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# « ECB's Climate Speeches and Market Reactions»

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# ECB's Climate Speeches and Market Reactions

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## Abstract

This paper study the impact of the European Central Bank's (ECB) climate related speeches on European stock markets. Using the database of 2594 speeches between 1997 and 2022 of the European Central Bank, we employ advanced textual analysis techniques, including keyword identification and topic modeling, to isolate speeches related to climate change. We then conduct an event study to estimate the differences in abnormal returns of a large panel of listed companies in response to the European Central Bank's speeches on climate change. Our analysis reveals that the ECB's communication on climate issues has intensified significantly since 2015. Using topic modelling methods, we classify climate speeches into two main themes: (i) green finance and economic policies, and (ii) climate-related risks The event study shows that financial markets tend to reallocate portfolios towards greener ones in the days following the ECB's climate speeches. Our results show that following a climatic speech by the ECB, green financial markets are benefiting from positive abnormal returns by around 1 percentage point. More specifically, we find that climate speeches dealing with green monetary policy and other economic policy instruments have a larger effect on green stock prices than speeches dealing with different types of climate risk.

**Keywords:** Central bank communication ; Climate change ; Event Study ; Textual Analysis
**JEL Classification:** E52 ; G14 ; Q54

## 1 Introduction

On July 4, 2022, the European Central Bank (ECB) announced that it would integrate environmental criteria into its asset purchase policy (Quantitative Easing or QE). The introduction of environmental criteria in the conduct of monetary policy sends a strong signal to all financial markets and contrasts with the ECB's old pillar of sectoral "neutrality". The July 4, 2022 announcement follows the ECB's major strategic review presented by its president, Christine Lagarde, which promised to "integrate climate change considerations into monetary policy". From October 2022, the financial institution of the Euro Area will shift its bond portfolio to companies with "good climate performance". The stated objective is to reduce the financial risk related to climate change in the Euro system's balance sheet and to support the ecological transition of the economy.

Central banks increasingly recognize climate change as a source of financial risk (Carney, 2015; Network for Greening the Financial System, 2019). Climate change and its environmental damages are indeed, likely to have direct consequences on price stability due to their impact on food and energy prices (Gallic and Vermandel, 2020).

Since the Bank of England Governor's speech, many economists have been calling for central banks to "green" their monetary policy. Thus, a dedicated field of literature proposes mechanisms to integrate climate change-related financial risks into the conduct of monetary policy by central banks. Whether through the implementation of green quantitative easing (Dafermos et al., 2017, Campiglio, 2016), or through the integration of climate risks into micro and macro prudential supervision (Boneva et al., 2022)). But one aspect of central bank action regarding climate change is still relatively new in the literature on central bank climate action: communication.

The literature has focused on identifying the climate discourse of central banks, using various methods such as dictionary approaches or topic modelling techniques (Arseneau et al., 2022 ; Arseneau et al., 2022). The results show that central banks with an explicit mandate to fight climate change engage more regularly in climate discourse (Arseneau and Mitsuhiro, 2023). The results also show that central banks deal with several climate change-related themes : risk, sustainable development, green finance (Campiglio et al., 2023 ; Arseneau et al., 2022) Companies with good environmental performance are positively affected by these discourses (Neszveda and Siket, 2023 ; Campiglio et al., 2023). Campiglio et al. (2023) tests the climate speeches impact of over a hundred central banks on data from American companies.

Regarding the ECB's climate speeches in particular, Neszveda and Siket (2023) are developing a green sentiment index to measure the climate intensity of ECB speeches. They examine whether the ECB's green speeches cause a significant divergence in stock returns depending on how companies perform in terms of emissions reduction. They find that the green tone of the ECB positively (negatively) affects the most (least) eco-friendly firms based on their emissions However, the autors do not distinguish between the different types of climate discourse (green finance and policies, climate-related risks), which may have different effects. An in-depth analysis of the ECB's climate speeches is interesting for at least two reasons. Firstly, the ECB has made the most speeches over the period 1997-2021 (Arseneau et al., 2022). Secondly, it stands out from the FED for its pro-active policy in the fight against climate change (DiLeo et al., 2023).

In this paper, we provide a European perspective on the impact of central bank climate speeches using stock market indices covering the EU as a whole and focusing on ECB speeches. To identify climate-related speeches given by the ECB, we use a keyword approach as well as topic modelling models to identify narratives characterized by distinct lexicons. To evaluate the impact of climate-related speeches by the ECB on European financial markets using an event study, we will use a diverse set of stock indices that capture a broad spectrum of the market. The selected indices for this study include a mix of benchmark and green indices, each providing insights into different segments of the european stock market.

Our findings indicate that the European Central Bank (ECB) has increasingly addressed climate change in its communications since 2015, coinciding with the Paris Agreement. Out of the 2,652 speeches analyzed from 1997 to 2022, 132 focused on climate change, with three-quarters of these delivered after 2015. The textual analysis, utilizing topic modeling, further reveals that the ECB discusses various dimensions of climate change, including climate risks and the future of monetary policy in this context. We categorize climate-related speeches into two primary groups: (i) those aimed at guiding stakeholders to adapt to upcoming public policy changes and their implications, and (ii) those providing insights into the

economic state regarding climate-related risks (both physical and transition risks) and the opportunities arising from climate change.

The event study we propose, try to discern market reactions surrounding ECB climate speeches, particularly focusing on green stock market indices. We observed abnormal returns within these indices during the post-speech event window implied a market inclination towards green portfolios, with sustained effects beyond the immediate post-event period. Overall, all climate-related speeches result in positive CARs (Cumulative abnormal returns), indicating a general market inclination towards green assets following the ECB's communication. Green finance and policies speeches, which focus on specific financial instruments and policies supporting sustainability, lead to significant increases in CARs, suggesting that investors respond positively to these targeted messages. In contrast, climate-related risks speeches produce more moderate CARs.

The results of this study have important implications for the ECB communication strategy and its role in sustainable finance. Positive market reactions to climate-related speeches, particularly those on green finance and policies, indicate that ECB messages are perceived as important by investors. This suggests that the ECB can use its communication strategy to influence market behavior and support the shift to sustainable investments.

The remainder of the paper is organized as follows: Section 2 reviews the literature on central banking communication and climate change. Section 3 presents the methodology to identify climate speeches. Section 4 presents the econometric strategy of our event study. Section 5 presents the main results. Section 6 concludes and discusses the policy implications of the results.

## 2    Literature review

Our research question is at the crossroad of two strands of the literature: (i) analysis of central bank communications regarding climate change and (ii) impact of environmental policies events, news, announcement on financial market.

### 2.1    Central bank communication

Central bank communication is a tool for transmitting central bank actions to the real economy. Beyond this aspect, the communication of central banks is also a determinant of the public's perception of the institution itself.

Exploring the communication strategies of central banks is compelling for a couple of significant reasons. Firstly, such strategies are increasingly acknowledged as crucial in shaping macro-financial dynamics (Blinder et al., 2008 ; Haldane and McMahon, 2018). Through public statements and announcements, which are meticulously analyzed by the financial markets, central banks guide expectations about future economic conditions, influencing asset prices considerably (Altavilla et al., 2019; Ehrmann and Talmi, 2020). Over the years, their role in macroeconomic and financial dynamics has become more pronounced, intensifying economies' reliance on their policy announcements (Issing, 2005). Secondly, the communication of central bankers plays a pivotal role in establishing their legitimacy and bolstering their accountability—an important balance to their independence from political bodies (Moschella et al., 2020).

The study of the impact of central banks communication on the economy and finance has been extensive and varied. For instance, Guthrie and Wright (2000) examined the use of central bank statements instead of open market operations to implement monetary policy in New Zealand. Additionally, several

studies, such as Demiralp and Jorda (2004), Ehrmann and Fratzscher (2004) and De Haan and Jansen (2006), have used dummy variables to classify days based on the presence or absence of central bank communication. De Haan and Jansen (2006) also looked at the effect of central bankers' comments on interest rates, inflation, and economic growth in the Eurozone. Gerlach (2007) also discussed the impact of interest rate-related statements made by the ECB, using a subjective dummy classification of the statement.

With respect to climate communication of central banks, Arseneau et al. (2022) use language processing techniques by analyzing a corpus of 17,000 central bank speeches to identify climate-related speeches. Their study concludes that (i) global warming-related communications have been growing exponentially in recent years, (ii) Central banks are communicating on a variety of sub-themes related to global warming: impact of climate on the economy, implications for price stability, sustainable finance... (iii) Central banks tend to use speculative language regarding global warming, language that indicates uncertainty. Arseneau and Mitsuhiro (2023) investigate the influence of central bank mandates on communication about climate change, using a comprehensive dataset of central bank speeches. The analysis reveals that central banks with explicit sustainability objectives frequently address climate change directly within the scope of these objectives. In contrast, central banks with indirect or no sustainability objectives discuss these issues within the broader context of their traditional mandates, such as financial and price stability. Deyris (2023) focuses on the ECB's communication, in addition to using speeches to identify climate issues, he also looks at exchanges with the European Parliament and conducts semi-structured interviews. Neszveda and Siket (2023) develops a green sentiment index. Using extra-financial data from French, German and Italian companies, they show that climate-related speech has a positive (negative) impact on the most (least) eco-friendly companies. Campiglio et al. (2023) investigates the role of central banks in the climate change discourse through their public communication strategies. The authors analyze a novel dataset of 32,359 speeches from 131 central banks spanning from 1986 to 2021. By applying natural language processing techniques, they identify three key narratives related to climate change: sustainable development, green finance, and climate-related financial risks. The study finds that central bank communication on climate issues is largely influenced by institutional factors rather than by a country's exposure to climate risks. Additionally, the paper demonstrates that more frequent and intense climate-related communication by central banks positively impacts the stock performance of firms with better environmental scores.

## 2.2 Market reactions to climate-related policy announcements, news and events

The event study method was first introduced by Ball and Brown (1968) and Fama et al. (1969) as a way to analyze the impact of emergencies on financial markets. It is based on the assumption that any effects will be quickly reflected in changes in prices shortly after the event (Liu et al., 2020). This method has been commonly used to study the effect of environmental measures on stock prices, with an emphasis on market reactions to environmental behaviors and policies (Klassen and McLaughlin, 1996 ; Jacobs et al., 2010). Recent research has also focused on market responses to the implementation of environmental policies (Chen et al., 2021; Li et al., 2021; He and Liu, 2018) and has found that capital markets tend to react differently to different types of policies. Environmental regulations have been found to have a negative impact on market returns, particularly in industries that are sensitive to environmental issues (Albrizio et al., 2017) as they are perceived as a cost burden and a threat to competitiveness (Stucki, 2019) due to the increased costs of meeting compliance standards (Clarkson et al., 2004) and the

additional expenses of environmental supervision (Shen et al., 2017). If investors are not optimistic about a company's investment prospects, they are more likely to sell their stock (Baker et al., 2012). When local governments issue corresponding policies and measures to enforce environmental regulations after a central government policy is implemented, it can affect productivity and force firms to use resources for non-productive purposes (Christainsen and Haveman, 1981) leading to stock price declines in industries that are sensitive to environmental issues (Zhao et al., 2018) as investors seek to avoid potential negative risks (Wang et al., 2019). Following the devastating 2011 earthquake in Japan, German Chancellor Angela Markel was the first to commit to the suspension of several nuclear reactors that led to a spike in carbon prices[1] . Financial markets are therefore able to anticipate future changes in energy prices as a result of political speeches and incorporate these future decisions into their portfolio. Krueger et al. (2020) contend that investors might adjust their portfolio allocations away from industries with a high environmental impact toward sectors that are more environmentally sustainable due to climate risk factors. Lin and Zhao (2023) assesses the impact of the Carbon Border Adjustment Mechanism (CBAM) announcements on Chinese financial markets. Their main estimation findings suggest that the CBAM event had a negative impact on both steel rebar and aluminum futures.

By integrating these two strands of literature, this paper investigates how ECB communication related to climate change, influence financial market reactions. The literature on central bank communication (e.g., Blinder et al., 2008; Haldane and McMahon, 2018; Altavilla et al., 2019; Ehrmann and Talmi, 2020) demonstrates that central bank statements and announcements play a crucial role in shaping market expectations and, consequently, in driving asset prices. Conversely, the literature on market reactions to environmental policies and events (Ball and Brown, 1968; Fama et al., 1969; Chen et al., 2021; Krueger et al., 2020) highlights how environmental announcements and events can lead to significant and immediate impacts on stock prices. This paper intersects these fields by examining how climate-related communications from the ECB can act as signals of forthcoming environmental policy and new risks, thereby influencing investor behavior and asset prices.

# 3   ECB climate speeches: identification and analysis

The first sub-section presents the ECB speech database, discusses the various options for identifying climate speeches and presents the chosen methodology. The second sub-section consists of a descriptive analysis of the speeches identified as dealing with climate change.

## 3.1   Identification of ECB climate speeches

On its website, the ECB provides a database of all speeches made by ECB officials between 1997 and 2022[2]. The ECB provides information on the date of the speech, the speaker, the title of the speech, the subtitle of the speech (generally the place and context of the speech) and the full content of the speech. After filtering out the speeches (speeches without content) we end up with 2,594 speeches between 1997 and 2022. Table 5 in the appendix provides the complete database structure.

We are therefore only studying official ECB communication, and not other aspects of ECB communication (social networks, media transcripts, press conferences). Reading the speeches database gives us an idea of the diversity of ECB communications. These range from opening speeches at a research conference, to a lecture at an economics master's degree, to a meeting with a member state finance ministry.

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[1]https://www.businessgreen.com/news/2033960/carbon-price-spikes-japan-nuclear-crisis

[2]Some of the oldest speeches predate the existence of the ECB and were given by the president of the European Monetary Institute.

A glance at the titles of the papers reveals that the ECB communicates on a wide variety of subjects. The ECB can discuss artificial intelligence, the digital euro, inflation, the history of the euro and new macroeconomic theories. As the ECB communicates only in English, it is impossible to distinguish between speeches addressed "to the markets" and those addressed "to the people" (Moschella et al., 2020). Figure 1 shows the evolution of ECB communications over time. There is a general upward trend in communication, with peaks observed during the financial crises (2007-2008).

We define a climate-related speech as a speech given by an official (by the Presidents, Vice-Presidents and Board Member) of the ECB that discusses the impact of climate change on the economy and/or the financial system but also the risks and opportunities generated by global warming adaptation and mitigation policies as well as the potential climate action of the central bank (i.e. the actions it could implement as part of its mandate to fight climate change in its own way). As described by Arseneau et al. (2022) there are three approaches in text analysis to classify text with respect to a topic.

The first is unsupervised topic models. When the researcher is not familiar with the topics present in the corpus, unsupervised topic models can be an effective way to organize a large amount of text into a more manageable set of categories, known as dimension reduction. One commonly used topic model is Latent Dirichlet Allocation (LDA), introduced by Blei et al. (2003), which has a simple structure and can be easily applied for dimension reduction. However, it may not be suitable for identifying text related to a specific and relatively new topic like climate change. These methods seek to discern the principal themes within a text corpus by examining the combined likelihood of word occurrences. However, topic modeling may not be suitable for our objective. Given its unsupervised nature, there is no assurance that the topic of climate will be recognized as one of the themes.

As an alternative, supervised machine learning techniques such as text regression or the Naive Bayes Classifier can be used. These methods are appropriate when the researcher knows the topics of interest and has a small sample of texts related to them. However, in this case, there is no initial set of speeches that have been identified as climate-related to use as a training set (Arseneau et al., 2022). Indeed, due to the sparse presence of the target topic within the collection of speeches, adequately training the algorithm would require manually labeling a substantial volume of speeches. Considering the average length of texts in our corpus, we do not view this as a viable approach.

Another approach is the dictionary approach, which involves using a pre-established dictionary or set of keywords to classify texts into known categories. This approach is best when there is a strong and reliable belief that a certain topic is present in the text but information to identify it is limited. This approach is promising for identifying climate-related speeches. This technique requires researchers to create or use an existing list of relevant keywords or sentences, search for them in the corpus, and establish a threshold for a speech to be considered relevant.

As our research question relates more to the impact of climate speeches than to the improvement of methods for identifying climate speeches, we rely largely on combinations of pre-existing dictionaries. One from the World Bank (2016) related to the environment in general and those of Arseneau et al. (2022) and Campiglio et al. (2023) dedicated to identifying climate speeches in central bank communications. We have grouped them together to produce a dictionary of 200 expressions relating to climate change. Expressions are preferred to individual keywords, as they help avoid false positives. The keyword "climate" is often associated with the expressions business climate or climate of confidence, which do not reflect the climate change theme. We carry out several tests, removing expressions that have no occurrences and removing false positives. Our process has removed more than a hundred expressions, and although conservative, this method allows us to avoid false positives. Table 1 shows the 83 final expressions used and their occurrences in the speeches.

| Expression | | |
|---|---|---|
| abrupt transition (2) | carbon emission (42) | carbon emissions (41) |
| carbon price (28) | carbon prices (15) | carbon pricing (13) |
| carbon tax (17) | carbon taxes (8) | climate action (15) |
| climate change (520) | climate crisis (36) | climate data (5) |
| climate event (3) | climate events (3) | climate exposure (3) |
| climate exposures (2) | climate finance (2) | climate goals (7) |
| climate hazard (1) | climate hazards (1) | climate impact (2) |
| climate policies (20) | climate policy (8) | climate protection (3) |
| climate related (2) | climate risk (135) | climate risks (95) |
| climate scenario (10) | climate scenarios (8) | climate science (1) |
| climate shock (1) | climate shocks (1) | climate stress test (36) |
| climate stress tests (3) | decarbonise (5) | disorderly transition (6) |
| environmental risk (110) | environmental risks (99) | global warming (27) |
| green bond (80) | green bonds (62) | green economy (3) |
| green finance (30) | green investment (20) | green investments (10) |
| green swan (16) | green swans (6) | green technologies (16) |
| green technology (1) | green transition (129) | green transitions (1) |
| greener (43) | greenhouse (38) | greening (19) |
| low carbon (2) | physical risk (36) | physical risks (29) |
| stranded asset (8) | stranded assets (8) | sustainable finance (33) |
| transition risk (51) | transition risks (43) | |

Table 1: Dictonnary of climate-related expressions and counting by occurrence in the 2594 ECB speeches (1997-2022)

## 3.2 Analysis of ECB climate speeches

Starting from the initial database of 2594 speeches, our keyword approach (see table 1 for the keywords) allowed us to identify 132 speeches related to global warming (see table 2). The first time the word climate change appeared in a speech by an ECB official was on March 23, 2007 in a speech by ECB Executive Board member Jurgen Stark entitled: "Fit for the future? Towards a lean and efficient public sector", at a conference on European Fiscal Policy challenges organized by the German Ministry of Finance and the Centre for European Economic Research. Table 6 in the appendix gives an overview of the speeches identified as relating to climate change.

|  | Number of Speeches |
|---|---|
| **Non Climate-related speeches** | 2462 |
| **Climate-related speeches** | 132 |
| **All speeches** | 2594 |

Table 2: Disassociation of climate-related and non climate-related speeches, 1997-2022

It can be seen that the ECB has been communicating on this subject for a long time, having already mentioned it in 2007. On the other hand, there has been an exponential increase in communication on this subject since 2015, coinciding with the Paris agreements (2015). Since then, the ECB has not stopped communicating on this subject, peaking in 2022 with over 40 speeches dealing with climate.

Climate speeches reveals a strong concern for various aspects of climate and the environment. The most frequent expression is *climate change* with 520 occurrences. Climate risks also feature prominently, with terms such as *climate risk*, *physical risk* and *transition risks*. Transitions towards greener practices are highlighted with *green transition*, *decarbonise* or *climate scenarios*. Financial tools related to green transition are also frequently used, notably *green bonds* and *sustainable finance*. Figure 8 in appendix shows the cloud of words most frequently used in ECB climate speeches. We can already see that these speeches don't seem to stray too far from traditional central bank communication, with the prevalence of the terms *inflation*, *interest rates*, *markets* and *expectations*. To verify that the intensification of climate
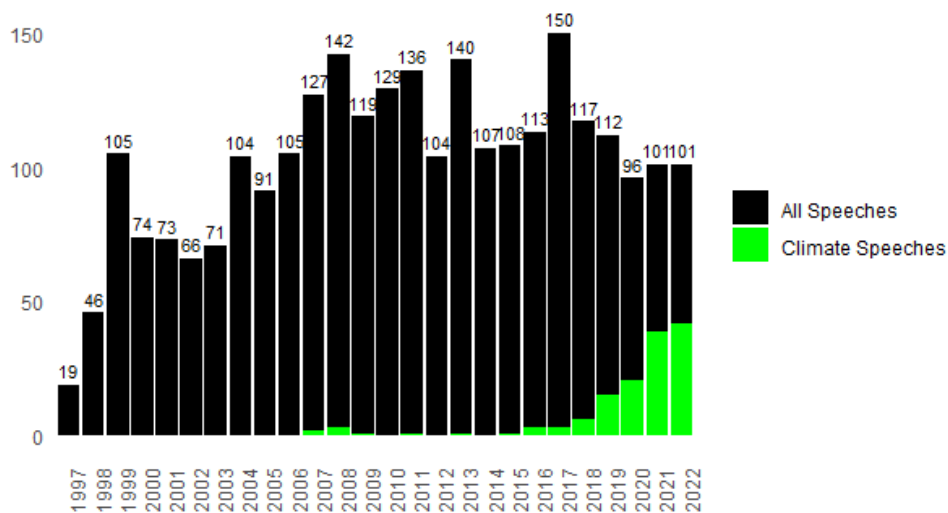


Figure 1: Trends in the intensity and nature of ECB communications, 1997-2022

change-related speeches is not simply the result of an intensification of central bank communication, figure 1 shows the ratios of climate-related rhetoric. It can be seen that the proportion of climate-related speeches has risen steadily, and that in almost 40% of speeches in 2021, the ECB mentioned climate change..

Simple identification of the ECB's climate speeches is not enough. We seek to understand what exactly the ECB is talking about when it comes to climate change. Table 6 in appendix provides a sample of the 132 speeches identified as dealing with climate change by our keyword methodology. It is interesting to note that beyond the common theme of climate change, the speeches are extremely varied.

Finally, we could classify climate-related speech into two broad categories: (i) those that seek to have agents integrate the changes in monetary policy that will take place over the next few years with the aim of integrating climate change , and discuss their implications (*Climate Change and Central Banks,Christine Lagarde, 2021.*), and (ii) those that seek to provide agents with information on the state of the economy regarding risks (physical and transitional) and opportunities generated by climate change (*Speaking notes on climate-related risks,* Luis de Guindos, 2019). The first category of speeches is linked to the anchoring of expectations. Forward guidance (Bernanke and Sack, 2004) is a tool used by central banks to influence the expectations of economic agents by communicating the central bank's intentions regarding future monetary policy. The second category of speech directly echoes the notion of central bank transparency. A central bank's transparency can be defined as the fact that it communicates the information at its disposal to other economic agents (Barbier-Gauchard et al., 2018).

To understand the different types of climate speech in more detail, we run a topic model on these 134 speeches. As briefly mentioned earlier, topic models are unsupervised algorithms designed to identify hidden topics within a corpus. They treat each document as a 'bag of words' and classify them based on the co-occurrence probabilities of terms. The underlying idea is that if two words frequently appear together, they are likely thematically related. After categorizing words into latent topics, the model can represent each document as a mixture of these topics, revealing its underlying themes. This approach enables the analysis of how overall topical interests have evolved over time and across different contexts. We use the latest version of the Latent Dirichlet Allocation (LDA) algorithm developed by Blei et al. (2003). The beta values in LDA topic modeling represent the probability that a word is associated with a particular topic. The higher the beta value, the more important the word is for that topic.

These results should be compared with those of Arseneau et al. (2022) and Campiglio et al. (2023) which also seek to identify the different themes addressed in the climate speeches of central banks. Arseneau et al. (2022) identify ten topics: financial stability; macroprudential policy; Climate Impact/Transition; Supervision and Regulation; Financial System; Sustainable Finance; Financial Innovation; Asset Allocation; Monetary Policy; and Central Bank Mandate. Campiglio et al. (2023) identify three topics: sustainable development, green finance and climate-related risks. The explanation for our different topics can be found in the fact that they use the speeches of 131 central banks over the period 1986-2021. They therefore capture a greater variety of speeches. In addition, the ECB has distinguished itself from other major central banks (DiLeo et al., 2023) by its declared intention to be a major player in climate policies.

| Green finance and policies | $\beta$ | Climate-related risks | $\beta$ |
|---|---|---|---|
| monetary policy | 0.0267390 | climate change | 0.0224933 |
| green bonds | 0.0214702 | climate related | 0.0123096 |
| carbon pricing | 0.0088131 | stress test | 0.0085954 |
| central banks | 0.0086776 | central banks | 0.0075883 |
| price stability | 0.0081686 | monetary policy | 0.0064675 |
| climate change | 0.0064798 | crypto assets | 0.0060846 |
| inflation expectations | 0.0058662 | financial stability | 0.0057707 |
| greening | 0.0056648 | transition risk | 0.0056670 |
| green transition | 0.0047442 | environmental risks | 0.0050705 |
| green monetary policy | 0.0046350 | related risks | 0.0048895 |
| fiscal policy | 0.0042621 | climate risks | 0.0046023 |
| green finance | 0.0037698 | physical risk | 0.0045883 |
| governing council | 0.0033753 | risk management | 0.0043214 |

Table 3: Top 15 Terms in each topic for the 132 ECB climate speeches (2006-2022)

Beyond the textual analysis, i.e. the words and sub-themes addressed by the ECB when it talks about climate change, it is also interesting to see the tone of the speeches. This is what sentiment analysis is all about. For this study, we use the *SentimentR* package (Rinker, 2022), previously validated in energy and climate research by Santi (2020) and Ikoro et al. (2018) on the 132 climate speeches. This tool accurately computes text polarity sentiment to adjust the impact of polarized words. Sentiment values for each speech is determined using the P/N ratio, derived from the count of positive (P) and negative (N) sentences identified through polarity assessment.

| Emotion | Counting by sentence |
|---|---|
| trust | 25318 |
| anticipation | 14486 |
| fear | 10442 |
| joy | 5996 |
| sadness | 5541 |
| anger | 4420 |
| surprise | 3290 |
| disgust | 1727 |
| trust_negated | 670 |
| anticipation_negated | 376 |

Table 4: Top 10 emotions by sentences in ECB climate speeches (2006-2022)

Table 4 lists the top ten emotions identified within the ECB climate speeches. The emotion count represents the number of sentences expressing each specific emotion within the ECB climate speeches. Since multiple sentences within a single speech can represent the same or different emotions, the total count can exceed the number of speeches analyzed The sentiment analysis identified 'trust' as the most common emotion in these communications, with 25,318 occurrences. The presence of 'anticipation' and 'fear' in the speeches aligns with the findings of Lucca and Trebbi (2009), who highlighted the impact of the emotional tone of central bank communications on financial markets. The use of 'anticipation' may help prepare markets for future policy changes. The expression of 'fear' could indicate the seriousness of climate change challenges, signaling to market participants the potential for significant measures to address these issues.

Furthermore, the occurrence of negated emotions such as 'trust/negated' and 'anticipation/negated', though less frequent, is notably significant. This aspect of ECB's communication might be indicative of a deliberate strategy to maintain a balance between providing clear guidance and preserving the necessary flexibility to adapt to evolving economic conditions and uncertainties associated with climate change (Arseneau et al., 2022).

The analysis suggests that the majority of the ECB's climate-related speeches are constructed to generate predominantly positive emotions, particularly trust. This strategic focus on building trust is likely aimed at stabilizing market expectations and fostering a sense of confidence in the ECB's approach to climate challenges. By doing so, the ECB not only reinforces its commitment to addressing climate risks but also influences market anticipation, potentially guiding investor behavior in a manner that aligns with the broader goals of financial stability and sustainable economic transition.

# 4    Impact of ECB's climate speeches on financial market

This section constitutes the empirical contribution of this work. In section 4.1, we presents the theoretical foundations of the event study methodology. In section 4.2, we present the application of event study to our research question.

## 4.1    Event study - theoretical approach

The event study method was first introduced by Ball and Brown (1968) and Fama et al. (1969) as a way to analyze the impact of emergencies on financial markets. It is based on the assumption that any effects will be quickly reflected in changes in prices shortly after the event (Liu et al., 2020).

Figure 4 represent the timeline of the event study. It's based on three different windows. The interval $t_1 - t_0$ corresponds to the estimation window which gives us the information required to calculate the normal returns (before the event date). The interval $t_2 - t_1$ is the event window, and the interval $t_3 - t_2$ corresponds to the post event window which is used to estimate the abnormal returns after the event.
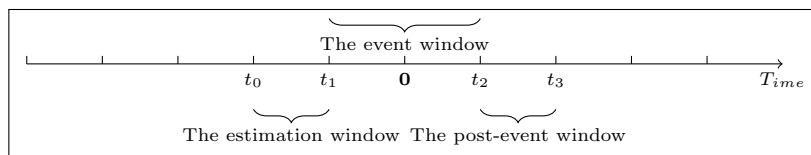


**Figure2**: Data structure of the event study

In order to measure the normal returns, we must first determine an estimator. Once chosen, it will allow us to calculate the expected and abnormal daily returns. The returns of the estimation period, i.e., the period before the event date, are used to calculate the abnormal returns (ARs). We follow the methodology of Dyckman et al. (1984), reused since by Selmi et al. (2022) which shows that the statistical market model gives better results. The return on stock $i$ at time $t$ is determined solely by the market return at time $t$ in the market model. We use the market model (equation 1) to calculate the expected returns $E(R_{i,t})$. $\alpha$ is the intercept and $\beta$ is the slope. $R_{mt}$ is defined as the rate of return of the benchmark index on day t.

$$AR_{i,t} = R_{i,t} - E(R_{i,t}) \tag{1}$$

$AR_{i,t}$ is the abnormal return of index $i$ on day $t$. $R_{i,t}$ is the current return of index $i$ at day $t$; $E(R_{i,t})$ is the normal return of index $i$ at day $t$.

$$AAR_t = \sum_{i=0}^{N} AR_{i,t} \tag{2}$$

$AAR_t$ is the average abnormal return at day t, N is the number of events included in the index. These AARs are then used to determine the cumulative average abnormal return (CAAR). We sum up all the AR from T1; T2 i.e starting and ending day of the event window to obtain the cumulative average abnormal return CAAR.

$$CAAR_t = \sum_{j=T1}^{T2} AAR_{t,j} \tag{3}$$

We now test if CAAR is statistically different from 0. We then calculate its t-statistic and compare it to its critical value.

$$t = \sqrt{\frac{(T2 - T1 + 1) \sum_{i=1}^{N} \sigma^2}{N^2}} \tag{4}$$

## 4.2   Financial data

With regard to our financial data, we need daily returns over the period of interest. To carry out the event study, we also need to have different stock market prices to analyze: green stock market prices and general stock market indices to use as benchmarks. Indeed, to be sure of the causal effect of the speeches, we need global stock market indices that will not be significantly affected by the ECB's climate-related communication. We collected data on the daily returns of several stock prices, which are summarized in Table 7 in appendix. Table 8 in the appendix gives descriptive statistics on the stock market returns of these different indices. The DAX, Eurostock50, and FCHI indices represent major companies in Germany, the Eurozone, and France, respectively. The DAX includes 40 major German companies, the Eurostock50 represents Eurozone supersector leaders, and the FCHI tracks the 40 largest French stocks. The S&P Europe 350 index includes 350 leading companies from developed European markets.

These 4 indices will be our benchmarks for our event study. In other words, we'll measure the difference in returns between our "green" indices and those 4 indices, which illustrate the general volatility of stock prices in Europe.

For the green stock market indices, we have selected 3 that we feel are consistent with our analysis, 2 European indices and one worldwide index to see if the ECB's communication is likely to have an impact beyond the eurozone. The Dow Jones Sustainability Europe Index (DJSEI), the Dow Jones Sustainability World Index (DJSWI) and the S&P Europe 350 ESG Index (SPEUROPE350ESG). The DJSEI and the DJSWI track companies with superior sustainability performance in Europe and globally, while the SPEUROPE350ESG targets companies with strong environmental, social, and governance practices.

The indices were selected to capture both general market trends and specific reactions within green sectors, providing a comprehensive view of market responses. We're going to apply the event study described above, using iteratively the different green stock market indices with the different benchmark indices. We will also vary the event window for the robustness of our results.

In addition, we'll run several types of regression based on climatic speeches. More specifically, we will first carry out the event study for all climate speeches. Then, we will take two sub-samples representing respectively (i) discourses dealing with the future of monetary policy in the context of climate change and (ii) discourses dealing with different types of climate risks . This distinction will enable us to identify which of the ECB's climate-related speeches have the greatest impact on financial markets.

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# 5  Results

This section presents the main results of our event study. First, we present the impact of all climate-related events on the cumulative average abnormal returns of green stock indices. Then, in a more detailed analysis, we evaluate the individual impact of each sub-topic speeches that we have identified via our topic model, i.e. (i) green finance and policies, (ii) climate risks.

## 5.1  Impact of ECB climate-related speeches

The graphs 3 and 4 illustrate the cumulative abnormal returns (CAR) surrounding all ECB climate-related speeches across three distinct indices: DJSEI, DJSWI, and S&P EUROPE 350 ESG (with Euro-Stock50 and FCHI as benchmark).

The analysis reveals a consistent trend of positive abnormal returns following these speeches, indicating a favorable market response to the ECB's communication on climate-related issues. Notably, the CAR for the DJSEI increases by approximately 0.5% to 1% in the days following the speeches, with this positive trend persisting throughout the event window. This increase suggests that the market not only reacts immediately but continues to adjust its portfolio allocations in favor of greener assets over time. Our results are similar to those of Ardia et al. (2023) and which showed that green firms outperform brown firms when media coverage of climate change increases. Neszveda and Siket (2023) found similar results based on French, German and Italian firms following ECB climate speeches.

This outperformance underscores the targeted impact of the ECB's communication on green investments, as the broader market indices do not exhibit significant abnormal returns. These findings suggest that investors view the ECB's climate-related speeches as credible signals of the institution's commitment to integrating climate considerations into its monetary policy framework, leading to a reallocation of capital towards sustainable investments. The prevalence of 'trust' and other positive emotions in the sentiment analysis suggests that markets perceive ECB climate communication as credible and stabilizing, which aligns with the positive CARs observed in green indices. The ECB is therefore suggesting that investing in green stocks is the right strategy for investors, as they will be supported by the ECB and national/european environmental policies.
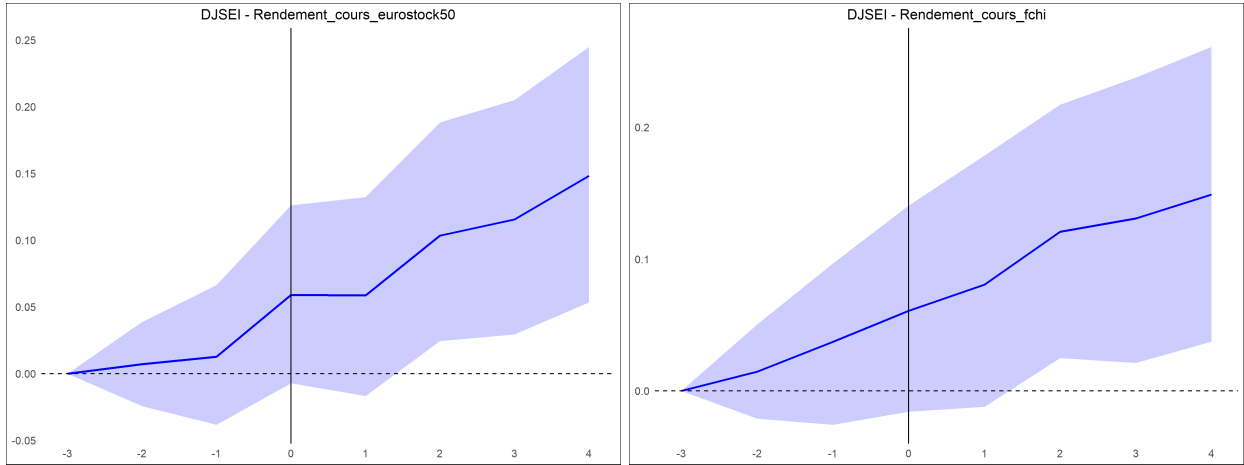
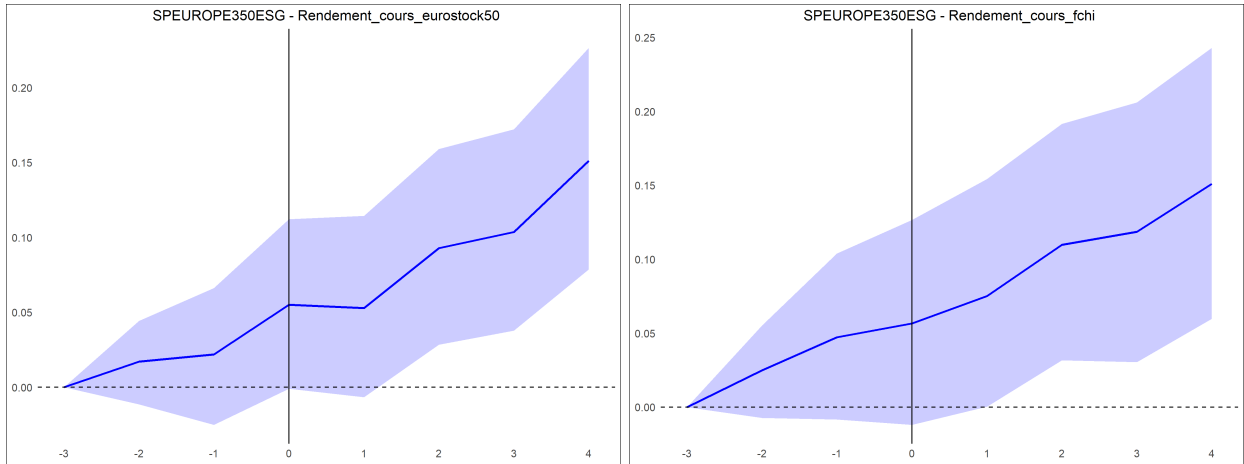Figure 3: Impact of climate speeches on the Dow Jones Sutainabily Europe index (a)



Figure 4: Impact of climate speeches on the Dow Jones Sutainabily Europe index (b)

## 5.2 Impact of green finance and policies speeches vs climate-related risks speeches

Once we have seen that the ECB's climate speeches have a significant effect on the financial markets, it is also interesting to distinguish this impact according to the content of the speech. To do this, we construct two subsamples of our climate speeches based on the results of topic modelling. We thus classify the speeches into two categories, one relating to green finance and policies and the other to climate-related risks. The results are shown in Figures 5, 6 and 7. The graph on the left shows the cumulative abnormal returns of the various green indices following speeches on the theme: green finance and policies. The graph on the right shows the cumulative abnormal returns of the various green indices following speeches relating to the theme: climate-related risks.

ECB speeches on "green finance and policies" have a clear impact on financial markets. These speeches, which cover topics such as green bonds and sustainable finance initiatives, result in positive cumulative abnormal returns (CARs) for green indices like DJSEI and DJSWI. For instance, the CAR for DJSEI

shows an immediate increase of up to 1% following these speeches, with this positive trend continuing throughout the event window. This suggests that investors view these speeches as signals of the ECB's commitment to supporting green financial instruments, leading to a measurable market response.

ECB climate-related risks speeches generate a more moderate market response compared to Green Finance and policies speeches. While CARs remain positive, the magnitude is generally lower. These speeches often discuss the challenges and uncertainties of climate change, such as transition and physical risks, leading investors to respond with caution. Despite the more measured response, the positive CARs suggest that investors recognize the importance of these risks and may be reallocating capital towards sectors better positioned to manage them. This indicates that the ECB's communication on climate-related risks is considered relevant, though it prompts a more cautious adjustment in market behavior.
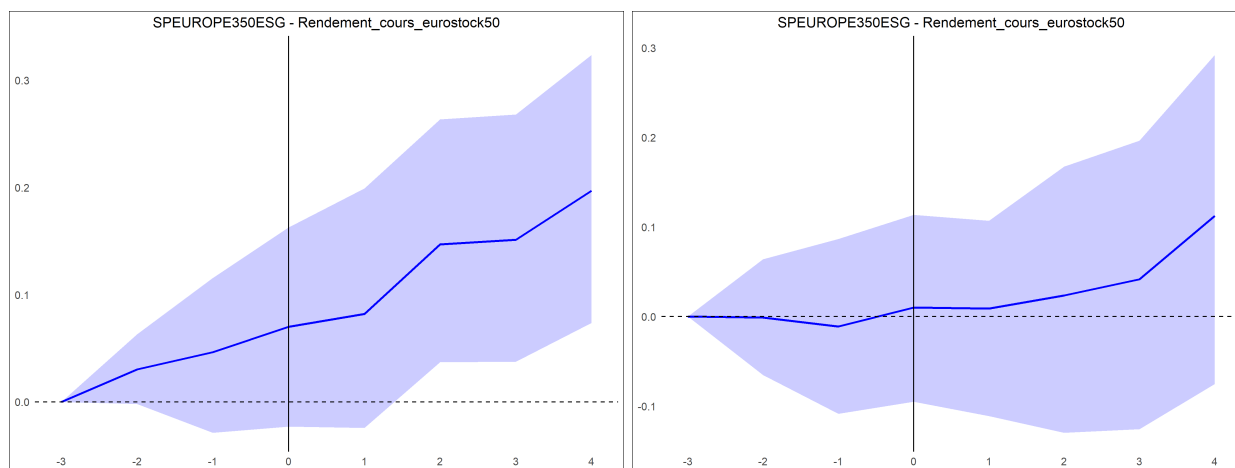


Figure 5: Impact of Green finance and policies speeches (left) vs Climate-related risks speeches (right) on S&PESG
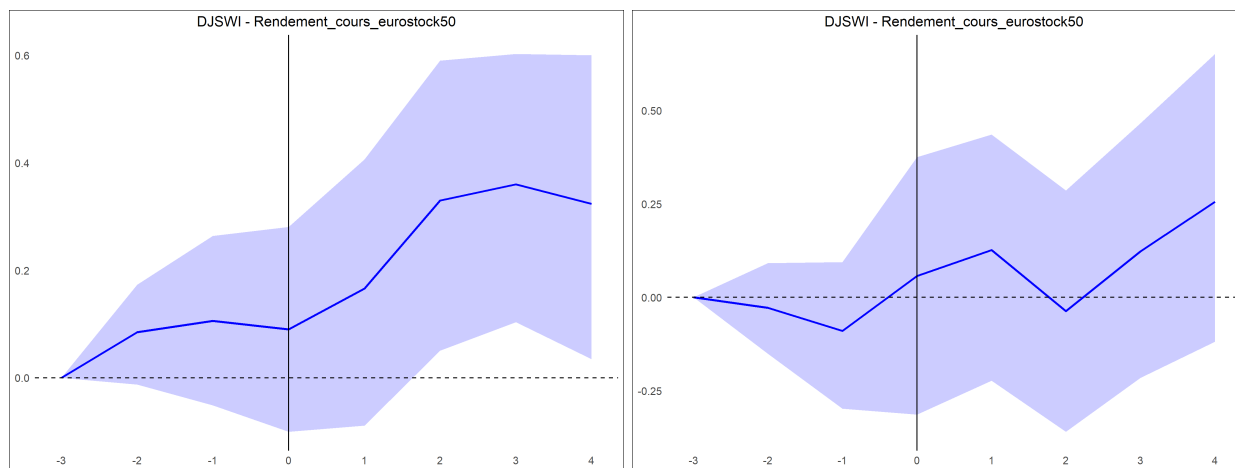


Figure 6: Impact of green finance and policies speeches (left) vs Climate-related risks speeches (right) on DJSWI
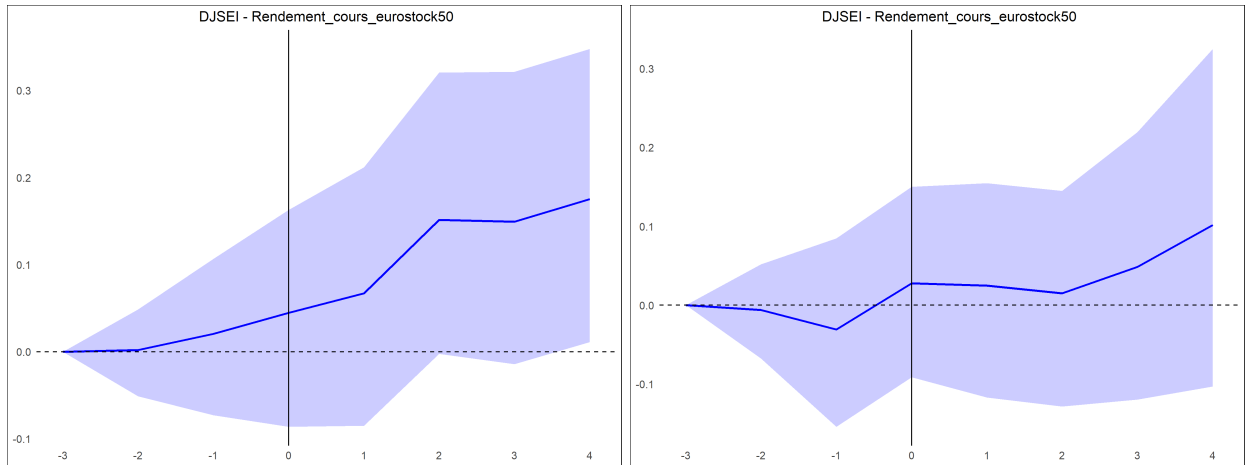
Figure 7: Impact of green finance and policies speeches (left) vs climate-related risks speeches (right) on DJSEI

The fact that markets react more strongly to speeches related to future monetary policy, compared to speeches providing information about climate risks, suggests that investors place greater weight on communications that directly influence financial instruments and regulatory environments. This can indicate that markets are more responsive to actionable guidance or policy signals that could affect the valuation of assets, such as the implementation of green bonds or sustainable finance initiatives. This may also indicate that financial markets have already integrated the various risks associated with climate change via other transmission channels (ESG criteria, news), and that in listening to central bank speeches they are only seeking information linked to the conduct of future monetary policy.

# 6 Conclusion

Central banks have increasingly become key participants in the public debate on climate change and the low-carbon transition, a shift largely driven by the recognition that climate change poses significant risks to financial stability and economic resilience (Campiglio et al., 2018 ; Network for Greening the Financial System, 2019 ; Awazu et al., 2020). The ECB is characterized by its pro-active approach to the fight against climate change, and also by the fact that it takes a different stance from the FED in this area (DiLeo et al., 2023).

We applied text analysis tools to a corpus of 2594 speeches made by the ECB between 1997 and 2022 in order to identify speeches related to climate change. Once identified, we analyzed the extent to which these speeches address a particular sub-theme related to climate change. We then used an event study methodology to identify the effect of these speeches on the financial markets.

Out of the 2,594 speeches analyzed, 132 focused on climate change, with three-quarters of these speeches delivered after 2015, the year the Paris Agreement was signed. The increase in these speeches peaks in 2021, where nearly one in two speeches addresses climate change issues. Finally, with the use of topic modelling techniques, we were able to classify climate-related speeches into two broad categories: (i) those that aim to help agents integrate the forthcoming changes in public policy and discuss their implications, and (ii) those that aim to provide agents with information on the state of the economy concerning the risks (both physical and transitional) and opportunities generated by climate change.

Sentiment analysis of speeches reveals that the ECB seeks to instill confidence and anchor agents' expectations (emotions that stand out most in sentiment analysis). The prevalence of 'trust' in the sentiment analysis suggests that markets perceive ECB climate communication as credible and stabilizing, which aligns with the positive CARs observed in green indices

The analysis of ECB climate-related speeches, shows distinct market reactions as reflected in cumulative abnormal returns (CARs) across different green indices. Overall, all climate-related speeches result in positive CARs, indicating a general market inclination towards green assets following the ECB's communication. Green Finance and policies speeches, which focus on specific financial instruments and policies supporting sustainability, lead to significant increases in CARs, suggesting that investors respond positively to these targeted messages. In contrast, Climate-related Risks speeches produce more moderate CARs, reflecting a cautious market response to the uncertainties associated with climate risks. This may also indicate that financial markets have already integrated the various risks associated with climate change via other transmission channels (ESG criteria, news), and that in listening to central bank speeches they are only seeking information linked to the conduct of future monetary policy.

The results of this study have important implications for the ECB communications strategy and its role in sustainable finance. Positive market reactions to climate-related speeches, particularly those on green finance and polices, indicate that ECB messages are perceived as important by investors. This suggests that the ECB can use its communication strategy to influence market behavior and support the shift to sustainable investments. Enhancing the accuracy of firm greenness measures is essential for financial markets to appropriately price equities, particularly as central banks adopt green promotional strategies. By increasing the frequency and clarity of its climate communications, the ECB can strengthen its ability to direct capital flows towards green assets. This approach could also serve as a benchmark for other central banks, highlighting the role of targeted communication in managing climate-related financial risks. As environmental factors are increasingly integrated into financial decisions, the ECB communication efforts could help align financial markets with broader climate objectives and promote financial stability within the European Union.

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# 7    Appendix

## 7.1    ECB speeches database

The complete database contains 2594 speeches by the presidents, vice-presidents and member boards of the European Central Bank from 02/07/1997 to 31/08/2023.The ECB has built a database[3] for researchers working on central bank communication. This database is updated every month and is structured as follows :

| Date | The original publication date of the speech on the ECB website. |
|---|---|
| **Speakers** | Only ECB Executive Board members' speeches are included. If a speech, or part of a speech, is given by a speaker who is not an Executive Board member, his/her name is not listed. |
| **Title** | The title of the speech |
| **Subtitle** | The subtitle of the speech. Usually in the format "Type by speaker, role, at occasion". |
| **Contents** | The contents of the speech are given in full including footnotes. |

Table 5: Structure of the ECB speech database

## 7.2    ECB climate speeches



Figure 8: Word clouds for climate-related speeches

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[3]The database is available at the following link: https://www.ecb.europa.eu/press/key/html/downloads.en.html

| Date | Speaker | Title |
|---|---|---|
| 2022-12-01 | Frank Elderson | The European Climate Law and the European Central Bank |
| 2022-03-17 | Isabel Schnabel | A new age of energy : climateflation and greenflation |
| 2021-10-12 | Christine Lagarde | The contribution of finance to combating climate change |
| 2021-07-11 | Christine Lagarde | Climate Change and Central Banks |
| 2021-06-29 | Christine Lagarde | Financing a green and digital recovery |
| 2019-11-21 | Luis de Guindos | Implications of the transition to a low-carbon economy for the euro area |
| 2019-05-23 | Luis de Guindos | Speaking notes on climate-related risks |

Table 6: Sample of speeches identified as climate speeches

## 7.3 Financial data

| Index | Description | Type |
|---|---|---|
| DAX | Includes 40 major German blue chip companies. | Benchmark |
| Eurostock50 | Provides a blue-chip representation of Eurozone Supersector leaders | Benchmark |
| FCHI | Tracks the 40 largest French stocks | Benchmark |
| SPEUROPE350 | The S&P Europe 350 indexes 350 leading blue-chip companies from developed European markets | Benchmark |
| DJSEI | Dow Jones Sustainability Europe Index, tracks leading sustainability-driven companies in Europe | Green |
| DJSWI | The Dow Jones Sustainability World Index follows global leaders in sustainability practices | Green |
| SPEUROPE350ESG | The S&P Europe 350 ESG Index focuses on companies with strong environmental, social, and governance practices | Green |

Table 7: Descriptions of key stock indices
All these indices in the form of daily returns are taken from the DOW Jones and Yahoo Finance websites. They cover the period 2000-2022.

| Variable | N | Mean | Standar error | Min | 25% | Mediane | 75% | Max |
|---|---|---|---|---|---|---|---|---|
| ReturnsDAX | 3265 | 0.01 | 1.06 | -11.32 | -0.38 | 0.01 | 0.41 | 9.65 |
| Returns_DJSEI | 3265 | 0.00 | 0.82 | -11.04 | -0.25 | 0.02 | 0.30 | 7.66 |
| Returns_djswi | 3265 | 0.01 | 0.87 | -27.08 | -0.21 | 0.03 | 0.29 | 7.63 |
| Returns_eurostock50 | 3265 | 0.01 | 0.99 | -15.56 | -0.30 | 0.02 | 0.37 | 9.24 |
| Returns_fchi | 3265 | 0.01 | 1.00 | -20.95 | -0.30 | 0.03 | 0.36 | 8.39 |
| Returns_spE350 | 3265 | 0.01 | 0.82 | -11.55 | -0.25 | 0.03 | 0.31 | 8.49 |
| Returns_spE350esg | 3265 | 0.01 | 0.86 | -14.73 | -0.25 | 0.03 | 0.30 | 8.40 |

Table 8: Descriptive Statistics of Stock Prices and Returns