The ECB's Green Put: From Cheap Talk to Priced Action*

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Abstract

Standard asset pricing theory predicts a "carbon premium" for high-emission firms, yet recent realized returns have shown the opposite. We show that European Central Bank (ECB) climate communication acts as a "Green Put," a systematic policy signal that has persistently penalized brown assets and limited the return premium they would otherwise have achieved. To capture these shocks, we construct the Central Bank Climate and Nature Communication (CB-CNC) index, a novel high-frequency measure of ECB sustainability involvement from 1997 to 2025. Using a Large Language Model, the index distinguishes between "Action" and "Materiality" focused communications and integrates "Nature" alongside "Climate." We find that only ECB "Action" shocks—not "Materiality" rhetoric—drive the repricing of brown firms in both equity and bond markets. A counterfactual analysis shows that the cumulative impact of this "Action" talk has effectively eliminated the brown premium, preventing high-emission firms from realizing approximately 30% in cumulative outperformance since 2018.

Keywords: Central bank communication, large language models, climate, nature, asset pricing.

JEL Classifications: E58, G11, G12, Q54

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1 Introduction

With these decisions we are turning our commitment to fighting climate change into real action

Christine Lagarde, President of the ECB, July 2022

Two empirical findings have been a major focus of recent asset pricing debates. First, central bank announcements are a primary driver of aggregate market returns, with a large fraction of the equity premium earned in anticipation of policy decisions (Lucca and Moench, 2015). Second, green assets have delivered high realized returns over the last decade, a finding that challenges the theoretical "carbon premium" (Bolton and Kacperczyk, 2021; Pástor et al., 2021; Pástor et al., 2022).

This paper argues these two findings are connected and that the European Central Bank (ECB) has become a new systematic driver of the relative pricing of green and brown assets. Recognizing that climate change and nature degradation pose systemic risks (Bolton et al., 2020; Dasgupta, 2021), and in line with its broader mandate,[1] the ECB has actively begun to integrate these considerations into its policy framework—most notably in the management of its monetary portfolios, collateral frameworks, and supervisory practices.[2] This shift in ECB communication toward concrete climate-related policy tools is likely to operate as a systematic policy shock—a "Green Put"—that alters investors' expectations and forces a reassessment of transition risk.[3] Therefore, these ECB's communication shocks should lead to an immediate, negative repricing of high-emission firms as the market prices in this new policy-driven information.

[1] Article 127(1) of the Treaty on the Functioning of the European Union stipulates that, while prioritizing price stability, the ECB must also support the Union's general economic policies.

[2] The efforts of the ECB and its national central banks have been recognized internationally, as the Eurosystem ranked first among G20 central banks in the 2024 Green Central Banking Scorecard published by Livingstone et al. (2024). "We have already taken concrete steps to integrate climate change considerations into our monetary policy framework, financial stability monitoring and banking supervision," see Lagarde (2022).

[3] This mechanism draws conceptually from the work of Cieslak and Vissing-Jørgensen (2022), which studies how the expectation of Federal Reserve policy accommodation influences market risk premia ("The Fed Put").

To test this hypothesis, we construct a novel high-frequency measure of ECB sustainability communication—the Central Bank Climate and Nature Communication (CB-CNC) index. This metric captures the ECB's evolving commitment to climate and nature preservation based on its speeches, press releases, and official statements from 1997 to 2025. A key contribution of this index is its design, which enables the distinction between credible action communication (covering policies, mandates and measures) and general materiality discussions about risks and impacts. This distinction is essential for identifying the specific communication that moves financial markets, as opposed to general "cheap talk." This granular classification is based on a Large Language Model (LLM), which allows us to perform a supervised, sentence-level analysis that captures full-document context and tracks shifts in ECB language over time, moving beyond traditional dictionary-based topic models (Campiglio et al., 2025; Arseneau and Osada, 2023; Arseneau et al., 2022; Ebeling, 2024; Neszveda and Siket, 2025). We are also the first to incorporate the ECB's emerging focus on nature and biodiversity risks in its communication.

We validate the CB-CNC index using several complementary approaches and highlight new facts on ECB climate communication. First, we confirm that peaks in the index coincide with identifiable major speeches detailing climate-related policy actions. Second, we show that these signals are systematically disseminated by major news outlets. Finally, we demonstrate that the CB-CNC index is distinct from other prominent climate news and monetary-policy surprises indices. Overall, the CB-CNC index displays a marked upward trend over the past decade, reflecting the institution's growing engagement with climate policy. References to nature and biodiversity remain infrequent but exhibit a modest uptick in recent years. Physical risk has re-emerged as the primary focus of discussion of materiality, as attention to transition risk has declined since its peak in 2022. Most noteworthy is how communication on concrete actions is increasingly focused on the ECB's own actions, which we find is the form most likely to be reflected in media coverage: "Action" shocks in our index are followed by immediate surges in Factiva media coverage, whereas "Materiality" statements are not.

Using the CB-CNC communication shocks as an exogenous source of variation, we then estimate their daily financial effects through local projection regressions (Jordà, 2005).[4] Our results show that only ECB "Action" communication shocks significantly affect the Brown-Minus-Green (BMG) equity portfolio, with brown firms underperforming green ones after such announcements. A similar pattern holds in credit markets, where brown issuers face widening spreads. In contrast, "Materiality" communication about general climate risks shows no statistically significant effects. Similarly, we find no systematic pricing effects for "Nature" communication, which aligns with its still-nascent status in the ECB's policy framework. Most importantly, a counterfactual exercise shows that the cumulative impact of the ECB's climate communication has erased the brown premium. This has prevented brown firms from achieving around 30 per cent cumulative outperformance relative to green assets since 2018. Together, these findings indicate that central-bank climate communication operates as a systematic policy shock with persistent effects, embedding transition risk into the valuations of both equity and credit markets.

Related literature— Our paper contributes to a growing asset-pricing literature that studies how climate- and nature-related risks are reflected in financial valuations. Standard asset pricing theory predicts that exposure to transition risk, arising from policy tightening, technological shifts, or changing investor preferences, should command a "carbon premium," compensating investors for holding high-emission assets (Bolton and Kacperczyk, 2021, 2023; Hsu et al., 2023; Ilhan et al., 2021; Pástor et al., 2021). Alternative explanations link the observed premium to valuation effects driven by firm fundamentals or mispricing (Atilgan et al., 2023). Recent work extends this logic to nature-related risks, suggesting that markets are beginning to price biodiversity loss (e.g., Coqueret et al., 2025; Garel et al., 2024; Giglio et al., 2025). However, this theoretical premium stands in contrast to the recent green assets

[4] Identification strategy in the spirit of those used for oil supply news (Känzig and Raghavan, 2025), news-based geopolitical-risk shocks in Caldara and Iacoviello (2022), and monetary-policy-uncertainty shocks in Husted et al. (2020).

outperformance. This episode is typically attributed to unexpected shocks to climate attention or policy credibility (e.g., Ardia et al., 2023; Monasterolo and de Angelis, 2020; Pástor et al., 2022; Ramelli et al., 2021). We contribute to this debate by identifying a primary institutional source of these shocks. We show that the ECB's "Action" communication has become a systematic driver of brown-versus-green repricing in Europe, effectively erasing the brown premium that would otherwise exist.

Our paper connects to studies on the effectiveness of central-bank action and the role of communication as a policy tool. A large empirical literature shows that central banks are among the most powerful drivers of asset prices: monetary-policy surprises generate immediate and sizeable movements in equities, bonds, and exchange rates (Bernanke and Kuttner, 2005; Gürkaynak et al., 2005; Altavilla et al., 2019; Istrefi et al., 2024). Most strikingly, Lucca and Moench (2015) document that U.S. equities earn about 80% of their annual excess return in the 24 hours preceding scheduled FOMC announcements, a pattern replicated in major international markets. We extend this framework to the environmental domain, arguing that central bank climate communication has become an important driver of asset prices. Regarding climate action, some papers highlight the growing tension between central banks' traditional objectives and their emerging climate responsibilities (Dikau and Volz, 2021; Feldkircher and Teliha, 2024; Hansen, 2022). More recently, empirical studies evaluating central-bank green measures suggest that these interventions can influence financing conditions (Giovanardi et al., 2023). Beyond direct interventions, communication has emerged as a complementary policy tool (Arseneau et al., 2022). Research in this area leverages natural language processing (NLP), using structural topic modeling (Feldkircher and Teliha, 2024; Campiglio et al., 2025) or dictionary approaches (Arseneau and Osada, 2023) to quantify this communication. The studies most closely related to ours examine the market impact of this communication. Several contributions, using topic modeling on global corpus of central-bank speeches (Campiglio et al., 2025) or dictionary-based methods focused on the ECB (Ebeling, 2024; Neszveda and Siket, 2025), find that increased climate communication correlates with short-term abnormal returns for green firms. Our results differ from this literature in three fundamental ways. First, whereas existing work identifies a "green boost," we show that ECB climate communication predominantly operates through a "brown penalty," consistent with a repricing of transition risk rather than a preference-driven green bubble. Second, while prior studies focus on short-term market reactions, our counterfactual analysis allows us to quantify the long-term economic magnitude of this repricing. We show that these policy shocks are not transitory; they have generated a persistent divergence in asset prices that has effectively erased the brown premium since 2018. Third, we attribute these differing conclusions to the precision of our CB-CNC index and the granularity of our asset pricing tests. Existing indices typically conflate general climate discussions with concrete policy signals. By developing the first LLM-based index that distinguishes credible Action (policies, mandates) from general Materiality (risks, warnings), we isolate the specific component of communication that carries a credible policy threat. This framework also allows us to evaluate the ECB's emerging discourse on nature and biodiversity, extending the analysis beyond climate for the first time.[5]

Methodologically, our paper contributes to the growing literature on text-based analysis of central-bank and climate-related communication. Earlier approaches—such as dictionary methods and structural topic modeling—have provided valuable insights but remain limited in their ability to capture context, tone, and semantic change over time. Recent advances employing LLM allow for more nuanced interpretations of policy language, enabling the detection of subtle shifts in emphasis and intent that evolve with the policy debate (Gambacorta et al., 2024; De Fiore et al., 2024; Park et al., 2025). We show that such models are particularly well suited to the analysis of climate and nature communication, where terminology, framing, and institutional focus change dynamically as sustainability frameworks mature. By applying LLMs to quantify this evolving discourse, we provide a richer and more context-aware measurement of central-bank communication than previously possible.

[5]Given the very recent emergence of nature-related communication frameworks, and the fact that the ECB has not (yet) operationalized nature or biodiversity considerations in a way comparable to its climate strategy, we do not detect systematic effects of nature-related communication.

Our approach complements recent applications of LLMs in financial economics—such as the construction of firm-level climate policy uncertainty indices (Zhao et al., 2024), assessments of climate-risk disclosures (Kölbel et al., 2024), and GPT-based analyses of green innovation (Leippold and Yu, 2025).

The remainder of the paper proceeds as follows. Section 2 describes the data and the construction of the CB-CNC index. Section 3 documents new facts on the evolution of ECB climate and nature communication. Section 4 quantifies the market impact of these communication shocks. Section 5 concludes.

2 The ECB Climate & Nature Communication Index

2.1 Data

The CB-CNC index is constructed from a corpus of over 5,000 ECB public communications. These include all speeches, press releases, statements, and Q&A sessions, spanning from 1997 to 2025. Speeches are obtained from the ECB Speeches dataset (ECB, 2019), a monthly-updated file which contains the complete list of speeches since the creation of the ECB. For each speech, its contents are given in full including footnotes. We further obtain the content of press releases, statements and Q&A sessions by scraping them in their entirety from the ECB website.

In line with previous studies (e.g., Acharya et al., 2025; Faccini et al., 2023), we filter this corpus using a large climate and nature dictionary to retain only those documents that contain at least one relevant climate or nature term. The dictionary is composed of 212 N-grams and is detailed in Appendix 6.4. The sole purpose of this step is to reduce the computational burden of our subsequent analysis. This pre-filtering identifies 404 communications—including 294 speeches, 47 press releases, 33 monetary policy statements, and 30 Q&A—potentially pertinent to climate or nature topics, reducing the data for the next step by a factor of ten.

2.2 CB-CNC Index Construction

We analyze the content of these filtered documents using a Large Language Model (Gemini 2.5 Flash). Before classification, each document is pre-processed to clean the text and segment it into individual sentences, which serve as the basic units of our analysis. Non-substantive units, such as headings, fragments (e.g., sentences with fewer than five words), and bibliographic citations are removed to isolate the core message.

A key feature of our methodology is that we do not analyze these sentences in isolation.

For each speech, the model is sent a single, structured request via the API. This request contains two components: (i) the entire document's text to serve as context, and (ii) a numbered list of individual sentences. The model is instructed to use the full context to inform its classification of each individual sentence. This "in-context" approach is crucial, as it allows the model to correctly interpret ambiguous pronouns (e.g., "we," "our," "this") and technical terms based on the speech's narrative, a significant advantage over methods that analyze fragments in isolation.

The model's core task is to assign a single classification code to each sentence based on a detailed, hierarchical schema summarized in Table 1. This schema requires the model to first identify the sentence's primary theme (Climate, Nature, or Other). If the theme is Climate or Nature, the model must then determine its purpose: is it an Action, a Materiality statement, or a General claim? These categories are then broken down into finer, policy-relevant subcategories. For example, an Action is classified by the actor (ECB or Others) and policy domain (Monetary Policy, Financial Supervision, etc.). A Materiality statement is classified by its risk type (Transition or Physical) and the system it affects (Economy or Financial System). We provide more details on the LLM prompt design and validation in Appendix 6.3.

This supervised top-down classification allows us to move beyond simple topic counts, such as dictionary-based approaches (e.g., Campiglio et al., 2025). It is also more appropriate for our research question than standard unsupervised methods like topic modeling (e.g., Faccini et al., 2023), which often produce topics that are difficult to interpret and whose number must be pre-specified by the user. Here, the classification is explicitly informed by our hypotheses regarding the structure and content of central bank communication, allowing for a direct and meaningful analysis of the categories that matter. An additional advantage of our LLM-based approach is that it adapts to language changes over time, unlike traditional NLP methods.

Table 1: Overview of the CB-CNC Classification Schema

Note: This table summarizes the hierarchical logic of the LLM classification. Each sentence in a relevant document is assigned one code.

Step 1: Theme	**Step 2: Subcategory**	**Step 3: Detail**
T1: Climate	**A: Action**	**ECB** → Monetary Policy → Financial Supervision → Non-Monetary Portfolios **Others (e.g., Govt.)**
	B: Materiality	**Transition Risk** → affecting Financial System → affecting Economy **Physical Risk** → affecting Financial System → affecting Economy
	C: General	(Non-specific claims)
T2: Nature	**A: Action**	(Same structure as Climate)
	B: Materiality	(Same structure as Climate)
	C: General	(Non-specific claims)
T3: Other	(Not applicable)	(Not applicable)

The model's output is a structured, sentence-level dataset mapping every analyzed sentence to a specific classification code; this detailed dataset is available from the authors upon request. To ensure replicability, we set the model's "temperature" parameter to 0 (e.g., De Fiore et al., 2024). The temperature parameter sets the degree of randomness in the model's output. Setting it to 0 makes the model's responses deterministic, meaning it will always select the most probable token. This is a desirable feature for a classification task, as it ensures that the Gemini 2.5 Flash model will always provide the same classification for the same input.

The final CB-CNC index (shown in Figure 3) and its various sub-indices (e.g., Climate Action, Climate Materiality, etc.) are constructed by summing the counts of their respective classification codes at various time frequencies (e.g., daily, quarterly, or annually). This aggregation allows us to quantify the ECB's evolving communication on climate and nature.

2.3 Index Validation

In this section, we proceed to some plausibility checks. We start by identifying and explaining the largest spikes in the CB-CNC index. Next, we validate the pertinence of both trends and relevance of the decomposition by studying its media reception using Factiva. In Appendix 6.2, we compare CB-CNC with existing indices (the Media Climate Change Concerns Index of Ardia et al. (2023), the Transition Risk Index of Bua et al. (2024) and the news shocks of Faccini et al. (2023)) and find that these indices exhibit low correlation with CB-CNC.

2.3.1 Largest spikes in the CB-CNC index

On the days of significant spikes in the CB-CNC index, the ECB officials delivered speeches that emphasized their commitment to integrating climate considerations into monetary policy operations and management of their non-monetary portfolios.

The largest spike in the CB-CNC index occurred on January 25, 2021, with three notable speeches delivered by Christine Lagarde, Fabio Panetta, and Frank Elderson. Christine Lagarde's speech emphasized that the ECB's active role in some markets can influence the development of certain market segments. She precised that the ECB held around a fifth of the outstanding volume of eligible green bonds and had taken action with regards to its non-monetary policy portfolio, including raising the share of green bonds in its own funds portfolio to 3.5% and investing in the green bond fund of the Bank for International Settlements. Lagarde's speech was reported by Reuters, which covered the ECB's establishment of a small climate change unit to lead Lagarde's green push. Fabio Panetta's speech stressed that in order to ensure that it remains financially sound, the ECB had to protect its balance sheet from the financial risks caused by climate change that are not correctly priced by the markets[6]. Panetta's remarks were reported by Reuters, which highlighted his assertion that the ECB can price climate risk better than the market. Frank Elderson's speech addressed the ECB's supervisory activities and the need for banks to adequately manage climate-related and environmental risks. He mentioned the ECB's recent publication of supervisory expectations and the upcoming climate risk stress test exercise. Elderson's speech was covered by Bloomberg, which noted the ECB's challenge to banks on their view of climate risks.

A second important spike in CB-CNC index corresponds to Christine Lagarde speech on July 11, 2021. She emphasized the ECB's commitment to integrating climate considerations into its policy operations, including new disclosure requirements for private sector assets as eligibility criteria for collateral and asset purchases. Moreover, she said that the ECB would also consider climate-change risks in its valuation and risk control frameworks for collateral, and adjust its corporate bond purchase framework to include climate change criteria. Bloomberg reported Lagarde's announcement of potential policy changes and measures for 2022.

[6] Fabio Panetta also mentioned that the ECB can contribute to the accurate valuation of these climate-related risks and promote awareness among investors, thereby helping to combat climate change.

On June 14, 2021, Isabel Schnabel proposed various actions for the ECB to address climate change, which we identify as yet another significant spike in our index. In particular, she mentioned that the ECB could amend its collateral framework, for example by including innovative green financial products as eligible collateral or by linking the eligibility as collateral to more comprehensive disclosures, reflecting European legislation such as the Corporate Sustainability Reporting Directive. She also stated that in view of market failures (if the market misprices the risks associated with climate change), it seems appropriate to replace the ECB market neutrality principle by a market efficiency principle. This would effectively induce a "tilting strategy" under which the ECB could adjust its monetary policy operations and asset purchases in line with sustainability considerations. Reuters reported Schnabel's suggestion that the ECB may tilt bond purchases towards companies that cut emissions.

2.3.2 Media Reception of ECB Climate Communication

To study the pertinence of our index, we further rely on the Factiva article repository to analyze its correlation with the number of articles of journals and magazines. Since our focus is on the ECB, we restrict the sample to business-oriented European journals published in six languages: English, French, German, Italian, Spanish, and Portuguese. The full list of journals is provided in the Appendix 6.1. From this set of journals, we select articles that mention the ECB in the title or snippet and contain a climate-related term in the title, snippet, or body.[7] ECB- and climate-related terms are translated into each journal's language and applied exclusively in that language (i.e., English terms are not used for French journals, and German terms are not used for Spanish journals). From the resulting set of articles, we count the number of climate-related ECB articles. For comparison, we also extract the number of all ECB-related articles in these journals, allowing us to compute

[7]We also apply a stricter filter in which climate-related terms must appear in the title or snippet. Appendix 6.1 presents a graph showing the evolution of article counts under this stricter filter. While the number of articles decreases, the trends and dynamics remain unchanged.

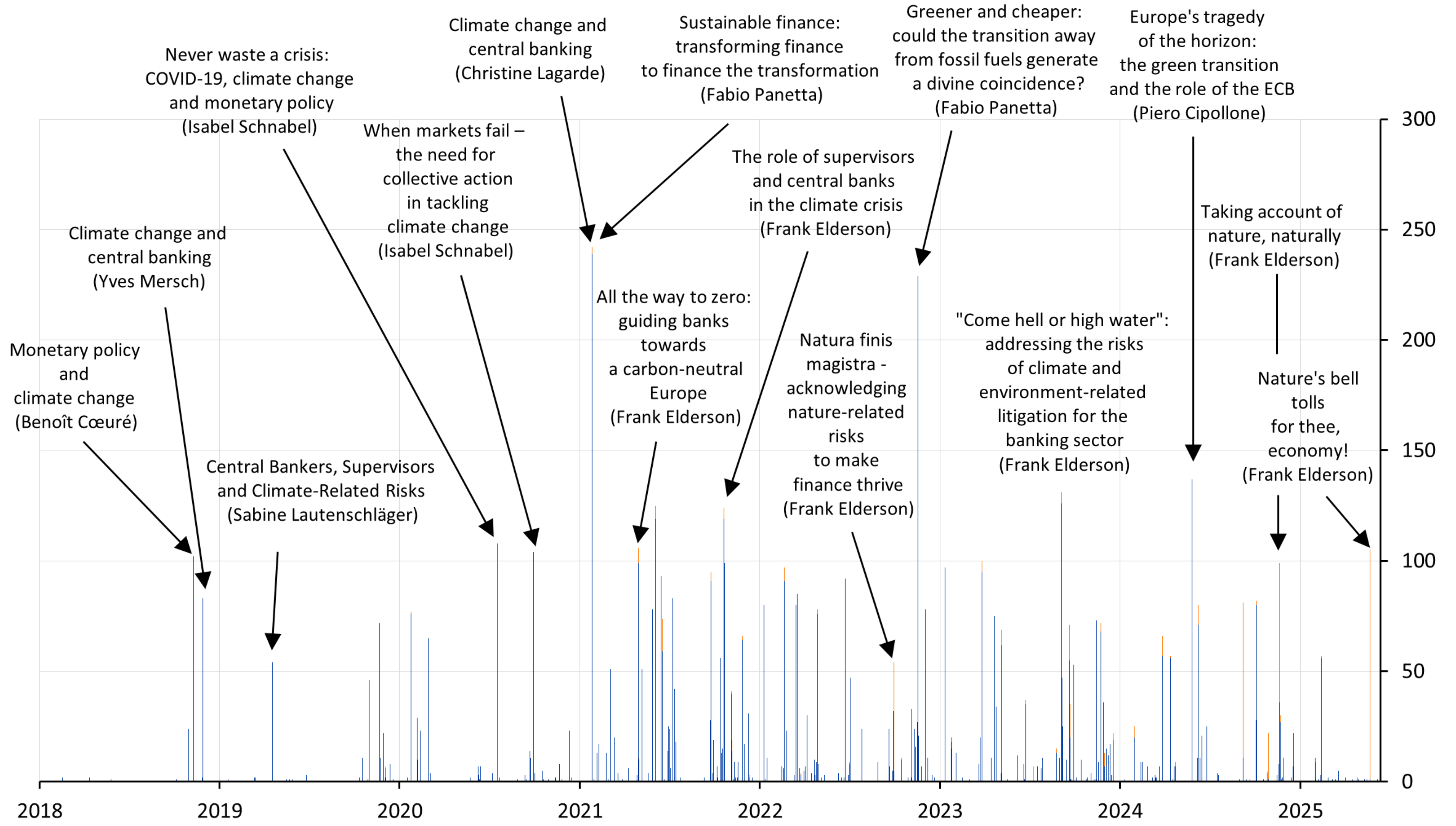


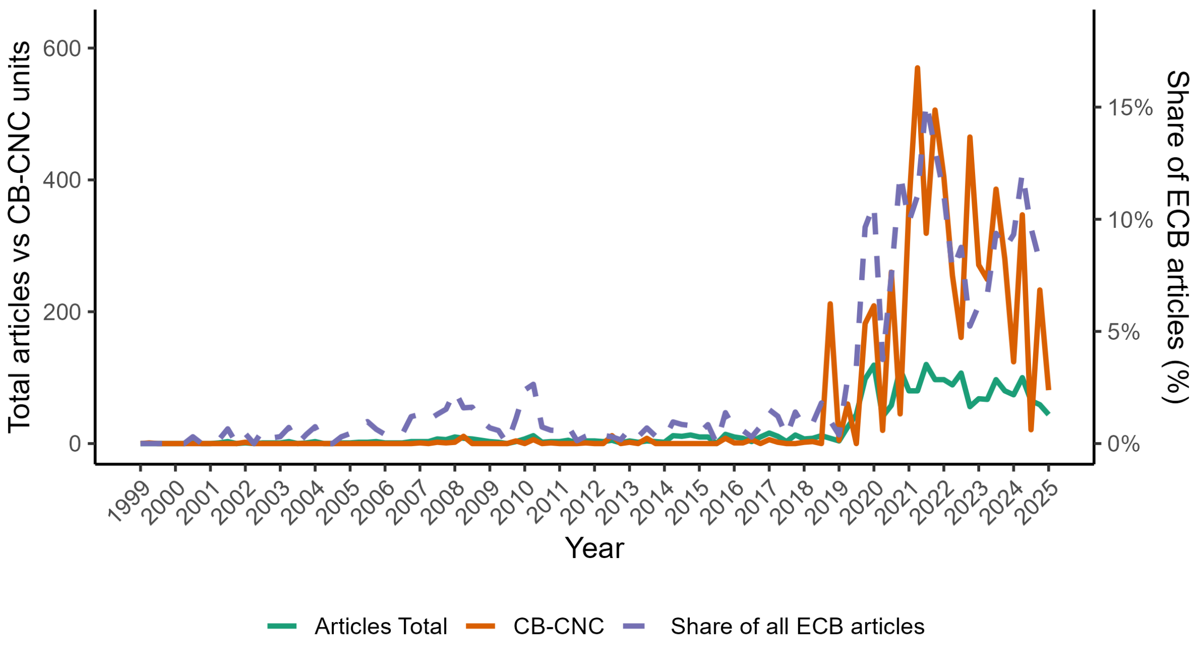
Figure 1: Identification and Explanation of CB-CNC spikes

Note: **The figure highlights daily spikes (number of climate & nature sentences) in the CB-CBC index and links them to specific speeches, illustrating that the index captures meaningful communication events (climate in blue, nature in orange).**

the share of ECB coverage devoted to climate communication. To mitigate the influence of day-to-day noise, we summarize results at the monthly frequency. We end up with 2,214 articles from 14 of the 17 considered journals, from January 2000 to March 2025.

In line with the evolution of the CB-CNC index, there is virtually no media coverage of ECB climate communication before 2018. Following the increase in ECB speeches and press releases on climate issues, however, we observe a substantial rise in coverage. Since 2019, roughly 10% of ECB-related articles have included climate content. This increase is broad-based: we find no evidence of language-specific differences in pick-up rates, as articles appear across the majority of sampled journals and in all six languages.

Figure 2: CB-CNC Index versus Press Articles on Climate & the ECB



Note: **The figure shows the CB-CNC index, the number of ECB-climate press articles, and their share of all ECB-related Factiva coverage, at a quarterly frequency. The strong comovement among these series provides evidence for the relevance of the CB-CNC index.**

3 New Facts on Central Bank Climate & Nature Communication

Our empirical analysis exploits the granularity and time-variation of our index and allows us to draw novel insights about central bank climate communication in general and trends in changes of focus in particular. We structure our results around three main stylized facts.

3.1 Nature has become an increasingly prominent theme in ECB communication, yet remains predominantly high level

Overall, nature remains secondary in central bank communication. Table 2 reports the distribution of communication types across the full sample period, and shows that it forms only 7.7% of ECB climate and nature communication. However, nature-related communication has grown notably in prominence within recent ECB communications. Figure 3 illustrates that this is a comparatively recent development, with the sharpest increase occurring in 2024 and 2025. Despite this rise in salience, nature-related communication remains largely high level and rarely articulates specific measures undertaken by the ECB itself. This qualitative difference is also apparent in the distribution of communication channels: whereas climate-related messages frequently appear in monetary policy statements and Q&A sessions, references to nature thus far have been confined to press releases and speeches.

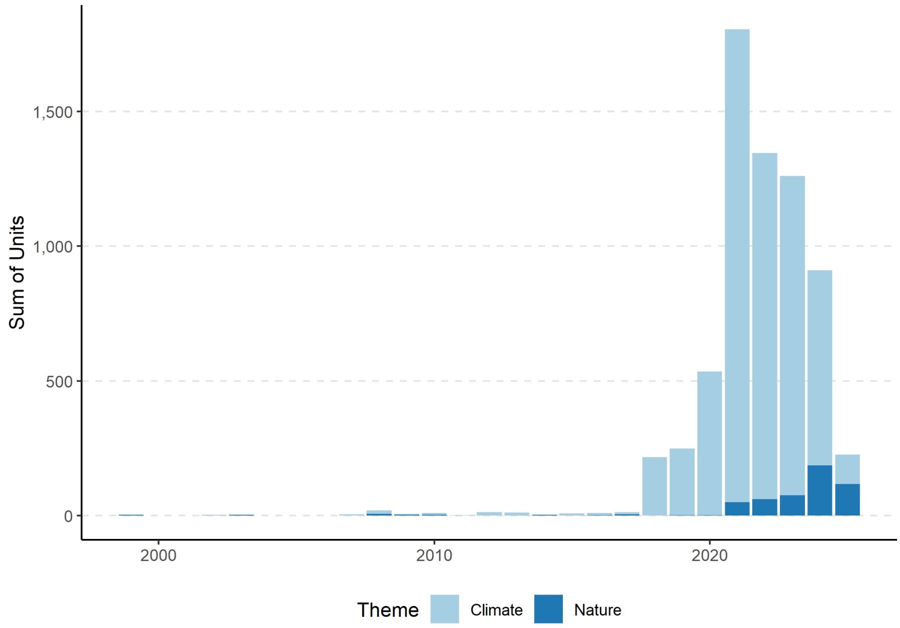
The discourse on nature is furthermore unusually concentrated among speakers. While climate-related communication is dispersed across the five principal speakers—who collectively account for 87.4 percent of all climate references—nature-related communication is driven almost exclusively by a single individual, Frank Elderson (see Appendix 6.2).

Table 2: Global Summary of Climate and Nature-Related Units

This table provides a summary of ECB climate and nature communication. All percentages are calculated as a share of their respective theme's total units (the top row). The overall split is 92.3% Climate (6,137 units) and 7.7% Nature (512 units).

	Climate		Nature	
Category	Units	(%)	Units	(%)
Total Classified Units	**6,137**	**100.0**	**512**	**100.0**
Action	**3,430**	**55.9**	**212**	**41.4**
ECB: Financial Stability	484	7.9	36	7.0
ECB: Monetary Policy	490	8.0	3	0.6
ECB: Non-MP Policies	89	1.5	6	1.2
ECB: Other	661	10.8	58	11.3
Other Actors	1,706	27.8	109	21.3
Materiality	**1,743**	**28.4**	**167**	**32.6**
Transition Risk	806	13.1	4	0.8
Physical Risk	433	7.1	88	17.2
Other Risk	504	8.2	75	14.6
Other	**964**	**15.7**	**133**	**26.0**

Figure 3: ECB Climate and Nature Communication Index



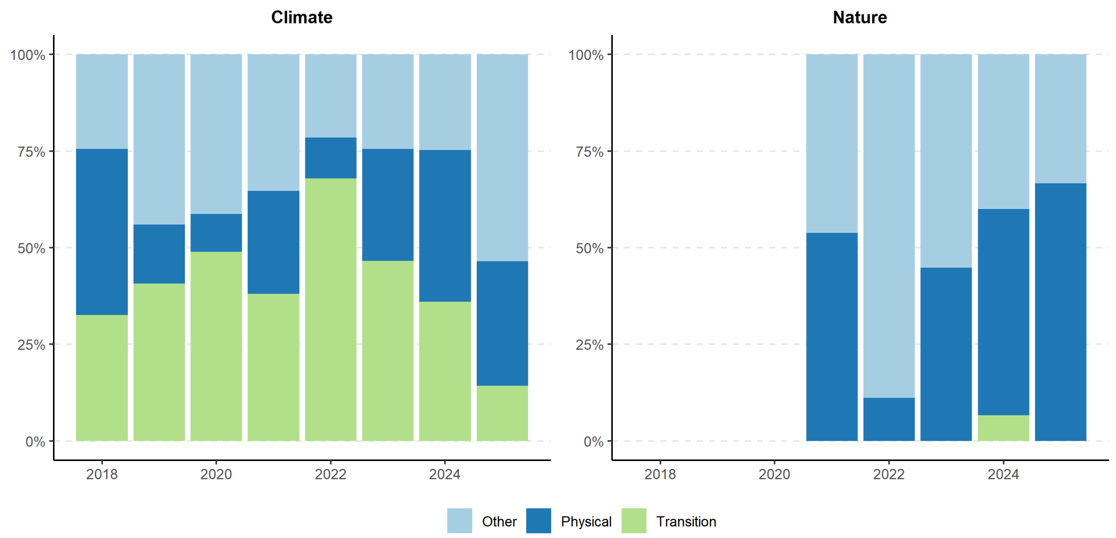
Note: **The figure shows annual totals of communication units, reported separately for climate and nature. The apparent decline in 2025 is mechanical, as the sample ends in March 2025.**

3.2 Physical risk has re-emerged as the primary focus, while attention to transition risk has declined

We next examine the decomposition of communication by risk materiality. From 2019 to 2022, transition risk featured prominently in central bank communication. Since then, the emphasis has shifted back toward physical risk. After peaking in 2022, references to transition risk declined and reached a new low in early 2025, with a corresponding rise in discussions of physical risk.

The reversal is partly attributable to the growing prominence of nature within the overall corpus: discussions of materiality in nature-related communication focus almost exclusively on physical risk. Nature loss-induced transition risk is referenced in only two speeches across the entire sample, namely in Frank Elderson's 2024 "Nature-related risk: legal implications for central banks, supervisors and financial institutions" and "Taking account of nature, naturally" speeches. Both refer to the risk of nature-related litigation.

Figure 4: Evolution of Physical and Transition Risk Mentions



Note: **The figure plots the sum of units per type of materiality per year, separately for climate and nature communication. The empty Nature columns for 2018 to 2020 result from the complete absence of nature-materiality mentions.**

3.3 Action-oriented messaging is more ECB-focused and is the main driver of media uptake

Action-oriented communication constitutes the predominant form of climate-related messaging, exceeding both materiality-related and other forms of communication. The prevalence of action-oriented communication is not medium-specific: Table 6 shows that it represents the majority of climate-related content in speeches, press releases, Q&A sessions, and monetary policy statements, with the latter two displaying particularly strong concentrations.

The aggregate statistics in Table 2, however, mask important historical trends. Specifically, action-oriented communication has become increasingly concrete over time. Whereas climate communication between 2019 and 2022 largely highlighted actions undertaken by non-ECB actors, recent years have seen a shift toward ECB-specific actions, with a growing emphasis on operational and financial-stability-related measures.

Action-oriented communication is also the form most likely to be reflected in media coverage. Drawing on the Factiva dataset introduced in the previous section, we estimate a series of time-series regressions in which the monthly count of climate-related articles serves as the dependent variable and contemporaneous communication indicators as explanatory variables. To prevent undue influence from periods with negligible communication activity, we restrict the sample to the post-2018 period.

Table 3 summarizes the results. Overall, climate-related communication is associated with increased media attention, whereas nature-related communication is not. Within climate-related communication, the effect is driven exclusively by action-oriented messages rather than materiality-focused ones. Moreover, the increase in media coverage is attributable specifically to communication about ECB actions, rather than the actions of other actors. Once action-oriented communication is accounted for, neither physical nor transition risk communication exhibits a statistically significant relationship with media uptake.

Table 3: Media Attention to ECB Climate & Nature Communication

This table reports the regressions results for the raw monthly counts of the main CB-CNC sub-indices from January 1, 2018, onwards. We find that communication on climate action, and in particular on the ECB's own actions rather than those of other actors, is stronly associated with the number of published news articles discussing both the ECB and climate. *, **, and * indicate significance at the 1%, 5% and 10% levels, respectively**

	Dependent variable:			
	Total Articles			
	(1)	(2)	(3)	(4)
Climate Comm.	0.081***			
	(0.017)			
Climate Action		0.129**		
		(0.056)		
Climate Action (ECB)			0.285***	0.308***
			(0.083)	(0.079)
Climate Action (non-ECB)			−0.045	−0.014
			(0.088)	(0.086)
Climate Materiality		0.050	0.103	
		(0.105)	(0.104)	
Transition Risk				0.101
				(0.148)
Physical Risk				−0.035
				(0.233)
Nature Comm.	0.042	0.045	0.041	0.058
	(0.094)	(0.094)	(0.091)	(0.112)
Observations	90	90	90	90
R^2	0.206	0.220	0.273	0.269
Adjusted R^2	0.188	0.192	0.239	0.225

4 The ECB's Green Put

In this section, we investigate the asset pricing implications of central bank communication on climate and nature-related topics. Using a local projection framework (Jordà, 2005), we estimate the dynamic response of stock returns to these high-frequency communication shocks. Our central hypothesis is that this impact is not uniform across the market but is instead conditional on firms' environmental characteristics.

We test this hypothesis in two ways: first, by examining the direct interaction between the shocks and a firm's continuous emission profile (i.e., CO_2 and SOx/NOx intensity), and second, by analyzing the differential impact on high- and low-emitting portfolios. We focus on the period 2018–2025, during which the ECB's communication on climate and nature has become increasingly important (see Figure 3).

4.1 Data and Variable Construction

Our analysis relies on a daily panel dataset combining firm-level stock prices and annual environmental data for European firms[8], all sourced from Refinitiv Datastream. A key methodological choice is the selection of emission proxies. We use CO_2 emission intensity as the primary proxy for climate-related transition risk, as it is the most established and standardized metric used by investors and regulators (Giglio et al., 2021). For nature-related risks, which are inherently more complex and multi-dimensional (Garel et al., 2024; Giglio et al., 2025), we use SOx/NOx emission intensity. These pollutants are key drivers of ecosystem degradation, water, and air pollution, making them a suitable, albeit partial, proxy for a firm's negative impact on natural capital.

To construct the panel, we merge the daily stock price for each firm i on day t with the one-year-lagged annual emissions data. This lag structure is crucial as it ensures that all environmental information is historically known to investors at any given date (Zhang,

[8] We focus on companies listed in the European stock markets, including members of the European Union, Norway, Switzerland and the United Kingdom.

2025). Moreover, we focus on firm-reported emissions to avoid introducing potential errors from third-party estimation (Aswani et al., 2024). Overall, 1,634 firms listed on European markets report their CO_2 emissions over the period considered, against 319 for SOx/NOx emissions.[9]

The daily stock price data is subject to a cleaning procedure to remove illiquid or erroneous series. We exclude stocks with stale, constant prices (more than 20 consecutive days), a high frequency of zero-returns (more than 10% of days), or implausible return volatility. We then compute daily log-returns, which we winsorize at the 1% and 99% levels to mitigate the influence of outliers.

Finally, we construct the primary variables of interest for our interaction model. We first log-transform the raw emissions data (CO_2, NOx, SOx) to manage their extreme skewness. Then, on each day t, we standardize these log-transformed variables across the entire cross-section of firms to create daily z-scores. Our final pollution variable is constructed as the composite average of the two individual pollution z-scores (NOx and SOx). This standardization allows us to interpret our regression coefficients as the differential impact of a communication shock on a firm with one-standard-deviation-higher emissions than the market average on that day.

4.2 Does Central Bank Communication Affect Stock Markets?

We begin by testing whether the effect of central bank communication shocks on stock returns is systematically linked to a firm's underlying emission characteristics. To capture this conditional relationship, we estimate the following local projection model for each horizon h:

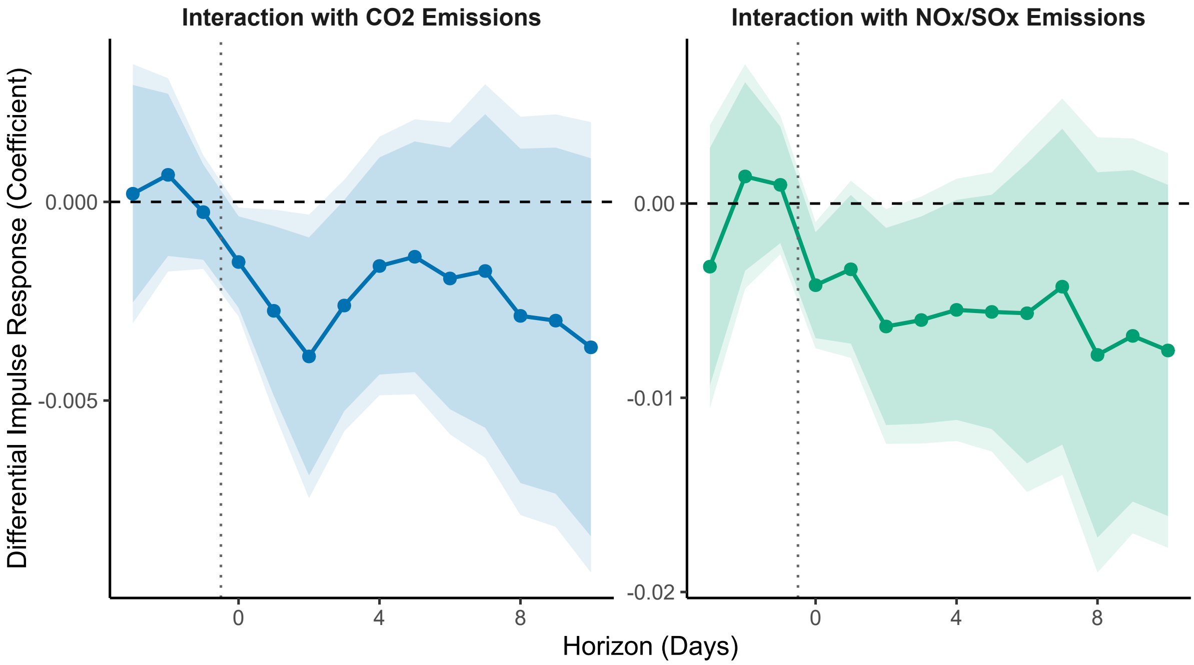
$$R_{i,t\to t+h} = \beta_{1,h} Shock_t^{ECB} + \beta_{2,h} Emission_{i,t} + \beta_{3,h}(Shock_t^{ECB} \times Emission_{i,t}) + \alpha_i + \delta_t + \epsilon_{i,t} \quad (1)$$

[9] The ten countries most represented are the United Kingdom (475 firms), Sweden (191), Germany (140), France (139), Switzerland (131), Italy (95), Spain (65), Norway (56), Denmark (49) and Belgium (46).

In this model, the dependent variable $R_{i,t\to t+h}$ represents the cumulative log-return for stock i from day t to $t+h$. The specification includes firm fixed effects α_i and time fixed effects δ_t to control for unobserved heterogeneity. The aggregate communication shock on day t is denoted by $Shock_t^{ECB}$, while $Emission_{i,t}$ is the continuous, standardized emission factor for firm i. The primary coefficient of interest is $\beta_{3,h}$, which measures how emissions amplifies or dampens the impact of ECB communication shocks on future cumulative returns.

Figure 5 plots the estimated coefficients $\beta_{3,h}$ for the aggregate CB-CNC shock. The results show a negative and statistically significant differential impact on more polluting firms. This effect is visible for both CO_2 emissions and, to a lesser extent, NOx/SOx emissions. The impact is immediate, with the coefficient becoming negative on the day of the shock ($h = 0$) and continuing to decline until $h = 2$, where it reaches approximately -0.005. This delayed response may be due to communications occurring after trading hours, or a lag in media dissemination and investor processing. The negative effect appears persistent over the 10-day horizon, though the widening confidence intervals reflect increased noise as other shocks accumulate.

Figure 5: Effect of CB-CNC Shocks on Stock Markets: Interaction with Emission Data



Note: **The figure plots the differential impulse response coefficients ($\beta_{3,h}$) from the local projection model in Equation 1. The dependent variable is the cumulative log-return from t to $t+h$. The model interacts the aggregate CB-CNC shock with standardized CO_2 emissions (left panel) and standardized NOx/SOx emissions (right panel), including firm and time fixed effects. The x-axis represents the horizon h in days. The solid line is the point estimate, and the dark and light shaded areas represent the 90% and 95% confidence intervals, respectively, based on robust standard errors clustered at the firm and time level.**

Robustness to Confounding Shocks— We test the robustness of this finding by assessing whether our aggregate CB-CNC index is merely capturing other, contemporaneous macroeconomic or climate-related news. We re-estimate Equation 1 for a representative horizon (h=2) and introduce interaction terms for four prominent external climate news indices and one monetary policy surprise index. The external climate news shocks are: the MCCC index of Ardia et al. (2023), the TRI index of Bua et al. (2024), and the International Summit (IS) and Natural Disaster (ND) indices of Faccini et al. (2023). For monetary policy (MP) surprises, we use the 2-year OIS abnormal returns series from Istrefi et al. (2024), which captures high-frequency surprises from both official meetings and inter-meeting communications.[10]

Table 11 presents the results. Column (1) shows our baseline estimate, where CB-CNC shocks and CO_2 interaction is negative and highly significant. Columns (2) through (6) introduce the control interactions one by one. Our coefficient of interest remains stable and statistically significant in all specifications. Column (7) presents the most stringent test, including all five control interactions simultaneously. Even in this specification, our $CB - CNC$ x CO_2 shock remains virtually unchanged at -0.001 and is highly significant ($p<0.01$). This confirms that our CB-CNC index captures a unique signal, distinct from general media-driven climate news or other monetary policy surprises. Interestingly, we find that one of the control variables, the International Summit news index of Faccini et al. (2023), also enters with a significant negative coefficient, suggesting that high-level political agreements on climate also penalize brown firms.

4.3 What Drives This Result?

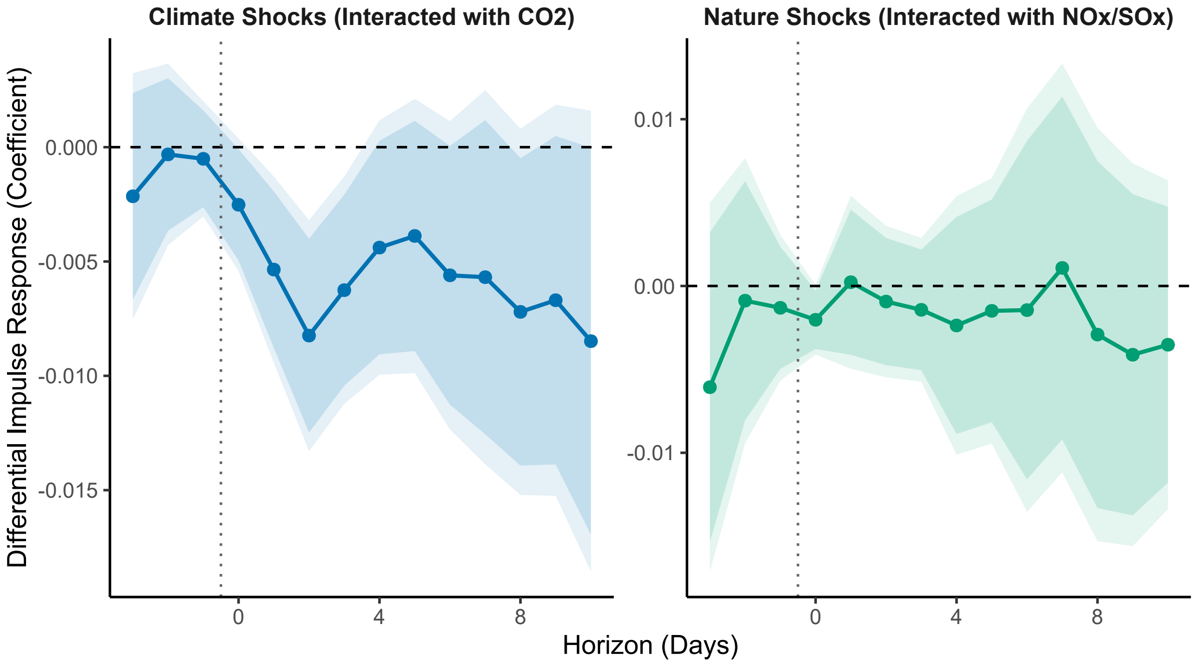
Climate- or Nature-Related Communication— To understand the drivers of this aggregate effect, we disaggregate the $Shock_t$ variable into its Climate and Nature components. Figure 6 plots the differential impact for each component separately, using their

[10] We report the correlation matrix between these indices in Table 9.

respective emission proxies (CO_2 for Climate, NOx/SOx for Nature).

The findings show that the negative valuation effect is driven entirely by climate-related communication. The left panel shows a strong negative response, identical to the aggregate shock. In contrast, the right panel shows that the differential impulse response for nature-related communication is not statistically different from zero. This aligns with our descriptive statistics; nature-related communication is more recent and may be perceived by investors as less focused on concrete, imminent measures. Furthermore, CO_2 intensity is a well-established proxy for transition risk, whereas NOx/SOx captures only one facet of the multi-dimensional nature risk, which markets may not yet be pricing systematically.

Figure 6: Differential Effect of Climate and Nature Shocks



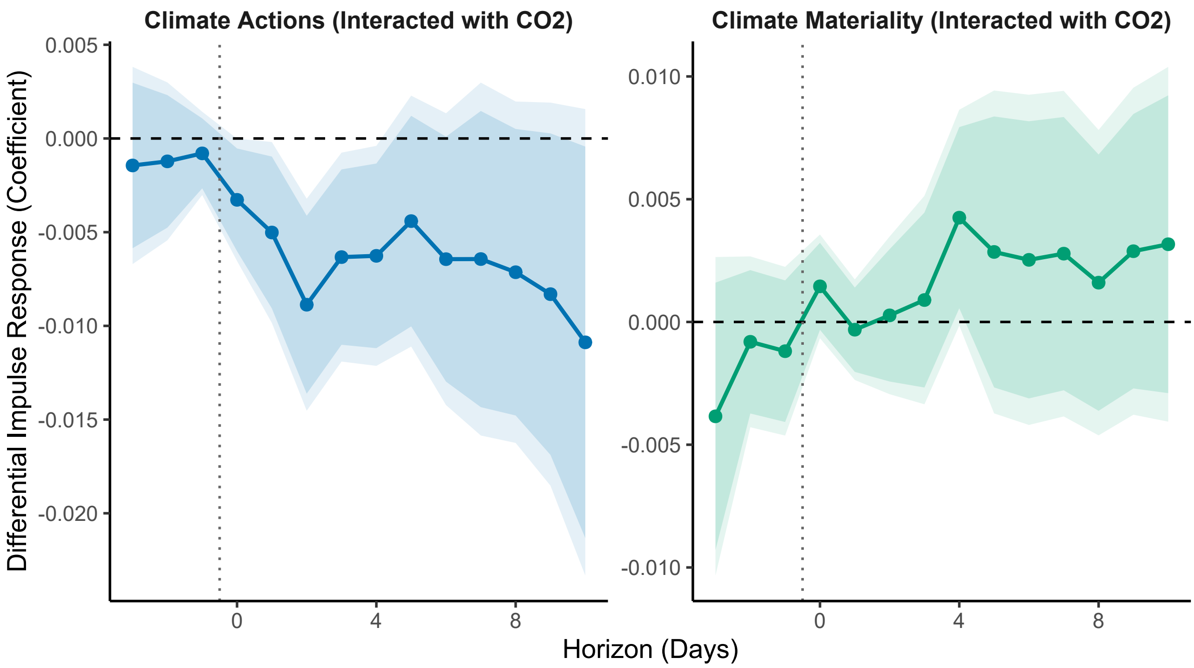
Note: **The figure plots the differential impulse response coefficients ($\beta_{3,h}$) from the local projection model in Equation 1. The model includes firm and time fixed effects. The left panel plots the response to the Climate Total shock, interacted with standardized CO_2 emissions. The right panel plots the response to the Nature Total shock, interacted with standardized NOx/SOx emissions. The x-axis represents the horizon h in days. The solid line is the point estimate, and the dark and light shaded areas represent the 90% and 95% confidence intervals, respectively, based on robust standard errors clustered at the firm and time level.**

Action- or Materiality-Related Communication— Given that the climate component is the primary driver, we decompose it further into Action and Materiality communications. Our hypothesis is that investors are more sensitive to credible signals of concrete measures (actions) than to general risk warnings (materiality).

However, testing this hypothesis presents an econometric challenge. A simple count of "Action" sentences and "Materiality" sentences may be insufficient to clearly distinguish their effects, as their raw daily counts are highly correlated (see Table 7). Indeed, on days the ECB discusses climate, it tends to discuss both its actions and the risks that motivate them. To disentangle these two effects, we must isolate communication days where "Action" was the dominant theme. We therefore construct our shock variables to capture unusually high shares of communication. First, for each day with climate communication, we calculate the share of "Action" and "Materiality" sentences relative to the total climate sentences for that day. Second, we create a dummy variable for each category that equals one if a day's share is above the historical mean share for that category. Our final Action shock variable is the original raw sentence count multiplied by this high-focus Action dummy (and zero otherwise). We apply the same method for Materiality. This process effectively decorrelates the two series (see Table 8), allowing us to test their independent impacts.

Figure 7 confirms our hypothesis using these filtered shock variables. The left panel (Climate Actions) shows a significant negative differential response for high-emitters, almost identical in magnitude and timing to the total climate shock. Conversely, the right panel (Climate Materiality) shows no such negative response; the coefficient is close to zero and often positive. This suggests investors are sophisticated, distinguishing credible signals of future policy or regulation, which directly impact firm valuations, from more general rhetoric. We confirm the robustness of this result by including the original Action and Materiality shock variables together in the same regression.

Figure 7: Differential Effect of Action and Materiality-Related Communication



Note: **The figure plots the differential impulse response coefficients ($\beta_{3,h}$) from the local projection model in Equation 1. The model includes firm and time fixed effects. The left panel plots the response to the orthogonalized Climate Action shock. The right panel plots the response to the orthogonalized Climate Materiality shock. Both shocks are interacted with standardized CO_2 emissions. These shock variables are constructed as described in the preceding paragraph to isolate high-focus communication days. The x-axis represents the horizon h in days. The solid line is the point estimate, and the dark and light shaded areas represent the 90% and 95% confidence intervals, respectively, based on robust standard errors clustered at the firm and time level.**

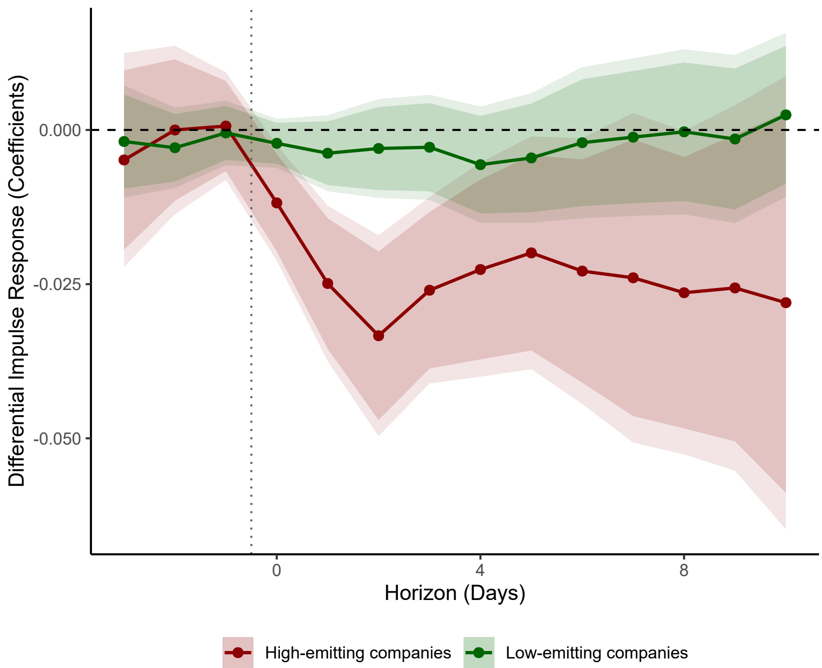
High- or Low-Emitting Companies— Having established that action-related climate shocks are the key driver, we now seek to identify which firms are most affected. Is the effect concentrated in the most polluting firms, the cleanest firms, or both? We move from a continuous interaction to a portfolio-based approach, categorizing firms as "Green" (bottom 10% of CO_2 emitters) or "Brown" (top 10%) and estimate the differential impulse response for these two groups relative to the "neutral" middle 80% using the following specification:

$$R_{i,t\to t+h} = \beta_h^{Green}(Shock_t^{ECB} \times Green_i) + \beta_h^{Brown}(Shock_t^{ECB} \times Brown_i) + \alpha_i + \delta_t + \epsilon_{i,t} \quad (2)$$

Here, $Green_i$ and $Brown_i$ are dummy variables. The coefficients β_h^{Green} and β_h^{Brown} measure the differential reaction relative to neutral firms, whose average response is captured within the time fixed effects.

Figure 8 clarifies the source of the continuous interaction effect. The "Brown" portfolio experiences a large, immediate, and statistically significant underperformance, with the coefficient dropping below -0.025 by $h = 2$. Conversely, the "Green" portfolio shows no reaction; its impulse response is flat and statistically indistinguishable from zero. This refines the findings of previous research. While some studies suggest a "green premium" from climate communication (e.g., Campiglio et al., 2025), our analysis indicates the effect is almost exclusively a "brown-penalizing factor". This is economically intuitive: central bank actions on climate primarily manifest as transition risks, which directly threaten the valuation of high-carbon firms, while low-carbon firms do not necessarily receive a direct, immediate benefit.

Figure 8: Effect of Climate Communication on High and Low-Emitting Companies



Note: **The figure plots the cumulative impulse response coefficients β_h^{Green} (Low-emitting companies, green line) and β_h^{Brown} (High-emitting companies, red line) from the local projection model in Equation 2. The model interacts the original Climate Action shock with dummy variables for firms in the bottom 10% (Green) and top 10% (Brown) of CO_2 emissions. The model includes firm and time fixed effects, and the coefficients are interpreted relative to the omitted middle 80% ("neutral") firms. The x-axis represents the horizon h in days. Solid lines are point estimates, and the dark and light shaded areas represent the 90% and 95% confidence intervals, respectively, based on robust standard errors clustered at the firm and time level.**

Which Communication Type Matters the Most?— Not all central bank communication is created equal. The literature on monetary policy distinguishes between official, scheduled policy announcements (e.g., FOMC meetings) and other communications (e.g., speeches) that occur between them. While official announcements are a primary source of policy shocks, a large body of work finds that "inter-meeting" communication, such as speeches, also transmits significant, independent policy signals (Istrefi et al., 2024). In fact, a substantial portion of market returns has been shown to accumulate in anticipation of official announcements, a phenomenon known as the "pre-FOMC drift" (Lucca and Moench, 2015).

This creates a clear test for our findings: Does the climate-related asset repricing occur on the few days of "official" communication (e.g., Monetary Policy Statements, Press Releases), or is it driven by the more frequent inter-meeting communication, primarily through speeches?

Table 10 presents the results of our baseline local projection model (Equation 1) estimated separately for each of the four communication types. The results show that the interaction term between CB-CNC shocks and CO_2 is negative and highly significant only in the Speeches specification (Column 4). The coefficients for Monetary Policy Statements, Q&A sessions, and Press Releases are all statistically indistinguishable from zero.

This suggests that, for climate communication, the market-moving shocks are not delivered on the official announcement days. Instead, the persistent narrative provided in speeches by ECB officials is the primary channel through which climate policy signals are transmitted to financial markets. This aligns with the view that inter-meeting communications are a critical and distinct channel for shaping market expectations.

4.4 What Is the Economic Magnitude of this Effect In the Long Term?

Our analysis so far reveals that ECB climate "Action" talk, identified at a high frequency, have a statistically significant, negative, and long-lasting impact on high-emitting firms. We now follow the methodology of Pástor et al. (2022) to investigate a more fundamental question: What is the economic magnitude of this effect? Are these policy shocks merely a source of short-term volatility, or are they a primary driver of the entire realized return path of the so-called "green premium"?

Methodology— We answer this by constructing a counterfactual return series for a Brown-Minus-Green (BMG) portfolio. This approach allows us to estimate what the performance of this factor would have been in a world without ECB climate policy shocks.

We conduct two parallel analyses, corresponding to the two panels in Figure 9. First, we construct the daily, equally-weighted BMG factor, long the top decile ("Brown") and short the bottom decile ("Green") of firms sorted on CO_2 emission intensity.

For the analysis in Panel A (raw returns), we estimate a time-series regression of this raw BMG return on our ECB Action shocks and a set of control variables:

$$BMG_t = \alpha + \sum_{k=0}^{2} \beta_k Shock_{t-k}^{ECB} + \sum_{j=0}^{2} \gamma_j X_{t-j}^{Controls} + \epsilon_t \tag{3}$$

where BMG_t is the daily BMG return. The key variable of interest is $Shock_t^{ECB}$, our daily Climate Action index. We include lags to capture delayed market reactions. To isolate the ECB's unique contribution, the vector X_t controls for other climate-related media news, specifically the MCCC index of Ardia et al. (2023) and the European Transition Risk Index of Bua et al. (2024). Faccini et al. (2023) indicators are not included in the main regression, as they are only available until January 2025. However, their inclusion does not significantly alter the results. A distinction must be made between our policy shock and the control variables. Our $Shock_t^{ECB}$ is a high-frequency (daily) event count, a series dominated by zeros. As such, it has no predictable, auto-regressive component, and the occurrence of a non-zero count is itself the policy surprise. We therefore use the raw index directly. In contrast, the MCCC and TRI are persistent indices; we thus follow standard practice (Pástor et al., 2022) and identify their shocks as the residuals from an AR(1) process to capture only their unexpected component.

For the analysis in Panel B (alphas), we first orthogonalize the BMG return series by regressing it on the daily Fama-French 5 factors for Europe[11]. The residual plus the intercept from this regression, BMG_t^{Alpha}, represents the daily BMG alpha. We then estimate a second regression using this alpha as the dependent variable in Equation 3. Both models are estimated using robust Newey-West standard errors.

For each model, we then compute a counterfactual series by purging the realized series (either BMG_t or BMG_t^{Alpha}) of the component attributable only to the ECB Action shocks. For example, the counterfactual for the raw return is:

$$BMG_t^{CF} = BMG_t - \sum_{k=0}^{2} \hat{\beta}_k Shock_{t-k}^{ECB} \tag{4}$$

This counterfactual series retains the intercept, the impact of all control variables, and the residual. It represents the BMG return path had the ECB's Action communication never occurred. Finally, following Pástor et al. (2022), we compute 95% confidence intervals for the counterfactual path by running 1,000 simulations, drawing new coefficient vectors from the robust variance-covariance matrix of the estimated model.

Results— Figure 9 plots the cumulative realized BMG returns against the cumulative counterfactual path. The top panel shows the cumulative raw returns. The realized BMG portfolio (black line) is highly volatile and ends the 2018-2025 period with a cumulative return near zero. In contrast, the counterfactual path (blue dashed line)—representing

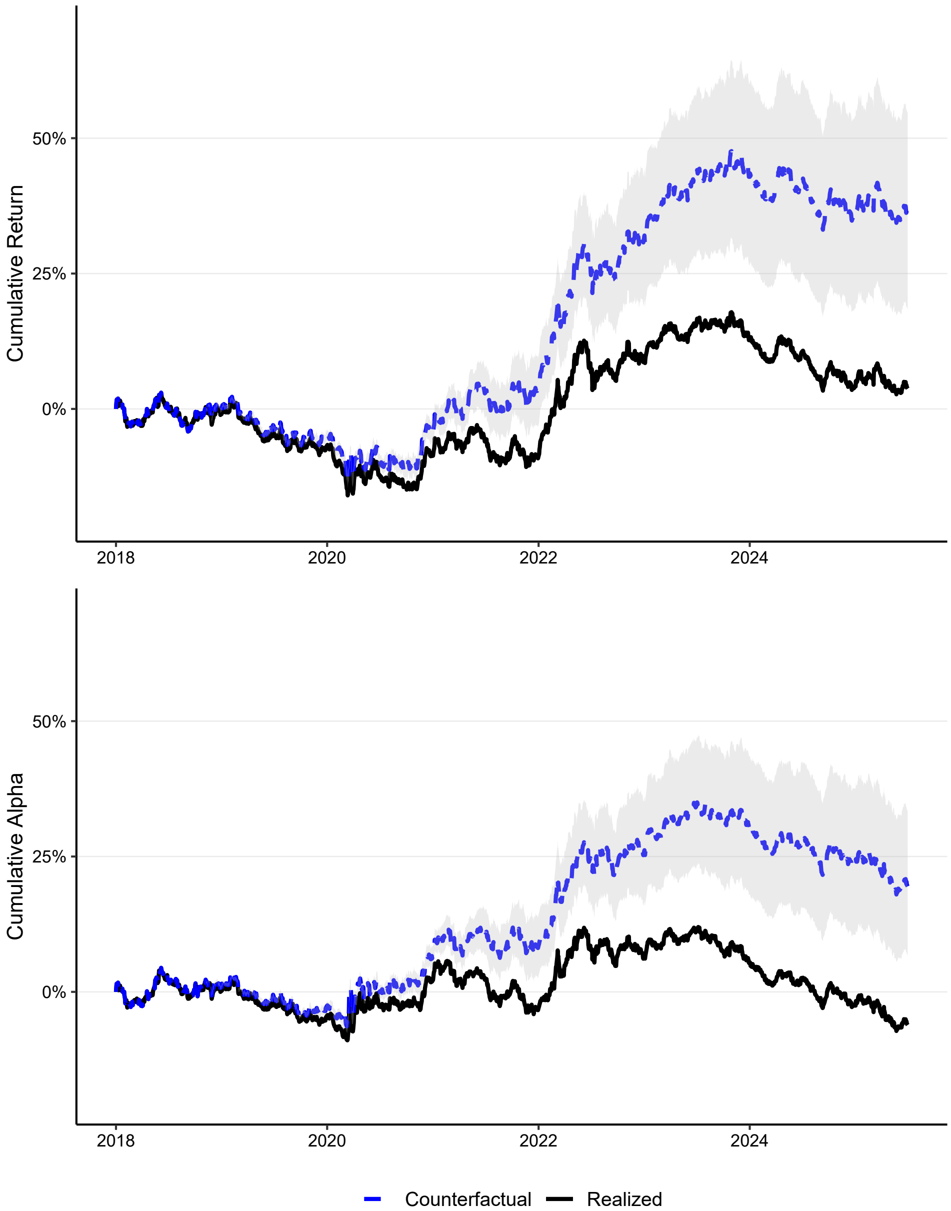
[11] The factors are downloaded from Kenneth French's website.

BMG performance without ECB Action shocks—is substantially positive, cumulating to over 30% over the same period. The realized return path lies entirely outside and below the 95% confidence interval of the counterfactual, indicating that the negative impact of ECB communication is both economically large and statistically significant.

The bottom panel, which uses the BMG alpha, confirms this finding. The realized alpha (black line) trends negative, finishing around -10%. The counterfactual alpha (blue dashed line) is again strongly positive, ending near +25%.

This analysis provides a new perspective on the green premium puzzle. Pástor et al. (2022) show that the BMG portfolio's underperformance was driven by unexpected "climate concern" shocks. Our findings reveal that the ECB's Action communication has become a primary, identifiable source of these shocks. The impact of this central bank communication is economically meaningful, imposing a significant "brown penalty" that has more than eliminated the carbon premium that might have otherwise existed in the European market.

Figure 9: Realized vs. Counterfactual Brown-Minus-Green (BMG) Performance



Note: The figure plots the cumulative performance of a daily Brown-Minus-Green (BMG) portfolio from 2018-2024. The top panel shows cumulative returns. The bottom panel shows cumulative Fama-French 5-factor alphas. The "Realized" line (black) is the actual BMG performance. The "Counterfactual" line (blue, dashed) shows the simulated performance after removing the effect of our ECB Climate Action shocks, based on Equation 3. The counterfactual regression controls for MCCC (Ardia et al., 2023) and TRI (Bua et al., 2024) news shocks. The shaded area is the 95% confidence interval from 1,000 bootstrap simulations.

4.5 Does Central Bank Communication Affect Corporate Bond Markets?

To test if these effects translate to credit markets, we conduct a similar analysis on corporate bond asset swap (ASW) spreads. We construct a daily panel by matching bond identifiers for European firms from the Eurosystem Centralised Securities Database (CSDB) with daily ASW spreads from Refinitiv Eikon. We first calculate daily changes in ASW spreads and winsorize them at the 5% and 95% levels to mitigate the influence of outliers. Our final database covers 2,065 bonds from 327 issuers over the period 2018-2025.

We estimate the same continuous interaction model as in Equation 1, with the cumulative change in the winsorized ASW spread as the dependent variable:

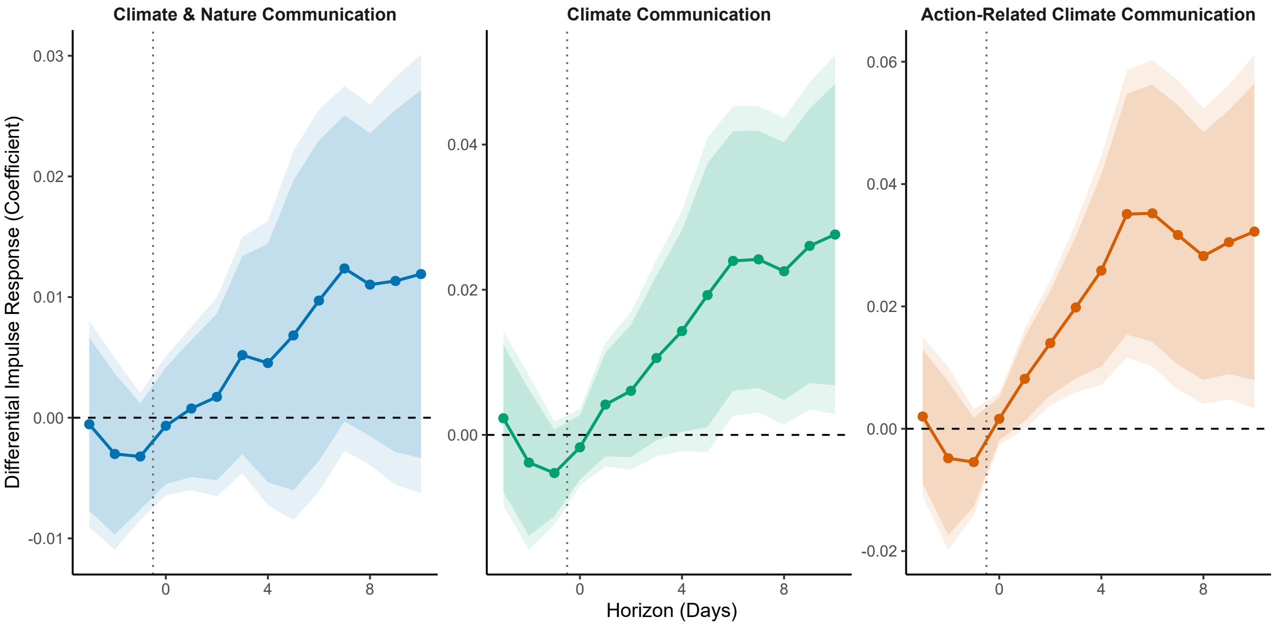
$$\Delta Spread_{i,t\rightarrow t+h} = \beta_{1,h} Shock_t^{ECB} + \beta_{2,h} Emission_{i,t} + \beta_{3,h}(Shock_t^{ECB} \times Emission_{i,t}) + \alpha_i + \delta_t + \epsilon_{i,t} \quad (5)$$

The specification includes bond fixed effects α_i and time fixed effects δ_t to control for unobserved heterogeneity.

Figure 10 displays the differential impact $\beta_{3,h}$. We find that climate communication leads to a positive and significant differential effect on spreads, indicating that high-emitting firms face increased credit risk and higher borrowing costs. This result is consistent with our findings from the stock market and related literature (Huynh and Xia, 2021; Seltzer et al., 2022).

Interestingly, the adjustment in the bond market appears slower and more persistent than that of the equity market. The differential spread rises steadily for six days post-shock. As shown in the panels, this effect is noisy and weak for the aggregate Climate & Nature Communication shock but becomes significant when focusing on Action-related climate communication. This reinforces our finding that bond investors, like equity investors, are pricing concrete policy actions.

Figure 10: Effect of Climate & Nature Communication on Corporate Bond Asset Swap Spread



Note: **The figure plots the differential impulse response coefficients ($\beta_{3,h}$) from the local projection model in Equation 5. The dependent variable is the cumulative change in the daily winsorized ASW spread. The model interacts the shock with standardized CO_2 emissions and includes bond and time fixed effects. The panels show the response to: (Left) the aggregate Climate & Nature Total shock, (Middle) the Climate Total shock, and (Right) the original Climate Action shock. The x-axis represents the horizon h in days. The solid line is the point estimate, and the dark and light shaded areas represent the 90% and 95% confidence intervals, respectively, based on robust standard errors clustered at the bond and time level.**

4.6 Discussion of Transmission Mechanisms

Our empirical results show that it is not central bank communication in general that moves markets, but the specific, credible signal of "Action" talk. We propose two complementary transmission channels to explain why this "Action" communication, and not "Materiality" rhetoric, drives the repricing of green and brown assets.[12]

First, "Action" talk is a direct signal of the central bank's future operations as a major, non-traditional market participant. This includes communication about adjusting its collateral framework or tilting its asset purchase programs towards greener assets. This mechanism is analogous to the preferred-habitat investor model of Vayanos and Vila (2021), which is widely used to explain the effects of large-scale asset purchases. In this context, the ECB, by credibly committing to future green purchases or collateral adjustments, signals its intent to act as a large, "green-preferred-habitat" investor. This creates an anticipated demand shock for green assets and a supply shock for brown. Arbitrageurs, due to risk aversion, do not fully offset this, leading to an immediate, negative price impact on brown assets (or a positive one on green) upon announcement, well before the purchases themselves occur (Istrefi et al., 2024; Lucca and Moench, 2015; Swanson, 2023).

Second, "Action" talk functions as a powerful coordinating signal that validates and strengthens private-sector environmental preferences. This is consistent with models where investors derive non-pecuniary utility from holding green assets (Pástor et al., 2021). When the ECB signals a concrete policy action, it legitimizes the green transition, which can increase customer demand for green products and, more importantly, amplify investors' "green tastes." This mechanism is formalized in the "ESG-efficient frontier" framework of Pedersen et al. (2021), where investors balance risk, return, and environmental characteristics. An ECB Action shock can be interpreted as a new, credible signal that increases the salience of the environmental factor, leading investors to tilt their portfolios toward the

[12] While these channels are not mutually exclusive, they provide a framework for understanding how central bank green communication can shape market expectations and behaviors.

"ESG-tangency portfolio" and away from brown assets. As Pástor et al. (2022) argue, an unexpected strengthening of these aggregate environmental concerns triggers the same dynamic we observe in our empirical results: a negative realized return shock for brown assets as the market re-prices this new information. Following this repricing, the cost of capital for brown firms rises, while it falls for green firms, potentially creating incentives for real economic change.

Both the preferred-habitat channel (à la Vayanos and Vila, 2021) and the preference-signaling channel (à la Pástor et al., 2021 and Pedersen et al., 2021) lead to a portfolio rebalancing effect that penalizes brown assets. This framework also explains our key finding: "Materiality" communication, which consists of general warnings about climate risk, has limited market impact. Such statements, disconnected from a credible commitment to policy action, are insufficient to trigger either the preferred-habitat or the preference-shifting mechanism and are therefore treated by markets as cheap talk.

5 Conclusion

This paper identifies a primary institutional source of the unexpected climate shocks that have driven the recent realized outperformance of green assets: the ECB's communication. By constructing the CB-CNC index, a novel high-frequency measure of sustainability communication derived from a Large Language Model, we are able to disentangle credible policy signals ("Action") from general risk commentary ("Materiality") and track the emergence of nature-related themes.

Our findings show that not all central bank talk is created equal. Only "Action" communication—signals of concrete policy interventions—operates as a systematic driver of asset repricing. We term this mechanism the "ECB's Green Put": a systematic policy shock that penalizes high-emission firms. The economic magnitude of this channel is substantial. Our counterfactual analysis reveals that, absent these specific ECB Action shocks, the theoretical "brown premium" would have materialized, resulting in a cumulative outperformance of brown assets of approximately 30% over the 2018–2025 period.

Conversely, we find that general "Materiality" statements are treated by markets as cheap talk, generating no significant pricing effects. Similarly, the ECB's emerging discourse on nature and biodiversity has not yet translated into asset repricing, likely because it has not yet been operationalized into credible policy tools. As central banks continue to expand their mandates, the CB-CNC framework provides a useful tool for tracking how these new frontiers of communication evolve from rhetoric into tangible market drivers.

References

Acharya, V. V., Giglio, S., Pastore, S., Stroebel, J., Tan, Z., and Yong, T. (2025). Climate transition risks and the energy sector. Technical report, CESifo.

Altavilla, C., Brugnolini, L., Gürkaynak, R. S., Motto, R., and Ragusa, G. (2019). Measuring euro area monetary policy. Journal of Monetary Economics, 108:162–179.

Ardia, D., Bluteau, K., Boudt, K., and Inghelbrecht, K. (2023). Climate change concerns and the performance of green vs. brown stocks. Management Science, 69(12):7607–7632.

Arseneau, D. M., Drexler, A., and Osada, M. (2022). Central bank communication about climate change. Finance and Economics Discussion Series 2022-031, Board of Governors of the Federal Reserve System.

Arseneau, D. M. and Osada, M. (2023). Central bank mandates and communication about climate change: Evidence from a large dataset of central bank speeches. Technical report, Bank of Japan.

Aswani, J., Raghunandan, A., and Rajgopal, S. (2024). Are carbon emissions associated with stock returns? Review of Finance, 28(1):75–106.

Atilgan, Y., Demirtas, O., Edmans, A., and Gunaydin, D. (2023). Does the carbon premium reflect risk or mispricing? Technical report, CEPR Discussion Paper No. 18594, Paris and London.

Bernanke, B. S. and Kuttner, K. N. (2005). What explains the stock market's reaction to federal reserve policy? The Journal of Finance, 60(3):1221–1257.

Bolton, P., Despres, M., Da Silva, L. A. P., Samama, F., and Svartzman, R. (2020). The green swan. BIS Books.

Bolton, P. and Kacperczyk, M. (2021). Do investors care about carbon risk? Journal of Financial Economics, 142(2):517–549.

Bolton, P. and Kacperczyk, M. (2023). Global pricing of carbon-transition risk. The Journal of Finance, 78(6):3677–3754.

Bua, G., Kapp, D., Ramella, F., and Rognone, L. (2024). Transition versus physical climate risk pricing in european financial markets: A text-based approach. The European Journal of Finance, pages 1–35.

Caldara, D. and Iacoviello, M. (2022). Measuring geopolitical risk. AER: Insights, 4(1):95–110.

Campiglio, E., Deyris, J., Romelli, D., and Scalisi, G. (2025). Warning words in a warming world: Central bank communication and climate change. European Economic Review, 178:105101.

Cieslak, A. and Vissing-Jørgensen, A. (2022). The credit policy of the ECB. Journal of Monetary Economics, 133:86–110.

Coqueret, G., Giroux, T., and Zerbib, O. D. (2025). The biodiversity premium. Ecological Economics, 228:108435.

Dasgupta, P. (2021). The economics of biodiversity: The dasgupta review. ISBN 978-1-911680-29-1; Available at: www.gov.uk/official-documents.

De Fiore, F., Maurin, A., Mijakovic, A., and Sandri, D. (2024). Monetary policy in the news: communication pass-through and inflation expectations. Bank for International Settlements, Monetary and Economic Department.

Dikau, S. and Volz, U. (2021). Central bank mandates, sustainability objectives and the promotion of green finance. Ecological Economics, 184:107022.

Ebeling, A. (2024). ECB's Climate Speeches and Market Reactions. Technical report.

ECB (2019). Speeches dataset.

Faccini, R., Matin, R., and Skiadopoulos, G. (2023). Dissecting climate risks: Are they reflected in stock prices? Journal of Banking & Finance, 155:106948.

Feldkircher, M. and Teliha, V. (2024). Speeches in the green: The political discourse of green central banking. Energy Economics, 135:107646.

Gambacorta, L., Kwon, B., Park, T., Patelli, P., and Zhu, S. (2024). Cb-lms: language models for central banking. BIS Working Papers 1215, Bank for International Settlements.

Garel, A., Romec, A., Sautner, Z., and Wagner, A. F. (2024). Do investors care about biodiversity? Review of Finance, 28(4):1151–1186.

Giglio, S., Kelly, B., and Stroebel, J. (2021). Climate finance. Annual Review of Financial Economics, 13(1):15–36.

Giglio, S., Kuchler, T., Stroebel, J., and Zeng, X. (2025). Biodiversity risk. Review of Finance, page rfaf063.

Giovanardi, F., Kaldorf, M., Radke, L., and Wicknig, F. (2023). The preferential treatment of green bonds. Review of Economic Dynamics, 51:657–676.

Gürkaynak, R. S., Sack, B. P., and Swanson, E. T. (2005). Do actions speak louder than words? the response of asset prices to monetary policy actions and statements. International Journal of Central Banking, 1(1):55–93.

Hansen, L. P. (2022). Central banking challenges posed by uncertain climate change and natural disasters. Journal of Monetary Economics, 125:1–15.

Hsu, P.-H., Li, K., and Tsou, C.-Y. (2023). The pollution premium. The Journal of Finance, 78(3):1343–1392.

Husted, L., Rogers, J., and Sun, B. (2020). Monetary policy uncertainty. Journal of Monetary Economics, 115:20–36.

Huynh, T. D. and Xia, Y. (2021). Climate change news risk and corporate bond returns. Journal of Financial and Quantitative Analysis, 56(6):1985–2009.

Ilhan, E., Sautner, Z., and Vilkov, G. (2021). Carbon tail risk. The Review of Financial Studies, 34(3):1540–1571.

Istrefi, K., Odendahl, F., and Sestieri, G. (2024). Ecb communication and its impact on financial markets. Documentos de Trabajo/Banco de España, 2431.

Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. American Economic Review, 95(1):161–182.

Känzig, D. R. and Raghavan, R. (2025). The macroeconomic effects of supply chain shocks: Evidence from global shipping disruptions. Unpublished manuscript.

Kölbel, J. F., Leippold, M., Rillaerts, J., and Wang, Q. (2024). Ask bert: How regulatory disclosure of transition and physical climate risks affects the cds term structure. Journal of Financial Econometrics, 22(1):30–69.

Lagarde, C. (2022). Imfc statement. https://www.ecb.europa.eu/press/key/date/2022/html/ecb.sp220421~589f9733bc.en.html. IMF Spring Meetings, 21 April 2022.

Leippold, M. and Yu, T. (2025). Firm-level green innovation beyond patents. Review of Finance. Advance online publication.

Livingstone, Z., Speer, S., Herbert, J., and Clavijo, M. (2024). The green central banking scorecard 2024 edition. https://www.datocms-assets.com/132494/1736848825-positive-money-green-central-banking-scorecard-report-2024-v8.pdf. Accessed: DATE.

Lucca, D. O. and Moench, E. (2015). The pre-fomc announcement drift. The Journal of Finance, 70(1):329–371.

Monasterolo, I. and de Angelis, L. (2020). Blind to carbon risk? an analysis of stock market reaction to the paris agreement. Ecological Economics, 170:106571.

Neszveda, G. and Siket, B. (2025). Green ecb speeches matter. Journal of Sustainable Finance Investment, 15(2):438–455.

Park, T., Perez-Cruz, F., and Shin, H. S. (2025). Mapping the space of central bankers' ideas. BIS Working Papers 1299, Bank for International Settlements.

Pástor, L., Stambaugh, R. F., and Taylor, L. A. (2022). Dissecting green returns. Journal of Financial Economics, 146(2):403–424.

Pedersen, L. H., Fitzgibbons, S., and Pomorski, L. (2021). Responsible investing: The esg-efficient frontier. Journal of Financial Economics, 142:572–597.

Pástor, L., Stambaugh, R. F., and Taylor, L. A. (2021). Sustainable investing in equilibrium. Journal of Financial Economics, 142:550–571.

Ramelli, S., Krueger, P., Wagner, A. F., Zeckhauser, R. J., and Ziegler, A. (2021). Investor rewards to climate responsibility: Stock-price responses to the opposite shocks of the 2016 and 2020 u.s. elections. Review of Corporate Finance Studies, 10(4):748–787.

Seltzer, L. H., Starks, L., and Zhu, Q. (2022). Climate regulatory risk and corporate bonds. Technical report, National Bureau of Economic Research.

Swanson, E. T. (2023). The importance of fed chair speeches as a monetary policy tool. AEA Papers and Proceedings, 113:394–400.

Vayanos, D. and Vila, J.-L. (2021). A preferred-habitat model of the term structure of interest rates. Econometrica, 89(1):77–112.

Zhang, S. (2025). Carbon returns across the globe. The Journal of Finance, 80(1):615–645.

Zhao, Y., Nagayasu, J., and Geng, X. (2024). Measuring climate policy uncertainty with llms: New insights into corporate bond credit spreads. Discussion Paper 143, Center for Data Science and Service Research, Tohoku University.

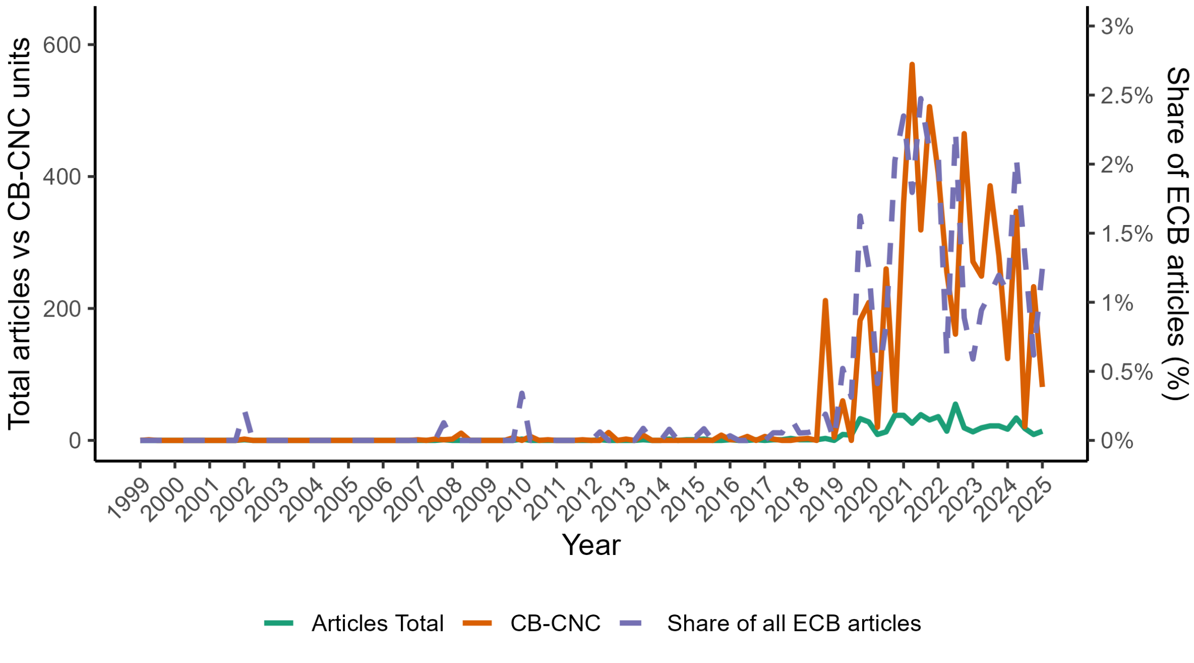
6 Appendix

6.1 Additional Information on the Use of Factiva

Table 4: List of Journals Used in the Factiva Analysis

Language	Journals
French	La Tribune; Les Echos; Les Echos Business; Challenges; L'AGEFI Alpha; L'AGEFI Actifs; L'AGEFI Quotidien
German	Handelsblatt; Börsen-Zeitung
English	The Washington Post; The Wall Street Journal; The New York Times; The Guardian; Forbes
Italian	Il Sole 24 Ore; Milano Finanza; ItaliaOggi
Spanish	Expansión; Cinco Días
Portuguese	Jornal de Negócios

Figure 11: CB-CNC Index versus Press Articles on Climate & the ECB (Title/Snippet Only)



Note: **The figure shows the CB-CNC index, the number of ECB-climate press articles, and their share of all ECB-related Factiva coverage, at a quarterly frequency. Compared to Figure 2, we restrict the articles to those where a climate term is included in either the article title and/or snippet.**

6.2 Additional Tables and Figures

Table 5: Summary of Climate and Nature Mentions by Speaker

This table lists the ECB stakeholders whose communications contain at least one unit related to climate or nature. The percentages represent each stakeholder's share of the total units devoted to this theme for all stakeholders included.

			Climate		**Nature**	
Speaker	Speeches	Total Units	Units	(%)	Units	(%)
Frank Elderson	39	2,435	2,023	38.1	412	86.2
Christine Lagarde	87	1,140	1,102	20.8	38	8.0
Isabel Schnabel	43	849	849	16.0	0	0.0
Fabio Panetta	19	430	425	8.0	5	1.0
Luis de Guindos	25	239	239	4.5	0	0.0
Benoît Cœuré	13	146	145	2.7	1	0.2
Piero Cipollone	2	142	142	2.7	0	0.0
Sabine Lautenschläger	6	128	128	2.4	0	0.0
Philip R. Lane	16	111	111	2.1	0	0.0
Yves Mersch	5	88	85	1.6	3	0.6
Jean-Claude Trichet	11	26	16	0.3	10	2.1
Mario Draghi	8	26	21	0.4	5	1.0
Gertrude Tumpel-Gugerell	1	5	5	0.1	0	0.0
Lorenzo Bini Smaghi	3	5	5	0.1	0	0.0
Tommaso Padoa-Schioppa	2	3	1	0.0	2	0.4
Vítor Constâncio	3	3	3	0.1	0	0.0
Jörg Asmussen	1	2	2	0.0	0	0.0
Sirkka Hämäläinen	2	2	0	0.0	2	0.4
Jürgen Stark	2	1	1	0.0	0	0.0
Total (All Speakers)	288	5,751	5,303	100.0	478	100.0

Table 6: Climate and Nature Units by Communication Type

This table presents the distribution of climate and nature units by communication type. Percentages for Action and Materiality are calculated as a share of their respective theme's total units.

	Climate			**Nature**		
Comm. Type	Units	% Action	% Materiality	Units	% Action	% Materiality
Press release	562	66.0	26.3	34	47.1	17.6
MP Statement	42	59.5	35.7	0	0.0	0.0
Q&A	230	74.8	13.0	0	0.0	0.0
Speeches	5,303	54.0	29.2	478	41.0	33.7
Total	**6137**	**55.9**	**28.4**	**512**	**41.4**	**32.6**

Table 7: Correlation Matrix of Final CB-CNC Daily Sub-Indices

This table reports the Pearson correlation matrix for the raw daily counts of the main CB-CNC sub-indices from January 1, 2018, onwards. Abbreviations are as follows: Clim. Tot. (Climate Total), Clim. Act. (Climate Action), Clim. Mat. (Climate Materiality), Nat. Tot. (Nature Total), Nat. Act. (Nature Action), and Nat. Mat. (Nature Materiality). The high correlation between Climate Action and Climate Materiality (0.74) motivates the orthogonalization procedure detailed in Section 4.2 to isolate the independent asset pricing effects of each shock.

	Clim. Tot.	Clim. Act.	Clim. Mat.	Nat. Tot.	Nat. Act.	Nat. Mat.
Clim. Tot.	1	0.96	0.88	0.12	0.12	0.11
Clim. Act.	0.96	1	0.74	0.12	0.12	0.11
Clim. Mat.	0.88	0.74	1	0.10	0.09	0.10
Nat. Tot.	0.12	0.12	0.10	1	0.97	0.94
Nat. Act.	0.12	0.12	0.09	0.97	1	0.86
Nat. Mat.	0.11	0.11	0.10	0.94	0.86	1

Table 8: Correlation of Adjusted Action and Materiality Indices

This table reports the Pearson correlation for the Adjusted (Adj.) daily Climate Action and Climate Materiality indices from January 1, 2018, onwards. These indices are constructed to mitigate the high co-movement observed in the raw sentence counts (see Table 7). The adjustment is performed by creating a high-focus dummy for each category, which equals one only on days where the share of Action (or Materiality) communication is above its historical mean. The final adjusted index is the original raw count multiplied by this dummy. As shown, this orthogonalization process successfully decorrelates the two series, allowing for an independent assessment of their market impact.

	Clim. Act. (Adj.)	Clim. Mat. (Adj.)
Clim. Act. (Adj.)	1.00	0.09
Clim. Mat. (Adj.)	0.09	1.00

Table 9: Correlation of CB-CNC Indices with External Climate News Shocks

This table reports the Pearson correlation matrix for our daily CB-CNC indices and external daily climate news shocks from January 1, 2018, onwards. All external indices are identified as the residuals from an AR(1) process. Abbreviations: ECB Clim. (ECB Climate Total), ECB Nat. (ECB Nature Total), MCCC (Media Climate Change Concerns, Ardia et al., 2023), TRI (Transition Risk Index, Bua et al., 2024), Faccini (IS) (International Summits news shock, Faccini et al., 2023), Faccini (ND) (Natural Disasters news shock, Faccini et al., 2023).

	ECB Clim.	ECB Nat.	MCCC	TRI	Faccini (IS)	Faccini (ND)
ECB Clim.	1.00	0.16	0.02	0.03	0.04	0.01
ECB Nat.	0.16	1.00	0.05	-0.03	-0.00	0.03
MCCC	0.02	0.05	1.00	0.10	0.10	0.15
TRI	0.03	-0.03	0.10	1.00	0.02	-0.03
Faccini (IS)	0.04	-0.00	0.10	0.02	1.00	0.13
Faccini (ND)	0.01	0.03	0.15	-0.03	0.13	1.00

Table 10: Effect of Climate Communication by Type

This table presents results from the local projection model (Equation 1) at horizon $h = 2$. The regression is estimated separately for four different communication types. The dependent variable is the 2-day cumulative log-return. The interaction term CB-CNC x CO_2 interacts the aggregate CB-CNC shock (for that specific communication type) with the standardized CO_2 emission intensity. All specifications include firm and time fixed effects. Robust standard errors, clustered at the firm and time level, are in parentheses. *, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.**

	Dependent variable:			
	2-day cumulative log-return			
	(1)	(2)	(3)	(4)
CO_2	0.02	0.02	0.02	0.02
	(0.02)	(0.02)	(0.02)	(0.02)
Mon. Policy x CO_2	0.001			
	(0.02)			
Q&A x CO_2		0.000		
		(0.002)		
Press Release x CO_2			0.001	
			(0.003)	
Speeches x CO_2				-0.001^{**}
				(0.000)
FE: Firm	Yes	Yes	Yes	Yes
FE: month-year	Yes	Yes	Yes	Yes
Observations	2,583,787	2,583,787	2,583,787	2,583,787
R^2	0.225	0.244	0.225	0.244
Adjusted R^2	0.224	0.243	0.224	0.243

Table 11: Robustness to Controlling for External Climate and Monetary Policy Shocks

This table presents robustness checks for the local projection model at horizon $h = 2$ (Equation 1). The dependent variable is the 2-day cumulative log-return. All specifications include firm and time fixed effects. Robust standard errors, clustered at the firm and time level, are in parentheses. *, **, and * indicate significance at the 1%, 5% and 10% levels, respectively. CB-CNC is our aggregate CB-CNC shock. Control variables are unexpected shocks from: MCCC (Media Climate Change Concerns, Ardia et al., 2023), TRI (Transition Risk Index, Bua et al., 2024), IS (International Summits, Faccini et al., 2023), ND (Natural Disasters, Faccini et al., 2023), and MP surprises (2-Year OIS abnormal shocks, Istrefi et al., 2024). All external climate indices are identified as the residuals from an AR(1) process. The daily monetary policy surprises is the sum of intra-day abnormal shocks.**

	Dependent variable:						
	2-day cumulative log-return						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CO_2	0.018	0.019	0.018	0.031	0.032	0.025	0.039^{*}
	(0.019)	(0.019)	(0.019)	(0.020)	(0.020)	(0.021)	(0.023)
CB-CNC x CO_2	-0.001^{***}	-0.001^{***}	-0.001^{***}	-0.001^{***}	-0.001^{***}	-0.001^{***}	-0.001^{***}
	(0.0003)	(0.0003)	(0.0003)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
MCCC (AR1) x CO_2		−0.004					0.005
		(0.011)					(0.013)
TRI (AR1) x CO_2			0.001				0.094
			(0.224)				(0.256)
IS (AR1) x CO_2				-0.017^{***}			-0.016^{**}
				(0.006)			(0.006)
ND (AR1) x CO_2					−0.004		−0.001
					(0.005)		(0.005)
MP surprises x CO_2						0.002	0.001
						(0.005)	(0.005)
FE: Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE: month-year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,924,678	2,924,678	2,923,529	2,703,442	2,703,442	2,569,081	2,379,140
R^2	0.275	0.275	0.275	0.276	0.276	0.269	0.269
Adjusted R^2	0.274	0.274	0.274	0.275	0.275	0.268	0.268

6.3 LLM Prompt Design and Validation

A central contribution of this paper is the granular, sentence-level classification of central bank communication. To create a robust classifier, we first conduct an initial human reading of a representative subset of ECB communications. This exercise reveals that the language used is complex, diverse, and nuanced.

This preliminary analysis shows that a simple keyword-based approach or an unsupervised topic model would be insufficient. For example, the "Action" category is not a homogeneous block. Our human reading reveals that it encompasses a wide spectrum of statements, including discussions of actual policies, proposed measures, and potential future tools. It also includes nuanced statements about policies deemed challenging or infeasible, and clarifications on the limits of the ECB's mandate.

Given this complexity, the classification prompt reported below was developed through an iterative process of refinement and human validation. We began with an initial schema, classified a subset of speeches using the LLM, and then manually reviewed the outputs against our own conceptualization of the categories. This feedback loop allowed us to refine the prompt's guiding principles to handle difficult cases—for example, explicitly instructing the LLM to distinguish between the act of conducting analysis (Action) and the findings of that analysis (Materiality). This process was repeated until the LLM's classifications consistently and accurately mirrored our intended schema. The final classifier demonstrates a sophisticated, context-aware understanding of the texts. The complete sentence-level classification dataset is available from the authors upon request.

LLM Prompt

You will be given the full content of a speech by a European central bank (ECB) member, followed by a numbered list of sentences extracted from it ("units"). Your task is to perform a thematic classification of EACH sentence. Use the full speech to understand the context for each sentence, but classify each sentence individually based on the schema below.

— GENERAL INSTRUCTIONS & GUIDING PRINCIPLES —

CRITICAL OUTPUT RULE: All sentences must be classified. Your response must only be a valid multi-line CSV with a header row. Each row must correspond to a single sentence from the provided list. Do not include any explanations or conversational text.

OUTPUT FORMAT: The CSV must contain these two columns: Sentence_Number, Classification_Code

GUIDING PRINCIPLES

* Semantic Focus: Base your classification on the sentence's underlying meaning and intent, not just on keywords.

* Pronoun Assumption: When the speaker uses "we," "us," or "our," assume they refer to the ECB, unless the context explicitly states otherwise (e.g., "we, as Europeans").

* Dominant Theme: If a sentence covers multiple topics, classify it based on its primary theme.

* Analysis vs. Findings: For sentences mentioning analytical work (e.g., research, analysis, stress tests), classify based on the main point. If the focus is on the act of conducting the work, classify it as an Action (Rule A). If the focus is on the findings or results, classify it as Materiality (Rule B) or General (Rule C).

— CLASSIFICATION SCHEMA —

Assign one classification code to each sentence by following these steps.

STEP 1: Assign a Primary Theme (T1–T3) T1 – Climate Focus: Topics related to climate change, global warming, green transition, decarbonisation, carbon markets(ETS), climate-related financial risks, etc. T2 – Nature Biodiversity Focus: Topics related to nature, biodiversity loss, ecosystems degradation, natural resources, water scarcity, pollution, etc. T3 – Other: Any sentence that does **not** meet the T1 or T2 definitions. (If classified as T3, stop here. No further sub-classification is needed.)

STEP 2: Assign a Subcategory (Rules A, B, or C) If a sentence is T1 or T2, assign a **subcategory label** using the rules below:

RULE A – Action-oriented (policies, tools, measures, mechanisms, mandates, etc.) Mentions, discussions, or evaluations of actual, proposed, potential, missing, or conceptual actions-related themes including not only affirmations of action but also those presented as challenging, infeasible, or that should have been done in the past, and those statements clarifying the limits of institutional roles.

- ** Actor: The ECB**

    - Monetary Policy (including collateral framework): T1_A_ECB_MP / T2_A_ECB_MP

    - Non-Monetary Portfolios (i.e., related to own funds and staff pension fund): T1_A_ECB_NMP / T2_A_ECB_NMP

    - Financial Supervision (e.g., climate stress tests): T1_A_ECB_FS / T2_A_ECB_FS

    - Other ECB Actions: T1_A_ECB_Other / T2_A_ECB_Other

- ** Actor: Others (i.e. government or society, supranational institutions, private sector or finance, unspecified or other)**

    - Government or Society: T1_A_Others / T2_A_Others

RULE B – Materiality Statements that describe or imply the material connection (risks, opportunities, impacts, or dependencies) between climate/nature and human systems (economy, financial system, or society) – including general statements, questions, warnings, references to awareness, acknowledgment, or double materiality. To build the classifi-

cation code, follow the two steps below. Combine the parts from Steps B1 and B2 to create the final code.

STEP B1: **Determine the main climate/nature aspect under consideration**

- Transition-related – Focus on the shift to a low-carbon/sustainable economy (e.g., policy changes, new technology, market sentiment, consumer preferences, litigation risk): T1_B_T / T2_B_T

- Physical-related - Focus on direct physical events or environmental degradation (e.g., floods, droughts, biodiversity loss): T1_B_P / T2_B_P

- General/Other: T1_B_Other / T2_B_Other

STEP B2: **Identify the human system under consideration**

- Economy: _E

- Financial system: _F

- Other/Global: _Other

Example: A sentence about transition risks affecting the financial sector → T1_B_T_F A sentence about biodiversity loss impacting society → T2_B_P_Other

RULE C – General (non-specific statements) General claims, beliefs, or values not describing specific actions or materiality: T1_C / T2_C

To illustrate the granularity of the final classification, Table 12 provides representative sentences for our key categories, drawn from the classified data.

Table 12: Detailed Examples of LLM Sentence Classification

This table shows examples of sentences from ECB communications and the corresponding classification assigned by the LLM.

Code	Speaker	Example Sentence	Date
A. Climate Action (T1_A)			
ECB: Monetary Policy	Benoît Cœuré	The ECB has purchased "green bonds" both under its public sector and corporate sector purchase programmes.	2018-11-08
ECB: Financial Supervision	Sabine Lautenschläger	So, we must monitor green finance just as we would monitor any other type of financial innovation.	2018-10-30
ECB: Non-Monetary Portfolios	Christine Lagarde	Investing parts of the own funds portfolio in the green bond fund of the Bank for International Settlements marks another step in this direction.	2021-01-25
Other Actors	Fabio Panetta	The Fit for 55 package aims to put the EU on course to meet its target of achieving a reduction of at least 55% in greenhouse gas emissions by 2030, relative to 1990 levels.	2022-07-01
B. Climate Materiality (T1_B) & General (T1_C)			
Transition Risk	Luis de Guindos	On aggregate, euro area bank exposures to the most carbon-intensive sectors, such as mining, are relatively contained.	2021-05-27
Physical Risk	Frank Elderson	As natural disasters become both more frequent and more severe, insurance costs are expected to rise.	2023-05-05
General	Isabel Schnabel	Climate scientists attribute these records to human-made climate change, exacerbated by the arrival of El Niño.	2023-09-05

6.4 Climate and Nature Dictionnary

Table 13: Climate and Nature Dictionary

This table presents our climate and nature dictionnary for the initial pre-processing step. The dictionary contains 212 N-grams related to climate and nature, listed alphabetically.

afforestation	climate transition	green tech	paris-compatible
agroecology	climate-nature	green transition	permafrost
air pollution	climate-related	greener econom	physical and transition
biodiversity	coastal area	greener energ	physical risk
biofuel	coral bleach	greenflation	plastic pollution
biological diversity	corporate sustainability	greenhouse effect	pollinat
carbon border	carbonis	greenhouse gas	polluting industr
carbon capture	deforestation	greening monetary policy	pollution control
carbon cycle	disorderly transition	greening portfolio	reforestation
carbon dioxide	dwindling ecosystem	greening the financial system	renewable energ
carbon emission	earth overshoot day	greenwashing	renewable source
carbon footprint	ecological corridor	habitat fragmentation	repowereu
carbon neutrality	ecological footprint	habitat restoration	scope 1 and 2 emission
carbon offset	ecosystem collapse	high-emitting	scope 1 emission
carbon pricing	ecosystem degradation	hydropower	scope 1, 2, and 3 emission
carbon sink	ecosystem service	invasive alien species	scope 2 emission
carbon storage	ecosystem tipping point	ipbes	scope 3 emission
carbon tax	emissions trading	ipcc	sea level
carbon-free	energy efficiency	just transition	sea-level
carbon-intensive	energy transition	keystone species	smart grid
circular economy	environmental cris	kyoto protocol	soil degradation
clean air	environmental degradation	land degradation	soil erosion
clean tech	environmental impact	land use	soil health
clean water	environmental justice	late-push transition	solar energ
climate action	environmental legislation	low-carbon	species richness
climate adaptation	environmental performance	mangrove	stranded asset
climate and energ	environmental polic	methane emission	surface temperature
climate and environm	environmental protection	microplastic	surface water
climate and natur	environmental regulation	mitigation and adaptation	sustainable and responsible
climate- and nature-	environmental risk	natural capital	sustainable energ
climate change	environmental, social, and governance	natural catastrophe	sustainable tech
climate commitment	erosion control	natural disaster	tidal energ
climate crisis	esg	natural environment	toxic waste
climate equity	eutrophication	natural hazard	transition polic
climate event	extreme weather	natural resource	transition risk
climate goal	fertile soil	natural scientist	transition scenario
climate hazard	fishing stock	nature crisis	trophic level
climate impact	flood and storm	nature degradation	unfccc
climate justice	forest fire	nature loss	water contamination
climate law	fossil fuel	nature protection	water cycle
climate mitigation	fossilflation	nature restoration	water flow
climate model	geothermal energ	nature's service	water management
climate neutrality	global heating	nature-based	water pollution
climate performance	global warming	nature-related	water quality
climate polic	green bond	net zero	water scarcity
climate projection	green deal	net-zero	water stress
climate resilience	green financ	ngfs	water suppl
climate risk	green fiscal	ocean acidification	weather event
climate scenario	green hydrogen	ocean ecosystem	weather-related
climate science	green innovation	orderly transition	wetlands
climate stress	green investment	overfishing	wildlife
climate summit	green lend	paris agreement	wind energ
climate tipping point	green loan	paris-aligned	wind power