



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 model, we identify 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 green and brown energy sectors. The results show that ECB green 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 the outbreak of the Russian–Ukrainian war or across ECB communication topics. We further find that ECB green speeches delivered by the President have a stronger effect on the return differential.

1. Introduction

Climate change represents one of the most pressing and complex global challenges. 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 (Batiston 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 behavior. 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 acknowledged 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 reshape the long-term outlook

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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 investor 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) speeches by the ECB on European energy markets. This paper addresses the gap in the literature by analyzing the financial impact of such ECB communication.

We use a sentence-embedding model to identify ECB green speeches over the period 2015–2024. We identify 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 positivity and trust. Using high-frequency identification (event study methodology), we provide evidence that ECB green communication positively and significantly affects the return differential between green and brown energy sectors. The findings remain consistent across various robustness analyses. Moreover, this effect is not significantly affected by the outbreak of the Russian–Ukrainian war or the ECB communication topics. We further find that ECB green speeches delivered by the President exert a stronger impact on the return differential, indicating heterogeneous effects of green communication by ECB officials.

This paper makes several contributions to the literature. 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; Jourde et al., 2025; Neszveda and Siket, 2025), this research contributes by focusing on speeches that explicitly mention the term “energy”, a domain central to the green transition and a major factor in both climate risk and economic opportunities. 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 important empirical insights. It links the textual analysis of ECB speeches with financial market data, providing empirical evidence of the relationship between green communication and the 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 most significant recent shocks, the Russian–Ukrainian war, on this relationship.

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 the evolution of ECB green communication

The evolution of the ECB green communication can be contextualized through pivotal events. In particular, this section presents key events based on their relevance to shifts in the institutional, regulatory, and geopolitical environment that have shaped the ECB approach to climate and energy issues. Thus, the focus is on events that illustrate the evolution of ECB communication with respect to climate and energy issues.

The negotiations of the *Paris Agreement* concluded in 2015 (United Nations Framework Convention on Climate Change (UNFCCC), 2015) and it 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. Existing literature (D’Orazio and Popoyan, 2023) suggests that broader mandates are associated with a higher likelihood of adopting climate-related policies.

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 and communicated 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 energy dependence of the EU on fossil fuels, and elevated climate and energy security issues on the policy 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 ECB energy-related communication has gradually intensified, broadened, and become more strategically oriented 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 policy measures, such as forward guidance. A substantial body of research shows that the tone, timing, and content of central bank have significant effects on financial markets, including asset prices, risk

premia, and expectations of investors (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 policy 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. In particular, 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 prominent 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 central bank communication extend beyond traditional financial variables. [Anastasiou et al. \(2023\)](#) show that negative tones in ECB communication significantly discourage firms from borrowing from banks, demonstrating 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 ensuring the effectiveness of monetary policy and the stability of the financial system. 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 communication. Firms with stronger environmental performance tend to benefit from green-leaning speeches while more polluting firms experience negative returns. These results suggest that climate-related language from central banks influences investor expectations and may contribute to market-based discipline in corporate sustainability performance. Similarly, [Ebeling \(2024\)](#) shows that climate-themed communication by the ECB can trigger measurable portfolio shifts toward greener assets. Based on a topic modeling analysis, he finds that speeches emphasizing green finance and monetary policy instruments, rather than risk narratives, tend to elicit stronger financial market responses. To evaluate the impact of climate-related ECB communication on financial assets, [Jourde et al.](#)

(2025) construct a corresponding index. They show that climate-related ECB communication reduces the return premium of brown assets.

[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 NGFS, are strong predictors of the frequency and scope of climate communication. In line with these results, [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.

[Deyris \(2023\)](#) traces the institutional evolution of ECB 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 partly by political pressures and reputational incentives.

Overall, the emerging literature suggests that climate-related 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 shape expectations, affect asset prices, 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 the volume of climate-related communication and its tangible impact on sustainable finance dynamics.

3.2. Central banks and the energy transition

Central banks are currently viewed not only as responsible for maintaining price and financial stability, but also as key contributors to 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 measures can be effective in supporting 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 had only a limited overall effect on renewable energy stocks since the implementation of quantitative easing.

Central banks deploy macroprudential tools, climate stress tests, and disclosure frameworks. Yet, their integration into core monetary policy operations remains limited ([Campiglio et al., 2025](#)). [D'Orazio and Popoyan \(2023\)](#) find that broader monetary policy mandates are 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 policy 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 possess both policy tools and communicative influence necessary to support the energy transition. Through regulation, communication, and asset purchases, central bank interventions can shape investor expectations and help direct capital toward cleaner energy systems.

This paper is related to the growing body of literature on climate-related communication by central banks. It contributes to this literature by focusing on the impact of both climate- and energy-related communication on the return differential between renewable and fossil energy sectors. It also explores the impact of ECB speeches related to communication topics, speaker identity, and heightened uncertainty associated with the Russian–Ukrainian war.

3.3. Hypothesis development

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

In the policy context, signaling theory explains how public institutions convey non-observable assessments and intentions 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 green and 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: Compared with regular ECB speeches, the positive effect of ECB green speeches on the relative performance of green and brown energy sector returns is stronger during the Russian–Ukrainian war period.

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 official speeches by the President, the Vice-President, and other members of the Executive Board. These 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, we use the FR Europe Renewable Energy Index, which captures the performance of European firms classified under the GICS (Global Industry Classification Standard) industry code 5020. It includes firms focused on renewable electricity generation and sustainable energy technologies, reflecting broad exposure to the European clean energy sector. For a robustness check, we replace this index with a narrower sub-industry index under the GICS industry code 502010, which captures firms more specifically involved in renewable energy. 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](#)), we use the STOXX Europe 600 Oil and Gas Index, 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 the returns on the MSCI Europe Index. It is a broad stock market index that measures the performance of large- and mid-cap equities across 15 developed European countries. All the indices are retrieved from the Refinitiv Eikon database. To control for global market volatility in the robustness analysis, we use the volatility index (VIX). The VIX index is compiled by the Chicago Board Options Exchange (CBOE), which is also the data source.

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 model, specifically the Sentence-BERT (SBERT) 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. 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. In the literature on climate-related communication, often, climate themes are treated separately from energy topics and any dictionary entries containing the word “energy” are excluded. We

use a curated list of climate-related expressions compiled from existing literature (Campiglio et al., 2025; Ebeling, 2024) and supplement it with manual additions of energy and ECB specific terms. For example, the expression “global warming” is often referred to as “global heating” in these speeches and so the latter is added to the keyword list. Table A.1 shows the full list of the curated expressions we use in the case of the dictionary-based method.

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 SBERT model 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 (Table A.2). 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 SBERT model measures semantic similarity between texts using cosine similarity. The green score computed using this approach, as well as the dictionary-based method, ranges from -1 (completely dissimilar) to $+1$ (identical in meaning). Nevertheless, in practical applications involving 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 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 the sustainability, even if they are not entirely focused on these topics.

Figs. 1 and 2 present the evolution of the monthly average green scores computed with 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 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 SBERT model 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 model 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 model, which can recognize semantic similarities rather than exact keyword matches, correctly assigns a green score higher than 0. Based on these considerations, we use the sentence-embedding model as our baseline approach in the analysis.

From Fig. 2, it is evident that, prior to 2019, average green scores were consistently lower, 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 Lagarde’s appointment as the ECB President. Lagarde frequently emphasized the role of the ECB in facilitating the green transition (Lagarde, 2021), and this leadership change coincided with an increase in the average green tone of energy-related speeches. This date also coincided 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 policy coordination (Hepburn et al., 2020).

A significant geopolitical shock, the start of the Russian–Ukrainian war in February 2022, did not produce a major upward spike in green speech content. This is 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 might help explain the observed relative flattening in green communication scores since 2022. To show the full-sample distribution of green scores of ECB speeches, Fig. 3 presents the histogram of green scores.

In Fig. 4, we plot the top 100 green scores of ECB speeches mentioning the word “energy”. We can observe a clustering of green scores between 2020 and 2024, reaffirming that this was a period of climate-intense communication. Speeches surrounding the ECB Strategy Review were particularly well represented. In Fig. 2, which plots monthly averages, green scores of ECB speeches were particularly high since the start of the Russian–Ukrainian war. However, when focusing on the top 100 speeches in Fig. 4, the green scores of several individual speeches around the outbreak of the war stood 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 delivered 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.

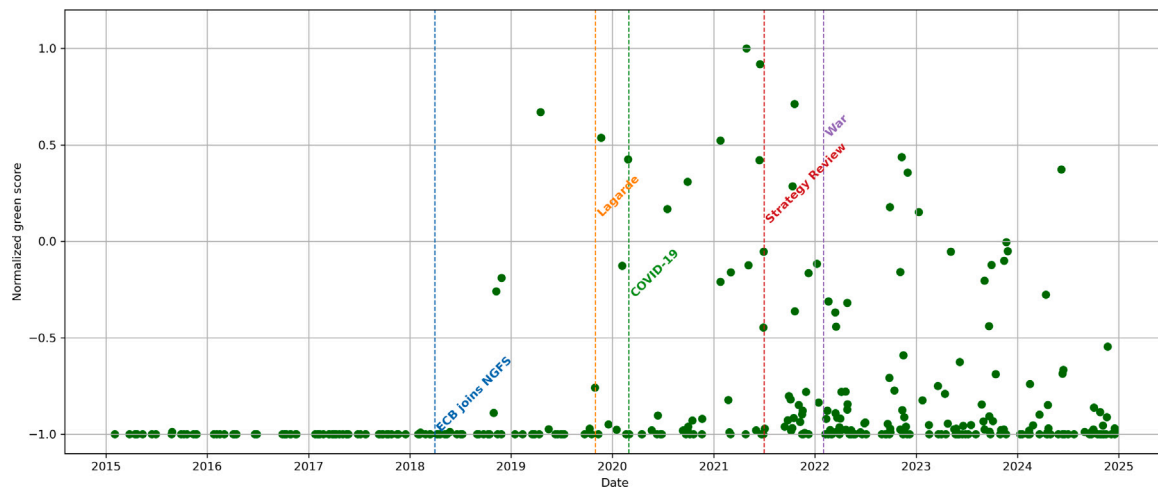


Fig. 1. Monthly average green scores of ECB speeches, based on the dictionary-based method. Note: Key events are highlighted in the figure.

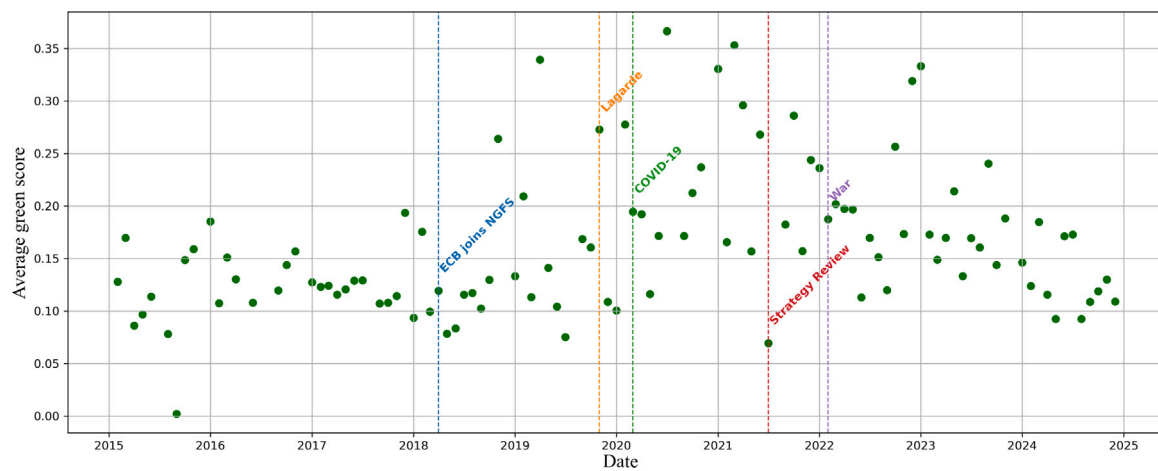


Fig. 2. Monthly average green scores of ECB speeches, based on the SBERT model. Note: Key events are highlighted in the figure.

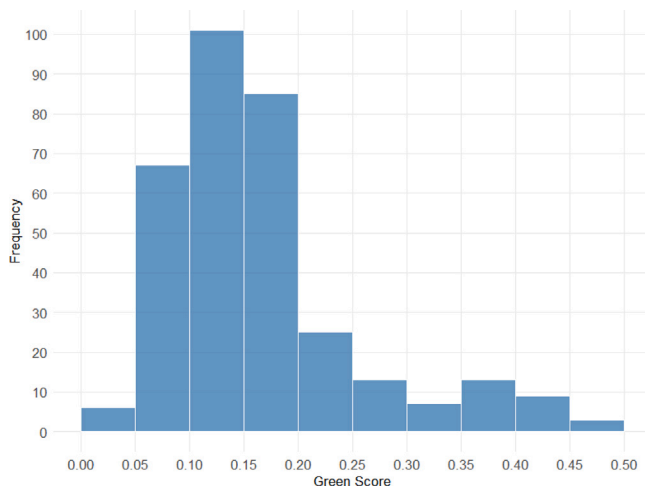


Fig. 3. Distribution of green scores.

Note: The histogram shows the full-sample distribution of the green scores of ECB speeches. The green scores are computed using the SBERT model.

4.3. Topic modeling and emotion analysis

To ensure that 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 paper employs Latent Dirichlet Allocation (LDA), a widely used unsupervised topic modeling technique. LDA assumes that each document is a mixture of topics and that each topic is a distribution over words (Blei et al., 2003). When applied to central bank green communication, it can reveal underlying thematic structures, an approach previously employed in related research (Arse-[neau et al., 2022](#); [Campiglio et al., 2025](#); [Ebeling, 2024](#)). As is common, we use the Gibbs sampling method for LDA topic modeling ([Table A.2](#)).

[Fig. 5](#) displays word clouds for two topics identified from the filtered speeches. These topics differ in focus and are distinct. Topic 1 centers on terms such as “banks”, “financial”, “stability”, “risk”, “climate”, and “change”, 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

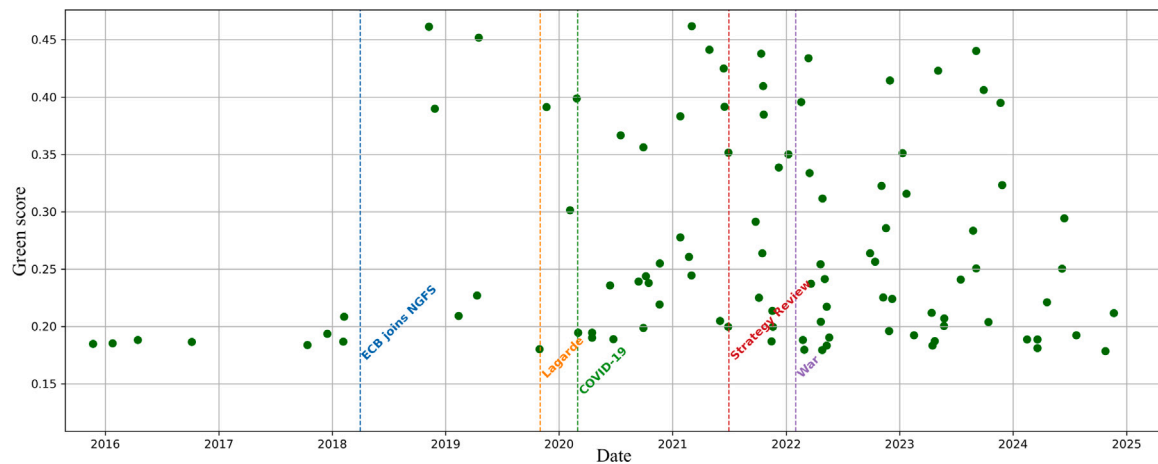


Fig. 4. Top 100 green scores of ECB speeches. Note: The green scores are computed with the SBERT model. Key events are highlighted in the figure.



Fig. 5. Word clouds of two dominant topics in ECB speeches.

Note: Using LDA techniques, two main topics are identified in ECB speeches. Topic 1 is focused on *climate and financial risk*, and Topic 2 is focused on *monetary policy and economic conditions*. This figure shows the top 15 words contained in each topic.

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 policy themes, as reflected by terms such as “monetary”, “policy”, “euro”, “economic”, “growth”, and “inflation”. This topic appears to capture ECB communication on how climate and energy issues intersect with monetary policy 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, economic growth projections, and monetary policy strategies. We label this group “*monetary policy and economic conditions*”. Taken together, Topic 1 emphasizes climate risk and financial structure, and Topic 2 situates climate discourse within a conventional macroeconomic policy framework. This categorization aligns with the previous literature on climate-related ECB communication (Ebeling, 2024).

Fig. 6 contains a bar chart, which displays the annual evolution of ECB speeches categorized under the two topics: “climate and financial risk” (Topic 1) and “monetary policy and economic conditions” (Topic 2). The latter topic emerges as more dominant across most years, reflecting the consistent emphasis of the ECB on integrating climate concerns within a broader macroeconomic framework. Notably, the peak in 2022 for the topic “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.

The steady rise and relative persistence of the topic “climate and financial risk”, 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 decline in 2024 may indicate a temporary prioritization of traditional economic stability concerns, while the sustained presence of climate-related risk discourse suggests its permanent role in ECB communication.

Fig. 7 highlights the five highest green scores of ECB speeches per year, providing insights into the evolving thematic focus of the ECB communication. Before 2020, the green-intensive ECB speeches were primarily associated with the topic “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.

Beginning in 2020, there was a notable shift in the focus of the topic. The majority of green-intensive ECB speeches were associated with the topic “climate and financial risk”. This aligned with a broader institutional pivot around the time of the ECB 2021 climate action plan and it was announced following the onset of the Russian–Ukrainian war in February 2022. While the monthly averages suggest that the war did

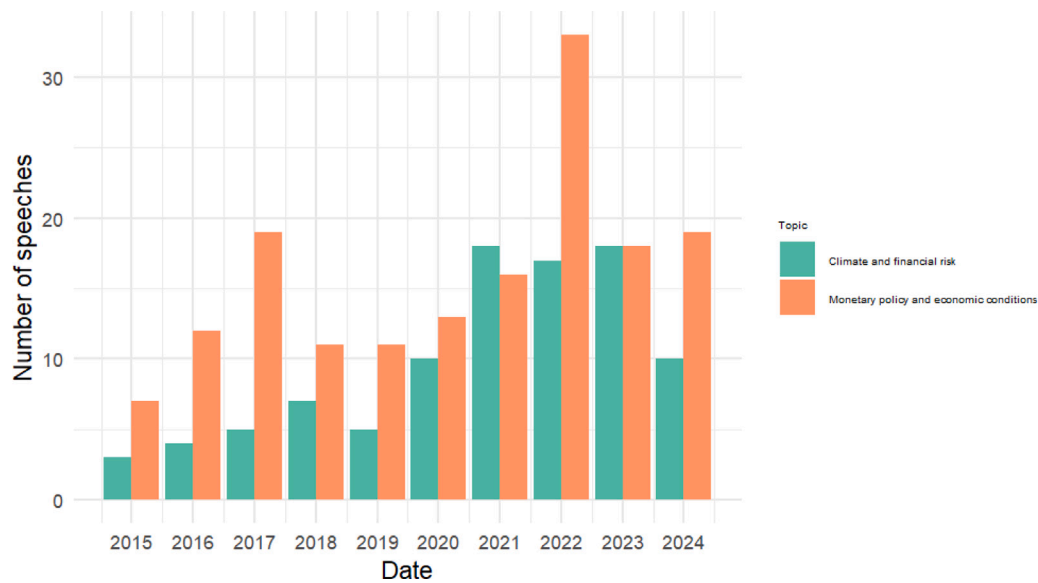


Fig. 6. Evolution of two identified topics in ECB green communication.

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

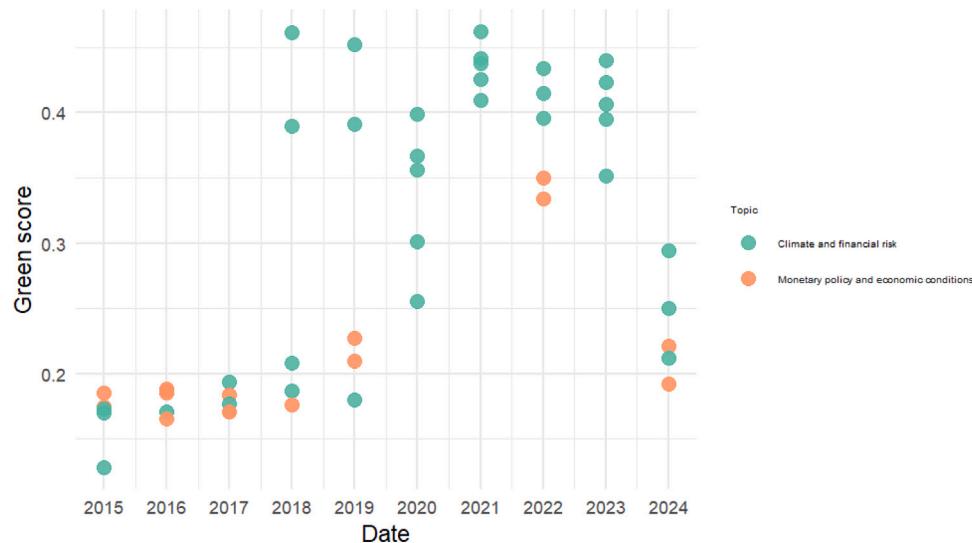


Fig. 7. Evolution of top five green scores of ECB speeches by topic.

Note: The figure shows the evolution of the five highest green scores of ECB speeches by topic.

not lead to a sustained spike in climate-related discourse, Fig. 7 shows that several individual speeches contained relatively high green content following the onset of the war. These features likely reflected 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 were more moderate than in the peak years from 2021 to 2023. While some speeches remained centered on the topic “climate and financial risk”, there was also a reemergence of the topic “monetary policy and economic conditions”, suggesting a shift in emphasis. This might reflect a broader recalibration of communication priorities, with climate-related issues remaining important but increasingly integrated into discussions of macroeconomic stability, inflation, and financial conditions. Thus, 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.

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.

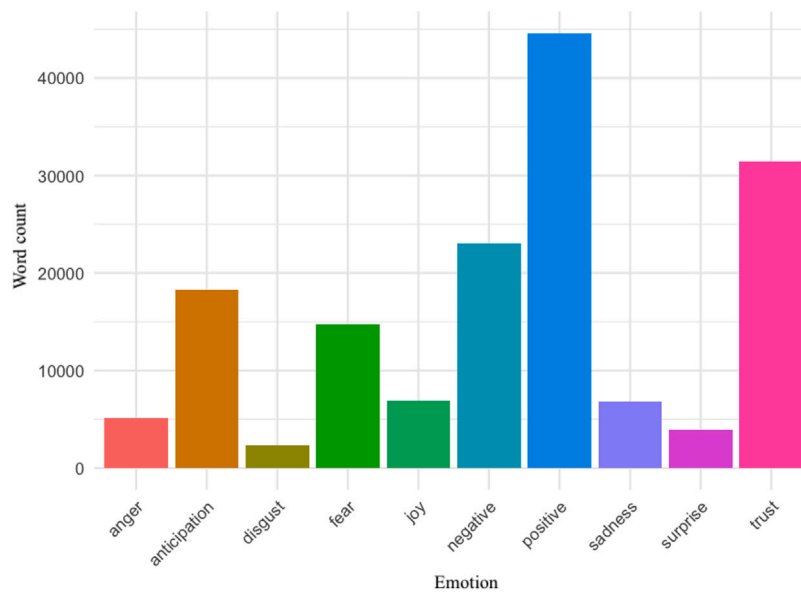


Fig. 8. Emotional content in ECB green communication.

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.

As illustrated in Fig. 8, 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 indicates that, alongside other functions, the ECB performs an important communicative role in maintaining credibility and anchoring expectations during periods of climate and energy volatility.

4.4. Descriptive statistics

The sample period spans from 2 February 2015 to 18 December 2024, covering nearly a decade of ECB green speeches. The dataset comprises 247 observations of ECB speeches with a green score of at least 0.1 and explicitly referencing 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 combined by averaging their green scores.

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 energy sectors.

To explore green speeches delivered by ECB officials, Table A.3 presents ten speakers with the highest number of ECB green speeches. The table includes ECB speeches that mention the term “energy” and have a green score value of at least 0.1. These speeches are used as the reference sample for the table. The highest number of speeches (77) in the sample was delivered by ECB President Christine Lagarde. The average green score of her speeches is 0.201. Former ECB President Mario Draghi delivered 29 speeches in the sample, resulting in an average green score of 0.153. Christine Lagarde and Mario Draghi together delivered 106 speeches, which is around 44% of the total speeches in the sample. The highest average green score (0.305) is recorded for the speeches (18) given by ECB Executive Board Member Frank Elderson.

Table 1 presents descriptive statistics for the daily observations of all variables used in the main analysis and robustness checks. 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. We standardize the green score to have zero mean and unit standard deviation before its inclusion in the regression analysis. The standardization of the green score allows us to interpret its estimated coefficient in the regression analysis as the effect of a one-standard-deviation increase in ECB green communication.

In the regression 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.

MSCI Europe Index returns, expressed in percentage terms and 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, MSCI returns fluctuate around zero but they exhibit lower volatility. The VIX index is also used as a control in robustness checks. Its mean is 19.330 and its standard deviation is 6.588. It ranges between 9.430 and 40.110.

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
VIX index	245	19.330	6.588	9.430	40.110

Note: The table presents the number of daily observations (Obs), the mean, the standard deviation (SD), the minimum (Min) and the maximum (Max) values of the variables. The green score is computed based on the sentence-embedding model. The return differential is the difference between green and brown energy returns. The alternative measure of the return differential is computed in a similar way by replacing the renewable energy index with a more narrowly defined index. MSCI returns represent the returns on the MSCI Europe Index. The VIX index is used in its original form.

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 ΔY_t represents the daily return differential between renewable and fossil fuel energy indices on a given day, X_t denotes the green score of ECB speeches for that day, ε_t is an error term, and β_t 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. In this setup, 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 estimation 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 the return differential 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 this 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).

To account for broader market movements or global market volatility that might affect the return differential, we add MSCI Europe Index returns or the VIX 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 MSCI Europe Index returns or the VIX index for a given day. This extension of the model helps us disentangle the impact of ECB green communication from general equity market trends or global market volatility. Thus, it helps ensure that the observed effect is not driven by coinciding macroeconomic news or global market fluctuations.

As mentioned previously, one of the disadvantages of the SBERT model is the risk of false positives. Therefore, we reclassify green speeches using a dictionary method (shown in Fig. 1), select speeches with a green score above 0, and rerun the regression. This alternative classification helps verify whether the observed effects are not artifacts of the sentence-embedding 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 whether the observed market effects are not affected by weakly green communication.

We substitute the baseline renewable energy index with a more narrowly defined sectoral index, as detailed in Section 4.1. This index is available from 2017, which slightly reduces the sample size. In particular, 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 sample used in our main analysis.

5.3. Extended framework

For further empirical analysis, we implement three extensions of the baseline regression model. In these extensions, we use the more narrowly defined renewable energy index, which is more relevant for our further analysis. The first extended model examines whether the effects of ECB green speeches on relative energy market returns changed after the start of the Russian–Ukrainian war on 24 February 2022. A dummy variable is defined as 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 β_3 captures the marginal change in the impact of the green content of ECB speeches

after 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 ECB speeches and the underlying 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 that takes the value 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, β_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 allow us to evaluate the effects of the timing and the framing of ECB green communication on the return differential.

In the third extension, we explore heterogeneity in the effects of green communication by different ECB officials. In particular, we examine whether the impact of ECB green communication on the return differential differs across speeches delivered by the ECB President and those given by other members of the ECB Executive Board. Thereby, we extend the baseline model with a dummy variable for speeches delivered by the President and with an interaction term between the dummy variable and the green score. We therefore consider the following model:

$$\Delta Y_t = \beta_0 + \beta_1 X_t + \beta_2 P_t + \beta_3 X_t \times P_t + \varepsilon_t \quad (6)$$

where P_t is a dummy variable that equals 1 if an ECB speech is delivered by the President and 0 otherwise. In the current specification of the model, the coefficient β_1 shows the reference effect of green speeches given by non-President members of the ECB Executive Board. β_2 measures the level effect of President speeches on the return differential for a speech with average green content. β_3 captures the additional effect of an increase in the intensity of ECB green speeches delivered by the President. Thus, this model allows us to examine whether the impact of ECB green communication depends on the identity of the speaker.

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 green and brown energy sectors, consistent with H1. In particular, a one-standard-deviation increase in the green score raises the return differential by 0.304 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 policy signals such as the green content of its communication.

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

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	−0.092 (0.145)
Green score	0.304** (0.145)
Adjusted R ²	0.014
Observations	247

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

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 0.304 percentage points is large relative to the average return differential, which is close to zero (Table 1). The estimated effect corresponds to approximately 13.252 percent of the volatility of the return differential.

We also estimate the effect of ECB green communication on the green and the brown energy returns separately. As reported in Table A.4, 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 on signaling theory, supporting the view that informational asymmetries between institutions and market participants can be mitigated when credible actors send clear and 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 policy developments and triggering anticipatory adjustments in asset allocations.

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 sectors. 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 Index returns as a control, (3) incorporating the VIX index as a control, (4) applying a higher threshold for the green score, or (5) using a more narrowly defined renewable energy index; the coefficient (β_1) related to the green score variable remains positive and statistically significant. Furthermore, (6) 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, (7) 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. However, (8) when testing for the lagged effect of ECB green speeches on the return differential, the green score coefficient becomes statistically insignificant.

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)	(8)
Constant	−0.094 (0.112)	−0.092 (0.145)	0.059 (0.458)	−0.064 (0.158)	−0.119 (0.164)	−0.092 (0.142)	−0.051 (0.198)	0.055 (0.149)
Green score	0.264** (0.112)	0.305** (0.146)	0.315** (0.148)	0.347** (0.158)	0.351** (0.165)	0.304** (0.131)	0.405** (0.199)	
MSCI returns		−0.021 (0.151)						
VIX index			−0.008 (0.022)					
Lagged g. score								−0.049 (0.150)
Adjusted R^2	0.018	0.010	0.010	0.019	0.016	0.014	0.023	−0.004
Observations	247	247	245	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 Index returns as a control, (3) incorporating the VIX index as a control, (4) applying a higher threshold for the green score, (5) using a more narrowly defined renewable energy index, (6) applying Newey–West corrected standard errors, (7) using the alternative method to measure the green content of ECB speeches, or (8) testing for the lagged effect of ECB green speeches on the return differential. Adjusted R^2 can be negative in models with low explanatory power.

This estimated effect suggests that the market reactions in green and brown energy sectors to the green content of ECB speeches are largely immediate.

The result of the immediate market reactions to the green content of ECB speeches is in line with the finding by [Neszveda and Siket \(2025\)](#). They find abnormal returns of green versus 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, broader market movements, green score calibration, or modeling assumptions.

6.3. Extended analysis

[Table 4](#) includes the results from the extended analysis. Since the more narrowly defined renewable energy 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 (5) of [Table 3](#).

In the extended specification (1) of [Table 4](#), the effect of ECB green communication on the return differential between green and brown energy sectors remains positive and significant. Moreover, the estimated effect of 0.423 is larger than the estimate of 0.351 obtained from the robustness analysis (5). 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 goals.

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 may affect the macro-financial landscape and investor sentiment. In such a setting, ECB long-term guidance about an accelerated shift to renewable energy may be combined with its short-term reassurance regarding fossil-fuel energy security, as immediate concerns about inflation and geopolitical risk dominate market attention. Thus, the potentially stronger positive impact of the ECB long-term guidance on the return differential during the Russian–Ukrainian war period may

be counteracted by the negative effect of its short-term reassurance regarding fossil-fuel energy security.

In column (2) of [Table 4](#), we explore whether the thematic framing of ECB speeches exerts a different effect. The effect of ECB green speeches on the return differential remains positive and significant. As in the previous case, the estimated effect of 0.486 is larger than the corresponding result obtained from the robustness analysis (5) of [Table 3](#). At the same time, we obtain insignificant results for the dummy variable representing ECB 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 significant 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 the return differential does not change significantly across different geopolitical and thematic contexts.

In the extended specification (3) of [Table 4](#), the effect of the green score on the return differential becomes not significant. This result indicates that the green content of speeches by non-President members of the ECB Executive Board does not significantly affect the return differential. The dummy variable for the impact of President speeches is not significant either. That is, there is no evidence that ECB President speeches have a different level effect on the return differential than speeches given by other members of the ECB Executive Board. At the same time, we find a significant result for the interaction term between the green score and the dummy variable for President speeches. This finding suggests that the effect of the green content of ECB speeches on the return differential is significantly stronger when the speaker is the President, reflecting an additional effect of President speeches. The estimated interaction effect is 0.888 and is significant at the 5 percent level, representing a substantial increase relative to the baseline estimate of 0.304. Thus, the positive average effect estimated in the baseline specification is primarily driven by speeches delivered by the ECB President.

The positive interaction effect suggests that green communication delivered by the ECB President has a stronger effect on the return differential between green and brown energy sectors. This finding may reflect the greater credibility, visibility, or policy relevance of presidential communication. Yet, the specification may not fully disentangle speaker identity from potentially greater informational content embedded in presidential speeches. The ECB President may choose strategic topics for speeches. Thus, the finding may reflect both a tendency of the ECB President to address high-priority topics and a speaker identity effect.

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	(3) Speaker
Constant	−0.067 (0.234)	−0.375 (0.279)	0.047 (0.214)
Green score	0.423** (0.212)	0.486** (0.210)	0.095 (0.192)
War dummy	−0.119 (0.330)		
Green score × war dummy	−0.197 (0.339)		
Topic dummy		0.353 (0.379)	
Green score × topic dummy		−0.219 (0.434)	
President dummy			−0.347 (0.328)
Green score × president dummy			0.888** (0.363)
Adjusted R ²	0.009	0.013	0.041
Observations	212	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 with the green score, and (2) a dummy variable for the topic *monetary policy and economic conditions* (with the topic *climate and financial risk* as the reference category) and its interaction with the green score, and (3) a dummy variable for President speeches (a total of 90 speeches delivered by Mario Draghi from April 2017 to October 2019 and Christine Lagarde from January 2020 to December 2024) and its interaction 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 model applied to ECB speeches from 2015 to 2024, we identify 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.

Based on a high-frequency identification strategy, we evaluate the impact of ECB green communication on the return differential between green and brown energy sectors. The results show that ECB green communication has a positive and statistically significant effect on the

return differential. 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, suggesting that heightened geopolitical and energy market uncertainty may offset the impact of ECB long-term green transition guidance on investor sentiment. The results also do not vary significantly across the two categorized topics of ECB communication. ECB green speeches have a stronger effect on the return differential when delivered by the President, indicating heterogeneity in the market effects of green communication by different ECB officials.

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 uncertainty.

While the findings provide important insights, several limitations should be acknowledged. The focus on ECB speeches may limit generalizability. The analysis focuses on short-term market reactions, consistent with the high-frequency identification strategy. Text-based methods may not fully capture contextual nuances, despite the use of the sentence-embedding model. Future research could extend the analysis to other central banks, explore longer-term market effects, and refine text analysis methods to better capture contextual nuances.

CRedit authorship contribution statement

Karen Davtyan: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Investigation, Formal analysis, Conceptualization. **Adel R. Kalozdi:** Writing – review & editing, Writing – original draft, Visualization, Validation, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

See [Tables A.1–A.4](#).

Table A.1

Expressions used in the dictionary-based method.

abrupt transition	brown penalizing 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	decarbonize
decarbonized	decarbonizing	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	tcfd	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 considerations	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	c&e risks	c&e 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: The table presents all expressions used to compute the green scores of ECB speeches with the dictionary-based method. The dictionary contains climate-related expressions compiled from the related literature (Campiglio et al., 2025; Ebeling, 2024) and supplemented with additions by the authors. Both singular and plural forms of the expressions are included to ensure comprehensive keyword matching. The abbreviations “green qe”, “c&e”, “eu”, “ngfs”, “cbam”, “tcfd”, and “cotwo” refer respectively to green quantitative easing, climate and environmental, European Union, Network for Greening the Financial System, Carbon Border Adjustment Mechanism, Task Force on Climate-related Financial Disclosures, and the textual representation of the chemical formula CO₂. The expression “climate minsky moment” refers to a sudden and disorderly repricing of climate-exposed assets triggered by a rapid reassessment of climate-related risks.

Table A.2

Model parameter settings.

SBERT model (Reimers and Gurevych, 2019)	
Model	MiniLM (Wang et al., 2020) with 384-dimensional embeddings
Reference terms	10 climate-related keywords based on the reference terms specified by Neszveda and Siket (2025): green, climate change, climate risk, climate-related, emission, global warming, environmental, carbon, ecological, ESG
Similarity metric	Cosine similarity
LDA model (Blei et al., 2003)	
Number of topics	2
Topic selection	2 to 5 topics tested; 3, 4, and 5 topics include overlapping terms (inflation, monetary, policy, euro) across topics; 2 topics show distinct clusters with minimal overlap, consistent with Ebeling (2024).
Identified topics	(1) Climate and financial risk; (2) Monetary policy and economic conditions
Gibbs sampling	Burn-in iterations = 1000; total iterations = 5000; saving every 50th sample; alpha (document-topic prior) = 0.1; delta (topic-word prior) = 0.001; random seed = 1234

Note: The SBERT model is based on the MiniLM architecture. The LDA model uses the C_v coherence metric for topic selection. Given that the vocabulary (14 467 terms) is relatively large for the corpus (256 documents), we remove the rarest 2% of terms (reducing the vocabulary to 4732 terms) before performing LDA topic modeling.

Table A.3

Green speeches by speaker.

Speaker	Number of green speeches	Average green score
Christine Lagarde	77	0.201
Luis de Guindos	31	0.162
Mario Draghi	29	0.153
Isabel Schnabel	23	0.218
Frank Elderson	18	0.305
Peter Praet	18	0.131
Philip R. Lane	14	0.175
Fabio Panetta	13	0.187
Benoît Cœuré	11	0.169
Yves Mersch	8	0.188

Note: The table presents ten speakers with the highest number of ECB green speeches. It includes ECB green speeches that mention the term “energy” and have a green score value of at least 0.1.

Table A.4

Estimated effect of the green score of ECB speeches on the green and brown energy returns.

	Green energy returns	Brown energy returns
Constant	−0.081 (0.153)	0.011 (0.082)
Green score	0.223 (0.154)	−0.082 (0.082)
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.

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