial risks, as energy supply disruptions increased the urgency and political relevance of the green transition.

In 2024, ECB speeches continued to reference green themes, but their intensity and focus appear moderate compared to the peak years from 2020 to 2023. The green scores were generally lower. While some speeches remained centered on “climate and financial risk,” there was also a reemergence of the topic of “monetary policy and economic conditions,” suggesting a shift in emphasis. This may reflect a broader recalibration of communication priorities, where climate remained important but was increasingly integrated into discussions of macroeconomic stability, inflation, and financial conditions. Rather than signaling disengagement, the 2024 pattern was in line with the maturation of the ECB green agenda, embedding it within a broader economic context rather than treating it as an independent issue.

**Figure 6: Top 5 green scores for ECB speeches per topic**



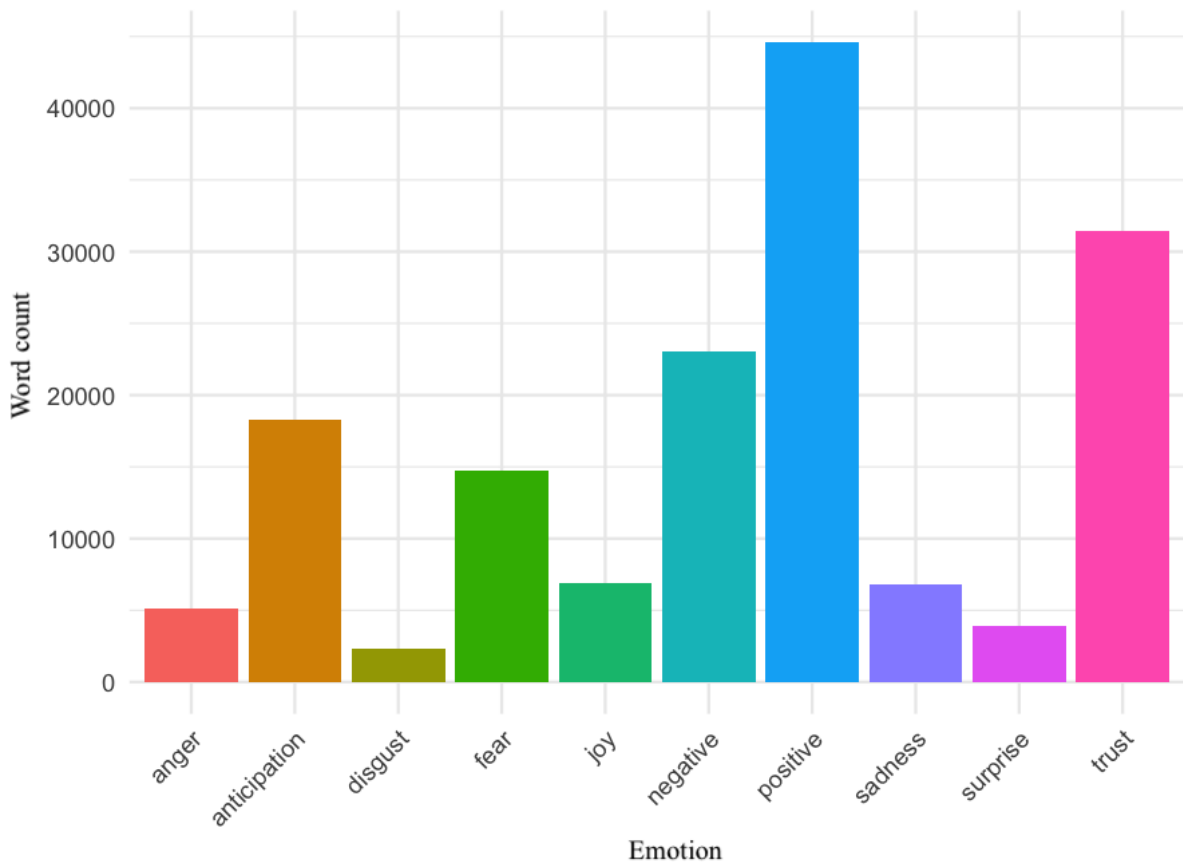
*Note:* The scatterplot provides the evolution of the highest 5 green scores for ECB speeches over the study period.

### 4.3.2 Emotion analysis

The emotional dimension of central bank communication has gained increased scholarly attention, particularly regarding its significance as a signal and its impact on asset prices (Shapiro and Wilson, 2022; Schmeling and Wagner, 2025). In the context of green policy, understanding the tone and emotional content of official discourse is crucial, as emotions such as urgency, trust, or concern can signal policy commitment and shape expectations (Tillmann and Walter, 2019). To explore this aspect of ECB communication, we apply the National Research Council (NRC) Emotion Lexicon (Mohammad and Turney, 2013), a widely used approach that classifies words into eight primary emotions: anger, anticipation, disgust, fear, joy, sadness, surprise, and trust, along with two sentiments: positive and negative. While this approach lacks contextual sensitivity (e.g., it does not detect negation), it remains useful in tracking emotional frequency and thematic tone across large texts.

As illustrated in Figure 7, the most prominent emotions are positive and trust, each appearing in over 40,000 and 30,000 instances, respectively. The dominant presence of these emotions suggests that ECB climate communication consistently conveys optimism and reliability, likely aiming to reassure both markets and the public of its commitment to responsibly managing the climate transition. The high frequency of anticipation- and fear-related words also reflects the dual nature of energy-related climate discourse. On one hand, there is the anticipation of a green transition and new policy measures. On the other hand, there is also uncertainty and risk associated with energy security, inflation, and geopolitical events such as the Russian–Ukrainian war. More extreme emotions such as anger, disgust, and sadness are relatively less frequent, indicating a strategic emphasis on stability and confidence in ECB communication. This emotional tone supports the notion that the ECB implements not only a financial but also a communicative function in maintaining credibility and anchoring expectations during periods of climate and energy volatility.

**Figure 7: Emotional content in ECB green communication**



*Note:* The National Research Council Emotion Lexicon is used to classify words into eight primary emotions: anger, anticipation, disgust, fear, joy, sadness, surprise, and trust, along with two sentiments: positive and negative.

#### 4.4 Descriptive statistics

The sample period spans from 2 February 2015 to 18 December 2024, covering nearly a decade of ECB green speeches. In the subperiod following the onset of the Russian–Ukrainian war on 24 February 2022, the sample includes slightly fewer observations, with 106 of the 247 classified as post-war. This enables a balanced comparison of the effects of ECB speeches across different geopolitical regimes.

In terms of content, the dataset covers the two dominant topics identified in the previous section: *climate and financial risk* (83 speeches) and *monetary policy and economic conditions* (173 speeches). This distinction enables the assessment of whether

the market reacts differently to green content when embedded in different strategic narratives. Overall, the data provide a robust foundation to explore how both the intensity and the context of ECB green communication affect market dynamics in the energy sector.

Table 1 presents descriptive statistics for all variables used in the main analysis and robustness checks. The dataset comprises 247 observations of ECB speeches with a green score above 0.1 and explicit references to energy. More ECB speeches occurred during the study period but we exclude those delivered on non-trading days. Speeches delivered on the same day are aggregated by averaging their respective green scores. In the estimation sample, the green score ranges from 0.1 to 0.462, with a mean of 0.189 and a standard deviation of 0.087, indicating substantial variation in the environmental emphasis of ECB communication.

In the empirical analysis, the dependent variable is the return differential, measured as the percentage difference between green and brown energy returns. It has a mean of -0.092, a standard deviation of 2.294, and ranges from -9.739 to 13.193. As is common in financial data, the return differential fluctuates around zero. It has high volatility, given that the data are daily. The alternative return differential has similar statistical characteristics.

The MSCI market returns (expressed in percentage), used as a control in robustness checks, have a mean of -0.014, a standard deviation of 0.962, and range from -4.056 to 3.014. As the return differentials discussed above, the MSCI market returns fluctuate around zero. However, they exhibit lower volatility.

**Table 1: Descriptive statistics**

Variables	Obs	Mean	SD	Min	Max
<i>Main analysis</i>					
Sample	247	–	–	2015-02-02	2024-12-18
Green score	247	0.189	0.087	0.100	0.462
Return differential	247	-0.092	2.294	-9.739	13.193
<i>Robustness and extended analysis</i>					
Alternative return differential	212	-0.119	2.410	-9.738	13.190
MSCI returns	247	-0.014	0.962	-4.056	3.014

*Note:* The table presents the number of observations (Obs), the mean, the standard deviation (SD), the minimum (Min) and the maximum (Max) values of the variables. The return differential is the difference between green and brown energy indices. The alternative measure of the return differential is computed in a similar way by replacing the renewable energy index with an alternative. MSCI returns are computed based on the MSCI Europe Index.

## 5 Methodological framework

### 5.1 Baseline model

To evaluate the impact of ECB green communication on financial markets, we use high frequency identification (event study methodology) commonly used in the central bank communication literature ([Blinder et al., 2008](#); [Gürkaynak et al., 2005](#); [Swanson, 2021](#)). Specifically, we investigate whether climate-related ECB speeches that explicitly mention the word “energy” has a statistically significant effect on the relative

performance of green versus brown energy index returns on the day of the speech. Our baseline specification of the regression model is as follows:

$$\Delta Y_t = \beta_0 + \beta_1 X_t + \varepsilon_t \quad (1)$$

where  $\Delta Y_t$  represents the daily return differential between the renewable and fossil fuel energy indices on a given day,  $X_t$  denotes the green score of ECB speeches for that day,  $\varepsilon_t$  is an error term, and  $\beta_i$ s are the parameters of the model. The model is estimated using ordinary least squares.

The specification and the estimation frequency of the model allow for measuring market responses to ECB green communication. This approach is consistent with previous studies examining the effects of central bank communication and its tone on asset prices ([Apel and Grimaldi, 2014](#); [Coenen et al., 2017](#); [Swanson, 2021](#)). By directly comparing green and brown energy returns, the model captures the relative advantage of investing in green energy assets following green communication.

Endogeneity concerns are largely mitigated by the high-frequency identification itself. Additionally, in this context, reverse causality is highly unlikely, as it is implausible that the return differentials of energy sector indices would influence the green tone of ECB speeches, which are independently crafted by policymakers. Furthermore, all ECB speeches occur before the closing time of financial markets, when information on energy sector indices becomes available.

## 5.2 Robustness framework

To ensure the robustness of our main findings, we also use alternative empirical approaches. To account for potential autocorrelation and heteroskedasticity in daily return data, we reestimate the main model using Newey-West standard errors. We

examine whether ECB speeches have a lagged effect on returns by reestimating the model with the green score lagged one period:

$$\Delta Y_t = \beta_0 + \beta_1 X_{t-1} + \varepsilon_t \quad (2)$$

In line with the model specification, we measure the return differential on the day following the ECB communication. If the day following the ECB communication falls on a weekend or holiday, we measure the return differential for the next working day.

We aim to ensure that the observed market reactions are not confounded by broader monetary policy shocks. We check whether ECB speeches are delivered on the same day as monetary policy decision announcements. In our estimation sample, ECB green speeches do not coincide with its monetary policy announcements. This feature of the sample reduces the risk that the results might be driven by concurrent policy signals rather than by the green content of the speeches and it helps us isolate the effect of green communication ([Neszveda and Siket, 2025](#)).

We account for broader market movements that might simultaneously affect returns by adding daily returns of the MSCI Europe index as a control variable to the model:

$$\Delta Y_t = \beta_0 + \beta_1 X_t + \beta_2 Z_t + \varepsilon_t \quad (3)$$

where  $Z_t$  represents the return of the MSCI Europe Index for a given day. This extension of the model allows us to isolate the impact of ECB green communication from general equity market trends to confirm that the observed effect is not driven by coinciding macroeconomic news.

As mentioned previously, one of the disadvantages of the S-BERT model is the risk of false positives. Therefore, we reclassify green speeches using a dictionary method (shown in Figure 1), select speeches with a green score above 0, and rerun the regression. This alternative classification helps verify that the observed effects are not artifacts

of the embedding-based model, thereby enhancing the robustness and validity of our findings.

We winsorize the dependent variable, daily return differentials, at the 1st and 99th percentiles to reduce the influence of outliers. We increase the green score threshold by 20 percent to 1.2 to ensure that the analysis focuses on ECB speeches with relatively stronger green content. That is, we consider only ECB speeches with a green score value higher than 1.2. This modification allows us to verify that the observed market effects are not driven by marginal or weakly green communication.

We substitute the baseline renewable energy index with a more narrowly defined sectoral index, as detailed in Subsection 4.1. This index is available in the Refinitiv Eikon database, covering data since 2017, which slightly reduces the sample. Approximately 30 speeches are excluded from the original dataset because they are dated before 2017. If the results remain consistent, this robustness check confirms that the findings are not sensitive to the construction of the green asset proxy or to the exact sample used in our main analysis.

### **5.3 Extended framework**

For further empirical analysis, we implement two extensions of the baseline regression model. In these extensions, we use a more narrowly defined renewable energy index, which we find more relevant for our further analysis. The first extended model examines whether the effects of ECB green speeches on relative energy market returns have changed since the start of the Russian–Ukrainian war on 24 February 2022. A dummy variable is defined as equal to 1 for speeches delivered on or after 24 February 2022 and 0 otherwise. In addition to the dummy variable, the baseline model is extended with an interaction term between the dummy and the green score of ECB



speeches to evaluate whether the effect differs between the pre-war and post-war periods. Correspondingly, the extended model is specified as follows:

$$\Delta Y_t = \beta_0 + \beta_1 X_t + \beta_2 W_t + \beta_3 X_t \times W_t + \varepsilon_t \quad (4)$$

where  $W_t$  is the dummy variable that takes the value 1 from the outbreak of the war onward and 0 otherwise. The coefficient  $\beta_3$  captures the marginal change in the impact of the green content of ECB speeches since the outbreak of the war. This formulation allows us to test whether the war altered market perceptions of green communication, possibly due to heightened awareness of energy security and geopolitical dependencies on fossil fuels.

The second extended model analyzes whether the thematic framing of speeches influences financial market reactions. According to earlier topic modeling, two dominant topics are identified in the ECB speech sample: *climate and financial risk*, and *monetary policy and economic conditions*. The baseline model is extended with a topic dummy variable and an interaction term between the green score of speeches and the assigned topic to determine whether one type of framing is associated with a stronger market response. Accordingly, the extended model takes the following form:

$$\Delta Y_t = \beta_0 + \beta_1 X_t + \beta_2 M_t + \beta_3 X_t \times M_t + \varepsilon_t \quad (5)$$

where  $M_t$  is a dummy variable equal to 1 if a speech is classified under the topic *monetary policy and economic conditions*, and 0 otherwise, with *climate and financial risk* being the reference category. The coefficient on the interaction term,  $\beta_3$ , captures whether green content associated with monetary policy discussions elicits a different market reaction. This examination is motivated by the notion that communication linked to monetary policy may be perceived by investors as more credible, thereby amplifying its relevance for financial markets (Drudi et al., 2021). Thus, these two

extensions of the baseline specification provide a more granular evaluation of the effects of the timing and framing of ECB green communication on investor reactions.

## 6 Results

### 6.1 Main results

The estimation results of the baseline model are presented in Table 2. They reveal a positive and statistically significant effect of the green score of ECB speeches on the return differential between the green and the brown energy sectors, consistent with H1. In particular, a one-unit increase in the green score raises the return differential by 3.483 percentage points. This finding suggests that investors respond to ECB green communication by reallocating capital toward greener assets. Hence, the direction and significance of the coefficient are consistent with the view that the ECB can influence market expectations through non-monetary signals, such as green content.

The magnitude of the estimated effect of the green score of ECB speeches on the return differential is not directly comparable to the results reported in the related literature. In any case, consistent with the related literature (Bauer et al., 2025; Campiglio et al., 2025; Joëts et al., 2023; Neszveda and Siket, 2025), we find that ECB green communication positively and significantly affects the relative performance of green returns compared with brown returns. The estimated effect on the return differential is also economically significant. The estimated effect of 3.483 is economically substantial, given that the mean and standard deviation of the return differential are -0.092 and 2.294, respectively (Table 1).

We also estimate the effect of ECB green communication on the green and the brown energy returns separately. As reported in Table A.2, the effects are not statistically significant, in line with the findings by Gordo et al. (2024). That is, the effect of ECB green communication is significant only for the return differential between the

green and brown returns. Thus, these results suggest that ECB green communication influences the relative performance of green versus brown returns, rather than affecting their individual levels.

The result from the estimation of the baseline model aligns with the growing literature on the market impact of central bank communication, including recent studies examining how climate-related narratives influence financial markets (Ebeling, 2024; Neszveda and Siket, 2025). From a theoretical perspective, the result is well-grounded in signaling theory, supporting the view that informational asymmetries between institutions and market participants can be mitigated when credible actors send clear, observable signals that convey their underlying intentions or future policy directions (Spence, 1978). In the current context, ECB green speeches serve as signals of institutional commitment to sustainability goals, reducing investor uncertainty about future regulatory or monetary developments and triggering anticipatory adjustments in asset allocation.

**Table 2: Estimated effect of the green score of ECB speeches on the return differential between the green and brown energy sectors**

	Return differential
Constant	−0.749** (0.345)
Green score	3.483** (1.662)
Adjusted $R^2$	0.014
Observations	247

*Note:* Standard errors are in parentheses. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels, respectively.

## 6.2 Robustness analysis

The results of the robustness analysis are presented in Table 3. They broadly confirm the main finding that ECB green communication has a statistically significant positive effect on the return differential between green and brown energy indices. The finding largely remains consistent across different model specifications and estimation samples.

Across the following estimation variations: (1) winsorizing the dependent variable to reduce outlier influence, (2) including MSCI Europe returns as a control, (3) applying a higher threshold for green scores, or (4) using a narrower renewable index; the coefficient ( $\beta_1$ ) related to the green score variable remains positive and statistically significant. Furthermore, (5) the Newey-West corrected standard errors also produces a robust and significant coefficient, indicating that the results are not affected by potential heteroskedasticity or autocorrelation in the residuals. In addition, (6) when using the alternative method to measure the green content of ECB speeches, the coefficient associated with the green score is still positive and significant, but its magnitude is smaller. However, (7) when testing for the lagged effect of ECB green speeches on the return differential on the following trading day, the green score coefficient becomes statistically insignificant. This estimated effect suggests that the financial market reaction to ECB speeches is largely immediate.

The result of the immediate financial market reaction to ECB speeches is in line with the finding by [Neszveda and Siket \(2025\)](#). They find abnormal returns of green vs. brown portfolios only in the contemporaneous event window when examining the green score effects of ECB speeches. Overall, the robustness analysis reinforces the validity of the baseline finding and confirms that it is not sensitive to sample selection, green score calibration, broader market movements, or modeling assumptions.

**Table 3: Robustness checks for the estimated effect of the green score of ECB speeches on the return differential between the green and brown energy sectors**

	Return differential						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	-0.663** (0.267)	-0.750** (0.346)	-0.877** (0.402)	-0.868** (0.388)	-0.749** (0.314)	-0.357 (0.249)	0.161 (0.356)
Green score	3.017** (1.286)	3.487** (1.666)	3.956** (1.801)	3.821** (1.794)	3.483** (1.415)	0.001** (0.000)	
MSCI index		-0.021 (0.151)					
Lagged g. score							-0.563 (1.712)
Adjusted $R^2$	0.018	0.010	0.019	0.016	0.014	0.023	0.004
Observations	247	247	203	212	247	137	247

*Note:* Standard errors are in parentheses. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels respectively. The models are estimated as follows: (1) winsorizing the dependent variable to reduce outlier influence, (2) including MSCI Europe returns as a control, (3) applying a higher threshold for green scores, (4) using a narrower renewable index, (5) applying Newey-West corrected standard errors, (6) using the alternative method to measure the green content of ECB speeches, or (7) testing for the lagged effect of ECB green speeches on the return differential.

### 6.3 Extended analysis

Table 4 includes the results from the extended analysis. Since the narrower renewable index is used in the extended analysis, the estimates are more directly comparable with the results obtained using this index in place of the baseline index. These results are reported in the robustness analysis variation (4) of Table 3.

In the extended version (1), the effect of ECB green communication on the green-vs-brown return differential remains positive and significant. Moreover, the estimated effect of 4.612 is considerably larger than the estimate of 3.821 obtained from the robustness analysis variation (4). However, the dummy variable for the

Russian–Ukrainian war and the interaction term between it and the green score are not significant. These results indicate that ECB green speeches have not had a heightened impact on the return differential since the onset of the war. That is, the current evidence does not support  $H_2$ . This finding underscores that during periods of acute crisis, markets may temporarily prioritize stability and immediate supply considerations over sustainability signals.

According to the ECB ([European Central Bank, 2024](#)), following the Russian–Ukrainian war, the increase in energy prices has been the largest energy shock since the 1970s. Consequently, the energy shock can affect the macro-financial landscape and investor sentiment. In such a setting, the communicative function of central banks may shift from long-term guidance to short-term reassurance, as immediate concerns about energy security, inflation, and geopolitical risk dominate market attention. This shift suggests that the effectiveness of ECB green communication may not be uniformly stronger during economic crises.

In the extended version (2), we explore whether the thematic framing of ECB speeches exerts a different effect. Again, the main effect of ECB green speeches on green-vs-brown return differential is positive, although it is at the 10% significance level in this case. The magnitude of the estimated effect is almost identical to the corresponding result obtained from the robustness analysis variation (4). At the same time, we obtain insignificant results for the dummy variable representing speeches focused on monetary policy and economic conditions, as well as for the interaction term between the dummy variable and the green score. That is, there is no difference in the effects of the speech topics. Overall, the analyses of both extended versions suggest that the positive relationship between ECB green communication and green-vs-brown return differential is robust across different geopolitical and thematic contexts, with no evidence of significant attenuation.

**Table 4: Alternative estimated effects of the green score of ECB speeches on the return differential between the green and brown energy sectors**

	Return differential	
	(1) Timing	(2) Topic
Constant	−0.970* (0.523)	−0.917 (0.630)
Green score	4.612** (2.312)	3.820* (2.301)
War dummy	0.301 (0.792)	
Green score × war dummy	−2.145 (3.700)	
Topic dummy		−0.073 (0.943)
Green score × topic dummy		0.920 (4.657)
Adjusted $R^2$	0.009	0.008
Observations	212	212

*Note:* Standard errors are in parentheses. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels respectively. The baseline model is extended with: (1) a dummy variable for the Russian–Ukrainian war and its interaction term with the green score, and (2) a dummy for the topic *monetary policy and economic conditions* (with the topic *climate and financial risk* as the reference category) and its interaction term with the green score.

## 7 Conclusion

This paper examines how ECB green communication affects financial markets. In particular, it examines the relative performance of renewable and fossil-based energy sectors. It contributes to the growing literature on central bank communication by focusing not only on the general tone of climate-related discourse but also on the

intersection between climate-related signaling and energy-related content, an area of increasing macroeconomic and financial importance.

Using a sentence-embedding method applied to ECB speeches from 2015 to 2024, this paper identifies 247 climate-related speeches that include the term “energy”. Natural language processing techniques are employed to classify both the thematic and emotional content of ECB speeches. This analysis reveals a dominant presence of topics related to climate and financial risk, as well as monetary policy and economic conditions, along with consistent emotional cues of positivity and trust.

The empirical analysis uses high-frequency identification to evaluate how ECB green communication influences investor reactions. The results of this analysis show that such ECB communication has a positive and statistically significant effect on the return differential between green and brown energy sectors. The results are robust across various sensitivity analyses. At the same time, the effect does not increase significantly after the onset of the Russian–Ukrainian war, indicating that geopolitical shocks may constrain the extent to which central bank communication shapes investor sentiment. The results also do not vary significantly across the two categorized topics of ECB communication.

As ECB authorities move toward integrating climate-related goals into their policy framework, their public communication serves as a vital tool. It helps guide market expectations and align financial flows with long-term sustainability objectives. Nevertheless, the effectiveness of central bank green communication may be constrained during periods of heightened geopolitical volatility.



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# A Appendix

**Table A.1: Expressions used for the dictionary-based method**

abrupt transition	brown penalising factors	carbon emission	carbon emissions	carbon price
carbon prices	carbon pricing	carbon tax	carbon taxes	climate action
climate actions	climate adaptation	climate aligned	climate change	climate changes
climate crisis	climate damage	climate data	climate economics	climate event
climate events	climate exposure	climate exposures	climate extremes	climate finance
climate friendly	climate goals	climate harm	climate hazard	climate hazards
climate impact	climate impacts	climate metrics	climate minsky moment	climate policies
climate policy	climate protection	climate related	climate relevant	climate risk
climate risks	climate scenario	climate scenarios	climate science	climate sensitivity
climate shock	climate shocks	climate stability	climate stress test	climate stress tests
climatologist	climatologists	climatology	cotwo	decarbonise
decarbonised	decarbonising	decarbonization	decarbonize	decarbonized
decarbonizing	disorderly transition	disorderly transitions	environment risk	environment risks
environmental risk	environmental risks	global warming	green bond	green bonds
green economy	green finance	green finances	green investment	green investments
green monetary	green policies	green policy	green qe	green quantitative easing
green supporting factor	green supporting factors	green swan	green swans	green technologies
green technology	green transition	green transitions	greener	greenhouse
greening	low carbon	ngfs	paris agreement	physical risk
physical risks	stranded asset	stranded assets	sustainable finance	sustainable finances
sustainable investing	tofd	transition risk	transition risks	european green deal
eu taxonomy	cbam	green monetary policy	nature-related risks	nature-related risk
natural environment	natural resources	nature degradation	nature and climate	climate and nature
climate-related risks	nature crisis	nature crises	climate crises	risk of climate
risk from climate	global heating	nature-related consideration	nature-related considerations	climate-related consideration
climate-related consideration	weather-related hazards	weather-related hazard	decline of nature	carbon uptake
nature-related financial risk	nature-related financial risks	climate-related risks	climate-related risk	biodiversity crisis
ecosystem degradation	deforestation regulation	cande risks	cande risk	sustainable finance disclosure regulation
climate law	green asset	green assets	climate-related catastrophe	greener technology
greener technologies	renewable energy	renewable energies	net zero emission	net zero emissions
natural disaster	natural disasters	climate neutrality	greening monetary policy	green capital markets
climate-neutrality	climate performance	climate-neutral	environmental damage	environmental damages

*Note:* This table contains all the expressions used to create the green score of ECB speeches. The dictionary contains climate-related expressions compiled from the related literature ([Campiglio et al., 2025](#); [Ebeling, 2024](#)) and own additions.

**Table A.2: Estimated effect of the green score of ECB speeches on the green and brown energy returns**

	Green energy returns	Brown energy returns
Constant	−0.561 (0.365)	0.188 (0.195)
Green score	2.548 (1.758)	−0.936 (0.938)
Adjusted $R^2$	0.004	0.00002
Observations	247	247

*Note:* Standard errors are in parentheses. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels respectively.