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Pricing Climate Transition Risk: Evidence from European Corporate CDS*

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The European low-carbon transition began in the last few decades and is accelerating to achieve net-zero emissions by 2050. This paper examines how climate-related transition indicators of a large European corporate firm relate to its CDS-implied credit risk across various time horizons. Findings show that firms with higher GHG emissions have higher CDS spreads at all tenors, including the 30-year horizon, particularly after the 2015 Paris Agreement, and in prominent industries such as Electricity, Gas, and Mining. Results suggest that the European CDS market is currently pricing, to some extent, albeit small, the exposure to transition risk for a firm across different time horizons. However, it fails to account for a company's efforts to manage transition risks and its exposure to the EU Emissions Trading Scheme. CDS market participants seem to find challenging to risk-differentiate ETS-participating firms from other firms.

JEL classification: G1, E58, G32, Q51, D53

Keywords: climate change; transition risk; credit risk; credit default swap; emissions trading system (ETS); financial markets

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"Climate change is the Tragedy of the *Horizon*." Marc Carney (2015)[1]

1 Introduction

Limiting global warming requires reducing substantially the greenhouse gases that economies emit. Transitioning to a lower-carbon economy involves extensive policy, legal, technology, and market changes. Financial risks that could result from the process of adjustment towards a lower-carbon economy are referred to as transition risk and represents one of the channels through which climate change can affect credit risk and financial stability (Carney, 2015).[2] Climate action and emission reduction are not a new phenomenon in Europe by comparison with other advanced economies such as the U.S.A, yet reaching net-zero by 2050 will require more efforts than the ones observed historically as reported in Figure 1.

The European Union has been gradually reducing its level of greenhouse gases (GHG) by over 20% in 2020 since its 1990 levels. This emission reduction was to a large extent achieved due to public policies such as the creation in 2005 of the first carbon market worldwide, the EU Emissions Trading Scheme (ETS). The EU net-zero target for 2050, which was enforced in 2019, is accompanied by a set of policies aimed to foster the low-carbon transition and by evolving market sentiment of investors (e.g., fossil fuel divestment, clean energy investment). However, concerns over climate-related financial risks only recently became more prevalent in the financial sector. This is partly due to the very long horizon of the low-carbon transition, i.e., 30 years, which goes beyond the time horizon of standard credit metrics, i.e. 2-3 year time horizon for credit ratings.

In this paper, we aim at assessing how the European market of credit default swaps reflects the relation between climate-related transition indicators[3] and credit risk at different

[1] Quote from the speech "Breaking the tragedy of the horizon - climate change and financial stability" given by the former Governor of the Bank of England and Chairman of the Financial Stability Board - see Carney (2015)

[2] See for instance BCBS (2021) and Alogoskoufis et al. (2021) for an outline of the transmission channel.

[3] The choice of the term "indicators of firm's transition risk" follows the terminology employed for instance in FSB (2021) and ECB (2021a). The detailed description of each indicator is provided in

time horizons. Single-name corporate CDSs are the primary markets for price discovery when compared to corporate bonds and often also lead equity markets in processing new information about underlying reference entities. We construct a dataset covering firm-level greenhouse gas emissions and transition management indicators, alongside standard determinants of CDS-market-implied credit risk. Given the very long time horizon of the low-carbon transition, the metrics of CDS-market-implied credit risk that we collect are the 1, 5, 10, and 30-year CDS spread.[4] The data covers European large corporate firms over the time period 2010 – 2021. All the data sources used in this study are either from commercial data providers that are widely used by financial institutions or public data. For instance, the CDS data is collected from IHS Markit and the transition risk indicators are collected from Bloomberg, Refinitiv, the Carbon Disclosure Project, and the EU Transaction Log. The choice of these data sources is deliberate to approach as much as possible the environment of data sources available to CDS market participants.

Taking as a base common CDS model specifications proposed in the CDS literature, we construct a panel regression and a difference-in-differences approach to assess how climate-related transition indicators relate to CDS-implied credit risk. Our findings show that firms with higher GHG emissions have higher CDS spreads at the 5, 10, and 30-year tenor, which reflect medium, long, and very-long-term credit risk time horizons, respectively. The relation appears to be causal as confirmed in a difference-in-differences analysis around the Paris Agreement that signalled a shift in climate-related policies and market sentiment. Following this event, high polluting European firms display higher CDS spreads than other European firms in the sample. This result is mainly driven by high emitters in salient industries, such as Electricity, Gas, and Mining. When considering a firm's efforts to mitigate its exposure to transition risk, findings show that CDS market participants do not appear to consider mitigation based on indicators of a firm's transition management efforts such as emission reduction targets, climate policies, remuneration,

sections 3.3 and 3.4. The results for each indicator are presented in sections 5.1-5.4.

[4]It is acknowledged that the liquidity for 30 year CDS instruments is lower than that of other CDS instruments and such contracts may be used for speculative strategies particularly. As such, our findings on the 30-year-CDS shall be read with these considerations in mind.

and / or risk management related to the energy transition. Finally, the results on the ETS participating firms suggest no differential treatment by the CDS market of GHG emissions (Scope 1) depending on the fact whether the firm is subject to the carbon market, i.e. ETS, and herewith directly exposed to emissions costs or not. Possible explanations for this empirical finding could be that CDS market participants find it difficult to risk-differentiate ETS-participating firms from other firms. The difficulty could be in leveraging the necessary data or in forming expectations on carbon price, i.e., EUA price. Also, CDS market participants are likely not considering in their assessment of a firm's credit risk positive ETS-related cash flows derived from a surplus of free allowances. As such, either CDS markets participants do not consider this information - pointing to a market inefficiency - or this is reflecting an agency problem. The EU ETS market may incentivize firms to purchase allowances instead of reducing emissions, creating an agency problem. An ETS-regulated firm may find more costly to make investments to change its operations to reduce emissions than to buy emissions allowances. The cost of emissions allowances may not be fully factored in by CDS market participants, as there is a lack of pricing differentiation. Additionally, changing a company's business model to reduce emissions could potentially increase its credit risk. Overall, the results in this paper suggest that the European CDS market is already pricing to some extent, albeit small, the GHG emissions (Scope 1) of a firm, but much of the available information on other climate-related transition indicators than GHG emissions is not yet embedded by CDS market participants, who are predominantly banks.

This paper is related to the wide and emerging literature on the pricing of climate-related transition risk in the financial system and more broadly to the literature on climate economics (see for instance the seminal work of Nordhaus, 1991). The first studies in the literature on the pricing of climate-related transition risk inspected the link to the CDS market using third-party corporate social responsibility (CSR) scores, ESG scores, and/or environmental scores as proxies for climate-related transition risk (Höck et al., 2020; Truong and Kim, 2019; Gao et al., 2021; Drago et al., 2019). Yet, such scores were shown later to have many shortcomings that discard them as adequate transition risk indicators (see for instance Boffo and Patalano, 2020). Due primarily to large discretion in environmental score methodology, such scores are often inconsistent over time, incomparable across firms and sectors, at times unreliable, and display a very low correlation when compared across different providers (Berg et al., 2022; Billio et al., 2021; Schnabel, 2020). By comparison with such scores, GHG emissions - as well as other raw indicators on transition risk (by comparison with composed metrics) - are a better base for assessing what market participants do price of transition risk and are exploitable under informed methodological choices that acknowledge and address caveats on availability, reliability, and comparability of such data (see for instance Busch et al., 2020; Kalesnik et al., 2020).

Instead of environmental scores, recent work has been focusing on firm-level GHG emissions. For instance, several studies explore the link between firm-specific GHG emissions and stock returns (Bolton and Kacperczyk, 2020, 2022), while the empirical literature pertaining to the European carbon market study in addition the link between carbon certificates and stock returns (Oestreich and Tsiakas, 2015; Brouwers et al., 2016). Another stream of literature investigates how the bond market, the syndicated loan market, and ratings relate to firm-level emissions.[5] However, GHG emissions taken alone do not reflect a firm's adaptation and mitigation efforts, which are necessary to assess a firm's transition risk in its entirety (see for instance EBA, 2021).

Another emerging stream of literature attempts to develop methods for measuring transition risk on firm-level (Sautner et al., 2023a; Ilhan et al., 2023, 2021; Sautner et al., 2023b) and use such composite metrics to investigate the relationship to CDS-implied credit risk (Kölbel et al., 2020; Blasberg et al., 2022; Zhang and Zhao, 2022). By comparison with this stream of work, this paper does not aim to measure transition risk, but rather to assess whether there is evidence of any form of pricing of transition risk indicators by CDS market participants in the past decade. The reason for this inquiry is that - particularly since 2015 - banks and investment firms have increasingly published commit-

[5]See for instance, Carbone et al. (2022); Kabir et al. (2021); Capasso et al. (2020); Seltzer et al. (2020); Safiullah et al. (2021); Ehlers et al. (2021); Kacperczyk and Peydró (2022).

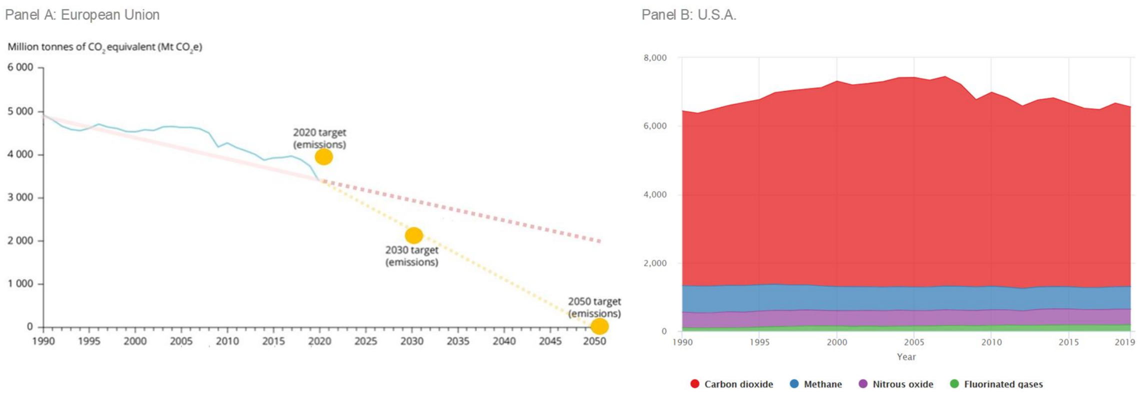
ments to support the low-carbon transition and account for climate-related transition risk (for bank commitments - see Kacperczyk and Peydró, 2022). However, commitments do not per se guarantee that financial market participants take action (ECB, 2022). One of the main challenges cited as impediment by financial market participants for accounting for transition risk are the data needs. Indeed, caveats on availability, reliability, and comparability of data on GHG emissions, emissions reduction targets and other indicators of a firm's transition exist. Yet, as emphasized by the Network for Greening the Financial System and the European Central Bank, such caveats should not prevent market participants from better leveraging already available data sources, using proxies, and exploiting such data under informed methodological choices (NGFS, 2021; Elderson, 2021).

We contribute to the literature on pricing climate related transition risk in three ways. First, thanks to the CDS term structure, we assess the relation between climate-related transition risk and credit risk for a variety of maturities, ranging from short-term to very-long-term credit risk. This provides a comprehensive picture of the time horizon of transition priced by the CDS market. Second, we evaluate transition risk in its whole by considering both GHG emissions and a firm's efforts to reduce emissions as well as a firm's exposure to the carbon market. Third, financial risks posed by climate change, i.e. physical and transition risks, are considered so unprecedented that very little reliance can be placed upon historical data to assess their magnitude (BCBS, 2021). However, in geographies were the transition already started decades ago, one can learn from historical data about the initial magnitude of the effect of climate-related transition risk on credit risk. This initial magnitude can partially inform the set of possible future values of magnitude of the effect of climate-related transition risk on credit risk. We obtain such estimates of magnitude by exploiting the unique setup of the European low-carbon transition, where - by comparison with other advanced economies such as the US - an up-and-running carbon market and actual emission reduction have been already observed over the past decade.

The remainder of this paper is organized as follows. Section 2 explains the background and outlines the hypotheses explored in this paper. Section 3 describes the dataset while

4 describes the research design. Section 5 presents and discusses the results for each hypothesis. Finally, Section 6 concludes.

Figure 1: EU Greenhouse Gas (GHG) in the European Union and in the United States.



Notes: Panel A: Historical GHG emissions (blue line) of European Union's member states, historical trend (red line) and future trend based on targets (yellow line). Source: European Environmental Agency and authors' adaptation `https://www.eea.europa.eu/data-and-maps/figures/greenhouse-gas-emission-trend-projections`. Panel B: Historical GHG emissions of United States. Y-axis: Million tonnes eCO2. X-axis: Time period 1990 - 2019 in years. Source: United States Environmental Protection Agency `https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks`. Y-axis: Million tonnes eCO2. X-axis: Time in years.

2 CDS-implied risk and tested hypotheses

In this section, we present the economic mechanism pertaining to CDS-implied credit risk and transition risk and outline the set of hypotheses that we test empirically.

A single name CDS is a credit derivative, where the buyer of a single name CDS pays to the seller a periodic amount over the tenor of the contract. In exchange for these payments, she gets protection against the occurrence of a credit event (e.g., default of the reference firm). If the credit event occurs, then the seller of the CDS contract compensates the buyer for the difference between the par value and the market value of the reference bond. Clearly, a higher spread for the CDS indicates greater perceived credit risk for the reference entity.

The CDS term structure reflects the shape of future losses (expected and unexpected) associated with the reference entity over different time horizons (i.e., 1, 5, 10, and 30 years). Its slope reflects the relative movement between short-run and long-run credit risk. The dynamic and trading activity of CDS spreads can be driven by name or sector-specific news events; for instance, the 2015 emissions scandal saw a significant increase in activity in Volkswagen's CDS (Q3-Q4 2015), while the 2015 drop in oil prices (oil price falls to 11-year low in December 2015) prompted increased trading volumes in energy sector names (i.e., Glencore).

Transition risks to a low-carbon economy might also affect CDS spreads depending on their timing and speed. These include changes in public sector policies (e.g., net-zero policies), technological innovation and changes in the affordability of existing technologies (e.g., electric cars), and changes in market sentiment of investors (e.g., ESG or clean energy investment, fossil fuel divestment), as well as of consumers (e.g., air travel). An acceleration in these drivers may increase a firm's exposure to transition risk.

A key variable for assessing a firm's exposure to transition risk is the level of its GHG emissions. Under the GHG protocol, these emissions are categorized under three *Scopes* for accounting and reporting purposes:

- *Scope 1.* It corresponds to the direct emissions of the firm from owned or controlled sources.
- *Scope 2.* It relates to the emissions associated with the firm's consumption of purchased energy.
- *Scope 3.* It includes all emissions that occur in the value chain of the firm, excluding Scope 2.[6]

The historical data availability on firm-specific GHG emissions reflects a fragmented landscape of disclosure requirements. The disclosure of emissions from owned or controlled sources (Scope 1) has been mandatory in some European countries but not in all (i.e., the UK starting from 2013). Also, where a firm does report its GHG emissions

[6]Generally, Scope 3 represents the highest emissions' category as it includes, among others, the emissions stemming from the usage of products sold by the firm (downstream emissions) as well as emissions stemming from the suppliers manufacturing the inputs (upstream emissions).

under Scope 1, it might not necessarily report the ones under Scope 2 and/or Scope 3. The resulting data landscape of firm-specific GHG emissions of listed companies is a relatively good coverage for self-reported GHG emissions under Scope 1, a somewhat lower coverage for Scope 2 and a very low coverage for Scope 3, which is affected by severe measurement challenges (Busch et al., 2020; Kalesnik et al., 2020). Recent emerging literature explores firm-specific self-reported and/or inferred GHG emissions data (see among others, Safiullah et al., 2021; Ehlers et al., 2021; Bolton and Kacperczyk, 2021a). The majority of these studies find a significant relation for Scope 1 GHG emissions and the financial variable of interest while evidence for Scope 2 and Scope 3 GHG emissions is ambiguous.

In the light of the above considerations, this study focuses on firm-specific self-reported GHG emissions under Scope 1 as an indicator of a firm's exposure to transition risk and the transmission mechanism to credit risk through the production costs channel described below.

2.1 Transition risk and credit risk time horizon

The transition to a low-carbon economy requires a long time horizon. The European Union's target for achieving net-zero is 2050 with an intermediate target of achieving a GHG reduction of 55% by 2030 (compared to its 1990 level of GHG emissions). Exposure to transition risk may affect the credit risk of a firm through higher operating costs, lower revenues, higher debt, and stranded assets. In the transmission mechanism through the production costs channel, operating costs may be affected by the government climate policy on carbon price and energy price. Carbon prices e.g., EUA price[7], may increase a firm's production costs proportionally to their Scope 1 emissions that are subject to the carbon market (e.g., EU ETS). Moreover, where a carbon tax raises the cost of purchasing goods whose consumption emits greenhouse gases, firms' revenues may be

[7]The carbon certificate under the EU ETS is the European Union Allowance (EUA). One EUA gives the holder the right to emit one tonne of carbon dioxide (CO2), or the equivalent amount of nitrous oxide (N2O) or perfluorocarbons (PFCs).

negatively affected, especially if they operate in high polluting sectors. To minimize the downside impact and remain competitive, firms need to adapt their business models. Analogously, firm's leverage may increase given that firms would have to raise additional capital to finance the change of their existing GHG-intensive production processes to more sustainable ones. Firms which have already a high leverage profile may encounter a financing constraint to leverage additional capital.

Finally, as one of the transition drivers is innovation, it is important to consider possible competition-related market pressures on the business models and ultimately future revenues of firms failing to adapt. For instance, competition with new green technologies may create pressure on the revenues of incumbents and increase their credit risk (see, for instance, Alogoskoufis et al., 2021; BCBS, 2021; Maurin et al., 2021).[8] If transition drivers significantly increase a firm's costs, reduce its revenues, and ultimately reduce its ability to repay and service debt, the credit risk associated with this firm increases. Therefore, uncertainties surrounding the timing and speed of the transition represent a source of risk for a firm with high GHG emissions. We develop the following hypothesis:

H1. The European single name CDS market reflects a positive relationship between a firm's exposure to transition risk and the CDS-implied credit risk term structure.

Accordingly, the assessment of transition risk includes information disclosed by the firm on its exposure to this risk and on the firm's strategy how to deal with it. We assess the firm's management of transition risk through a set of climate-transition-related indicators covering targets, climate-related internal governance (policies and remuneration), and risk management practices (e.g., internal CO2 pricing). These practices reflect the firm's effort in the transition to a low carbon economy and should be associated with lower credit risk. Hence, we formulate the second hypothesis:

[8] On January 27, 2021, the Guardian was writing "Rating agency S&P warns 13 oil and gas companies they risk downgrades as renewables pick up steam" - `https://www.theguardian.com/business/2021/jan/27/rating-agency-sp-warns-13-oil-and-gas-companies-they-risk-downgrades-as-renewables|-pick-up-steam`

H2. The European single name CDS market reflects a negative relationship between a firm's efforts to manage its exposure to climate-related transition risk and the CDS-implied credit risk term structure.

Regardless the self-reported GHG emissions, a firm is required to report emissions on certain activities that are subject to the Emission Trading System (EU ETS). The EU ETS was launched in 2005 as the first carbon market worldwide, which is to date still the world's biggest carbon market and represents a fundamental element in the EU's policy on climate change, as it is a key tool for reducing greenhouse gas emissions cost-effectively in European countries.[9] It operates on the principle of cap-and-trade, where an overall emissions cap is set for the whole system. Under such a scheme, the basic principle states that whether a firm emits more than the amount of carbon certificates that it holds, it must buy additional certificates from firms that are polluting less. Conversely, if a firm emits less than the amount of carbon certificates that it holds, the firm can sell the excess carbon certificates to firms that are polluting more. The carbon certificate under the EU ETS is the European Union Allowance (EUA): one EUA gives the holder the right to emit one tonne of carbon dioxide (CO2), or the equivalent amount of nitrous oxide (N2O) or perfluorocarbons (PFCs).[10] EUAs are either allocated to firms for free or they are auctioned. The allocation rules are established for each trading period (or phase). Since its launch in 2005, EU ETS run three trading periods (2005-2007, 2008-2012, 2013-2020) and is currently in its fourth phase (2021-2030). The price of an EUA was relatively low since the launch of the ETS in 2005, yet during phase 3 (2013-2020) it increased from EUR 4.43 per tonne eCO2 to 48.25, i.e., an increase of over 1000%, particularly steep since 2017. Hence, the EU ETS a carbon market that puts an explicit

[9]The United Kingdom was part of the EU ETS until it established its own carbon market in May 2021.

[10]The EU ETS does not cover all types of greenhouse gases. Particularly, methane (CH4), which is the type of greenhouse gas with the highest coefficient of global warming, is not included in EU ETS. The EU accounts for 2.3% of global methane emissions and represents a small share in comparison with the Russian Federation and the United States being responsible for 15% and 14% of global emissions, respectively. Yet, the EU is the largest buyer of natural gas on the international market – having a 46% share - buying mainly from the Russian Federation, Norway, Algeria, Nigeria, Qatar, and the United States.

price on the emissions of a firm resulting from economic activities subject to the EU ETS, while such an explicit price does not exist for firms with activities not subject to the EU ETS. Against this background, we develop the following hypothesis:

H3a. The European single name CDS market reflects a different relationship between a firm's exposure to transition risk and the CDS implied credit risk depending on the fact whether the firm is subject to the carbon market, EU ETS, or not.

The allocation of free EUAs to firms is primarily done based on the carbon leakage concept where firms in carbon-intensive and trade-exposed industries are given compensation to prevent those firms from relocating. This concept has been disputed since it may overly compensate firms for the risk of relocation as shown by Martin et al. (2014). Over time, the market experienced several reforms addressing shortcomings of the original design.[11]

The "Market Stability Reserve" (MSR) reform of the EU ETS Carbon Market was confirmed in February 2017 by the EU Parliament and the EU Council. The reform focused on how to absorb the structural oversupply of EUA and make the total supply of emission allowances more flexible, and hence intended to make carbon emissions more expensive for firms.[12] These proposals have been transposed into legislation in November 2017 and the MSR has been operationalised in January 2019 to remove the excess supply of EUA from the market and store the excess in a reserve.[13] Firms with an EUA surplus are expected to have additional liquidity that they can tap in, by comparison with firms with an EUA deficit, which have to engage resources to compensate for the deficit.

Hence, this mechanism may affect a firm's credit risk. Oestreich and Tsiakas (2015) show based on a sample of German firms that receiving free EUAs is associated with higher stock returns, which may be attributable to higher cash flows for the firm. Brouw-

[11] One of the main issues was the surplus of allowances that accumulated in the EU ETS that has led to lower carbon prices and thus a weaker incentive of firms to reduce emissions. Another important issue is that firms pass through the costs of their emissions over to consumers in the product prices that they charge, e.g., electricity companies.

[12] More information on the MSR may be found on `https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets/market-stability-reserve_en`

[13] In 2019, the number of EUA allocated for free and auctioned has been the lowest ever observed since the initiation of the EU ETS in 2005.

ers et al. (2016) show that disclosure of a shortfall of allowances appears to be relevant for returns if carbon price is high and the scarcity of EUA is anticipated and particularly for firms less able to pass through environmental costs. Therefore, we state the following hypothesis for the carbon-related transition risk:

H3b. The European single name CDS market reflects a negative relationship between a firm's positive cash flows derived from EUA surplus and a firm's CDS-implied credit risk.

2.2 Shift in market awareness after the Paris Agreement in 2015

In December 2015, a group of 195 countries agreed in Paris on the adoption of an international treaty to limit global warming below 2 degrees Celsius, preferably to 1.5 degrees, compared to preindustrial levels. To achieve this goal, the involved countries aim at reducing GHG emissions to net-zero by 2050.

The Paris Agreement was reached during the 21st Conference of the Parties (COP 21), a yearly meeting of the United Nations Framework Convention on Climate Change (UNFCCC). The COP 21 stands out for several reasons in the history of yearly COP negotiations that have been conducted since 1995. First, it is the first-ever legally binding global agreement on climate change. It implies that if countries do not respect their emission reduction commitments, the signatory states may be sued by society. For instance, climate change-related litigation against governments (e.g., France and the Netherlands) and companies (e.g., Royal Dutch Shell and RWE) grew significantly since the Paris Agreement (Setzer and Byrnes, 2020), carrying financial and reputational consequences for the involved parties. Second, since large-scale investments are fundamental to reduce emissions significantly, the COP 21 emphasized the role of climate finance and saw large private investors joining new private and public investments in "clean energy".[14]

[14]On November 30, 2015, Financial Times was writing "COP21 Paris climate talks: billionaires join forces in energy push. Gates, Bezos, Ma, Ambani, Zuckerberg and Branson among those eyeing low-emission technology". https://www.ft.com/content/1fcae3aa-96f5-11e5-9228-87e603d47bdc. See also the report of the Institutional Investors Group on Climate Change "How the investor voice shaped COP21. Into the post-Paris climate era". https://www.nordea.com/en/doc/iigcc-post-paris-cop21-report.pdf

Third, the Financial Stability Board (FSB) established the task force on Climate-related financial disclosures to provide recommendations for a disclosure framework considering physical, liability, and transition risks associated with climate change.[15] Access to high-quality financial information allows market participants and policymakers to understand and better manage those risks, which are likely to grow with time.[16] In the view of a low-carbon economy in which fossil fuel is phased out, an expectation for businesses to prepare to answer "What's your strategy for 'net zero'?" has been set out.[17]

Therefore, we exploit the Paris Agreement to test a possible causal relationship between CDS-implied credit risk and GHG emissions:

H4. In the aftermath of the Paris Agreement in December 2015, European top-polluters receive higher CDS-implied credit risk by comparison with other European firms.

Overall, the Paris Agreement increased the awareness of financial markets of possible implications of the low-carbon transition, including both opportunities, e.g., green investments, and risks, e.g., transition risk. Related empirical evidence has been provided by the studies of Monasterolo and De Angelis (2020) and Bolton and Kacperczyk (2021a), who used the Paris Agreement as an instrument to identify a shift in the pricing of carbon risk in the stock market.

3 Data and variables

We consider European non-financial firms since the determinants of credit risk are different in nature than those of financial firms. The sample is constructed based on four blocks of data describing the activity of a set of European firms: i) CDS-specific data - described in section 3.1; ii) Traditional determinants of CDS-implied credit risk - de-

[15]Speaking at the COP21 Mark Carney, the chair of the FSB, said "The FSB is asking the Task Force on Climate-related Financial Disclosures to make recommendations for consistent company disclosures that will help financial market participants understand their climate-related risks".

[16]Official announcement of the TCFD on December 4, 2015 - `https://www.fsb.org/2015/12/fsb-to-establish-task-force-on-climate-related-financial-disclosures/`

[17]On December 4, 2015, Financial Times wrote "COP21 Paris talks: Carney weighs in on fossil fuel pollution. Bank of England governor presses business on climate strategy" - `https://www.ft.com/content/012e37c4-9a99-11e5-be4f-0abd1978acaa`

scribed in section 3.2; iii) Indicators of exposure to and management of climate-related transition risk - described in section 3.3; and iv) Indicators of carbon market related exposure and management - described in section 3.4.

The timespan of the sample is February 2010 to April 2021 at a monthly frequency. The resulting panel dataset is composed of 20,031 firm-month observations that correspond to the CDS contracts of 210 non-financial firms. Table 1 presents the composition of the resulting sample by year, country, and industry. The number of uniquely observed firms in each year is in the range of 136 to 174 unique firms over the 11 years of the sample. Most observations relate to UK, French, and German-incorporated firms, constituting circa 60% of the total number of observations as well as of total number of firms. The most represented sector in the sample is manufacturing, including GHG-intensive activities (e.g., manufacture of coke and refined petroleum products) as well as other non-GHG-intensive manufacturing activities. The second most represented sector by number of firms is information and communication (with predominantly communication firms), and the third is electricity, gas, steam, and air conditioning supply (with predominantly electricity firms).

3.1 CDS-implied credit risk

The CDS contracts are all single name, denominated in euro, with tier "senior unsecured debt", and document clause "modified-modified restructuring". Each single name CDS in the final sample has a spread quoted for a tenor of 1 year, 5 years, 10 years, and 30 years, respectively. CDS spreads are observed as per end-of-month and have been downloaded from IHS Markit.[18]

Following Augustin and Izhakian (2020), we winsorize the CDS spreads at the 99%

[18] Where a single-name CDS for a specific reference entity is not available for each of these four tenors concomitantly, such entities are excluded. The reason for excluding such records is to ensure validity of results across four different tenors, i.e., corresponding to different credit risk time horizons, for the same set of firms. Furthermore, given the nature of these contracts and of the market, a quote for a CDS contract with a specific tenor for a specific reference firm is not continuously available throughout time, unlike for the stock of a specific firm. We exclude records where the single-name CDS for a specific reference firm has a spread observation for less than 12 consecutive months.

Table 1: Sample composition by year, country, and sector.

Year	N#	F#	Country	N#	F#	Sector (NACE1)	N#	F#
2010	1,208	136	Austria	192	3	B-Mining and quarrying	305	4
2011	1,662	151	Belgium	500	6	C-other-Manufacturing other	6,723	67
2012	1,747	154	Czech Rep.	97	1	C-topghg-Manufacturing top emitting	2,720	27
2013	1,739	156	Denmark	480	6	D-Electricity, gas, steam, air con.	2,276	24
2014	1,793	161	Finland	917	8	E-Water supply	309	3
2015	1,806	164	France	4,479	41	F-Construction	602	8
2016	1,773	164	Germany	3,366	37	G-Wholesale and retail trade	1,351	16
2017	1,834	172	Greece	238	2	H-Transportation and storage	1,039	12
2018	1,962	174	Hungary	99	1	I-Accommodation and food service	618	6
2019	1,958	172	Ireland	21	1	J-Information and communication	2,724	26
2020	1,942	170	Italy	1,144	16	M-Professional, scientific, technical act.	495	6
2021	607	156	Luxembourg	270	2	N-Administrative and support services	624	7
			Netherlands	1251	12	Q-Human health and social work	149	2
			Poland	87	1	R-Arts, entertainment and recreation	96	2
			Portugal	260	3			
			Spain	967	11			
			Sweden	1371	14			
			UK	4,292	45			
Obs.	20,031	210	Obs.	20,031	210	Obs.	20,031	210

Notes: The table shows the number of observations in the resulting sample by year, country, and sector (NACE1 classification). Where a NACE1 class includes - among other sectors - high-polluting sectors, these sectors are defined in a separate class. The class C-topghg includes the following activities: (C) 19 - Manufacture of coke and refined petroleum products, (C) 20 - Manufacture of chemicals and chemical products, (C) 23 - Manufacture of basic metals (C) 24 - Manufacture of other non-metallic mineral products. The class D includes (D) 35 - Electricity, gas, steam and air conditioning supply activities. The class H includes (H) 51 - Air transport activities. The timespan of the sample is February 2010 to April 2021.

levels and use the natural logarithm of CDS spreads to exclude the possibility of any results being driven by outliers. In addition, we construct the end-of-month CDS slope (*lnSlope(5y-1y), lnSlope(10y-1y), lnSlope(30y-1y)*).

The description of variables employed for capturing the CDS-implied credit risk of a reference firm are reported in the online Appendix (Tables A1 and A2) along with the summary statistics (Table A3). The majority of firms in the sample are large corporate firms, as indicated by the market capitalization above 10 billion euros. The mean of the CDS spread is indicative of the CDS-implied credit risk in terms of implied expected and unexpected losses: 0.51% for 1-year maturity, 1.28% for 5-year maturity, 1.63% for 10-year maturity, and 1.73% for 30-year maturity. Assuming a loss given default of 45%

in line with the Basel Framework for credit risk estimates[19], the implied probability of default of the average firm in the sample is: 1.13% for 1-year maturity, 2.84% for 5-year maturity, 3.62% for 10-year maturity, and 3.84% for 30-year maturity, corresponding approximately to the profile of a corporate firm with an S&P-rating BB (Tasche, 2013).

Finally, Figure 2 shows the time series of the main CDS variables: the natural logarithm of spread and the natural logarithm of slope at different time horizons. The longer the time horizon of the CDS contract, the higher the CDS spread and the CDS-implied credit risk.

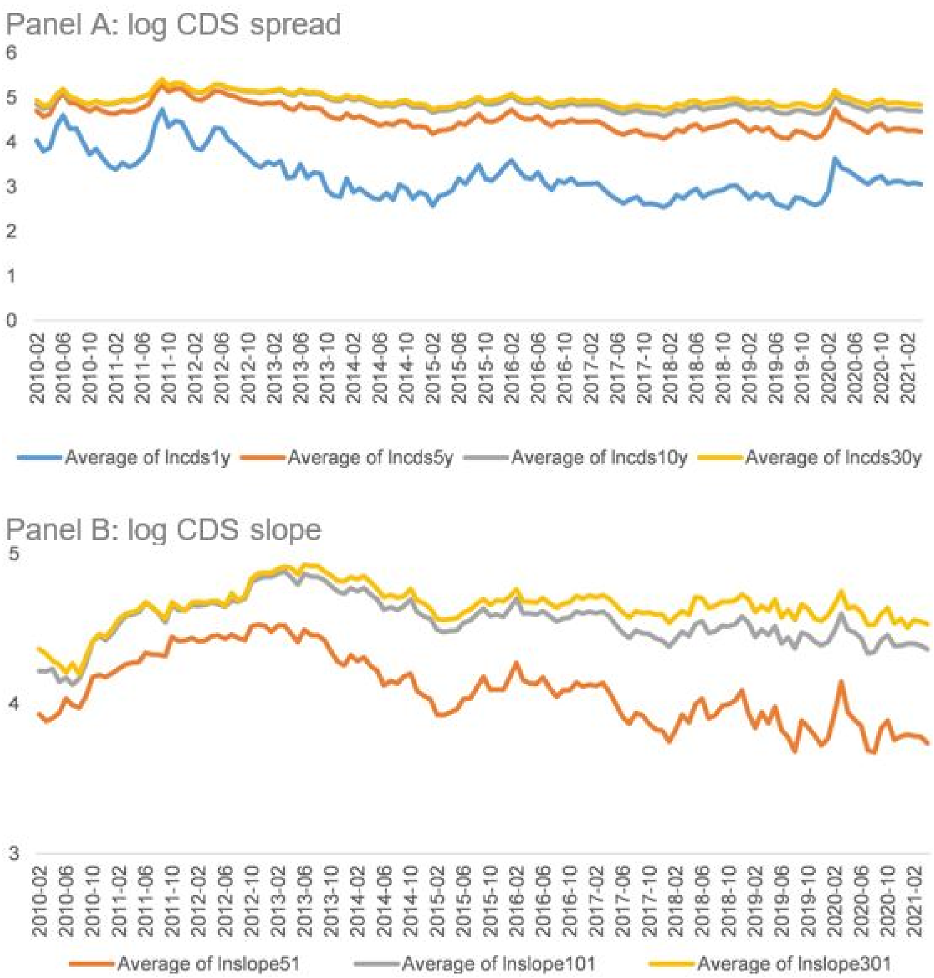
3.2 Firm-specific reference and financial data

We select a set of traditional determinants of CDS-implied credit risk based on prior literature on CDS. Particularly, we explore separately the determinants as per the model of Augustin and Izhakian (2020) and the determinants as per the model of Galil et al. (2014).

Both studies consider credit ratings as a determinant of CDS spread. Long-term issuer credit ratings in class A are typically associated with low credit risk (negative relationship), while ratings in class B are associated with moderate credit risk (negative relationship for investment grade BBB, positive relationship for speculative grade BB/B), and ratings in class C are associated with high credit risk (positive relationship). Given that close to half of the firm-month observations in the sample of this study do not have a rating, we follow Galil et al. (2014) and specify a set of rating-related dummies: i) unrated for firms that do not have a rating; ii) investment grade class A rating; iii) investment grade class B rating; and iv) speculative grade class B and C rating. The rating considered is the one issued by S&P or Moody's for the reference firm. Whereas half of the sample is unrated, the remaining half has an average rating of 13, corresponding to a B-class investment grade on S&P's and Moody's rating scales.

[19]See paragraph 32.5 "Under the foundation approach, senior claims on corporates, sovereigns and banks not secured by recognised collateral will be assigned a 45% LGD.". https://www.bis.org/basel_framework/chapter/CRE/32.htm

Figure 2: Time series of the natural logarithm of CDS spread and CDS slope.



Notes: The values correspond to the average end-of-month natural logarithm of CDS spread (Panel A) and CDS slope (Panel B) observed in the sample. Panel A, Y-axis: Natural logarithm of CDS spread. Panel B, Y-axis: Natural logarithm of CDS slope. X-axis: Time in month-periods. Time period Feb. 2010 - Apr. 2021.

The other variables included in the model of Augustin and Izhakian (2020) are:

- *Leverage.* It is proxied by the ratio between the sum of short-term and long-term debt and total assets. More leveraged firms are typically associated with higher credit risk, i.e., higher spreads (positive relationship).
- *Liquidity.* It is proxied by the composite depth of the 5-year CDS. Liquidity is usually associated with lower credit risk, as companies covered by more dealers tend to have lower CDS spreads (negative relationship). Yet in certain market

circumstances specific to the single name CDS market, liquidity increases with credit risk as in the case of the Volkswagen emission scandal in 2015 (positive relationship).

- *Firm size.* It is proxied by market capitalization. The larger the size of the firm, the better its ability to repay debt in normal as well as adverse conditions (negative relationship).

The variables included in the model of Galil et al. (2014) are:

- *Stock return.* It is a proxy of changes in a firm's market value of equity. Merton (1974) suggests a negative relation between a firm's market value of equity and its probability of default. As higher stock returns increase a firm's value, then theoretically CDS spreads, as a proxy of credit risk, are expected to decrease (negative relationship).

- *Historical volatility of the stock.* It is a proxy of firm's asset volatility. In line with Merton (1974), it is expected to lead to greater credit risk, i.e., higher CDS spread (positive relationship).

The data are collected from IHS Markit, Refinitiv, Datastream, and Bloomberg. The detailed description of the variables are provided in the online appendix (Table A4) along with summary statistics (Table A5).

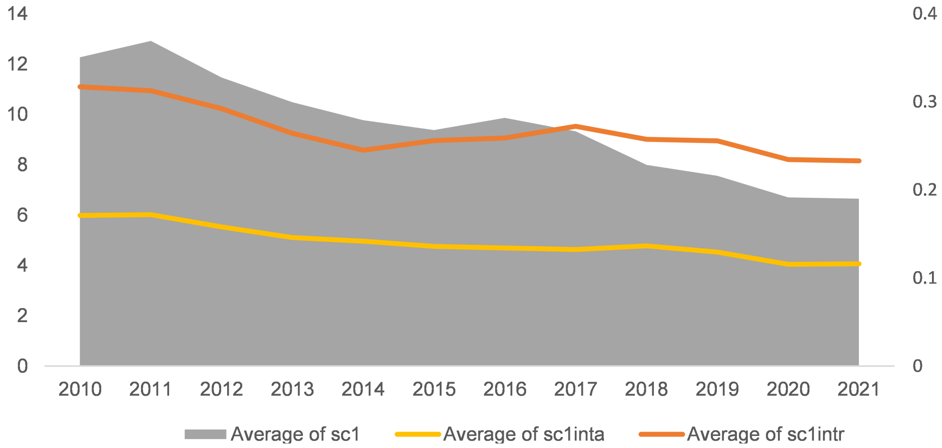
To select the baseline model, we evaluate the specifications proposed by Augustin and Izhakian (2020) and Galil et al. (2014). When comparing the results obtained with the two alternative specifications, the results appear to be comparable based on the sign of the relationship and statistical significance. Given the similar results, the set of controls used follows the specification from the most recent contribution of Augustin and Izhakian (2020). Result are presented in the online Appendix B.

3.3 Indicators of exposure and management to climate-related transition risk

Given the different coverage of firms by different data providers, we collect Scope 1 data from three different sources: Refinitiv, Bloomberg, and the Carbon Disclosure Project (CDP). Upon comparing the distribution of emissions across the three data providers, the distributions appear to be similar for the set of considered firms coherently with Busch et al. (2020) and Bolton and Kacperczyk (2021a). Therefore, we construct the variable *Scope1* by taking the maximum value reported as Scope 1 for a specific firm among the three data providers. The sample mean of the distribution of observations of Scope 1 emissions is 9.54 million tonnes eCO2, while the median is 0.4 million tonnes eCO2. Furthermore, we construct additional metrics allowing an assessment of the emission intensity of the firm. A higher Scope 1 emission intensity indicates a less efficient production technology employed by the firm for each unit of revenue (*Scope1Rev*) or for each unit of total assets (*Scope1TA*). The sample mean of the distribution of observations of Scope 1 emissions intensity by revenue is 0.27, while the median is 0.03 million tonnes eCO2 / billion EUR. For the considered firms, the GHG emissions under Scope 1 have on average decreased between 2010-2021, both in absolute as well as in relative terms as captured by intensities (see Figure 3).

Given the documented use of environmental scores by market participants in investment strategies (Boffo and Patalano, 2020), we collect the score for the environmental pillar (*E-score*) of Refinitiv's ESG score. The average of the distribution of E-score observations employed in this study is 72.97. The type of business activity that the firm performs is related to greenhouse gases that the firm emits in the course of operating its activity. Firms that have business activities relating to a GHG-intensive sector (NACE sector) are likelier to have higher firm-level greenhouse gases than firms in other sectors. Finally, the country of the firm (*country*) may codetermine the level of emissions through the channel of country-specific environmental policies and the country's overall sentiment for environmental matters (Baiardi and Morana, 2021). The detailed description of the

Figure 3: Time series of the Scope 1 GHG emissions and corresponding emissions intensity.



Notes: The values correspond to the average of Scope 1 GHG emissions - in absolute and relative terms - observed in the sample. Left-axis: million tonnes eCO2. Right-axis: million tonnes eCO2 by billion euros. X-axis: Time in years. Time period Feb. 2010 - Apr. 2021.

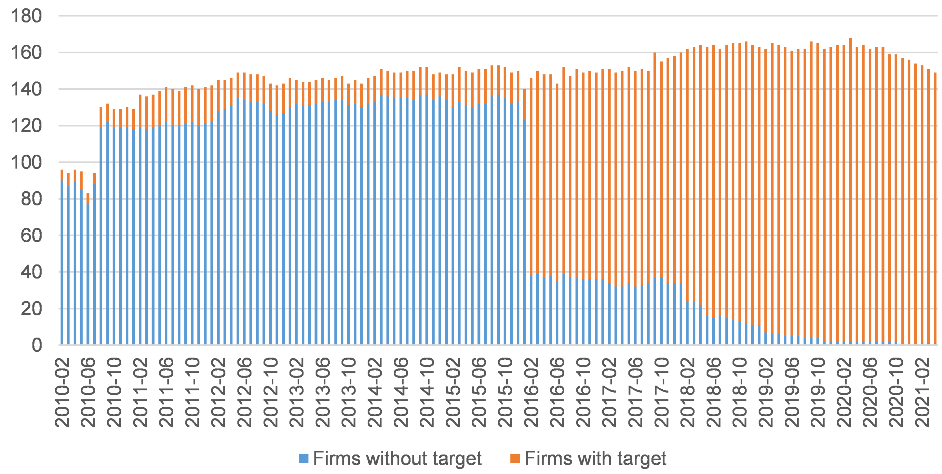
variables are provided in the online appendix (Table A6) along with summary statistics (Table A7).

The set of qualitative variables employed in this study for assessing the firm's management of climate-related transition risk includes indicators on: (i) internal policies, (ii) target setting, (iii) emissions trading, and (iv) internal carbon pricing. Also in this case, the data is retrieved from Refinitiv, Bloomberg, and CDP.

These indicators are qualitative in nature and widely used in the empirical literature on corporate social responsibility and ESG. Dedicated dummy variables indicate whether the firm has set a target to reduce GHG emissions (*Target*) or to increase its energy efficiency (*EETarget*). The 49% of observations in the sample indicate an existing target to reduce greenhouse gas emissions in the reference firm and 33% of observations in the sample indicate an existing energy efficiency target. Most firms started setting up transition-risk-related targets after the Paris Agreement in 2015 as shown in Figure 4.

Firms that commit to a target are expected to manage their exposure to transition risk (Bolton and Kacperczyk, 2021b). Whether a firm has linked its climate-related targets to its management remuneration is captured by the dummy *TargetIncentives*, which takes the value 1 for 83% of observations in the sample. This variable allows assessing

Figure 4: Evolution of number of CDS-reference firms with and without an emission reduction target.



Notes: The values correspond to the number of firms observed in the sample with and without an emission reduction target. Y-axis: Number of CDS-reference firms with an observed CDS quote for tenor 1, 5, 10, and 30 years. X-axis: Time in month-periods. Time period Feb. 2010 - Apr. 2021.

further the degree of commitment of the firm for reducing emissions. The existence of internal policies on climate-related matters is reflected through the dummies *ClimatePolicy*, *GHGPolicy*, and *EEPolicy*. Firms engaging in the trading of GHG certificates are captured through the dummy *GHGTrading* and constitute 54% of the observations in the sample. Internal carbon pricing is a practice voluntarily adopted by firms to embed the climate footprint in their operations and business models (Bento and Gianfrate, 2020) and can be seen as an internal risk management tool (Gollier, 2020; Breidenich et al., 2021). Firms that have an internal carbon pricing framework are captured through the dummy *CO2InternalPrice*. The 93% of observations in the sample indicate an existing internal carbon pricing in the reference firm. The detailed description of the variables are provided in the online appendix (Table A8) along with summary statistics (Table A9).

3.4 Indicators of carbon market related exposure

The set of indicators employed for assessing a firm's exposure to and management of transition risk through the European carbon market (EU ETS) are collected from the EU Transaction Log for the Phase 3 (2013 - 2020). Under the EU ETS, stationary installations and airlines are required to report their verified emissions for the previous year by end of March and to hand in a corresponding number of allowances (EUA) by end of April. The data on verified emissions, free allowances, and surrendered allowances, is made publicly available in May. Against this background, all ETS related indicators are therefore lagged by 5 months in the analysis in this paper.

Firms having at least one installation under the European Union's EU ETS are identified through the dummy *ETS*. The 34% of observations relate to firms that conduct activities that are subject to the EU ETS. Whereas almost a quarter of observations shows a surplus of free allowances (*EUAexcess*), the vast majority of observations show a deficit of free allowances and hence a need for the firm to buy additional EUA to compensate for its actual ETS-related greenhouse gas emissions (*EUAdeficit*). The data on free allowances (*ETS-EUA*) and ETS-related GHG emissions (*ETS-GHG*) for installations subject to the ETS is retrieved from the publicly available EU Transaction Log. The stationary installations and airlines are mapped to an owner firm using Bureau van Dijk Orbis database.

In total, we identify 70 firms in the sample that hold at least one ETS installation either directly or indirectly through one or more of their undertakings. The NACE1-sectors of these 70 firms (not limited to C-Manufacturing and D-Electrictiy, Gas, and Air Conditioning Supply) are varied and representative of the full sample.The detailed description of the variables are provided in the online appendix (Table A10) along with summary statistics (Table A11).

4 Identification strategy

In the following, we describe our identification strategies for the specified hypotheses that rely on a panel regression methodology and a DiD approach.

4.1 Panel regressions for transition risk and credit risk horizon

The empirical specification employed for the test of hypothesis *H1* focuses on the direction and the significance of the relationship between transition risk and credit risk at different time horizons. Therefore, we estimate the following model:

$$\begin{aligned} \textit{CDS-tenor}_{i,t} = & \alpha + \beta_1 \textit{ExposureTR}_{i,t} + \\ & \Sigma_{j=1}^{N} \gamma_j \textit{Controls}_{j,i,t} + \rho \textit{FirmFE}_i + \tau \textit{TimeFE}_t + \varepsilon_{i,t}, \end{aligned} \tag{1}$$

where the dependent variable $\textit{CDS-tenor}_{i,t}$ is the measure of firm CDS-implied credit risk at tenor 1, 5, 10, or 30 years, corresponding to $\textit{lnCDS-}1y_{i,t}$, $\textit{lnCDS-}5y_{i,t}$, $\textit{lnCDS-}10y_{i,t}$, $\textit{lnCDS-}30y_{i,t}$, respectively.

The independent variable $\textit{ExposureTR}_{i,t}$ corresponding to GHG absolute emissions under Scope 1, i.e. $\textit{Scope1}_{i,t}$, or Scope 1 GHG emissions relative to total assets, i.e., $\textit{Scope1TA}_{i,t}$, or relative to revenues, i.e., $\textit{Scope1Rev}_{i,t}$, described in the section 3.3. Variables from a company's annual statement are lagged by 3 months, since companies typically release their annual statements for a certain calendar year in the month of March following that calendar year.

The vector $\textit{Controls}_{j,i,t}$ includes the control variables described as traditional determinants of CDS-implied credit risk in the section 3.2 and is common throughout the different specifications in this section.

Unobserved variation at firm and time level are captured through firm fixed-effects $\textit{FirmFE}_i$ and time fixed-effects $\textit{TimeFE}_t$. Firm fixed effects are included to absorb unobserved and time-invariant firm-specific characteristics while time fixed effects are included to account for unobservable macroeconomic factors that may affect credit spreads over time. All regressions are clustered on both the time and firm dimensions to account for cross-sectional and serial correlation in error terms.

Analogously, we test hypothesis *H2* on the direction and the significance of the relationship among firm's management of transition risk and credit risk at different time horizons.

Thus, we specify the following model:

$$\begin{aligned} \textit{CDS-tenor}_{i,t} =& \alpha + \beta_1 \textit{ManagementTR}_{k,i,t} + \\ & \Sigma_{j=1}^{N} \gamma_j \textit{Controls}_{j,i,t} + \rho \textit{FirmFE}_i + \tau \textit{TimeFE}_t + \varepsilon_{i,t}, \end{aligned} \tag{2}$$

where the vector $\textit{ManagementTR}_{i,t}$ includes the variables used to proxy for a firm's management of transition risk $\textit{Target}_{i,t}$, $\textit{EETarget}_{i,t}$, $\textit{TargetIncentives}_{i,t}$, $\textit{ClimatePolicy}_{i,t}$, $\textit{GHGPolicy}_{i,t}$, $\textit{EEPolicy}_{i,t}$, $\textit{GHGTrading}_{i,t}$, $\textit{CO2InternalPrice}_{i,t}$, described in Section 3.3.

Furthermore, we test whether management activities have a mitigating effect for exposure to transition risks and credit risk with a full specification:

$$\begin{aligned} \textit{CDS-tenor}_{i,t} =& \alpha + \beta_1 \textit{ExposureTR}_{i,t} + \beta_2 \textit{ManagementTR}_{k,i,t} + \\ & \beta_3 \left(\textit{ExposureTR}_{i,t} \times \textit{ManagementTR}_{i,t} \right) + \\ & \Sigma_{j=1}^{N} \gamma_j \textit{Controls}_{j,i,t} + \rho \textit{FirmFE}_i + \tau \textit{TimeFE}_t + \varepsilon_{i,t}, \end{aligned} \tag{3}$$

Finally, we test the hypotheses *H3a-b*. Hypothesis *H3a* relates to the relationship between a firm's exposure to carbon-related transition risk and the CDS-implied credit risk. Therefore, we estimate the following model:

$$\begin{aligned} \textit{CDS-tenor}_{i,t} =& \alpha + \beta_1 \textit{ExposureETS}_{i,t} \times \textit{ExposureTR}_{i,t} + \\ & \Sigma_{j=1}^{N} \gamma_j \textit{Controls}_{j,i,t} + \rho \textit{FirmFE}_i + \tau \textit{TimeFE}_t + \varepsilon_{i,t}, \end{aligned} \tag{4}$$

The independent variable $\textit{ExposureETS}_{i,t}$ corresponds to a dummy variable indicating firms that are subject to the EU ETS and firms that are not subject to the EU ETS.

Hypothesis *H3b* tests the relationship between a firm's positive cash flows derived from EUA surplus and a firm's CDS-implied credit risk:

$$\begin{aligned} \textit{CDS-tenor}_{i,t} =& \alpha + \beta_1 \textit{ExposureTR}_{i,t} + \beta_2 \textit{EUA-GHG}_{i,t} + \\ & \Sigma_{j=1}^{N} \gamma_j \textit{Controls}_{j,i,t} + \rho \textit{FirmFE}_i + \tau \textit{TimeFE}_t + \varepsilon_{i,t}. \end{aligned} \tag{5}$$

The independent variables *EUA-GHG* corresponds to a firm's free allowances minus ETS emissions, expressed in million tonnes.

In an alternative specification, we replicate the analyses on the slopes of the CDS term structure, lnSlope(5y-1y)$_{i,t}$, lnSlope(10y-1y)$_{i,t}$, lnSlope(30y-1y)$_{i,t}$, which is a measure of a firm's CDS term structure at term 5, 10, or 30 years relative to 1 year, respectively.

4.2 DiD approach to measure the shift in market awareness after the Paris Agreement

In order to test hypothesis *H4*, we employ a difference-in-differences (DiD) design, which is a quasi-experimental identification strategy that allows estimating causal effects. We use such a framework to investigate whether there have been changes in CDS spread for European high polluting firms versus other European firms, before and after the Paris Agreement. This rational is linked to the study of Bolton and Kacperczyk (2021a) that find a strong and positive effect on returns for high polluting firms defined based on Scope 1 emissions:

$$\begin{aligned} \textit{CDS-tenor}_{i,t} =& \alpha + \beta_0 \textit{Treatment}_i \times \textit{postParis}_t + \\ & \Sigma_{j=1}^{N} \gamma_j \textit{Controls}_{j,i,t} + \rho \textit{FirmFE}_i + \tau \textit{TimeFE}_t + \varepsilon_{i,t}. \end{aligned} \tag{6}$$

The indicator variable $\textit{Treatment}_i$ is defined for each firm i similar to the specification used by Bolton and Kacperczyk (2021a): brown firms are identified as those that belong to the top quartile of GHG emissions $\textit{Scope1}_{i,t}$. In our case, the quartiles are determined based on the values as of November-2015, i.e., the period just before the Paris Agreement.

The indicator variable $\textit{postParis}_t$ takes the value 1 for the period when the shock occurs, i.e., December 2015, and for the four month-periods following the shock, and the value 0 for the four month-periods preceding the shock. The treatment (control) group includes the firms for which the indicator variable $\textit{Treatment}_i$ takes the value 1 (0). β_0 is the difference-in-differences coefficient of interest. The set of controls is described in the section 3.2 as well as firm and time fixed effects.

For robustness, we employ three alternative specifications for defining brown firms:

(i) firms in the top quartile of GHG intensity, calculated based on $Scope1TA_{i,t}$; (ii) firms in the top quartile of GHG intensity, calculated based on $Scope1Rev_{i,t}$; (iii) firms in the bottom quartile of environmental score based on $E\text{-}score_{i,t}$.

As an additional analysis, we inspect the effect of the Paris Agreement on the CDS-market-implied credit risk of low polluting firms, instead of high polluting firms. The later rational is linked to the study of Monasterolo and De Angelis (2020) suggesting that after the Paris Agreement stock market investors have started globally to consider low-carbon assets as an appealing investment opportunity. Green firms are identified as those that belong to the bottom quartile of GHG emissions $Scope1_{i,t}$. For robustness, we employ three alternative specifications for identifying green firms: (i) firms in the bottom quartile of GHG intensity based on $Scope1TA_{i,t}$; (ii) firms in the bottom quartile of GHG intensity, calculated based on $Scope1Rev_{i,t}$; (iii) firms in the top quartile of environmental score based on $E\text{-}score_{i,t}$.

Finally, by the means of a triple difference-in-differences, we separately investigate on a dedicated subsample whether following the Paris Agreement the CDS market assesses differently high polluting firms operating in high polluting industries, which are exposed to public scrutiny, by comparison with high polluting firms in low polluting industries. High polluting industries, such as Electricity, gas, steam and air conditioning supply and Mining of metal ores, have been exposed to more scrutiny by the public (e.g., activists and NGOs) than low polluting industries, affecting market sentiment. Furthermore, market participants at times make use of aggregate industry-level emissions data rather than of granular firm-level emissions data. Given the major oil price decline throughout 2015-2016, this analysis is conducted on a subsample of data excluding firms active in Oil and Basic Metals sectors, to rule out the possibility that the results of changes in CDS-implied credit risk are driven by the oil price decline.

The hypothesis is tested with the following equation:

$$\begin{aligned} \textit{CDS-tenor}_{i,t} = & \alpha + \beta_0 \textit{Treatment}_i \times \textit{Scrutiny}_i \times \textit{postParis}_t + \\ & \beta_1 \textit{Treatment}_i \times \textit{postParis}_t + \\ & \beta_2 \textit{Scrutiny}_i \times \textit{postParis}_t + \\ & \Sigma_{j=1}^{N} \gamma_j \textit{Controls}_{j,i,t} + \rho \textit{FirmFE}_i + \tau \textit{TimeFE}_t + \varepsilon_{i,t} \end{aligned} \tag{7}$$

where the indicator variable $\textit{Scrutiny}_i$ is equal to 1 for firms in high polluting sectors and $\textit{Treatment}_i$ is equal to 1 for firms in the top quartile of GHG emissions $\textit{Scope1}_{i,t}$.

5 Results

In this section, we present the results of the regression analyses on the panel model specification including proxies for exposure to transition risk (hypothesis H1). Next, we illustrate the results of the panel regression analyses on the model specification including proxies for the management of transition risk (hypothesis H2). Furthermore, we present the results for the carbon market related exposure (hypotheses H3a-b). Finally, we discuss the results of the DiD analysis on the relationship between low-carbon-transition indicators and CDS-implied credit risk (hypothesis H4).

5.1 Exposure to Transition Risk and CDS-implied credit risk

The regression results of Equation 1 testing the relation between CDS spread and the exposure to transition risk as proxied by Scope 1 are presented in Table 2, Panel A. Estimates are reported consecutively without fixed effects, with country-sector-time fixed effects, and with firm-time fixed effects. The Scope 1 emissions of a firm from owned or controlled sources are positively associated with a firm 1, 5, and 10-year natural logarithm of CDS spread as shown in columns 3, 6, 9, and 12. The sign of the coefficient is stable for all tenors and the relation is statistically significant at a 5% level for the 1 and 5-year CDS spreads and at 10% level for the 10-year CDS spread. The regression coefficient of Scope 1 on the natural logarithm of 30-year CDS spread is statistically significant in the specification with country-firm-time fixed effects. When expanding to firm-time fixed effects, the standard errors increase, by comparison with country-sector-time fixed effects, suggesting a decrease in the accuracy of measurement when expanding to firm-time fixed effects. This further suggests that the lack of statistical significance of this coefficient in the specification with firm-time fixed effects occurs solely because of no sufficient within-firm variation. The magnitude of the coefficient for Scope 1 indicates that an increase in one unit of Scope 1 is associated with a 0.47% increase in the 1-year CDS spread, 0.37% in the 5-year CDS spread, 0.24% in the 10-year CDS spread, and 0.23% in the 30-year CDS spread. Given that the average 5-year CDS spread for the sample of this study is 127 bps, this implies that, on average, an increase of 1 million tonnes eCO2 in Scope 1[20] is associated with a spread that is 0.47 bps higher. Similarly, given that the average 30-year CDS spread is 173 bps, this implies that, on average, an increase of 1 million tonnes eCO2 in Scope 1 emissions results in a spread that is 0.40 bps higher, by comparison with 0.47 bps higher for the 5-year CDS spread.

In addition to the panel regression results for Scope 1 in absolute terms *Scope1*, Table C1 in Appendix C shows the results for two alternative specifications: Scope 1 relative to revenues *Scope1Rev* and Scope 1 relative to total assets *Scope1TA*. The results are shown for the full sample, i.e., February 2010 to April 2021 (Panel A) as well as for the post-Paris subsample, i.e. January 2016 to April 2021 (Panel B). Over the full period, i.e., February 2010 to April 2021, only Scope 1 in absolute terms displays a significant positive relationship with the CDS spread at certain tenors, but not Scope 1 in relative terms, i.e. intensities.

The second panel shows that over the period post Paris Agreement, all three alternative specifications of Scope 1 display a positive relationship with the CDS spread at all tenors. Furthermore, we evaluate the relation between Scope 1 and the natural logarithm of 5-year CDS spread in each year of the sample by the means of a cross-sectional

[20]For an indicative reference of the order of magnitude, the sample mean of the distribution of observations of Scope 1 emissions is 9.54 million tonnes eCO2, while the median is 0.4 million tonnes eCO2.

Table 2: Scope 1 emissions in absolute and relative terms and CDS spread.

	lnCDS-1y	*lnCDS-5y*	*lnCDS-10y*	*lnCDS-30y*
Scope1	0.0047**	0.0037**	0.0024*	0.0023
	(0.0023)	(0.0016)	(0.0014)	(0.0014)
Controls	Y	Y	Y	Y
Time F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Cluster firm	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y
Firms	210	210	210	210
Observations	20,031	20,031	20,031	20,031
R-squared	0.787	0.827	0.837	0.835

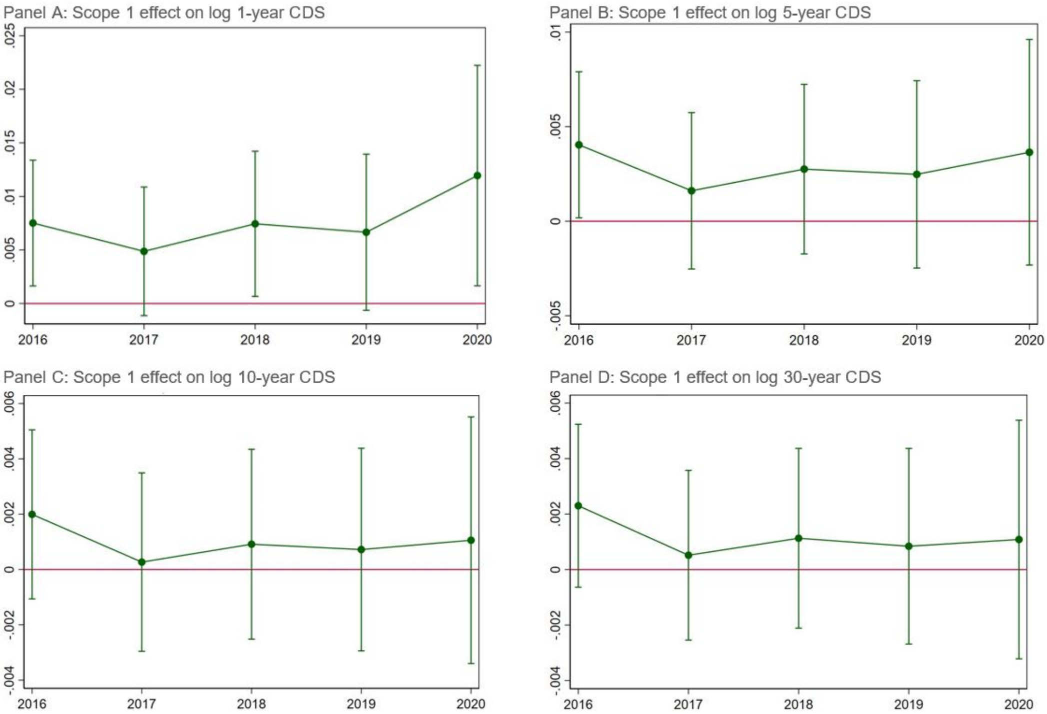
	lnCDS-1y	*lnCDS-5y*	*lnCDS-10y*	*lnCDS-30y*
Scope1	0.0043**	0.0040***	0.0025**	0.0028**
	(0.0019)	(0.0014)	(0.0012)	(0.0011)
Controls	Y	Y	Y	Y
Time F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Cluster firm	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y
Firms	195	195	195	195
Observations	10,075	10,075	10,075	10,075
R-squared	0.840	0.879	0.893	0.895

Notes: The dependent variable is the natural logarithm of CDS spread for the tenor 1 year, 5 years, 10 years, and 30 years, respectively. Panel A shows the results for the full sample period Feb. 2010 to Apr. 2021. Panel B shows the panel regression results for the sample period Jan 2016 to Apr. 2021, which is following the Paris Agreement (Dec. 2015). The definition of all variables is given in tables A1 and A6. All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

regression. The marginal effect of a one unit increase in Scope 1 on the natural logarithm of the 5-year CDS spread are presented in Figure 5.

The positive sign of the relationship is remarkably stable over all years of the sample.

Figure 5: Average marginal effect of Scope 1 on the natural logarithm of CDS spread



Notes: Panels A, B, C, D show the marginal effect with 95% confidence interval of Scope 1 on the natural logarithm of the 1, 5, 10, and 30-year CDS spread respectively. For a firm who is average on all characteristics, the marginal change of a 1-unit increase in Scope 1 indicates the corresponding percentage increase in the natural logarithm of the CDS spread in the respective year. The underlying sample contains firms that have a continuous CDS quote throughout the period Jan. 2016 - Dec. 2020. Y-axis: Average marginal effect. X-axis: Time in years.

Where the relation is statistically significant, the magnitude of the yearly marginal effect of Scope 1 on the natural logarithm of 5-year CDS spread is in the range (0.27%; 0.47%).

Finally, we evaluate the marginal effect of a one unit increase in Scope 1 for each industry group to determine for which industry groups the relation between the CDS spread is positive and statistically significant. The results are presented in Table 3 for the major NACE1 sectors with the following breakdown: top-GHG polluting manufacturing activities (category C-topghg including NACE2 19, 20, 23, 24), manufacturing of cars (category C-car including NACE2 29), other manufacturing activities (category C), electricity, gas, and air conditioning supply (NACE1 D), information and communication (NACE1 J), transportation and storage (NACE1 H, which includes the high emitting air travel sector), and all other activities (category Rest). The relation between Scope 1 and the spread is positive and statistically significant for the industry groups electricity, gas, and air conditioning supply, as well as for transportation and storage. Higher Scope 1 emissions in firms active in these sectors are associated with higher CDS spreads across all maturities of the CDS term structure. Interestingly, the estimate coefficient for firms in top polluting manufacturing activities is negative, albeit not statistically significant across the CDS term structure.

To support the regression results on CDS spread and Scope 1 GHG emissions, we report in the online Appendix the results on CDS slope and Scope 1 GHG emissions (Table C5).[21] Furthermore, we repeat the analysis using the natural logarithm of Scope 1, instead of Scope 1 (Table C2) and also for the CDS slope (Table C4). The conclusions regarding H1 are qualitatively unaffected.

[21] Table C5 shows that the level of Scope 1 emissions of a firm is significantly positively associated with the natural logarithm of the slope 5y-1y, which is the difference between the 5-year and the 1-year CDS spread. The sign of the coefficients in the specifications on the slope 10y-1y and 30y-1y is also positive, albeit not statistically significant because of insufficient within-firm variation, as indicated by the increasing standard errors for the coefficients in the firm-time fixed effects specification by comparison with those in the country-sector-time fixed effects specification. The results on hypothesis 1 show that there is a positive relationship between a firm's exposure to transition risk, as proxied by the firm's Scope 1 emissions, and the firm's CDS-implied credit risk, particularly for the tenor 1 and 5 years, i.e., short and medium term.

Table 3: Scope 1 emissions by sector and CDS spread.

	lnCDS-1y	lnCDS-5y	lnCDS-10y	lnCDS-30y
C×Scope1	0.023	-0.048	-0.043	-0.055
	(0.098)	(0.076)	(0.060)	(0.052)
C-car×Scope1	0.47	0.39	0.47	0.34
	(0.41)	(0.31)	(0.29)	(0.26)
C-topghg×Scope1	-0.018	-0.012*	-0.0076	-0.0064
	(0.014)	(0.0066)	(0.0049)	(0.0043)
D×Scope1	0.0048***	0.0046***	0.0029***	0.0031***
	(0.0016)	(0.0012)	(0.00099)	(0.00098)
J×Scope1	0.65	1.84	1.23	0.77
	(2.60)	(1.51)	(1.12)	(1.00)
H×Scope1	0.13***	0.084***	0.059**	0.055**
	(0.050)	(0.025)	(0.022)	(0.024)
Rest×Scope1	0.036	-0.010	-0.020	-0.0063
	(0.076)	(0.058)	(0.050)	(0.041)
Controls	Y	Y	Y	Y
Sector F.E.	Y	Y	Y	Y
Country F.E.	Y	Y	Y	Y
Time F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Cluster firm	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y
Firms	195	195	195	195
Observations	10,075	10,075	10,075	10,075
R-squared	0.842	0.880	0.894	0.895

Notes: The dependent variable is the the natural logarithm of CDS spread for the tenor 1 year, 5 years, 10 years, and 30 years, respectively. The panel regression results are shown on the subsample period January 2016 to April 2021, which is following the Paris Agreement (December 2015). The definition of all variables is given in tables A1 and A6. The class C-topghg includes the following GHG-intensive activities: 19 - Manufacture of coke and refined petroleum products, 20 - Manufacture of chemicals and chemical products, 23 - Manufacture of basic metals 24 - Manufacture of other non-metallic mineral products. The class Manufacturing other includes all manufacturing firms except Manufacturing of cars and Manufacturing topghg. The interacted variables correspond to the interaction between sector-group dummies (C, C-topghg, D, J, Other), where each group has more than 2000 observations, and Scope 1 percentage changes. All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

5.2 Management of Transition Risk and CDS-implied credit risk

The regression results of Equation 2 on CDS spread and a firm's efforts of managing transition risk are presented in Table 4.

The act of disclosing an emission reduction target (*Target*) and the act of trading emissions certificates (*GHGTrading*) are both significantly negatively associated with the natural logarithm of the 1, 5, 10, and 30-year CDS spread. Furthermore, the act of linking the emission reduction target to the remuneration of the management of the firm (*TargetIncentives*) is significantly associated with a lower 30-year CDS spread. The results on the transition management indicators *EETarget*, *ClimatePolicy*, *GHGPolicy*, *EEPolicy*, and *CO2InternalPolicy* do not suggest that related transition management efforts are associated with lower CDS spreads (i.e. lower CDS-implied credit risk).[22] As the benchmark specification, we select firm and time fixed effects to control for unobserved heterogeneity at the firm level, which can have a significant impact on the results of the analysis. In online Appendix C, we report in Table C3 the results with alternative specifications without fixed effects and with sector, country, and time fixed effects.

Next, by interacting transition-management-related dummies (*Target*, *GHGTrading*, *TargetIncentives*) with the variable *Scope1*, we test whether such activities have a mitigating effect for Scope 1 on the CDS spread as per Equation 3. The regression results are included in Table 5 and show that where the firm discloses an emission reduction target, the marginal effect of Scope 1 emissions on the CDS spread is reduced at all tenors, i.e., 1, 5, 10, and 30 years. Particularly, the marginal effect of a one unit increase in Scope 1 results in a 0.44% increase in the natural logarithm of the 5-year CDS spread for a firm that does not disclose a target versus a 0.28% increase in the natural logarithm of the 5-year CDS spread for a firm that discloses a target. This result suggests that the CDS market considers firm's commitments to reduce emissions as a factor reducing the magnitude of the effect of Scope 1 on the perceived credit risk. However, this result is ambiguous as it may be driven by the massive adoption of targets in the aftermath of the

[22]The results are stable in a robustness specification where each of these dummy variables are tested separately.

Table 4: Exposure management and CDS spread.

	lnCDS-1y	lnCDS-5y	lnCDS-10y	lnCDS-30y
Target	-0.14**	-0.079**	-0.063**	-0.057**
	(0.054)	(0.036)	(0.028)	(0.028)
EETarget	0.035	0.017	0.014	-0.0028
	(0.063)	(0.045)	(0.037)	(0.035)
TargetIncentives	-0.11	-0.070	-0.064	-0.072*
	(0.079)	(0.049)	(0.039)	(0.038)
ClimatePolicy	0.0097	-0.0052	-0.010	-0.016
	(0.073)	(0.048)	(0.037)	(0.036)
GHGPolicy	0.0035	-0.10	-0.067	-0.049
	(0.094)	(0.064)	(0.049)	(0.047)
EEPolicy	0.12	0.074	0.038	0.022
	(0.13)	(0.064)	(0.052)	(0.050)
GHGTrading	-0.14**	-0.11**	-0.080**	-0.065*
	(0.066)	(0.046)	(0.037)	(0.034)
CO2InternalPrice	0.10	0.082	0.030	0.011
	(0.099)	(0.072)	(0.056)	(0.052)
Controls	Y	Y	Y	Y
Time F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Cluster firm	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y
Firms	210	210	210	210
Observations	20,031	20,031	20,031	20,031
R-squared	0.789	0.829	0.839	0.836

Notes: The dependent variable is the percentage change of the natural logarithm of CDS spread for the tenor 1 year, 5 years, 10 years, and 30 years, respectively ($lnCDS\text{-}1y\Delta^{\%}$, $lnCDS\text{-}5y\Delta^{\%}$, $lnCDS\text{-}10y\Delta^{\%}$, $lnCDS\text{-}30y\Delta^{\%}$). The independent variables are percentile change of Leverage, percentile change of size, percentile change of liquidity, and dummies corresponding to the rating class or to unrated. The definition of all variables is given in tables A1 and A4. The results for each type of tenor-specific dependent variable are presented with firm and time fixed effects. All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Paris Agreement as shown in Figure 4. Finally, the act of trading emission certificates does not appear to have a mitigating effect.[23]

[23]The results hold when controlling in addition for Refinitiv's environmental score, suggesting that the interaction between the exposure and the management of transition is an information that is not captured by the environmental score.

A pertinent question is whether CDS market participants price credible targets differently from non-credible ones. Carbone et al. (2021) discuss the credibility of emission reduction targets, after documenting that credit rating agencies and stock market participants account for these targets. The authors provide descriptive evidence on the credibility of targets for 859 US and European firms. The credibility of a target depends on several factors, including how consistently a firm reduces emissions over time, whether the target is verified (e.g., SBTi), how realistic achieving the target is given the company's operational steps and financials, and how ambitious the targets are relative to the overall global target of achieving net-zero by 2050 or with country-level intermediate targets. The authors show that the vast majority of firms with a disclosed target in 2019 reduced their GHG emission intensity over the last year (as well as over the preceding 3 years), whereas firms that did not disclose a target showed little change in GHG emission intensity. This suggests that firms with an emission reduction target have tended to reduce their emission intensity by more than firms that did not disclose a target. Bolton and Kacperczyk (2021c) also find that firms that make commitments reduce their emissions afterwards. Furthermore, the authors document that most firms with a self-disclosed target in 2019 reduced their emission intensity over the previous year, as well as over the three years preceding 2019, independent of whether the target was SBTi verified or not, although the median firm with an SBTI target reported slightly stronger reductions over this period. Therefore, existing literature suggests that firms with an emission reduction target tend to reduce their emission by more than those without a target, although further empirical research on credibility is necessary as more data become available.

In the online Appendix C, we report the results on CDS slope and such indicators (Table C6). The act of disclosing an emission reduction target is significantly negatively associated with the slope 5y-1y while the act of trading emissions certificates is associated negatively with the slope 5y-1y and 10y-1y and significant at 10% level. However, in interaction with Scope 1 as per Equation 1, these variables do not show a significant relationship with the CDS slope (Table C7 in the online Appendix). The results on qualitative indicators of management do not suggest that these are accounted for in the

Table 5: The mitigating effect of proxies of management on Scope 1 in relation with the natural logarithm of CDS spread

	lnCDS-1y	lnCDS-5y	lnCDS-10y	lnCDS-30y
Scope1	0.0047*	0.0037**	0.0021	0.0000
	(0.0025)	(0.0018)	(0)	(0.0017)
Target	-0.11**	-0.067*	-0.054*	-0.048*
	(0.055)	(0.036)	(0.029)	(0.028)
Target×Scope1	-0.0026***	-0.0017**	-0.0012*	-0.0013**
	(0.00089)	(0.00077)	(0.00061)	(0.00058)
GHGTrading	-0.13*	-0.10**	-0.083**	-0.073**
	(0.072)	(0.049)	(0.038)	(0.036)
GHGTrading×Scope1	0.0021	0.0014	0.0021	0.0027
	(0.0028)	(0.0024)	(0.0019)	(0.0021)
Controls	Y	Y	Y	Y
Time F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Cluster firm	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y
Firms	210	210	210	210
Observations	20,031	20,031	20,031	20,031
R-squared	0.789	0.829	0.839	0.837

Notes: The dependent variable is the natural logarithm of the spread in basis points for the tenor 1, 5, 10, and 30 years(*lnCDS-1y*, *lnCDS-5y*, *lnCDS-10y*, *lnCDS-30y*). The independent variables are Scope 1 emissions of the firm (*Scope1*), the act of disclosing an emission reduction target (*Target*), and the act of trading emissions certificates (*GHGTrading*). The definition of all variables is given in tables A1, A6, and A8. The results are presented for a regression with firm - time fixed effects. All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

CDS market. Particularly, the act of disclosing an emission reduction target is associated with lower CDS spread and CDS slope, however this result is not conclusive in the light of the fact that a big wave of firms in our sample disclosed targets just after the Paris Agreement.[24]

[24] While we cannot disentangle distinctly the consideration of emission reduction targets by CDS market participants in our sample, other existing studies provide suggestive evidence that such targets are being considered by credit rating agencies and stock market participants.

5.3 Transition Risk and the European carbon market

CDS spreads may be more sensitive to changes in transition risk for firms that pursue an activity which is subject to the EU ETS, since the carbon market puts a price on ETS-related emissions. Against this background, we verify as reported in Equation 4 whether the estimated coefficients of Scope 1 for firms subject to the ETS are stronger and significantly different from the estimated coefficients on non-ETS firms. Table 6 shows the results of eventual differential effects of perceived transition risk exposure, as proxied by Scope 1, across firms that are subject to the EU ETS and firms that are not subject to the EU ETS. The results are shown on two samples: the full sample covering EU ETS Phase 3 (2013-2020) and the subsample starting 2017 when the CO2 price, i.e. EUA spot price, started increasing at a faster pace.

Regarding the full sample, all findings indicate a positive relationship albeit not statistically significant. However, the results on the subsample 2017-2021 show a positive and statistically significant relationship between Scope 1 and the CDS spread across all maturities for both ETS-firms and non-ETS firms. The post-estimation test fails to reject the hypothesis that the estimated coefficients for ETS differ in a statistically significant manner from the estimates for non-ETS firms.

Overall, the empirical results suggest that CDS market participants do not differentiate between firms subject to the EU ETS and those that are not. There could be two possible explanations for this outcome. CDS market participants may not integrate and leverage data on ETS market participation, indicating a market inefficiency as information is not reflected in CDS-implied credit risk pricing. This observation is consistent with the 2021 ECB review of risk management practices on climate risks in financial institutions, which found that only very few institutions have put in place climate and environmental risk practices with a discernible impact in their credit risk differentiation.[25] An alternative explanation of this empirical finding could be that CDS market participants cannot form based on EU ETS data expectations on the credit risk profile of a firm.

[25] Further details can be found at https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.202111guideonclimate-relatedandenvironmentalrisks~4b25454055.en.pdf.

Table 6: Transition risk through the ETS and CDS spread.

	lnCDS-1y	lnCDS-5y	lnCDS-10y	lnCDS-30y
Scope1				
- ETS	0.0030	0.0029	0.0013	0.0014
	(0.0023)	(0.0018)	(0.0015)	(0.0015)
- non-ETS	0.0035	0.0036**	0.0018	0.0020
	(0.0023)	(0.0017)	(0.0015)	(0.0015)
Controls	Y	Y	Y	Y
Time F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Cluster firm	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y
Observations	13,527	13,527	13,527	13,527
R-squared	0.790	0.847	0.866	0.867

	lnCDS-1y	lnCDS-5y	lnCDS-10y	lnCDS-30y
Scope1				
- ETS	0.011**	0.0086**	0.0062**	0.0065**
	(0.0049)	(0.0039)	(0.0026)	(0.0026)
- non-ETS	0.0072***	0.0061***	0.0041***	0.0039***
	(0.0023)	(0.0014)	(0.0011)	(0.0011)
Controls	Y	Y	Y	Y
Time F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Cluster firm	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y
Observations	8,299	8,299	8,299	8,299
R-squared	0.862	0.897	0.911	0.913

Notes: The table shows the results of an OLS regression with firm - time fixed effects for each type of tenor-specific dependent variable. The top panel shows the results on the ETS Phase 3 period 2013-2021, while the bottom panel shows the results on the subsample 2017-2021.

EU ETS market operates on a cap-and-trade system where allowances are traded based on supply and demand, making it difficult for investors to form expectations about future allowance prices and their impact on a firm's financial performance. The widespread heterogeneity can disperse the effect of investors' preferences, leading to no impact on the firm's creditworthiness on average.

However, our results indicate a positive and statistically significant relationship between Scope 1 emissions and CDS spreads for the subsample 2017-2021, suggesting that

CDS market participants became potentially more sensitive to firm-level emissions information once the carbon price started rising steadily. This may be due to increased awareness and recognition of the financial risks associated with implementation of stricter emission reduction policies in Europe.

It is important to note that the EU ETS framework operates on a system where a firm's emissions-related costs are determined by the verified amount of emissions minus the allowances received for free. When a firm falls short of its allowances, it must acquire the necessary amount on the carbon market. If a firm has a positive balance of free allowances, it can use them to generate cash, potentially reducing its credit risk. Conversely, a negative balance of allowances results in costs for the firm, which could lead to higher credit risk. Following Equation 5, Table 7 shows the results on CDS spread of Scope 1 and of the balance of allowances for the subsample of ETS-exposed firms. The estimated coefficient for *EUA-GHG* suggests that a higher balance is associated with a lower 1-year CDS spread. Yet, the estimate is not statistically significant. For the remaining maturities, the estimates are positive, contrary to the expected sign. When repeating the analysis for *EUA-GHGeur*, which is the monetary balance of allowances minus emissions upon applying the carbon price, the obtained estimates have different signs across maturities and are not statistically significant. These results suggest that CDS market participants are likely not considering ETS-related cash flows in their estimates of credit risk of a firm.

The EU ETS market might create an agency problem, where firms may not take adequate measures to reduce their emissions because they can purchase allowances on the market to comply with the regulations. They face conflicting incentives, as they are economically motivated to decrease their emissions to comply with their emissions allowance targets, but at the same time, they are provided with the option to purchase additional allowances from other firms if they fail to achieve their targets.

Since CDS market participants do not seem to differentiate between firms subject to the EU ETS and those that are not, firms might anticipate the fact that the cost of buying allowances is not priced in the market. As a result, firms may not fully consider the financial implications of their decision to purchase allowances instead of reducing emissions, potentially leading to a misalignment of interests between market participants and society's goals to mitigate climate change. Moreover, changing a firm's business model to reduce emissions could be for certain firms potentially more costly than buying allowances equivalent to emissions, leading to potentially higher credit risk if the firm does not successfully manage the transition.

In this respect, the European taxonomy could promote more sustainable investments and guide firms to activities that contribute to mitigating climate change. By providing a clear and standardized classification system for environmentally sustainable activities, the taxonomy could help CDS market participants to better differentiate between firms that align and those that do not align with the EU's environmental goals, hence, by having an impact on the firm's creditworthiness.

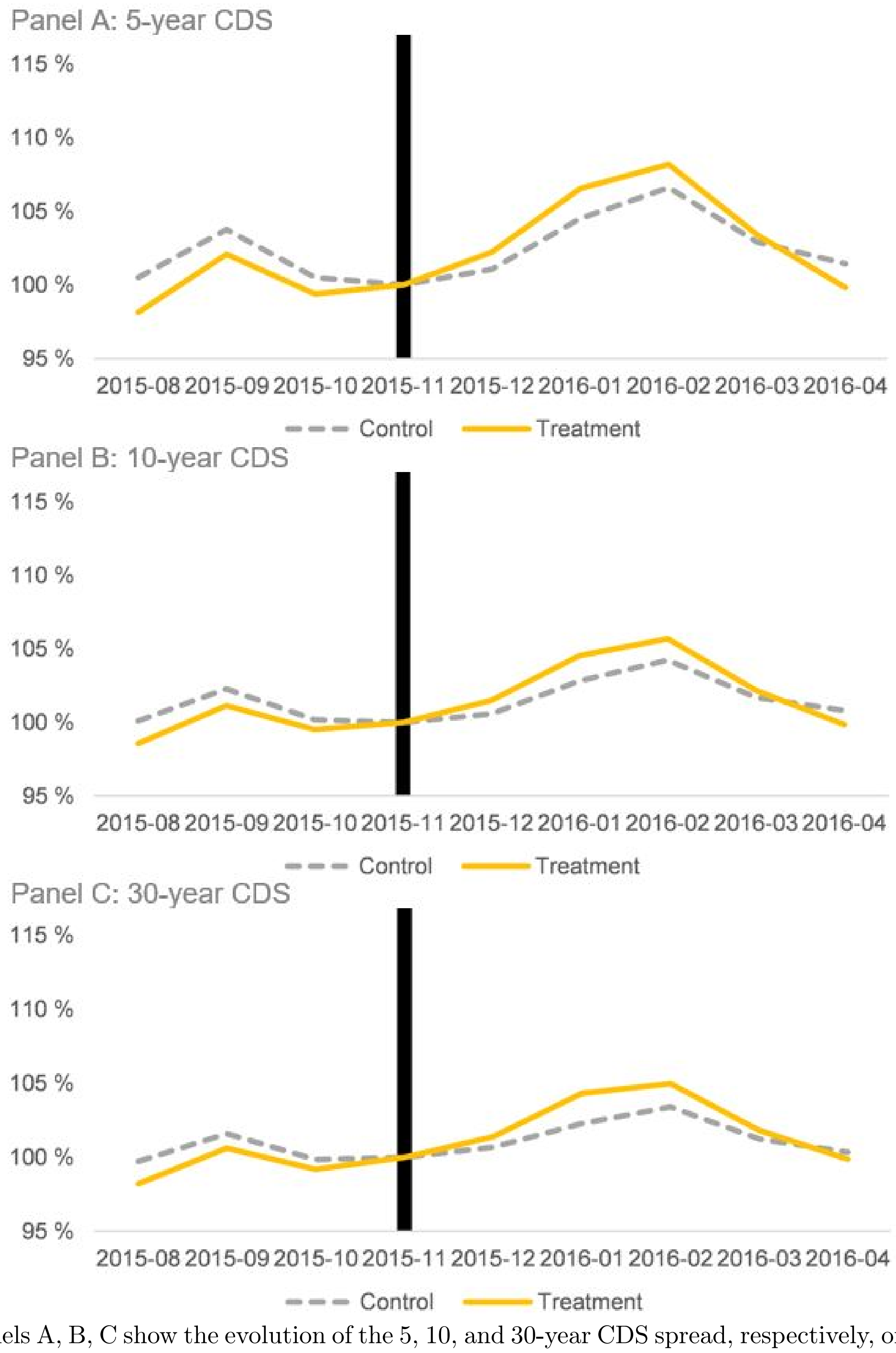
5.4 Emissions and CDS-implied credit risk after the Paris Agreement

For the purpose of the DiD on the Paris Agreement, we construct a subsample that includes only firms who have a quote for a CDS spread continuously for 9 months in a row around the Paris Agreement.

Figure 6 shows the evolution of the CDS spread for the tenor 5, 10, and 30 years of the treatment and control groups over the 9 months around the date of the Paris Agreement, i.e., December 2015.

The observed CDS spread of the treatment group (high polluting firms) was below the CDS spread of the control group (all other firms) before the event. Interestingly, the relation inverted in the months immediately after the event and the effect lasted for several months. The CDS spread of the treatment group was again below the one of the control group four months after the event for tenors 5, 10, and 30 years, and two months after the event for tenor 1 year. The results of the difference-in-differences regressions on CDS spread for "brown" firms are shown in Table 8.

Figure 6: Time series of the natural logarithm of CDS spread around the Paris Agreement



Notes: Panels A, B, C show the evolution of the 5, 10, and 30-year CDS spread, respectively, of two groups of firms. The treatment group includes firms in the top quartile of the Scope 1 emissions distribution as of 2015-11. The control group includes all other firms. Observations are scaled at 100 for the period November 2015, i.e period just before the event. Y-axis: Value of the natural logarithm of the CDS spread relative to the value as of 2015-11. X-axis: Time in month-periods.

Table 7: Transition risk of ETS-exposed firms and CDS spread

	lnCDS-1y	lnCDS-5y	lnCDS-10y	lnCDS-30y
Scope1	0.0089***	0.0069***	0.0049***	0.0047***
	(0.0028)	(0.0017)	(0.0013)	(0.0013)
EUA-GHG	-0.0020	0.0076	0.0095	0.012**
	(0.017)	(0.0083)	(0.0065)	(0.0058)
Controls	Y	Y	Y	Y
Time F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Cluster firm	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y
Observations	2,915	2,915	2,915	2,915
R-squared	0.839	0.900	0.913	0.914

	lnCDS-1y	lnCDS-5y	lnCDS-10y	lnCDS-30y
Scope1	0.0086***	0.0064***	0.0043***	0.0040***
	(0.0028)	(0.0017)	(0.0013)	(0.0013)
EUA-GHGeur	0.00040	0.000055	-0.000034	-0.000076
	(0.00060)	(0.00033)	(0.00026)	(0.00026)
Controls	Y	Y	Y	Y
Time F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Cluster firm	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y
Observations	2,915	2,915	2,915	2,915
R-squared	0.839	0.900	0.913	0.914

Notes: The table shows the results of an OLS regression with firm - time fixed effects for each type of tenor-specific dependent variable only for ETS-exposed firms. The top panel shows the results on the ETS Phase 3 period 2013-2021, while the bottom panel shows the results on the subsample 2017-2021. The top panel shows the results of the balance of allowances and emissions in million tonnes eCO2 (*EUA-GHG*), while the bottom panel shows the results of the monetary balance of allowances and emissions in million EUR after having applied the carbon price (*EUA-GHGeur*).

Estimates are presented for each of the four tenors of the CDS spread (1, 5, 10, and 30 years respectively), showing a DiD specification with controls and with firm-time fixed effects as per Equation 6. The DiD estimates for the treatment (*TreatScope1Q4* $\times$ *PostEvent*) have all a positive sign, indicating that after the Paris Agreement the CDS spreads increased for the treatment group more than for the control group. The coefficients are statistically significant for the 5, 10, and 30-year CDS spreads. These

Table 8: Difference-in-Differences on CDS spread around the Paris Agreement in December 2015 and treated firms in top quartile of Scope 1 distribution.

	lnCDS-1y	lnCDS-5y	lnCDS-10y	lnCDS-30y
TreatScope1Q4×PostEvent	0.051	0.082***	0.068***	0.077***
	(0.045)	(0.029)	(0.022)	(0.022)
PostEvent	-0.016	0.033	0.027*	0.026*
	(0.042)	(0.020)	(0.015)	(0.015)
Controls	Y	Y	Y	Y
Time F.E.	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y
Cluster firm	Y	Y	Y	Y
Firms	128	128	128	128
Observations	1,152	1,152	1,152	1,152
R-squared	0.381	0.459	0.454	0.398

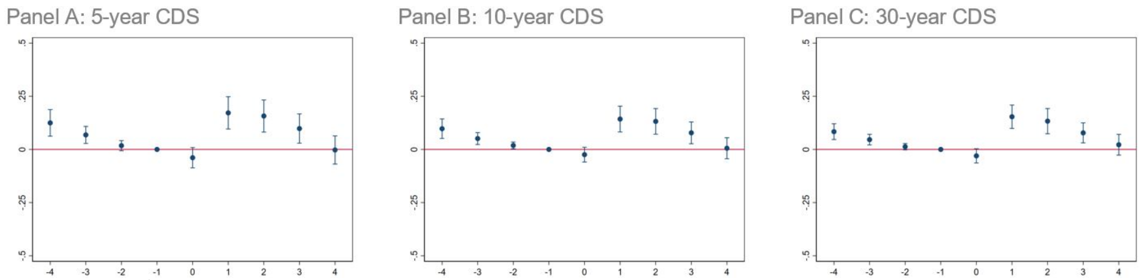
Notes: All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

results highlight that following the Paris Agreement European high polluting firms get higher spreads, i.e., higher CDS-implied credit risk. The increase is by an additional 0.082, 0.068, and 0.077 units relative to the change in the natural logarithm of the spread for the control group.

The DiD approach assumes the existence of a common trend among both treatment and control groups, i.e., CDS spread for the treatment and control group would have developed similarly after the event as before the event in case there would have been no Paris Agreement. This assumption ensures that any difference between both groups results from the event itself and can be tested by comparing the evolution of the CDS spread of the treatment and control groups before the event. If treatment and control groups evolve similarly over time, the common trend assumption is likely to hold.

Figure 7 shows the point estimates for each period from a regression following closely the Equation 6, but where the variable *Treatment* is interacted with yearly dummies, instead of the *postParis* dummy. The pre-treatment coefficients are nearly zero in their point estimate. Moreover, the standard errors of the estimates are very small, suggesting that these are very precisely estimated near-zero differences between firms in the treatment and control group prior to the Paris Agreement.

Figure 7: Treatment effect for each period of the event window for the DiD results around the Paris Agreement on the natural logarithm of CDS spread



Notes: Panels A, B, C show the treatment effect for each period of the event window for the DiD results around 2015-12 on the natural logarithm of 5, 10, and 30-year CDS spread, respectively. The treatment group includes firms in the top quartile of the Scope 1 emissions distribution as of 2015-11. The control group includes all other firms. Y-axis: Value of the natural logarithm of the CDS spread relative to the value as of 2015-11. X-axis: Time in month-periods.

In Table C8 of the online Appendix C, we present alternative specifications that include a basic difference-in-differences with no fixed effects and one with firm and time fixed effects. In both cases, the estimated coefficient for the 1-year CDS spread in the DiD analysis is statistically significant.

5.4.1 Robustness and additional analysis

To check the robustness of our findings, we run alternative robustness analyses. We also report results of additional analysis.

The oil price decline in 2015-2016

Low oil prices affect negatively the revenues of oil companies. Oil companies have two broad groups of activities: (i) upstream activities that include locating, testing, and setting up drilling sites for oil extraction, (ii) downstream activities that include refining and distributing of oil-related products, e.g., gasoline. Upstream activities heavily rely on industrial manufacturing companies, e.g., steel and heavy machines for the supply of materials necessary for oil drilling operations. While declining oil prices directly affect oil companies, a related contraction in upstream activities of these firms may negatively affect the supplying manufacturing sectors.

With this background, we construct a subsample that excludes firms active in the oil and basic metal sectors and run the DiD regressions on this subsample. The results are shown in the online Appendix (Table C9) and are quantitatively similar to the results on the full sample. This robustness check rules out the possibility that the DiD results are driven by the oil price decline observed in 2015-2016.

Alternative definitions of the treatment

In the following, we use alternative definitions of the treatment. First, we consider Scope 1 emission intensity by revenues and emission intensity by total assets. We report in the online Appendix (Tables C12 and C13) the DiD results. As expected, all DiD coefficients have a positive sign for all tenors, albeit not statistically significant, with the exception of the point estimate for the 30-year CDS spread using emission intensity by total assets.

Second, the treatment definition is based on the bottom quartile of the E-score distribution (Table C14 in the online Appendix). The DiD coefficients have a negative sign, suggesting a decrease in credit risk for firms with bad environmental scores following the Paris Agreement. The results are statistically significant at 10% level for the 5, 10, and 30 years CDS spread. This outcome suggests that the E-score does not allow differentiating between high emitting firms and other firms in a non-ambiguous manner.

Alternative definitions of the dependent variable

In an alternative specification, we use as dependent variable the natural logarithm of the CDS slope, instead of the CDS spread (Table C15 in the online Appendix). The DiD estimates for the treatment ($\textit{TreatScope1Q4} \times \textit{PostEvent}$) have all a positive sign, indicating that after the Paris Agreement the CDS slope increased for the treatment group more than for the control group. The DiD estimated coefficients are statistically significant for all terms of the slope, i.e., 5y-1y, 10y-1y, and 30y-1y. The increase in the natural logarithm of the 5y-1y, 10y-1y, and 30y-1y CDS slope is by an additional 0.086, 0.061, and 0.071 units, respectively, relative to the change in the natural logarithm of the corresponding CDS slope for the control group. This suggests that CDS market participants expect the short, medium and long term credit risk of these firms to be higher than that for firms in the control group.

Figure C1 in the online Appendix shows the point estimates for each of the 9 periods of the observation window from a regression following Equation 6, but where the variable *Treatment* is interacted with yearly dummies, instead of the *postParis* dummy. Similar as in the DiD analysis on CDS spread, the pre-treatment coefficients are nearly zero in their point estimate. Moreover, the standard errors of the estimates are very small, suggesting that these are very precisely estimated near-zero differences between firms in the treatment and control group prior to the Paris Agreement.

Temporariness of the effect

To inspect whether the effect of the Paris Agreement on the market sentiment of European CDS market participants was only momentary, we extend the observation window around the event from 9 months to 49 months (2 years before and 2 years after). The results are presented in Table C10 in the online Appendix. Albeit none of the results are statistically significant in the specification with controls and firm-time fixed effects, the DiD coefficients have a positive sign for the 5, 10, and 30-year CDS spread. A possible explanation for the observed variation is that in June 2016 and the subsequent months the European CDS market was affected by the Brexit vote.[26]

Additional analysis on low-emitting firms

Whereas the above analysis is looking at high-emitting firms relative to other firms, we ask in an alternative specification whether the Paris Agreement had a positive effect on the CDS-implied credit risk of low emitting firms relative to other firms. The unreported results of this additional analysis are more ambiguous and do not allow answering this

[26]IHS Markit was writing on June 24 "A shock result in yesterday's UK referendum has seen wild reaction in the credit market". https://ihsmarkit.com/research-analysis/24062016-credit-credit-markets-in-freefall-after-shock-brexit-result.html

question.[27]

5.4.2 High polluting firms operating in high polluting industries

Finally, Table 9 shows the results of the triple difference-in-differences regressions on the natural logarithm of CDS spread of "brown" firms in scrutinized industries as per Equation 7.

Table 9: Triple difference-in-differences for changes in CDS spread around the Paris Agreement in December 2015 and differentiating between scrutinized and other sectors.

	lnCDS-5y	lnCDS-10y	lnCDS-30y
TreatScope1Q4×Scrutiny×PostEvent	0.13**	0.14***	0.13***
	(0.051)	(0.038)	(0.035)
TreatScope1Q4×PostEvent	0.045	0.027	0.038*
	(0.033)	(0.024)	(0.023)
Scrutiny×PostEvent	-0.098***	-0.11***	-0.099***
	(0.020)	(0.014)	(0.014)
PostEvent	0.038*	0.032**	0.029*
	(0.021)	(0.015)	(0.016)
Controls	Y	Y	Y
Time F.E.	Y	Y	Y
Firm F.E.	Y	Y	Y
Cluster firm	Y	Y	Y
Firms	120	120	120
Observations	1,080	1,080	1,080
R-squared	0.437	0.434	0.375

Notes: All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

The results are presented for the natural logarithm of the 5, 10, and 30-year CDS spread, respectively, showing first the estimated DiD coefficients for a DiD specification with firm-time fixed effects, and then for a DiD specification with controls and with

[27]Results are available upon request for interested readers.

firm-time fixed effects. The triple DiD estimated coefficient for high polluting firms in scrutinized industries (*Treatsc1Q4* × *Scrutiny* × *PostEvent*) has a positive sign and is statistically significant at 1% level, indicating that after the Paris Agreement the 5, 10, and 30-year CDS spreads increased particularly for high polluting firms in scrutinized industries by comparison with the control group. The increase in the 5, 10, and 30-year natural logarithm of the CDS spread for these firms is by an additional 0.13, 0.014, and 0.13 units, respectively, relative to the change in the natural logarithm of the spread for the control group. The estimated coefficient for *Scrutiny* × *PostEvent* is negative and statistically significant at 1% level, indicating that post Paris non-top-polluting firms that are active in scrutinized sectors have experienced a decrease in CDS spreads. In Table C8 of the online Appendix C, we report the results with alternative specifications for sector, country, time, and firm fixed effects. Furthermore, similarly as reported for CDS spread, Table C16 in Appendix C shows the robustness results of the triple DiD regressions on the natural logarithm of the CDS slope of "brown" firms in scrutinized industries. The triple DiD estimated coefficient is positive for all three terms, i.e., 5y-1y, 10y-1y, and 30y-1y, albeit not statistically significant.

Overall, the results on the *H4* confirm that following the Paris Agreement European high polluting firms get higher CDS spreads and slopes, i.e., higher CDS-implied credit risk for medium, long, and very long term. The results on the parallel trend assumption in conjunction with the DiD results suggest the existence of a potential causal relationship between a firm's exposure to transition risk, as proxied by Scope 1 emissions, and medium, long, and very long term credit risk, as proxied by CDS spread and slope. These DiD results on the 2015 Paris Agreement are robust to the oil price decline observed in 2015-2016. Finally, following the Paris Agreement, the CDS spread of high polluting firms, which are active in scrutinized industries, increased more than the CDS spread of high polluting firms in non-scrutinized industries, suggesting that the scrutiny of the industry plays a role in the CDS market's assessment of a firm's exposure to transition risk.

6 Conclusion

The European low-carbon transition started in the last decades and is accelerating for reaching the EU's next GHG reduction target by 2030 and net-zero by 2050. In this paper, we study how in Europe a firm's climate-related transition risk, as proxied by disclosed GHG emissions and transition management indicators, relates to the firm's CDS-implied short, medium, long, and very-long-term credit risk. As proxies for the time horizon of the effect of climate-related transition risk on credit risk, we use the 1, 5, 10, and 30-year CDS spread. Based on a sample composed of over 200 European large corporate firms, we find that firms with higher Scope 1 GHG emissions have higher CDS-implied credit risk and the relation appears to be causal as confirmed in a difference-in-differences analysis around the Paris Agreement. Particularly, after the Paris Agreement, the relation between Scope 1 emissions and CDS spreads is reflected at all time horizons of the CDS term structure. This result is mainly driven by high emitters in salient industries, such as Electricity, Gas, and Mining.

When looking at transition management, CDS market participants do not appear to price the mitigation effects of qualitative indicators of transition management such as targets, policies, remuneration, and / or risk management. Moreover, the results suggest no differential treatment of the Scope 1 GHG emissions based on the fact whether the firm is subject to the EU ETS and herewith exposed to emissions costs or not. Two possible explanations arise regarding the observed phenomenon. Firstly, it could be attributed to market inefficiency, where participants in the CDS market do not incorporate the provided data in their decision-making processes. This perspective gains support from the 2021 ECB review of risk management practices on climate risks in financial institutions, which provides additional evidence by indicating that banks lack a comprehensive data strategy and fail to integrate transition-related information, including the EU ETS, in their assessments of creditworthiness. The second interpretation revolves around the challenges faced by CDS market participants in forming expectations due to the nature of the ETS market. The difficulty potentially hinders the ability of CDS market participants to accurately anticipate future allowance prices and their impact on a firm's financial performance due to the EU ETS market's cap-and-trade system, where allowances are traded based on supply and demand. Finally, CDS market participants are likely not considering ETS-related cash flows gained from a surplus of free allowances in their assessment of a firm's credit risk.

Overall, the results in this paper suggest that the European CDS market is already pricing to some extent, albeit small, the information of Scope 1 emissions of a firm, but much of the readily available information on other climate-related transition indicators - whether on transition management efforts or carbon market exposure - is not reflected. For instance, banks and investment firms are the main type of market participants on the European CDS market as well as on the European regulated carbon markets, e.g., EEX, ICE Endex and Nasdaq Oslo, where emissions allowances and derivatives thereof are traded (see for instance ESMA (2021) regarding carbon markets).

This study contributes to the wider discussion on the data needs of financial institutions for assessing the climate related transition risk of non-financial corporations to which they are exposed (Elderson, 2021; ECB, 2021b; NGFS, 2021) by highlighting what is already available yet not used. A wide range of climate-related transition risk indicators are available in data sources such as Bloomberg and Refinitiv, which most financial institutions use in day-to-day business, as well as in publicly available sources, such as the EU Transaction Log run by the European Commission. While this paper analysis whether and to which extent climate-related transition indicators are priced into credit risk, future research shall assess what would be the just level of the impact of the climate-related transition risk on credit risk to be priced in and how the just level compares to the current level. Moreover, future work shall consider the estimation of shadow climate-related transition CDS spreads, where climate-related transition indicators of a firm are evaluated in standardized transition scenarios that offer a forward-looking assessment of losses related to a particular firm at different time horizons.

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Pricing Climate Transition Risk: Evidence from European Corporate CDS - Online Appendix -

In these appendices, we include complementary information to the article:

A Descriptive statistics and data description

B Specification of the baseline model for the determinants of CDS

C Supplementary empirical results

A Descriptive statistics and data description

This section includes the descriptive statistics and data description for the built dataset used in the empirical analyses.

- The description of variables employed for capturing the CDS-implied credit risk of a reference firm are presented in Tables A1 and A2 along with the summary statistics prensented in Table A3.
- The description of the firm-specific reference and financial data are provided in Table A4 along with the summary statistics presented in Table A5.
- The description of the indicators of exposure to climate-related transition riskare provided in Table A6 along with the summary statistics presented in Table A7.
- The description of the indicators of management to climate-related transition risk are presented in Table A8 along with the summary statistics included in Table A9.
- The description for the indicators of carbon market related exposure are reported in Table A10 along with summary the statistics of the variables in Table A11.
- Table A12 provides the correlation matrix between the main variables.

Table A1: Data description of variables related to CDS-implied credit risk in levels

Variable	Frequency	Source	Description from source
CDS-1y	Daily	IHS Markit	The par spread in basis points associated to the CDS with tenor 1 year. The spread is winsorized at 99th percentile.
CDS-5y	Daily	IHS Markit	The par spread in basis points associated to the CDS with tenor 5 years. The spread is winsorized at 99th percentile.
CDS-10y	Daily	IHS Markit	The par spread in basis points associated to the CDS with tenor 10 years. The spread is winsorized at 99th percentile.
CDS-30y	Daily	IHS Markit	The par spread in basis points associated to the CDS with tenor 30 years. The spread is winsorized at 99th percentile.
lnCDS-1y	Monthly	Constructed	Natural logarithm of end-of-month CDS par spread with tenor 1 year.
lnCDS-5y	Monthly	Constructed	Natural logarithm of end-of-month CDS par spread with tenor 5 years.
lnCDS-10y	Monthly	Constructed	Natural logarithm of end-of-month CDS par spread with tenor 10 years.
lnCDS-30y	Monthly	Constructed	Natural logarithm of end-of-month CDS par spread with tenor 30 years.
lnSlope(5y-1y)	Monthly	Constructed	Natural logarithm of the slope of the term structure of CDS spreads corresponding to the difference between the 5-year and the 1-year CDS spread levels.
lnSlope(10y-1y)	Monthly	Constructed	Natural logarithm of the slope of the term structure of CDS spreads corresponding to the difference between the 10-year and the 1-year CDS spread levels.
lnSlope(30y-1y)	Monthly	Constructed	Natural logarithm of the slope of the term structure of CDS spreads corresponding to the difference between the 30-year and the 1-year CDS spread levels.

Notes: The table presents the name, frequency, source, and description, as given in the source, of all variables related to CDS-implied credit risk employed in the analysis. The CDS variables correspond to euro-denominated senior CDS contracts with modified restructuring credit event clause (documentation clause MM14). The corresponding seniority of debt on which the CDS curve is priced on is senior unsecured debt. In the sample, end-of-month spreads are employed.

Table A2: Data description of variables related to CDS-implied credit risk in changes

Variable	Frequency	Source	Description from source
lnCDS-1y$\Delta^{\%}$	Monthly	Constructed	Percentage change of the natural logarithm of monthly 1-year CDS spread levels (CDS-1y).
lnCDS-5y$\Delta^{\%}$	Monthly	Constructed	Percentage change of the natural logarithm of monthly 5-year CDS spread levels (cdsp5y).
lnCDS-10y$\Delta^{\%}$	Monthly	Constructed	Percentage change of the natural logarithm of monthly 10-year CDS spread levels (CDS-10y).
lnCDS-30y$\Delta^{\%}$	Monthly	Constructed	Percentage change of the natural logarithm of monthly 30-year CDS spread levels (CDS-30y).
lnSlope(5y-1y)$\Delta^{\%}$	Monthly	Constructed	Percentage change of the natural logarithm of the slope of the term structure of CDS spreads corresponding to the difference between the 5-year and the 1-year CDS spread levels.
lnSlope(10y-1y)$\Delta^{\%}$	Monthly	Constructed	Percentage change of the natural logarithm of the slope of the term structure of CDS spreads corresponding to the difference between the 10-year and the 1-year CDS spread levels.
lnSlope(30y-1y)$\Delta^{\%}$	Monthly	Constructed	Percentage change of the natural logarithm of the slope of the term structure of CDS spreads corresponding to the difference between the 30-year and the 1-year CDS spread levels.

Notes: The table presents the name, frequency, source, and description, as given in the source, of all variables related to CDS-implied credit risk employed in the analysis. The CDS variables correspond to euro-denominated senior CDS contracts with modified restructuring credit event clause (documentation clause MM14). The corresponding seniority of debt on which the CDS curve is priced on is senior unsecured debt. In the sample, end-of-month spreads are employed.

Table A3: Summary statistics of variables related to CDS-implied credit risk

Variable	Obs.	Mean	Median	St. dev.	Min	Max
CDS-1y	20031	51.33	20.65	108.06	2.42	895.43
CDS-5y	20031	127.15	82.37	137.17	11.63	895.43
CDS-10y	20031	163.74	116.12	140.06	29.34	895.43
CDS-30y	20031	173.18	126.59	139.27	35.62	895.43
lnCDS-1y	20031	3.21	3.03	1.03	0.88	6.80
lnCDS-5y	20031	4.52	4.41	0.75	2.45	6.80
lnCDS-10y	20031	4.87	4.75	0.62	3.38	6.80
lnCDS-30y	20031	4.95	4.84	0.59	3.57	6.80
lnSlope(5y-1y)	19751	4.09	4.04	0.72	-6.57	6.56
lnSlope(10y-1y)	19761	4.56	4.50	0.62	-5.15	6.55
lnSlope(30y-1y)	19752	4.66	4.61	0.59	-5.69	6.50

Notes: The table presents for each variable the respective number of observations, the mean, the median, the standard deviation, the minimum, and the maximum value. The definition of variables is given in the online Appendix (Tables A1 and A2).

Table A4: Data description of variables used as determinants of CDS-implied credit risk

Variable	Frequency	Source	Description from source
Liquidity	Monthly	IHS Markit	The number of contributors whose contributions were included in the final composite value for the 5 year tenor CDS as per end-of-month.
Size	Monthly	Refinitiv	End-of-month consolidated market value of a company in bln EUR. It is the share price multiplied by the number of ordinary shares in issue.
StockRets	Monthly	Refinitiv	End-of-month stock return. It incorporates the daily price change and any relevant dividends for the specified period. The dividend reinvested Total Return methodology is used.
HistVolat	Monthly	Datastream	The historical volatility is estimated as a standard deviation of the returns over the past five years.
Leverage	Yearly	Bloomberg, Refinitiv	Short and long term debt divided by total assets (reported). Where this information is not available in Bloomberg, Refinitiv data is used instead.
TotAssets	Yearly	Bloomberg, Refinitiv	Total assets (reported) in local currency converted to bln EUR. Where this information is not available in Bloomberg, Refinitiv data is used instead.
Revenues	Yearly	Refinitiv	Revenue from all of a company's operating activities after deducting any sales adjustments and their equivalents, in local currency converted to bln EUR.
Unrated	Monthly	Refinitiv	Dummy taking the value 1 when the firm doesn't have a S&P or a Moody's rating
InvGradeA	Monthly	Refinitiv	Dummy taking the value 1 when the firm has a S&P or a Moody's rating in the class A of rating grades
InvGradeB	Monthly	Refinitiv	Dummy taking the value 1 when the firm has a S&P or a Moody's rating in the class BBB of rating grades
SpecGrade	Monthly	Refinitiv	Dummy taking the value 1 when the firm has a S&P or a Moody's rating in the class BB, B, or C of rating grades
RatingValue	Monthly	Refinitiv	Corresponding alphanumeric value on a scale going from 1 (worse) to 21 (best) of the S&P and Moody's rating

Notes: The table presents the name, frequency, source, and description, as given in the source, of all variables used as determinants of CDS-implied credit risk in the analysis.

Table A5: Summary statistics of traditional determinants of CDS-implied credit risk.

Variable	Obs.	Mean	Median	St. dev.	Min	Max
Leverage	20031	0.30	0.28	0.14	0.00	1.14
Liquidity	20031	6.79	7.00	2.95	2.00	17.00
Size	20031	23.22	11.97	30.15	0.081	316.08
HistVolat	20031	0.28	0.24	0.20	0	12.45
StockRets	20031	-0.04	-0.07	1.88	-23.86	19.86
TotAssets	19769	40.68	22.01	57.59	0.773	497.11
Revenues	18074	25.55	13.18	41.64	0	398.72
Unrated	20031	0.35	0	0.48	0	1.00
InvGradeA	20031	0.19	0	0.39	0	1.00
InvGradeB	20031	0.36	0	0.48	0	1.00
SpecGrade	20031	0.07	0	0.26	0	1.00
RatingValue	12490	13.53	14.00	2.09	3.00	19.00

Notes: The table presents for each variable the respective number of observations, the mean, the median, the standard deviation, the minimum, and the maximum value. The definition of variables is given in the online Appendix (Table A4).

Table A6: Data description of variables used as measures of exposure to transition risk

Variable	Frequency	Source	Description from source
GHGsScope1(BBG)	Yearly	Bloomberg	Scope 1: Direct Greenhouse Gas (GHG) Emissions of the company, in millions of metric tonnes of carbon dioxide equivalent (CO_2e). GHG are defined as those gases which contribute to the trapping of heat in the Earth's atmosphere and they include Carbon Dioxide (CO_2), Methane, and Nitrous Oxide. Scope 1 Emissions are those emitted from sources that are owned or controlled by the reporting entity. Examples of Direct Emissions include emissions from combustion in owned or controlled boilers, furnaces, vehicles , emissions from chemical production in owned or controlled process equipment. Emissions reported as CO_2 only will NOT be captured in this field. Values are converted to millions of metric tonnes.
GHGsScope1(Ref)	Yearly	Refinitiv	Direct of CO_2 and CO_2 equivalents emission in million tonnes. Direct emissions from sources that are owned or controlled by the company (scope 1 emissions). Following gases are relevant: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCS), perfluorinated compound (PFCS), sulfur hexafluoride (SF_6), nitrogen trifluoride (NF_3). We follow green house gas (GHG) protocol for all our emission classifications by type. Values are converted to millions of metric tonnes.
GHGsScope1(CDP)	Yearly	CDP	Scope 1 Activity Emissions Globally Total global amount of scope 1 emissions emitted by the company, measured in millions of metric tonnes of carbon dioxide equivalent. Scope 1 emissions are direct GHG (greenhouse gas) emissions from sources that are owned or operated by the company. Sources include combustion facilities, company owned or operated transportation, and physical or chemical processes. The information is directly from the company's response to the CDP climate change information request.
CO2ETS	Monthly	Bloomberg	End-of-month value of European Climate Exchange OTC 1 Year CO_2 Emission EU ETS Price Index
Scope1	Yearly	Constructed	Maximum Scope 1 GHG Emissions based on Refinitiv, Bloomberg, CDP, in million tonnes eCO_2
Scope1(EUR)	Monthly	Constructed	Scope1 multiplied by CO2ETS
Scope1TA	Yearly	Constructed	Scope1 in mln. tonnes eCO_2 divided by total assets in bln. EUR. Values are winsorized at 90th percentile.
Scope1Rev	Yearly	Constructed	Scope1 in mln. tonnes divided by revenues in bln. EUR Values are winsorized at 90th percentile.

Notes: Notes: The table presents the name, frequency, source, and description, as given in the source, of all variables used as measures of exposure to transition risk.

Table A7: Summary statistics of variables related to exposure to transition risk.

Variable	Obs.	Mean	Median	St. dev.	Min	Max
Scope1	20031	9.54	0.40	25.02	0.0001	181.70
Scope1ln	20031	-0.63	-0.92	2.78	-9.05	5.20
Scope1(EUR)	20031	113.63	4.58	346.21	0.0008	8,190.24
Scope1Rev	18074	0.27	0.03	0.40	0.0001	1.18
Scope1TA	19769	0.14	0.02	0.21	0.0001	0.63
GHGsScope1(BBG)	16178	9.22	0.36	24.75	0.0001	181.70
GHGsScope1(Ref)	17778	9.77	0.40	25.59	0.0001	181.70
GHGsScope1(CDP)	19138	9.46	0.40	24.86	0.0001	181.69
E-score	19276	72.97	76.87	17.56	0	98.75

Table A8: Data description of variables used as measures of management of transition risk

Variable	Frequency	Source	Description from source
TargetIncentives	Yearly	CDP	Dummy taking the value 1 if firm indicates that it provides incentives for individual management of climate change issues including attainment of GHG Targets. The information is directly from the company's response to the CDP climate change information request.
ClimatePolicy	Yearly	Bloomberg	Dummy taking the value 1 if the firm has a Climate Change Policy
GHGPolicy	Yearly	Refinitiv	Dummy taking the value 1 if the firm has a policy to improve emission reduction. - in scope are the various forms of emissions to land, air or water from the company's core activities - processes, mechanisms or programs in place as to what the company is doing to reduce emissions in its operations - system or a set of formal, documented processes for controlling emissions and driving continuous improvement
EEPolicy	Yearly	Refinitiv	Dummy taking the value 1 if the firm has a policy to improve its energy efficiency. - in scope are the various forms of processes/ mechanisms/ procedures to improve energy use in operation efficiently - system or a set of formal documented processes for efficient use of energy and driving continuous improvement
GHGTrading	Yearly	Refinitiv	Dummy taking the value 1 if the firm reports on its participation in any emissions trading initiative. - emissions trading (cap and trade) is a market-based approach used to control pollution by providing economic incentives for achieving reductions in the emissions of pollutants - if a company claims to participate in an emission trading scheme in the future we grade as false
CO2InternalPrice	Yearly	Refinitiv	Dummy taking the value 1 if the firm has an internal price on carbon.
EETarget	Yearly	Refinitiv	Dummy taking the value 1 if firm sets Targets or objectives to be achieved on energy efficiency. In scope, are the short-term or long-term reduction Target to be achieved on efficiently using the energy from business operations
ETS	Yearly	EUTL	Dummy taking the value 1 if firm is in the EUTL register of the EU ETS. Data available starting 2013, start of EU ETS Phase 3.
EUAexcess	Yearly	EUTL	Dummy taking the value 1 if firm has allowances in excess. Data available starting 2013, start of EU ETS Phase 3.
EUAdeficit	Yearly	EUTL	Dummy taking the value 1 if firm has allowances in deficit Data available starting 2013, start of EU ETS Phase 3.
EUAexcessBalance	Yearly	EUTL	Free allowances in excess, expressed in million tonnes eCO2, in absolute value Data available starting 2013, start of EU ETS Phase 3.
EUAdeficitBalance	Yearly	EUTL	Free allowances in deficit, expressed in million tonnes eCO2, in absolute value Data available starting 2013, start of EU ETS Phase 3.
EUA-GHG	Yearly	EUTL	Free allowances minus ETS emissions, expressed in million tonnes eCO2. Data available starting 2013, start of EU ETS Phase 3.
EUA-GHGeur	Yearly	EUTL	Free allowances minus ETS emissions, expressed in million EUR Data available starting 2013, start of EU ETS Phase 3.

Notes: The table presents the name, frequency, source, and description, as given in the source, of all variable used as measures of management of transition risk.

Table A9: Summary statistics of variables used as measures of management of transition risk

Variable	Obs.	Mean	Median	St. dev.	Min	Max
Target	20031	0.49	0	0.50	0	1
EETarget	20031	0.33	0	0.47	0	1
TargetIncentives	20031	0.83	1	0.38	0	1
ClimatePolicy	20031	0.83	1	0.37	0	1
GHGPolicy	20031	0.02	0	0.13	0	1
energeffpolicy	20031	0.04	0	0.19	0	1
GHGTrading	20031	0.54	1	0.50	0	1
CO2InternalPrice	20031	0.93	1	0.26	0	1

Table A10: Data description of the variable *Target* used as an indicator of management of transition risk

Variable	Frequency	Source	Description from source
Target	Yearly	Constructed	Dummy taking the value 1 if one of the following variables is equal to 1: GHGTargetDum, SciBDum, NetZeroDum. In addition, where one of the following variable is not NA, the dummy receives the value 1: GHGTargetYear, GHGTarget%, GHGBaseYearTarget%, GHGTargetIntTargetYear, GHGTargetIntScope1-2%, GHGTargetABSTargetYear, GHGTargetABS%
GHGTargetDum	Yearly	Refinitiv	Has the company set Targets or objectives to be achieved on emission reduction? In scope are the short-term or long-term reduction Target to be achieved on emissions to land, air or water from business operations
ScienceBDum	Yearly	Bloomberg	Dummy taking the value 1 if firm has Science Based Targets
NetZeroDum	Yearly	Bloomberg	Dummy taking the value 1 if firm has Net Zero Emissions Target
GHGTargetYear	Yearly	Refinitiv	The year by which the emission reduction Target is due to be reached.
GHGTarget%	Yearly	Refinitiv	Percentage of emission reduction Target set by the firm
GHGBaseYearTarget%	Yearly	CDP	Percentage reduction from the base year that the most ambitious intensity emissions reduction Target relates to. The information is directly from the company's response to the CDP climate change information request.
GHGTargetIntTargetYear	Yearly	CDP	CDP Target Year Intensity Target
GHGTargetIntScope1-2%	Yearly	CDP	CDP % Chg in Abs Scope 1 & 2 Emiss Intens Target
GHGTargetABSTargetYear	Yearly	CDP	CDP Target Year Absolute Target
GHGTargetABS%	Yearly	CDP	CDP Emissions Reduction Absolute Target

Notes: The table presents the name, frequency, source, and description, as given in the source, of all variable used as measures of management of transition risk.

Table A11: Summary statistics of variables used in relation to the ETS

Variable	Obs.	Mean	Median	St. dev.	Min	Max
CO2ETS	13529	15.17	8.85	10.41	4.43	48.25
ETS	13529	0.34	0	0.47	0	1
ETS-GHG	4559	4.22	0.32	7.56	0	40.06
ETS-EUA	4559	3.02	0.23	7.30	0	48.88
EUAexcessBalance	4559	0.27	0	1.63	0	14.88
EUAdeficitBalance	4559	1.47	0.04	4.68	0	39.96
EUAexcess	4559	0.22	0	0.41	0	1
EUAdeficit	4559	0.78	1	0.41	0	1
EUA-GHG	4559	-1.20	-0.04	5.04	-39.96	14.88
EUA-GHGeur	4559	-17.13	-0.52	73.97	-910.30	500.91

Table A12: Correlation of main variables

	lnCDS-5y	Liquidity	Leverage	Size	Unrated	InvGradeA	InvGradeB	SpecGrade	Scope1	Target	GHGTrading
lnCDS-5y	1										
Liquidity	-0.136	1									
Leverage	0.182	-0.036	1								
Size	-0.411	0.119	-0.093	1							
Unrated	0.168	-0.201	-0.051	-0.197	1						
InvGradeA	-0.343	0.100	-0.083	0.507	-0.360	1					
InvGradeB	-0.121	0.122	0.031	-0.117	-0.549	-0.364	1				
SpecGrade	0.377	0.004	0.138	-0.141	-0.208	-0.138	-0.210	1			
Scope1	0.082	0.140	-0.109	0.181	-0.190	0.156	0.028	0.074	1		
Target	-0.227	0.117	0.001	0.073	-0.035	-0.058	0.124	-0.057	-0.070	1	
GHGTrading	-0.062	-0.069	-0.005	-0.172	0.206	-0.202	0.022	-0.087	-0.369	0.200	1

B Specification of the baseline model for the determinants of CDS

For the selection of the baseline model, we evaluate two specifications from the existing literature on CDS-implied credit risk and traditional determinants thereof: the specification following Augustin and Izhakian (2020) and the specification following Galil et al. (2014). Augustin and Izhakian (2020) use as a dependent variable the natural logarithm of CDS spread, the percentile change in CDS spread, and the slope of the CDS term structure. For explaining the dependent variable, the authors use as a baseline specification the following traditional determinants of CDS: Leverage, credit rating (mapped to a scale from 1-best to 21-worst), Liquidity (CDS depth), Size (number of shares outstanding multiplied by the stock price at the beginning of the month). Galil et al. (2014) use as a dependent variable the CDS spread and changes in CDS spread. For explaining the dependent variable, the authors use the following variables: stock return, historical volatility, Leverage, and investment-grade-dummies for A-class and BBB, speculative-grade-dummy, and Unrated-dummy. Both studies test empirically the above specifications using a sample of US firms.

We present the results on the specification inspired from Augustin and Izhakian (2020) in Table B1 for the natural logarithm of the 1, 5, 10, and 30-year CDS spread. Leverage is positively associated in a statistically significant way with the natural logarithm of the CDS spread across all tenors. The magnitude of the coefficient decreases as the CDS tenor increases. Size is negatively associated in statistically significant way with the natural logarithm of the CDS spread across all tenors. An investment grade rating is negatively associated with CDS spreads across all tenors. Conversely, a speculative grade rating is positively associated with CDS spreads across all tenors. The relation between CDS spread and speculative grade dummy is statistically significant when introducing country-sector-time fixed effects. When expanding to firm-time fixed effects, the sign of the regression coefficients remains remarkably stable, while standard errors increase, by comparison with the results using country-sector-time fixed effects. The increase in standard errors indicates a decrease in the accuracy of measurement when expanding to firm-time fixed effects. This further suggests that the lack of statistical significance in the firm-time fixed effects specification occurs solely because of no sufficient within-firm variation, as credit ratings are rather stale in nature and do not vary remarkably over time. Finally, Liquidity is positively associated in a statistically significant way with the natural logarithm of 5-year CDS spread. Overall, the regression results of the model specification for the natural logarithm of CDS spread are qualitatively similar with the ones obtained by Augustin and Izhakian (2020). The regression results for CDS spread percentage changes for each CDS tenor are reported in Table B2 and for the CDS slope in Table B3. The regression results are also similar to the ones obtained by Augustin and Izhakian (2020) under these specifications.

The results on the specification inspired from Galil et al. (2014) are shown in Table B4 for the 1, 5, 10, and 30-year CDS spread. Leverage is positively associated in a statistically significant way with the CDS spread across all tenors. An investment grade rating is negatively associated with 5, 10, and 30-year CDS spreads. Conversely, a speculative grade rating is positively associated with 10 and 30-year CDS spreads. The relation is statistically significant at 10% level. The results for stock return and historical volatility are ambiguous, as none of the coefficients obtained under a firm-time fixed effects specification are statistically significant. The regression results for CDS spread percentage changes for each CDS tenor are reported in Table B5. Differences between these results and the ones obtained by Galil et al. (2014) may be attributed to differences in sample composition, e.g., focus on European firms during 2010-2021 in this paper versus US firms during 2007-2011 in Galil et al. (2014).

Table B1: Determinants of the natural logarithm of CDS spread using the specifications inspired from Augustin and Izhakian (2020)

Variables	lnCDS-1y	lnCDS-1y	lnCDS-1y	lnCDS-5y	lnCDS-5y	lnCDS-5y	lnCDS-10y	lnCDS-10y	lnCDS-10y	lnCDS-30y	lnCDS-30y	lnCDS-30y
Leverage	0.79***	0.70***	1.71***	0.55***	0.55***	1.29***	0.50***	0.52***	1.03***	0.50***	0.50***	0.98***
	(0.048)	(0.25)	(0.39)	(0.031)	(0.19)	(0.27)	(0.025)	(0.16)	(0.21)	(0.024)	(0.15)	(0.19)
Liquidity	-0.050***	-0.049***	0.0090	-0.015***	-0.010	0.010*	-0.0026**	0.0036	0.0072	0.00040	0.0049	0.0051
	(0.0022)	(0.011)	(0.0082)	(0.0015)	(0.0075)	(0.0058)	(0.0012)	(0.0066)	(0.0046)	(0.0012)	(0.0064)	(0.0043)
Size	-0.0074***	-0.0041***	-0.0065***	-0.0066***	-0.0048***	-0.0068***	-0.0052***	-0.0042***	-0.0053***	-0.0047***	-0.0038***	-0.0046***
	(0.00025)	(0.0014)	(0.0023)	(0.00018)	(0.0013)	(0.0018)	(0.00014)	(0.0011)	(0.0014)	(0.00014)	(0.0011)	(0.0012)
InvGradeA	-0.46***	-0.51***	-0.19	-0.60***	-0.56***	-0.22	-0.58***	-0.51***	-0.20	-0.58***	-0.51***	-0.19
	(0.052)	(0.19)	(0.27)	(0.038)	(0.15)	(0.20)	(0.031)	(0.14)	(0.16)	(0.028)	(0.13)	(0.14)
InvGradeB	-0.43***	-0.35**	-0.14	-0.45***	-0.38***	-0.15	-0.41***	-0.36***	-0.12	-0.40***	-0.36***	-0.11
	(0.051)	(0.18)	(0.27)	(0.037)	(0.14)	(0.20)	(0.030)	(0.13)	(0.16)	(0.027)	(0.12)	(0.14)
SpecGrade	0.66***	0.62***	0.31	0.56***	0.52***	0.21	0.48***	0.44***	0.20	0.45***	0.41***	0.21
	(0.057)	(0.19)	(0.27)	(0.040)	(0.15)	(0.20)	(0.033)	(0.14)	(0.16)	(0.030)	(0.14)	(0.14)
Unrated	-0.044	0.066	0.011	-0.19***	-0.091	-0.054	-0.20***	-0.12	-0.027	-0.20***	-0.13	-0.014
	(0.051)	(0.18)	(0.27)	(0.037)	(0.14)	(0.20)	(0.031)	(0.13)	(0.16)	(0.028)	(0.13)	(0.14)
Constant	3.69***	3.58***	2.84***	4.91***	4.77***	4.32***	5.16***	5.03***	4.72***	5.20***	5.10***	4.80***
	(0.054)	(0.19)	(0.28)	(0.039)	(0.15)	(0.21)	(0.032)	(0.14)	(0.16)	(0.029)	(0.13)	(0.15)
Sector F.E.	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Country F.E.	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	210	210	210	210	210	210	210	210	210	210	210	210
Observations	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031
R-squared	0.236	0.580	0.786	0.333	0.595	0.826	0.357	0.585	0.837	0.359	0.574	0.835

Notes: The dependent variable is the natural logarithm of CDS spread for the tenor 1 year, 5 years, 10 years, and 30 years, respectively. The definition of all variables is given in tables A1 and A6. All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Table B2: Determinants of CDS spread percentage changes using the specifications inspired from Augustin and Izhakian (2020)

VARIABLES	lnCDS-1y$\Delta^{\%}$	lnCDS-1y$\Delta^{\%}$	lnCDS-1y$\Delta^{\%}$	lnCDS-5y$\Delta^{\%}$	lnCDS-5y$\Delta^{\%}$	lnCDS-5y$\Delta^{\%}$	lnCDS-10y$\Delta^{\%}$	lnCDS-10y$\Delta^{\%}$	lnCDS-10y$\Delta^{\%}$	lnCDS-30y$\Delta^{\%}$	lnCDS-30y$\Delta^{\%}$	lnCDS-30y$\Delta^{\%}$
Leveragepc	0.00028	0.000098	0.00014	0.00014	0.000039	0.000043	0.000066	0.000026	0.000029	0.000050	0.000014	0.000016
	(0.00021)	(0.00012)	(0.00013)	(0.000096)	(0.000063)	(0.000062)	(0.000047)	(0.000038)	(0.000038)	(0.000038)	(0.000035)	(0.000034)
Liquidity$\Delta^{\%}$	0.024***	0.015***	0.015***	0.011***	0.0071***	0.0072***	0.0061***	0.0037***	0.0038***	0.0050***	0.0024***	0.0024***
	(0.0025)	(0.0045)	(0.0045)	(0.00092)	(0.0018)	(0.0018)	(0.00055)	(0.00089)	(0.00090)	(0.00054)	(0.00088)	(0.00089)
Sizepc	-0.21***	-0.082**	-0.084**	-0.084***	-0.035**	-0.036**	-0.056***	-0.026**	-0.026**	-0.052***	-0.024**	-0.024**
	(0.074)	(0.034)	(0.034)	(0.028)	(0.014)	(0.014)	(0.019)	(0.0100)	(0.010)	(0.017)	(0.0093)	(0.0094)
InvGradeA	0.0071*	0.0076*	0.012***	0.0025*	0.0026	0.0049***	0.0021**	0.0020*	0.0035***	0.0019**	0.0019*	0.0031**
	(0.0043)	(0.0040)	(0.0038)	(0.0013)	(0.0016)	(0.0012)	(0.00086)	(0.0010)	(0.0011)	(0.00087)	(0.00099)	(0.0012)
InvGradeB	0.0045	0.0047	0.0062**	0.0017	0.0017	0.0022***	0.0014*	0.0013	0.0017**	0.0012	0.0013	0.0017**
	(0.0040)	(0.0029)	(0.0031)	(0.0013)	(0.0012)	(0.00071)	(0.00081)	(0.00090)	(0.00069)	(0.00082)	(0.00088)	(0.00067)
SpecGrade	0.0013	0.0018	0.0014	0.00071	0.00070	0.00011	0.00061	0.00049	-9.6e-06	0.00044	0.00043	0.00011
	(0.0044)	(0.0025)	(0.0040)	(0.0014)	(0.0012)	(0.00099)	(0.00096)	(0.0010)	(0.0010)	(0.00097)	(0.0010)	(0.00092)
Unrated	0.0030	0.0037*	0.0036	0.0015	0.0012	0.00033	0.0014*	0.00100	0.00028	0.0012	0.00086	0.00024
	(0.0040)	(0.0021)	(0.0033)	(0.0012)	(0.00086)	(0.00094)	(0.00082)	(0.00068)	(0.00080)	(0.00083)	(0.00066)	(0.00080)
Constant	-0.0036	-0.0035	-0.0048*	-0.0027**	-0.0024**	-0.0027***	-0.0019**	-0.0016*	-0.0017***	-0.0015*	-0.0013*	-0.0014**
	(0.0039)	(0.0025)	(0.0029)	(0.0012)	(0.0010)	(0.00056)	(0.00078)	(0.00080)	(0.00061)	(0.00079)	(0.00077)	(0.00065)
Sector F.E.	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Country F.E.	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	210	210	210	210	210	210	210	210	210	210	210	210
Observations	19,560	19,560	19,560	19,560	19,560	19,560	19,560	19,560	19,560	19,560	19,560	19,560
R-squared	0.084	0.425	0.427	0.114	0.464	0.467	0.114	0.414	0.419	0.097	0.356	0.360

Notes: The dependent variable is the percentage change of the natural logarithm of the tenor 1 year, 5 years, 10 years, and 30 years, respectively. The definition of all variables is given in tables A1 and A6. All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Table B3: Determinants of slope of CDS using the specifications inspired from Augustin and Izhakian (2020)

VARIABLES	lnSlope(5y-1y)	lnSlope(5y-1y)	lnSlope(5y-1y)	lnSlope(10y-1y)	lnSlope(10y-1y)	lnSlope(10y-1y)	lnSlope(30y-1y)	lnSlope(30y-1y)	lnSlope(30y-1y)
Leverage	0.38***	0.37**	0.95***	0.35***	0.38**	0.70***	0.32***	0.33**	0.55**
	(0.028)	(0.17)	(0.21)	(0.025)	(0.15)	(0.17)	(0.027)	(0.15)	(0.23)
Liquidity	0.019***	0.026***	0.012**	0.028***	0.036***	0.0075	0.029***	0.034***	0.0052
	(0.0017)	(0.0086)	(0.0059)	(0.0016)	(0.0082)	(0.0048)	(0.0015)	(0.0079)	(0.0045)
size	-0.0057***	-0.0053***	-0.0075***	-0.0042***	-0.0045***	-0.0058***	-0.0036***	-0.0040***	-0.0049***
	(0.00017)	(0.0014)	(0.0016)	(0.00015)	(0.0013)	(0.0013)	(0.00014)	(0.0012)	(0.0012)
InvGradeA	-0.64***	-0.53***	-0.17	-0.59***	-0.44***	-0.15	-0.58***	-0.46***	-0.13
	(0.034)	(0.14)	(0.19)	(0.028)	(0.14)	(0.16)	(0.026)	(0.14)	(0.14)
InvGradeB	-0.45***	-0.38***	-0.078	-0.39***	-0.34**	-0.060	-0.36***	-0.35***	-0.044
	(0.033)	(0.13)	(0.19)	(0.027)	(0.13)	(0.15)	(0.025)	(0.13)	(0.13)
SpecGrade	0.50***	0.46***	0.25	0.42***	0.39***	0.23	0.40***	0.36***	0.25*
	(0.035)	(0.14)	(0.18)	(0.029)	(0.14)	(0.15)	(0.028)	(0.14)	(0.13)
Unrated	-0.31***	-0.22*	0.080	-0.29***	-0.21	0.091	-0.27***	-0.21	0.10
	(0.034)	(0.13)	(0.21)	(0.028)	(0.13)	(0.17)	(0.026)	(0.13)	(0.16)
Constant	4.35***	4.21***	3.92***	4.68***	4.56***	4.44***	4.76***	4.68***	4.56***
	(0.035)	(0.14)	(0.19)	(0.029)	(0.14)	(0.16)	(0.027)	(0.14)	(0.15)
Sector F.E.	N	Y	N	N	Y	N	N	Y	N
Country F.E.	N	Y	N	N	Y	N	N	Y	N
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	N	Y	N	N	Y	N	N	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	210	210	210	210	210	210	210	210	210
Observations	19,751	19,751	19,751	19,761	19,761	19,761	19,752	19,752	19,752
R-squared	0.282	0.481	0.725	0.266	0.444	0.714	0.266	0.428	0.702

Notes: The dependent variable is the natural logarithm of the slope of the term structure of CDS spreads corresponding to the difference between the 5 years, 10 years, and 30 years, and the 1-year CDS spread levels, respectively. The definition of all variables is given in tables A1 and A6. All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Table B4: Regression results for CDS spread in levels using the specifications inspired from Galil et al. (2014)

Variables	1y	1y	1y	5y	5y	5y	10y	10y	10y	30y	30y	30y
Leverage	87.3***	69.0***	168**	121***	104***	251***	131***	119***	246***	134***	122***	236***
	(6.00)	(25.5)	(65.3)	(6.77)	(32.6)	(64.4)	(6.59)	(33.5)	(58.8)	(6.48)	(33.3)	(56.3)
HistVolat	107***	67.7	49.6	159***	102	61.2	162***	108	59.7	157***	107	57.5
	(37.2)	(57.2)	(44.1)	(53.5)	(83.8)	(57.6)	(53.5)	(87.9)	(57.4)	(52.2)	(87.6)	(55.3)
StockRets	1.33*	-0.62	-0.20	2.23***	-0.26	0.24	1.87**	-0.29	0.22	1.63**	-0.28	0.21
	(0.73)	(0.98)	(0.69)	(0.76)	(1.11)	(0.72)	(0.73)	(1.09)	(0.68)	(0.72)	(1.08)	(0.68)
InvGradeA	-47.6***	-42.2**	-22.4	-122***	-106***	-45.8*	-140***	-119***	-52.0*	-141***	-119***	-49.1*
	(7.22)	(18.1)	(17.6)	(9.57)	(25.3)	(27.4)	(9.31)	(27.9)	(29.4)	(8.89)	(27.4)	(28.0)
InvGradeB	-44.5***	-43.7**	-25.5	-99.9***	-94.2***	-41.0	-109***	-102***	-43.3	-106***	-101***	-39.3
	(6.72)	(18.0)	(17.9)	(8.77)	(25.0)	(27.6)	(8.46)	(27.3)	(29.6)	(8.05)	(26.8)	(28.2)
SpecGrade	38.4***	34.3	10.6	86.2***	81.6**	46.3	99.4***	95.2***	54.4*	103***	98.5***	58.9*
	(8.31)	(24.3)	(23.5)	(10.3)	(34.1)	(32.5)	(9.90)	(35.9)	(32.2)	(9.47)	(35.4)	(30.8)
Unrated	-9.17	-3.30	-8.47	-47.8***	-30.4	-12.3	-55.8***	-36.2	-11.5	-53.6***	-35.1	-7.58
	(6.64)	(20.5)	(18.6)	(8.53)	(27.8)	(28.1)	(8.22)	(30.0)	(30.2)	(7.81)	(29.5)	(29.0)
Constant	21.1	34.3	2.99	117***	127***	59.4*	158***	163***	99.1***	166***	171***	108***
	(13.6)	(26.4)	(28.7)	(19.1)	(35.9)	(35.3)	(19.1)	(38.4)	(35.0)	(18.5)	(38.0)	(33.4)
Sector F.E.	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Country F.E.	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	210	210	210	210	210	210	210	210	210	210	210	210
Observations	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031
R-squared	0.128	0.352	0.585	0.270	0.470	0.722	0.312	0.499	0.756	0.318	0.500	0.760

Notes: All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Table B5: Regression results for CDS spread changes using the specifications inspired from Galil et al. (2014)

Variables	Δ1y	Δ1y	Δ1y	Δ5y	Δ5y	Δ5y	Δ10y	Δ10y	Δ10y	Δ30y	Δ30y	Δ30y
Leveragedelta	-7.19	-19.9	-20.4	20.5	4.93	3.73	18.5	4.03	2.98	12.1	-3.30	-4.29
	(18.1)	(18.5)	(19.1)	(16.1)	(10.3)	(14.4)	(22.2)	(17.4)	(21.2)	(24.0)	(20.7)	(23.4)
HistVolatdelta	4.60	3.10	3.55	5.50	3.80	5.59	5.38	3.92	6.08*	4.71	3.18	5.13*
	(4.43)	(3.10)	(3.15)	(5.32)	(3.20)	(3.44)	(5.20)	(3.07)	(3.23)	(4.96)	(2.75)	(3.03)
StockRets	1.10***	0.13	0.14	1.12***	0.051	0.074	1.09***	0.067	0.096	1.15***	0.073	0.096
	(0.24)	(0.32)	(0.33)	(0.21)	(0.31)	(0.32)	(0.19)	(0.29)	(0.31)	(0.20)	(0.31)	(0.32)
InvGradeA	1.38	1.52	2.64*	1.91	1.63	3.00***	1.97	1.61	2.73***	1.84	1.56	2.47**
	(2.06)	(1.17)	(1.55)	(1.69)	(1.43)	(1.12)	(1.56)	(1.41)	(0.97)	(1.61)	(1.38)	(1.03)
InvGradeB	1.67	1.23	2.43*	1.99	1.40	2.48***	1.98	1.40	2.20***	1.89	1.39	2.14***
	(2.06)	(0.98)	(1.33)	(1.69)	(1.31)	(0.70)	(1.57)	(1.33)	(0.60)	(1.61)	(1.27)	(0.63)
SpecGrade	3.17	2.44	1.48	1.48	0.52	0.49	1.44	0.50	0.71	1.47	0.63	1.11
	(2.76)	(2.66)	(2.96)	(2.27)	(2.49)	(2.40)	(2.12)	(2.38)	(2.43)	(2.17)	(2.57)	(2.50)
Unrated	1.40	1.07	-0.20	1.40	0.66	-2.01	1.41	0.60	-2.28	1.30	0.43	-2.57*
	(2.09)	(0.72)	(1.92)	(1.71)	(1.08)	(1.65)	(1.59)	(1.13)	(1.58)	(1.63)	(1.17)	(1.54)
Constant	-1.49	-1.24	-1.37	-1.84	-1.29	-1.01**	-1.72	-1.14	-0.66	-1.57	-1.01	-0.45
	(2.05)	(0.76)	(1.22)	(1.67)	(1.15)	(0.49)	(1.55)	(1.19)	(0.40)	(1.59)	(1.18)	(0.41)
Sector F.E.	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Country F.E.	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	210	210	210	210	210	210	210	210	210	210	210	210
Observations	19,560	19,560	19,560	19,560	19,560	19,560	19,560	19,560	19,560	19,560	19,560	19,560
R-squared	0.005	0.147	0.155	0.006	0.226	0.234	0.006	0.221	0.230	0.006	0.210	0.217

Notes: All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

C Complementary empirical results

In this section, we include additional results as a complement to the main analysis.

- Table C1 presents the results including two alternative specifications: scope 1 relative to revenues *Scope1Rev* and scope 1 relative to total assets *Scope1TA*.
- Table C2 presents the results on the natural logarithm of Scope 1 and the natural logarithm of CDS spread.
- Table C3 presents the results with alternative specifications for sector, country, time, and firm fixed effects.
- Table C4 presents the results natural logarithm of Scope 1 and the natural logarithm of CDS slope.
- Table C5 presents the results on CDS slope and Scope 1 GHG emissions.
- Table C6 presents the results on the exposure management and the logarithm of the CDS slope.
- Table C7 presents the results of proxies of management on Scope 1 in relation with the natural logarithm of CDS slope.
- Table C8 presents alternative specifications that include a basic difference-in-differences with no fixed effects and one with firm-time fixed effects.
- Table C9 presents the results for a subsample that excludes firms active in the oil and basic metal sectors on the DiD approach.
- Table C10 presents the results in the DID regressions on Paris Agreement for a 49-months-event-window and treated firms in top quartile of scope 1 distribution.
- Table C11
- Tables C12-C13-C14 present the results for alternative definitions of the treatment in the DID regressions.
- Table C15 presents the results for alternative definitions of the dependent variable in the DID regressions.
- Table C16 presents the robustness results of the triple DiD regressions on the natural logarithm of the CDS slope of "brown" firms in scrutinized industries.
- Figure C1 shows the point estimates for each of the 9 periods of the observation window from a regression following Equation 6, but where the variable *Treatment* is interacted with yearly dummies, instead of the *postParis* dummy.

Table C1: Scope 1 emissions in absolute and relative terms and CDS spread

	lnCDS-1y	lnCDS-1y	lnCDS-1y	lnCDS-5y	lnCDS-5y	lnCDS-5y	lnCDS-10y	lnCDS-10y	lnCDS-10y	lnCDS-30y	lnCDS-30y	lnCDS-30y
Scope1	0.0047**			0.0037**			0.0024*			0.0023		
	(0.0023)			(0.0016)			(0.0014)			(0.0014)		
ScopeRev		0.038			0.18			0.15			0.15	
		(0.30)			(0.20)			(0.15)			(0.13)	
Scope1TA			0.26			0.46			0.29			0.24
			(0.54)			(0.37)			(0.27)			(0.24)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Time F.E.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	210	193	208	210	193	208	210	193	208	210	193	208
Observations	20,031	18,074	19,769	20,031	18,074	19,769	20,031	18,074	19,769	20,031	18,074	19,769
R-squared	0.787	0.790	0.788	0.827	0.832	0.829	0.837	0.843	0.840	0.835	0.840	0.837

	lnCDS-1y	lnCDS-1y	lnCDS-1y	lnCDS-5y	lnCDS-5y	lnCDS-5y	lnCDS-10y	lnCDS-10y	lnCDS-10y	lnCDS-30y	lnCDS-30y	lnCDS-30y
Scope1	0.0043**			0.0040***			0.0025**			0.0028**		
	(0.0019)			(0.0014)			(0.0012)			(0.0011)		
Scope1Rev		0.41**			0.25**			0.20**			0.21***	
		(0.19)			(0.12)			(0.085)			(0.074)	
Scope1TA			0.87**			0.71**			0.49**			0.51**
			(0.34)			(0.30)			(0.23)			(0.22)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Time F.E.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	195	181	193	195	181	193	195	181	193	195	181	193
Observations	10,075	9,314	9,949	10,075	9,314	9,949	10,075	9,314	9,949	10,075	9,314	9,949
R-squared	0.840	0.845	0.842	0.879	0.882	0.880	0.893	0.895	0.894	0.895	0.896	0.895

Notes: The dependent variable is the natural logarithm of CDS spread for the tenor 1 year, 5 years, 10 years, and 30 years, respectively. Panel A shows the results for the full sample period Feb. 2010 to Apr. 2021. Panel B shows the panel regression results for the sample period Jan 2016 to Apr. 2021, which is following the Paris Agreement (Dec. 2015).The definition of all variables is given in tables A1 and A6. All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Table C2: Natural logarithm of Scope 1 and the natural logarithm of CDS spread

	lnCDS-1y	lnCDS-1y	lnCDS-1y	lnCDS-5y	lnCDS-5y	lnCDS-5y	lnCDS-10y	lnCDS-10y	lnCDS-10y	lnCDS-30y	lnCDS-30y	lnCDS-30y
Scope1ln	0.054***	0.020	0.047	0.046***	0.039***	0.036	0.044***	0.047***	0.018	0.043***	0.048***	0.016
	(0.0026)	(0.019)	(0.048)	(0.0017)	(0.013)	(0.033)	(0.0013)	(0.011)	(0.027)	(0.0013)	(0.010)	(0.026)
Leverage	0.91***	0.71***	1.72***	0.65***	0.57***	1.30***	0.60***	0.54***	1.03***	0.59***	0.53***	0.99***
	(0.048)	(0.25)	(0.40)	(0.031)	(0.19)	(0.27)	(0.025)	(0.15)	(0.21)	(0.023)	(0.14)	(0.19)
Liquidity	-0.056***	-0.053***	0.0090	-0.020***	-0.018**	0.011*	-0.0077***	-0.0052	0.0072	-0.0044***	-0.0042	0.0051
	(0.0022)	(0.011)	(0.0081)	(0.0015)	(0.0080)	(0.0058)	(0.0012)	(0.0067)	(0.0045)	(0.0011)	(0.0064)	(0.0043)
Size	-0.0081***	-0.0044***	-0.0065***	-0.0072***	-0.0055***	-0.0068***	-0.0058***	-0.0050***	-0.0053***	-0.0053***	-0.0047***	-0.0047***
	(0.00026)	(0.0016)	(0.0023)	(0.00018)	(0.0013)	(0.0018)	(0.00015)	(0.0012)	(0.0014)	(0.00014)	(0.0011)	(0.0012)
InvGradeA	-0.53***	-0.50***	-0.21	-0.66***	-0.55***	-0.24	-0.63***	-0.50***	-0.21	-0.64***	-0.49***	-0.20
	(0.052)	(0.18)	(0.25)	(0.037)	(0.14)	(0.19)	(0.030)	(0.13)	(0.16)	(0.027)	(0.12)	(0.14)
InvGradeB	-0.46***	-0.35**	-0.16	-0.47***	-0.38***	-0.16	-0.43***	-0.36***	-0.13	-0.42***	-0.36***	-0.12
	(0.050)	(0.17)	(0.26)	(0.036)	(0.13)	(0.19)	(0.029)	(0.12)	(0.16)	(0.027)	(0.12)	(0.14)
SpecGrade	0.61***	0.62***	0.30	0.52***	0.51***	0.20	0.43***	0.43***	0.19	0.41***	0.40***	0.20
	(0.057)	(0.19)	(0.26)	(0.039)	(0.14)	(0.19)	(0.032)	(0.13)	(0.15)	(0.029)	(0.13)	(0.13)
Unrated	-0.025	0.074	-0.011	-0.17***	-0.075	-0.071	-0.19***	-0.096	-0.036	-0.19***	-0.11	-0.022
	(0.051)	(0.18)	(0.25)	(0.037)	(0.13)	(0.19)	(0.030)	(0.12)	(0.16)	(0.028)	(0.12)	(0.14)
Constant	3.77***	3.62***	2.89***	4.97***	4.85***	4.35***	5.22***	5.12***	4.74***	5.26***	5.19***	4.81***
	(0.053)	(0.19)	(0.27)	(0.038)	(0.14)	(0.20)	(0.031)	(0.13)	(0.16)	(0.028)	(0.12)	(0.14)
Sector F.E.	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Country F.E.	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	210	210	210	210	210	210	210	210	210	210	210	210
Observations	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031
R-squared	0.255	0.581	0.787	0.358	0.602	0.827	0.391	0.600	0.837	0.394	0.592	0.835

Notes: All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Table C3: Exposure management and CDS spread

	lnCDS-1y	lnCDS-1y	lnCDS-1y	lnCDS-5y	lnCDS-5y	lnCDS-5y	lnCDS-10y	lnCDS-10y	lnCDS-10y	lnCDS-30y	lnCDS-30y	lnCDS-30y
Target	-0.34***	-0.10	-0.14**	-0.25***	-0.058	-0.079**	-0.14***	-0.040	-0.063**	-0.079***	-0.034	-0.057**
	(0.014)	(0.075)	(0.054)	(0.0092)	(0.059)	(0.036)	(0.0075)	(0.050)	(0.028)	(0.0071)	(0.048)	(0.028)
EETarget	-0.0083	-0.032	0.035	0.028***	-0.0039	0.017	0.042***	-0.00041	0.014	0.047***	0.00070	-0.0028
	(0.014)	(0.062)	(0.063)	(0.0090)	(0.048)	(0.045)	(0.0073)	(0.040)	(0.037)	(0.0070)	(0.039)	(0.035)
TargetIncentives	-0.29***	-0.17*	-0.11	-0.19***	-0.15**	-0.070	-0.13***	-0.14**	-0.064	-0.12***	-0.13**	-0.072*
	(0.021)	(0.094)	(0.079)	(0.013)	(0.075)	(0.049)	(0.011)	(0.063)	(0.039)	(0.011)	(0.059)	(0.038)
ClimatePolicy	0.20***	0.063	0.0097	0.10***	0.020	-0.0052	0.10***	0.015	-0.010	0.11***	0.016	-0.016
	(0.019)	(0.077)	(0.073)	(0.012)	(0.060)	(0.048)	(0.010)	(0.050)	(0.037)	(0.0098)	(0.047)	(0.036)
GHGPolicy	0.41***	0.32	0.0035	0.22***	0.12	-0.10	0.17***	0.10	-0.067	0.14***	0.094	-0.049
	(0.059)	(0.20)	(0.094)	(0.044)	(0.15)	(0.064)	(0.037)	(0.14)	(0.049)	(0.035)	(0.13)	(0.047)
EEPolicy	-0.31***	-0.21	0.12	-0.31***	-0.19*	0.074	-0.26***	-0.15	0.038	-0.25***	-0.15	0.022
	(0.034)	(0.13)	(0.13)	(0.023)	(0.10)	(0.064)	(0.019)	(0.093)	(0.052)	(0.019)	(0.091)	(0.050)
GHGTrading	-0.22***	-0.072	-0.14**	-0.17***	-0.087	-0.11**	-0.15***	-0.097**	-0.080**	-0.14***	-0.095**	-0.065*
	(0.014)	(0.071)	(0.066)	(0.0090)	(0.053)	(0.046)	(0.0074)	(0.045)	(0.037)	(0.0070)	(0.043)	(0.034)
CO2InternalPrice	-0.036	-0.052	0.10	0.012	-0.013	0.082	-0.042***	-0.042	0.030	-0.076***	-0.058	0.011
	(0.024)	(0.11)	(0.099)	(0.018)	(0.078)	(0.072)	(0.015)	(0.063)	(0.056)	(0.014)	(0.059)	(0.052)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sector F.E.	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Country F.E.	N	Y	N	N	Y	N	N	Y	N	N	Y	N
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	210	210	210	210	210	210	210	210	210	210	210	210
Observations	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031	20,031
R-squared	0.290	0.586	0.789	0.388	0.602	0.829	0.399	0.595	0.839	0.392	0.585	0.836

Notes: The dependent variable is the percentage change of the natural logarithm of CDS spread for the tenor 1 year, 5 years, 10 years, and 30 years, respectively ($lnCDS\text{-}1y\Delta^{\%}$, $lnCDS\text{-}5y\Delta^{\%}$, $lnCDS\text{-}10y\Delta^{\%}$, $lnCDS\text{-}30y\Delta^{\%}$). The interacted variables correspond to the interaction between sector-group dummies (C, C-topghg, D, J, Other), where each group has more than 2000 observations, and Scope 1 percentage changes. The independent variables are percentile change of Leverage, percentile change of size, percentile change of liquidity, and dummies corresponding to the rating class or to unrated. The definition of all variables is given in tables A1 and A4. The results for each type of tenor-specific dependent variable are presented for an OLS regression, regression with country - sector - time fixed effects, and regression with firm - time fixed effects. All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Table C4: Natural logarithm of Scope 1 and the natural logarithm of CDS slope

	lnSlope(5y-1y)	lnSlope(5y-1y)	lnSlope(5y-1y)	lnSlope(10y-1y)	lnSlope(10y-1y)	lnSlope(10y-1y)	lnSlope(30y-1y)	lnSlope(30y-1y)	lnSlope(30y-1y)
Scope1ln	0.026***	0.047***	0.039	0.026***	0.054***	0.019	0.026***	0.053***	0.016
	(0.0018)	(0.013)	(0.029)	(0.0017)	(0.011)	(0.023)	(0.0015)	(0.010)	(0.022)
Leverage	0.44***	0.40**	0.96***	0.41***	0.41***	0.70***	0.38***	0.36**	0.55**
	(0.028)	(0.16)	(0.21)	(0.025)	(0.14)	(0.17)	(0.027)	(0.14)	(0.23)
Liquidity	0.016***	0.017*	0.012**	0.025***	0.025***	0.0075	0.026***	0.024***	0.0052
	(0.0018)	(0.0089)	(0.0059)	(0.0016)	(0.0080)	(0.0048)	(0.0015)	(0.0078)	(0.0045)
Size	-0.0061***	-0.0061***	-0.0075***	-0.0045***	-0.0054***	-0.0059***	-0.0040***	-0.0049***	-0.0049***
	(0.00017)	(0.0014)	(0.0016)	(0.00015)	(0.0012)	(0.0013)	(0.00014)	(0.0012)	(0.0012)
InvGradeA	-0.67***	-0.51***	-0.18	-0.62***	-0.42***	-0.15	-0.61***	-0.44***	-0.14
	(0.033)	(0.13)	(0.18)	(0.027)	(0.13)	(0.15)	(0.025)	(0.13)	(0.14)
InvGradeB	-0.46***	-0.38***	-0.093	-0.40***	-0.32***	-0.067	-0.38***	-0.34***	-0.050
	(0.032)	(0.12)	(0.18)	(0.026)	(0.12)	(0.15)	(0.024)	(0.12)	(0.13)
SpecGrade	0.48***	0.46***	0.24	0.39***	0.39***	0.23	0.37***	0.35***	0.25*
	(0.034)	(0.12)	(0.18)	(0.028)	(0.12)	(0.14)	(0.027)	(0.12)	(0.13)
Unrated	-0.30***	-0.20	0.061	-0.28***	-0.19	0.082	-0.26***	-0.18	0.096
	(0.033)	(0.12)	(0.20)	(0.027)	(0.12)	(0.17)	(0.025)	(0.12)	(0.16)
Constant	4.38***	4.30***	3.96***	4.72***	4.66***	4.45***	4.80***	4.78***	4.58***
	(0.035)	(0.13)	(0.18)	(0.029)	(0.13)	(0.15)	(0.027)	(0.13)	(0.15)
Sector F.E.	N	Y	N	N	Y	N	N	Y	N
Country F.E.	N	Y	N	N	Y	N	N	Y	N
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	N	Y	N	N	Y	N	N	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	210	210	210	210	210	210	210	210	210
Observations	19,751	19,751	19,751	19,761	19,761	19,761	19,752	19,752	19,752
R-squared	0.291	0.491	0.726	0.277	0.463	0.714	0.278	0.448	0.702

Notes: The dependent variable is the CDS slope for the tenor 5 years, 10 years, and 30 years, respectively (*lnSlope(5y-1y)*, *lnSlope(10y-1y)*, *lnSlope(30y-1y)*). The interacted variables correspond to the interaction between sector-group dummies (C, C-topghg, D, J, Other), where each group has more than 2000 observations, and Scope 1 percentage changes. The independent variables are percentile change of Leverage, percentile change of Size, percentile change of Liquidity, and dummies corresponding to the rating class or to Unrated. The definition of all variables is given in tables A1 and A4. The results for each type of tenor-specific dependent variable are presented for an OLS regression, regression with country - sector - time fixed effects, and regression with firm - time fixed effects. All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Table C5: Scope 1 and the natural logarithm of CDS slope

	lnSlope(5y-1y)	lnSlope(5y-1y)	lnSlope(5y-1y)	lnSlope(10y-1y)	lnSlope(10y-1y)	lnSlope(10y-1y)	lnSlope(30y-1y)	lnSlope(30y-1y)	lnSlope(30y-1y)
Scope1	0.0042***	0.0062***	0.0035*	0.0034***	0.0059***	0.0018	0.0031***	0.0055***	0.0013
	(0.00015)	(0.0011)	(0.0021)	(0.00012)	(0.0010)	(0.0018)	(0.00012)	(0.00094)	(0.0017)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sector F.E.	N	Y	N	N	Y	N	N	Y	N
Country F.E.	N	Y	N	N	Y	N	N	Y	N
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	N	Y	N	N	Y	N	N	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	210	210	210	210	210	210	210	210	210
Observations	19,751	19,751	19,751	19,761	19,761	19,761	19,752	19,752	19,752
R-squared	0.301	0.505	0.726	0.282	0.473	0.714	0.282	0.456	0.702

Notes: The dependent variable is the CDS slope for the tenor 5 years, 10 years, and 30 years, respectively (*lnSlope(5y-1y)*, *lnSlope(10y-1y)*, *lnSlope(30y-1y)*). The results for each type of tenor-specific dependent variable are presented for an OLS regression, regression with country - sector - time fixed effects, and regression with firm - time fixed effects. All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Table C6: Exposure management and the logarithm of the CDS slope

	lnSlope(5y-1y)	lnSlope(5y-1y)	lnSlope(5y-1y)	lnSlope(10y-1y)	lnSlope(10y-1y)	lnSlope(10y-1y)	lnSlope(30y-1y)	lnSlope(30y-1y)	lnSlope(30y-1y)
Target	-0.26***	-0.051	-0.067*	-0.12***	-0.034	-0.055	-0.043***	-0.020	-0.027
	(0.010)	(0.060)	(0.039)	(0.0089)	(0.050)	(0.033)	(0.0083)	(0.047)	(0.030)
EETarget	0.071***	0.073	0.031	0.088***	0.074	0.029	0.083***	0.063	-0.0091
	(0.0092)	(0.053)	(0.054)	(0.0083)	(0.048)	(0.048)	(0.0081)	(0.044)	(0.047)
TargetIncentives	-0.067***	-0.12	-0.025	-0.0050	-0.11	-0.028	-0.0081	-0.11*	-0.039
	(0.014)	(0.076)	(0.042)	(0.013)	(0.065)	(0.033)	(0.012)	(0.059)	(0.031)
ClimatePolicy	-0.027**	0.0023	-0.014	-0.0097	-0.00016	-0.025	0.010	-0.0079	-0.041
	(0.013)	(0.058)	(0.044)	(0.011)	(0.049)	(0.035)	(0.011)	(0.045)	(0.035)
GHGPolicy	0.082**	-0.056	-0.13	0.063**	-0.031	-0.079	0.042	-0.024	-0.057
	(0.038)	(0.13)	(0.082)	(0.031)	(0.12)	(0.062)	(0.030)	(0.11)	(0.057)
EEPolicy	-0.27***	-0.17*	0.058	-0.22***	-0.12	0.018	-0.22***	-0.12	-0.0037
	(0.023)	(0.097)	(0.055)	(0.021)	(0.087)	(0.054)	(0.020)	(0.084)	(0.052)
GHGTrading	-0.067***	-0.068	-0.078*	-0.058***	-0.087*	-0.067*	-0.054***	-0.089**	-0.050
	(0.010)	(0.053)	(0.047)	(0.0091)	(0.047)	(0.038)	(0.0085)	(0.044)	(0.035)
CO2InternalPrice	0.018	-0.056	0.011	-0.028	-0.068	-0.036	-0.11***	-0.11*	-0.053
	(0.021)	(0.076)	(0.065)	(0.020)	(0.068)	(0.050)	(0.016)	(0.057)	(0.046)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sector F.E.	N	Y	N	N	Y	N	N	Y	N
Country F.E.	N	Y	N	N	Y	N	N	Y	N
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	N	Y	N	N	Y	N	N	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cluster time	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	210	210	210	210	210	210	210	210	210
Observations	19,751	19,751	19,751	19,761	19,761	19,761	19,752	19,752	19,752
R-squared	0.321	0.488	0.727	0.282	0.453	0.716	0.279	0.440	0.703

Notes: The dependent variable is the CDS slope for the tenor 5 year, 5 years, 10 years, and 30 years, respectively ($lnCDS\text{-}1y\Delta^{\%}$, $lnCDS\text{-}5y\Delta^{\%}$, $lnCDS\text{-}10y\Delta^{\%}$, $lnCDS\text{-}30y\Delta^{\%}$). The interacted variables correspond to the interaction between sector-group dummies (C, C-topghg, D, J, Other), where each group has more than 2000 observations, and Scope 1 percentage changes. The independent variables are percentile change of Leverage, percentile change of size, percentile change of liquidity, and dummies corresponding to the rating class or to Unrated. The definition of all variables is given in tables A1 and A4. The results for each type of tenor-specific dependent variable are presented for an OLS regression, regression with country - sector - time fixed effects, and regression with firm - time fixed effects. All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Table C7: The mitigating effect of proxies of management on Scope 1 in relation with the natural logarithm of CDS slope.

	lnSlope(5y-1y)	lnSlope(10y-1y)	lnSlope(30y-1y)
Scope1	0.0034	0.0000	0.00050
	(0.0025)	(0.0023)	(0)
Target	-0.057	-0.049	-0.024
	(0.039)	(0.033)	(0.029)
Target×Scope1	-0.0015	-0.00084	-0.00080
	(0.00094)	(0.00076)	(0.00068)
Scope1	0	0.0013	0
	(0)	(0)	(0.0021)
GHGTrading	-0.085*	-0.080**	-0.070*
	(0.049)	(0.039)	(0.036)
GHGTrading×Scope1	0.0014	0.0025	0.0036
	(0.0034)	(0.0026)	(0.0028)
Controls	Y	Y	Y
Time F.E.	Y	Y	Y
Firm F.E.	Y	Y	Y
Cluster firm	Y	Y	Y
Cluster time	Y	Y	Y
Firms	202	202	202
Observations	19,751	19,761	19,752
R-squared	0.727	0.716	0.703

Notes: All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Table C8: Difference-in-Differences on CDS spread around the Paris Agreement in December 2015 and treated firms in top quartile of Scope 1 distribution

	lnCDS-1y	lnCDS-1y	lnCDS-1y	lnCDS-5y	lnCDS-5y	lnCDS-5y	lnCDS-10y	lnCDS-10y	lnCDS-10y	lnCDS-30y	lnCDS-30y	lnCDS-30y
TreatScope1Q4×PostEvent	0.079*	0.079*	0.051	0.098***	0.098***	0.082***	0.080***	0.080***	0.068***	0.087***	0.087***	0.077***
	(0.046)	(0.046)	(0.045)	(0.030)	(0.030)	(0.029)	(0.024)	(0.024)	(0.022)	(0.023)	(0.023)	(0.022)
PostEvent	0.15***	-0.034	-0.016	0.091***	0.024	0.033	0.066***	0.021	0.027*	0.063***	0.022	0.026*
	(0.029)	(0.042)	(0.042)	(0.014)	(0.022)	(0.020)	(0.010)	(0.016)	(0.015)	(0.011)	(0.016)	(0.015)
TreatScope1Q4	0.19			0.19			0.17			0.16		
	(0.16)			(0.13)			(0.12)			(0.11)		
Controls	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	128	128	128	128	128	128	128	128	128	128	128	128
Observations	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152
R-squared	0.027	0.343	0.381	0.037	0.410	0.459	0.035	0.401	0.454	0.036	0.356	0.398

Notes: All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Table C9: Difference-in-Differences on Paris Agreement and treated firms in top quartile of scope 1 distribution excluding oil and basic metals.

	lnCDS-1y	lnCDS-1y	lnCDS-1y	lnCDS-5y	lnCDS-5y	lnCDS-5y	lnCDS-10y	lnCDS-10y	lnCDS-10y	lnCDS-30y	lnCDS-30y	lnCDS-30y
TreatScope1Q4×PostEvent	0.070	0.070	0.055	0.068**	0.068**	0.060**	0.051**	0.051**	0.045**	0.061***	0.061***	0.055***
	(0.046)	(0.046)	(0.044)	(0.030)	(0.031)	(0.027)	(0.023)	(0.023)	(0.020)	(0.022)	(0.022)	(0.019)
PostEvent	0.14***	-0.028	-0.015	0.089***	0.034	0.037*	0.064***	0.029*	0.031**	0.060***	0.028*	0.028*
	(0.031)	(0.044)	(0.045)	(0.015)	(0.022)	(0.021)	(0.011)	(0.016)	(0.015)	(0.011)	(0.017)	(0.016)
TreatScope1Q4	0.074			0.084			0.085			0.080		
	(0.15)			(0.13)			(0.11)			(0.11)		
Controls	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	120	120	120	120	120	120	120	120	120	120	120	120
Observations	1,080	1,080	1,080	1,080	1,080	1,080	1,080	1,080	1,080	1,080	1,080	1,080
R-squared	0.015	0.328	0.365	0.015	0.384	0.435	0.015	0.370	0.431	0.015	0.319	0.373

Table C10: Difference-in-Differences on Paris Agreement for a 49-months-event-window and treated firms in top quartile of scope 1 distribution.

	lnCDS-1y	lnCDS-1y	lnCDS-1y	lnCDS-5y	lnCDS-5y	lnCDS-5y	lnCDS-10y	lnCDS-10y	lnCDS-10y	lnCDS-30y	lnCDS-30y	lnCDS-30y
TreatScope1Q4×PostEvent	-0.0041	-0.0048	-0.069	0.069	0.069	0.013	0.068*	0.068*	0.024	0.068*	0.068*	0.028
	(0.067)	(0.067)	(0.057)	(0.048)	(0.049)	(0.040)	(0.040)	(0.040)	(0.033)	(0.039)	(0.039)	(0.033)
PostEvent	0.091*	-0.48*	-0.29	-0.031	-0.52***	-0.37**	-0.043*	-0.41***	-0.29***	-0.0061	-0.33***	-0.22**
	(0.046)	(0.27)	(0.26)	(0.031)	(0.16)	(0.15)	(0.024)	(0.11)	(0.11)	(0.023)	(0.10)	(0.100)
TreatScope1Q4	0.076			0.064			0.077			0.083		
	(0.13)			(0.12)			(0.11)			(0.10)		
Controls	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	113	113	113	113	113	113	113	113	113	113	113	113
Observations	5,537	5,537	5,537	5,537	5,537	5,537	5,537	5,537	5,537	5,537	5,537	5,537
R-squared	0.006	0.372	0.433	0.007	0.330	0.447	0.012	0.299	0.432	0.013	0.236	0.368

Notes: All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Table C11: Triple difference-in-differences for changes in CDS spread around the Paris Agreement in December 2015 and differentiating between scrutinized and other sectors

VARIABLES	lnCDS-5y	lnCDS-10y	lnCDS-30y	lnCDS-5y	lnCDS-10y	lnCDS-30y
TreatScope1Q4×Scrutiny×PostEvent	0.15***	0.16***	0.15***	0.13**	0.14***	0.13***
	(0.054)	(0.042)	(0.038)	(0.051)	(0.038)	(0.035)
TreatScope1Q4×PostEvent	0.044	0.026	0.037	0.045	0.027	0.038*
	(0.038)	(0.028)	(0.026)	(0.033)	(0.024)	(0.023)
TreatScope1Q4×Scrutiny	-0.14	0.030	0.11			
	(0.23)	(0.20)	(0.20)			
Scrutiny×PostEvent	-0.10***	-0.11***	-0.11***	-0.098***	-0.11***	-0.099***
	(0.015)	(0.011)	(0.011)	(0.020)	(0.014)	(0.014)
TreatScope1Q4	0.017	0.034	0.022			
	(0.18)	(0.16)	(0.16)			
Scrutiny	0.28***	0.074	0.0072			
	(0.061)	(0.053)	(0.052)			
PostEvent	0.090***	0.066***	0.061***	0.038*	0.032**	0.029*
	(0.015)	(0.011)	(0.011)	(0.021)	(0.015)	(0.016)
Controls	N	N	N	Y	Y	Y
Time F.E.	Y	Y	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y	Y	Y
Cluster firm	Y	Y	Y	Y	Y	Y
Firms	120	120	120	120	120	120
Observations	1,080	1,080	1,080	1,080	1,080	1,080
R-squared	0.1218	0.1234	0.1302	0.437	0.434	0.375

Notes: All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Table C12: Difference-in-Differences on Paris Agreement and treated firms in top quartile of (scope 1 / revenue) distribution

	lnCDS-1y	lnCDS-1y	lnCDS-1y	lnCDS-5y	lnCDS-5y	lnCDS-5y	lnCDS-10y	lnCDS-10y	lnCDS-10y	lnCDS-30y	lnCDS-30y	lnCDS-30y
TreatScope1RevQ4×PostEvent	0.052	0.052	0.036	0.051*	0.051*	0.041	0.039*	0.039*	0.033	0.038*	0.038*	0.032
	(0.048)	(0.048)	(0.045)	(0.029)	(0.029)	(0.027)	(0.022)	(0.022)	(0.020)	(0.021)	(0.021)	(0.019)
PostEvent	0.15***	-0.030	-0.014	0.10***	0.034	0.042**	0.074***	0.029*	0.035**	0.073***	0.033**	0.037**
	(0.030)	(0.041)	(0.041)	(0.015)	(0.021)	(0.020)	(0.012)	(0.016)	(0.015)	(0.012)	(0.016)	(0.016)
TreatScope1RevQ4	0.13			0.15			0.15			0.15		
	(0.14)			(0.12)			(0.10)			(0.10)		
Controls	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	128	128	128	128	128	128	128	128	128	128	128	128
Observations	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152
R-squared	0.020	0.341	0.380	0.025	0.398	0.450	0.026	0.386	0.444	0.026	0.337	0.383

Table C13: Difference-in-Differences on Paris Agreement and treated firms in top quartile of (scope 1 / total assets) distribution

	lnCDS-1y	lnCDS-1y	lnCDS-1y	lnCDS-5y	lnCDS-5y	lnCDS-5y	lnCDS-10y	lnCDS-10y	lnCDS-10y	lnCDS-30y	lnCDS-30y	lnCDS-30y
TreatScope1TAQ4×PostEvent	0.066	0.066	0.052	0.051*	0.051*	0.043	0.036	0.036	0.030	0.040*	0.040*	0.035*
	(0.045)	(0.045)	(0.043)	(0.030)	(0.030)	(0.027)	(0.023)	(0.023)	(0.020)	(0.021)	(0.021)	(0.020)
PostEvent	0.15***	-0.031	-0.017	0.10***	0.036	0.043**	0.077***	0.032**	0.037**	0.074***	0.034**	0.037**
	(0.029)	(0.043)	(0.043)	(0.015)	(0.022)	(0.021)	(0.011)	(0.016)	(0.015)	(0.012)	(0.016)	(0.016)
TreatScope1TAQ4	0.11			0.17			0.17			0.17		
	(0.15)			(0.13)			(0.11)			(0.11)		
Controls	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	128	128	128	128	128	128	128	128	128	128	128	128
Observations	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152
R-squared	0.017	0.342	0.381	0.027	0.398	0.450	0.029	0.385	0.443	0.030	0.337	0.383

Table C14: Difference-in-Differences on Paris Agreement and treated firms in bottom quartile of escore distribution

	lnCDS-1y	lnCDS-1y	lnCDS-1y	lnCDS-5y	lnCDS-5y	lnCDS-5y	lnCDS-10y	lnCDS-10y	lnCDS-10y	lnCDS-30y	lnCDS-30y	lnCDS-30y
TreatE-scoreQ1×PostEvent	-0.054	-0.054	-0.035	-0.061**	-0.061**	-0.052*	-0.042**	-0.042**	-0.036*	-0.037*	-0.037*	-0.032*
	(0.057)	(0.057)	(0.058)	(0.028)	(0.028)	(0.027)	(0.020)	(0.020)	(0.019)	(0.020)	(0.020)	(0.019)
PostEvent	0.18***	-0.0013	0.0055	0.13***	0.064***	0.066***	0.096***	0.051***	0.053***	0.093***	0.053***	0.054***
	(0.027)	(0.038)	(0.037)	(0.015)	(0.021)	(0.020)	(0.012)	(0.016)	(0.015)	(0.012)	(0.016)	(0.016)
TreatE-scoreQ1	-0.17			-0.082			-0.078			-0.085		
	(0.13)			(0.10)			(0.090)			(0.088)		
Controls	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	128	128	128	128	128	128	128	128	128	128	128	128
Observations	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152
R-squared	0.022	0.341	0.380	0.015	0.399	0.452	0.012	0.386	0.444	0.013	0.336	0.382

Table C15: Difference-in-Differences on CDS slope around the Paris Agreement and treated firms in top quartile of scope 1 distribution

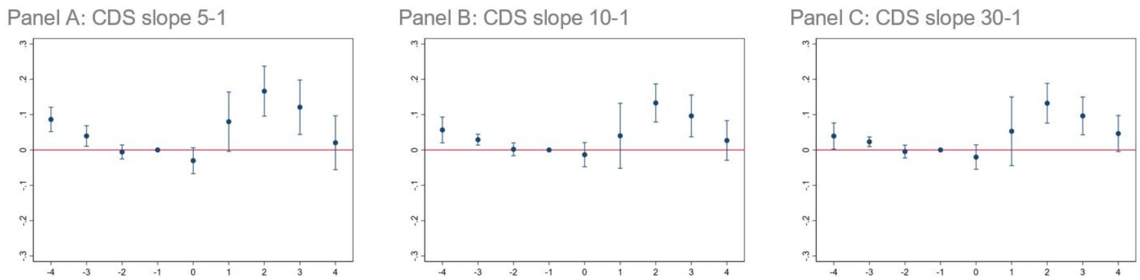
	lnSlope(5y-1y)	lnSlope(5y-1y)	lnSlope(5y-1y)	lnSlope(10y-1y)	lnSlope(10y-1y)	lnSlope(10y-1y)	lnSlope(30y-1y)	lnSlope(30y-1y)	lnSlope(30y-1y)
TreatScope1Q4×PostEvent	0.094***	0.094***	0.086***	0.066**	0.066**	0.061**	0.074***	0.074***	0.071**
	(0.030)	(0.031)	(0.030)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.028)
PostEvent	0.061***	0.047**	0.049**	0.036***	0.032**	0.033**	0.033**	0.032*	0.032*
	(0.015)	(0.022)	(0.021)	(0.013)	(0.016)	(0.016)	(0.013)	(0.017)	(0.017)
TreatScope1Q4	0.21*			0.18*			0.17*		
	(0.12)			(0.10)			(0.10)		
Controls	N	N	Y	N	N	Y	N	N	Y
Time F.E.	N	Y	Y	N	Y	Y	N	Y	Y
Firm F.E.	N	Y	Y	N	Y	Y	N	Y	Y
Cluster firm	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firms	128	128	128	128	128	128	128	128	128
Observations	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152
R-squared	0.046	0.223	0.246	0.040	0.140	0.156	0.039	0.101	0.111

Table C16: Triple difference-in-differences for changes in CDS slope around the Dec. 2015 Paris Agreement and differentiating between scrutinized and other sectors.

VARIABLES	lnSlope(5y-1y)	lnSlope(10y-1y)	lnSlope(30y-1y)	lnSlope(5y-1y)	lnSlope(10y-1y)	lnSlope(30y-1y)
TreatScope1Q4×Scrutiny×PostEvent	0.082	0.11**	0.10**	0.00011	0.051	0.041
	(0.055)	(0.047)	(0.046)	(0.062)	(0.049)	(0.048)
TreatScope1Q4×PostEvent	0.049	0.031	0.045*	0.053	0.034	0.048**
	(0.038)	(0.027)	(0.024)	(0.034)	(0.025)	(0.023)
Scrutiny×PostEvent	-0.065***	-0.099***	-0.093***	0.0071	-0.045**	-0.037*
	(0.016)	(0.013)	(0.014)	(0.035)	(0.021)	(0.021)
TreatScope1Q4×PostEvent	0.049	0.031	0.045*	0.053	0.034	0.048**
	(0.038)	(0.027)	(0.024)	(0.034)	(0.025)	(0.023)
PostEvent	0.061***	0.037***	0.033**	0.055**	0.037**	0.033*
	(0.016)	(0.013)	(0.014)	(0.022)	(0.017)	(0.018)
TreatScope1Q4	0.031	0.055	0.040			
	(0.19)	(0.16)	(0.16)			
Scrutiny	0.055	-0.14***	-0.22***			
	(0.056)	(0.048)	(0.048)			
Controls	N	N	N	Y	Y	Y
Time F.E.	Y	Y	Y	Y	Y	Y
Firm F.E.	Y	Y	Y	Y	Y	Y
Cluster firm	Y	Y	Y	Y	Y	Y
Firms	120	120	120	120	120	120
Observations	1,080	1,080	1,080	1,080	1,080	1,080
R-squared	0.0655	0.0364	0.0369	0.217	0.132	0.091

Notes: All regressions are clustered on both the time and firm dimension to account for cross-sectional and serial correlation in the error terms. Robust standard errors are reported in parentheses. The statistical significance of the estimated parameters is indicated by *** for a p-value of 0.01, ** for a p-value of 0.05, and * for a p-value of 0.10.

Figure C1: Treatment effect for each period of the event window for the DiD results around the Paris agreement on CDS slope



Notes: Panels A, B, C show the treatment effect for each period of the event window for the DiD results around 2015-12 on the natural logarithm of 5-1, 10-1, and 30-1 CDS slope, respectively. The treatment group includes firms in the top quartile of the scope 1 emissions distribution as of 2015-11. The control group includes all other firms. Y-axis: Value of the natural logarithm of the CDS slope relative to the value as of 2015-11. X-axis: Time in month-periods.

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