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CLIMATE RISKS, SHORT AND LONG

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ABSTRACT

We study how climate policy risk is priced across the maturity structure of equity cash flows. Using textual analysis of European news articles, we construct indices of transition and physical climate risk and, drawing on recent advances in measuring the temporal dimension of text, classify climate news by the horizon it references. We combine these indices with prices of dividend futures and dividend swaps, which allow us to decompose stock price reactions to climate news into short- and long-term cash-flow components. Heightened transition-risk news lowers stock prices, and the decline is concentrated in long-maturity dividend claims. The evidence suggests that investors expect most firms to defer adaptation, leaving near-term earnings and payouts largely unchanged while bearing greater long-run exposure. Finally, firm-level sensitivities identify which companies the market perceives as adapting early — accepting short-term losses to invest in the transition — versus those most exposed to stranded-asset risk.

Keywords: Dividend Futures; Climate Risk; Transition Risk; Equity Term Structure.

JEL classification: G12; G13; G54

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1 Introduction

For many years, the absence of quantifiable metrics, the lack of data, and the incompleteness of financial markets have hindered the effort to address climate change. These challenges have led to a lack of attention and effort towards mitigating climate risks. More recently, however, there has been a sharp shift in the focus of policymakers and the private sector towards sustainable finance. Nevertheless, accurately measuring climate risks and understanding their impacts on economic outputs remain significant, but difficult, challenges to overcome.

Two key challenges arise in understanding the effects of climate risks: measuring the size of these risks using data available today, and identifying the point in the future at which any changes will materialise. At the same time, financial markets themselves are evolving to better incorporate climate-related information. The development of old and new financial instruments -such as green bonds, or various previously illiquid derivatives- is beginning to provide the tools necessary for a more nuanced understanding of climate risks. Yet the integration of these instruments into mainstream financial analysis remains in its nascent stages, and their informational content is still largely unexploited.

In this study, we aim to provide a new approach to extracting and analysing information about different types of climate risks, specifically through a temporal lens. In particular, by examining the effect of these risks -and of the corresponding climate-related policies- on the prices of specific financial derivatives, such as on dividend futures,[1] we are able to determine and distinguish the long- and the short-term components of the various climate risks. As a result, dividend futures encode temporal information that allow us to examine the extent to which climate risks affect firms in the short or in the long term.

Our motivation is based on the following simple principle: some firms may be able

[1] As we further explain below, dividend futures constitutes a relatively under-researched set of derivatives, with which an investor can trade on a firm's dividend of specific maturity, instead of simply buying the stock, which would expose the investor to the totality of all future dividends.

to adapt to new environmental challenges, and may thus increase investment in the short term in order to gain longer-term benefits; others will prefer to maintain their current practices, thereby risking large losses in the long run. To illustrate the economic mechanism behind our focus, consider the following example. Suppose a law passes dictating that carbon emissions must be reduced by 50% by 2040. This news may affect firms in different ways: a "brown" firm will view it as bad news, while the opposite may be true for a "green" firm. Moreover, a firm that is negatively affected will realize that its future earnings will be lower. Crucially, however, the news need not affect only earnings after 2040; the firm's management may instead choose to react immediately, accepting some short-term losses by investing heavily in greener technologies in order to benefit in the long run. Our goal is to decompose stock price responses into their temporal components, so that we can identify each firm's sensitivity to short-term and long-term climate risk.

Our paper addresses the above concerns and contributes to the recently growing literature on the financial effects of climate change policies in a number of ways. First, we construct indices of physical and transition climate change risks[2] using textual analysis of the news coverage of the topic. We build a dictionary of climate-related phrases and words to track news related climate risks and regulations; subsequently, we further categorise climate-related articles according to the time-frame that their wording implies, into long-term or short-term. We download the articles using Factiva's database, and we focus on European news articles that appear in Reuters. Our methodology closely follows the seminal paper of Engle et al. (2020), as well as the work of Bua et al. (2024) who implement a similar technique to distinguish between news related to physical or transition risk. As for the temporal dimension we use the work of Byrne et al. (2023) who introduce "the third T" of text analysis (where the first two T's refer to topic and tone).

[2] Physical risk describes the risk associated with a potential for physical damage, such as wildfires or flooding, and the financial losses resulting from such an exposure. Transition risk, on the other hand, focuses on the risks stemming from the actions we take to mitigate climate change, and to transition to a lower-carbon economy away from fossil fuels.

While these measures are on themselves informative, our second important contribution is to link them to broader financial data to reveal investors' pricing of these risks.[3] This pricing can help us infer investors' beliefs about future cashflows and hence about economic outputs caused by climate change concerns and associated policies. The financial literature has so far extensively studied the effect of climate-risks on stock prices (see, e.g., Hsu et al. (2023), Bolton and Kacperczyk (2021), Faccini et al. (2023)). One question that is yet to be resolved in any of these studies, however, is whether any climate risk (or any corresponding regulatory intervention) affects a firm's prospects in the short-term or in the long-term. In order to examine this temporality aspect, we use tools from the recent literature on the "duration of equity" (see, e.g., Van Binsbergen and Koijen (2017), Gormsen and Lazarus (2023)) in combination with data about the analysts' earnings and dividends forecasts of various horizons.

Our study leverages data from two -closely related- types of financial derivatives: dividend futures and dividend swaps. The former are exchange-traded futures contracts that allow investors to take positions on future dividends of specific maturities of a single asset or an index, while the latter are (over the counter) derivative contracts in which two parties agree to exchange a floating leg that consists of actual dividends of a reference asset, with a predetermined fixed leg, based on an estimate of these future dividends. They can thus allow us to infer information about the term structure of equity returns, i.e., the relationship between returns and the time horizon over which these are realized. By looking at the price reaction of these derivatives on days where climate-change interest is increased (e.g., because a new policy is announced), we can understand the temporal dimension of the pricing effect, which we can then translate into the perceived belief about future earnings. Indeed, our findings suggest that long-term dividends are more heavily affected by climate change news, indicating that investors anticipate greater long-term

[3] We recognise here that dividend changes also have a signalling value and may convey information about future cash flows (see, Ham et al. (2020)), which implies that the pricing of the various dividends is not independent of each other.

impacts on earnings due to climate policies. This observation supports the notion that many firms are slow to adopt greener investments, resulting in a delayed impact on their earnings retention and dividend distributions.

Our results can also help shed light on a major regulatory concern, which is the existence of "stranded assets" (see e.g, Campiglio et al. (2018)); these are assets that are currently valuable but could undergo rapid and disruptive devaluation as investors belatedly realize that a firm's processes may be inconsistent with climate targets. Since we can measure pricing risky payoffs at different horizons we can also find risks of a sudden decline in (or even end of) cashflows due to climate-change. Ultimately, building upon this study, we can work towards creating a measure of "stranding risk" which would be a key input into the active debate on how to design climate stress tests. These issues, are also very important for financial stability; indeed, since the seminal speech by Carney (2015), central banks have repeatedly emphasized the role of climate change on systemic risk.

1.1 Literature review

Our paper is closely related to two main strands of the literature. First, we contribute to a large body of empirical research that studies the asset pricing implications of climate risks. Bansal et al. (2016), Bolton and Kacperczyk (2021) and Hsu et al. (2023) focus on the long-run risks associated with climate change, and argue that polluting firms carry a higher risk premium. Baker et al. (2022) find that green municipal bonds are issued at a premium. Dunn et al. (2018) provide empirical evidence that firms with low environmental score have higher expected returns. Choi et al. (2020) show that there is underperformance of stocks of carbon-intensive firms when there is an abnormally warm weather (associated with increased attention to climate risks). Alessi et al. (2021) show that there is a factor associated with climate risk and that there is negative associated risk premium (called greenium). Similarly, Pástor et al. (2022), study the recent outperformance of green stocks, and conclude that this can be attributed to growing environmental concerns rather than higher expected returns.

These findings corroborate the theoretical predictions of Pástor et al. (2021) who find that in equilibrium green assets should have lower returns due to the increased preferences for these assets and the lower risks.[4] Overall, research has often shown that these risks matter for investors, but the academic debate is still ongoing; for instance, Hartzmark and Sussman (2019) find that sustainability of mutual funds is viewed by investors as a positive predictor of future performance (even though the authors do not find evidence supporting such outperformance), while Bernardini et al. (2021) show that there was a significant low-carbon premium, when investing in European electric utilities. A more extensive review of this literature can be found in Giglio et al. (2021).

From this literature, we are even more closely related to the more recent research effort that uses textual analysis of climate news to uncover how these concerns are incorporated into prices. Engle et al. (2020) use textual analysis in order to construct a measure of aggregate climate change risk, based on the idea that news coverage of this issue increases when the corresponding risks are higher; they then use their proxy to hedge for climate risk. Bua et al. (2024) build up on this work, and construct vocabularies for transition and physical risk, so that they can measure these indicators separately. Similarly, Faccini et al. (2023) utilize US news articles to decompose climate change risks into four categories: natural disasters, global warming, international summits, and U.S. climate policy; they find that only their climate policy proxy is priced in the cross-section of US equities. Finally, Ardia et al. (2023) use the innovations to a climate change concerns index, constructed through articles from US newspapers, and find that an increase in this

[4] Barnett et al. (2020) also provide a comprehensive framework to study how climate-related uncertainties can affect pricing and decision-making, while Pedersen et al. (2021) describe how the efficient frontier of investing can be adjusted when investors have a preference for ESG stocks.

index is associated with an increase (decrease) in the price of green (brown) stocks.[5]

Second, our study is closely related to a very recent literature examining the *"equity term structure"* and the prices of dividend strips. Building on the idea that the value of an equity can be decomposed into the sum of its future cashflows, each of which associated with a potentially different discount rate, researchers have recently studied the term structure of equity risk premia. Van Binsbergen et al. (2012) recover prices and returns of short-term dividends used arbitrage-pricing methods. Van Binsbergen and Koijen (2017) study the returns on dividend strips and find a downward sloping term structure, while Boguth et al. (2023) account for noise when pricing synthetic dividend strips and argue that there is no robust evidence of such a downward slope. Filipović and Willems (2020) build a mathematical framework to jointly price dividend derivatives and interest rates. Giglio et al. (2023) use an affine model of prices, dividends and returns to estimate the prices of dividend strips. Gormsen and Lazarus (2023), on the other hand, study the duration of equity, by using data of dividend futures to measure the weighted average of the times to maturity of the various dividends, and find that various anomalies heavily weight on stocks with low duration of cash flows. Finally, Nagel and Xu (2023) examine the stock price movements on FOMC announcement days and have used dividend futures to decompose these movements into changes in the default-free yields and in equity premia.

The rest of this paper is organised as follows: Section 2 presents the theoretical underpinning behind our approach. Section 3 describes the data and the empirical methodology of the research. Section 4 presents the main results of the regression analysis, while Section 5 concludes.

[5] The distinction between a green and a brown stock is still up to debate as the climate-related measures such as the ESG scores may differ between various providers (see, Berg et al. (2022).)

2 Dividend strips - Theory

Any asset can be valued as the sum of its future cashflows discounted at the appropriate rates. The same principle can be applied to equities. Assuming there is no arbitrage in the market, the price of any stock is equal to the risk neutral expectation of its future dividends, discounted at the risk-free rate. Until recently, this simple relationship had not been explored, as the prices of individual dividend strips had not been traded. After 2010 however, there has been an increased use of dividend derivatives (futures and swaps) that can allow us to obtain the prices of individual dividend strips. This allows us to decompose a stock price/return using observable data (see e.g., Knox and Vissing-Jørgensen (2022)).

To formalize the above, let P_t be the price of a stock at time t, D_{t+n} its dividend at time $t+n$ and $R_{t,n}$ be the appropriate discount rates (stemming from the equity term structure). Let us also assume that the price of a dividend strip (i.e., the present value of the corresponding dividend) traded at time t and maturing in n years (at $t+n$) is denoted by $P_{n,t}$. Then:

$$
\begin{aligned}
P_t &= \sum_{n=1}^{\infty} \frac{E_t[D_{t+n}]}{R_{t,n}} \\
&= \sum_{n=1}^{\infty} P_{n,t}
\end{aligned}
$$

Finally, let us consider a maturity of up to K_S years as being short-term (e.g., $K_S = 3$), and anything more than that to be perceived as long term; we can also use $\mathcal{S}, \mathcal{L}$ to denote the short and long-term (price components) respectively. Therefore, we have:

$$
\begin{aligned}
P_t &= \sum_{n=1}^{K_S} P_{n,t} + \sum_{n=K_S+1}^{\infty} P_{n,t} \\
&\equiv \mathcal{S}_t + \mathcal{L}_t
\end{aligned}
$$

The price $P_{n,t}$ is directly related to the price of a dividend future through the following simple relationship (note that the futures contract will be settled on date $t+n$):

$$P_{n,t} = \frac{F_{n,t}}{(1+y_{t,n}^{Nom})^n}$$

where $F_{n,t}$ is the dividend futures price and $y_{t,n}^{Nom}$ is the riskless nominal yield.

Let us also denote by $w_{t,n}$ the weight of the n-th dividend strip, i.e.,

$$w_{t,n} = \frac{P_{n,t}}{P_t}$$

Clearly, the weights sum up to 1 ($\sum\limits_{n=1}^{\infty} w_{t,n} = 1$). These weights allow us to think about the one-period return of the asset as:

$$R_{t+1} = \frac{P_{t+1} + D_{t+1}}{P_t} = \sum_{n=1}^{\infty} w_{t,n} R_{n,t+1}$$

where $R_{n,t+1} = \frac{P_{n-1,t+1}}{P_{n,t}}$.

When using empirical data on dividend derivatives, it is hard to find observations for the whole term structure maturities. Therefore, we define as above the short-term and long-term weights as $w_t^{\mathcal{S}} = \sum\limits_{n=1}^{K_S} w_{t,n}$ and $w_t^{\mathcal{L}} = 1 - w_t^{\mathcal{S}}$ respectively.

The work of Knox and Vissing-Jørgensen (2022) has shown that the weights $w_{t,n}$ are equal to the elasticity of the stock price to the expected dividend at $t+n$, and so $w_t^{\mathcal{S}}$ can be perceived as the relative importance of the short-term cashflows to the price at time t. In our study, we try to measure the weights (or proxies of them) using data on the prices of dividend futures and dividend swaps.

3 Data and methodology

For this work, we use a number of different databases. We outline the data collection (corresponding to news articles, dividend derivatives and analyst forecasts) and the methods we have used in the following subsections:

3.1 Climate risk index - textual analysis

First, to build our own proxy of climate change risk (based on the notion that higher risks are associated with larger number of such news articles), we retrieve a large number of daily news articles written on Reuters from Factiva database. We extract all such European articles from January 2010-July 2024 tagged as CCAT, MCAT, ECAT, GCAT (corporate/ industrial news, commodity/financial market news, economic news and political/general news, respectively).[6] We then follow the analysis outlined in Engle et al. (2020) and Bua et al. (2024) to construct a physical and a transition risk index through textual analysis. Our methodology is the same as the one outlined in these two papers, so we refer the readers to these papers if they are interested in the details.

In short, we build vocabularies of words associated with physical and transition risk and we collect them in two separate documents. Using these documents and the Reuters news articles we find the term frequency scores (tf) of the various terms. Subsequently, we multiply the term frequency score of each term with their corresponding inverse document frequency (idf) scores extracted from the news articles (high idf implies that a term is not common in many documents). This identifies two climate risk vocabularies where words are weighted by their importance (see also, Figure 1). To construct the corresponding risk indices, we compute the cosine similarity (of the tf-idf scores) between any news article and the corresponding physical/transition risk documents. This consti-

[6]We exclude news whose titles start with "update", those with repeated titles, and those with an action tag of "rep" which are replacements of previous articles.

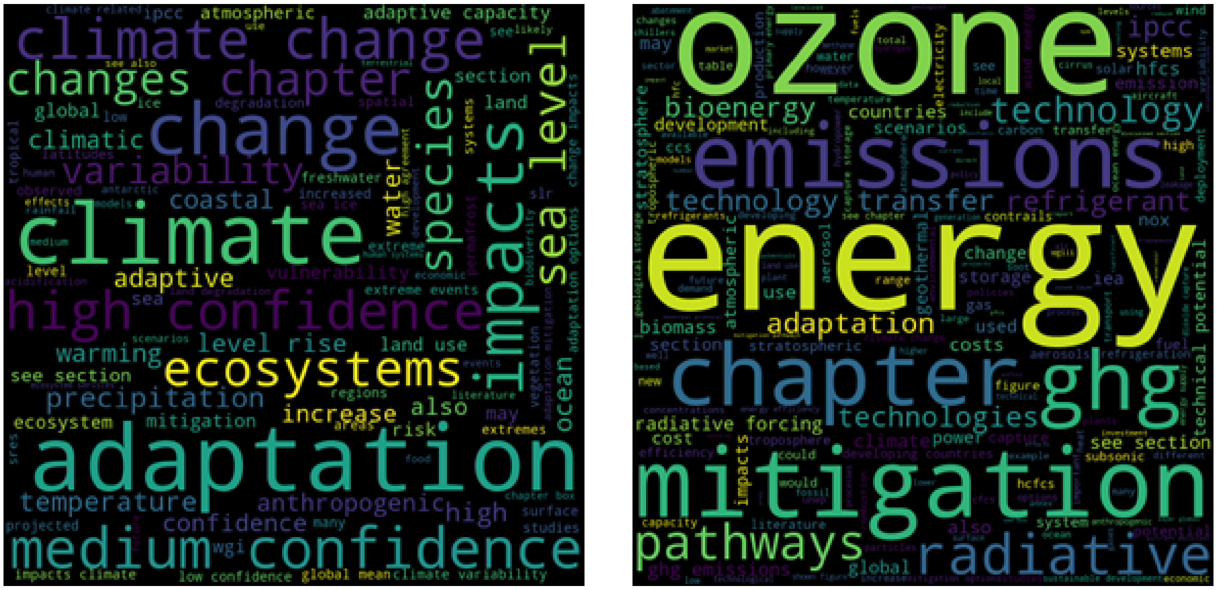

FIGURE 1: The word clouds created from textual analysis corresponding to physical risk (left) and transition risk (right).

tutes our PRI/TRI (physical/transition risk indices) that capture the similarity between the distribution of 'climate risk' words in the news article and the distribution in the risk documents, weighted by the relevance of each word for the two types of risk.

3.1.1 The temporal dimension of climate news

While the PRI and TRI indices described above capture the *intensity* of climate-related news coverage, they are silent about the *horizon* at which the underlying risks are expected to materialise. A news article discussing an imminent regulatory change and one discussing emission targets for the middle of the century may obtain similar climate-risk scores, even though they convey very different information about the timing of the associated cashflow effects. Since our aim is precisely to study how climate risks are priced across maturities, we augment the standard text-based indices with a temporal dimension, following a methodology similar to that of Byrne et al. (2023), who introduce "the third T" of text analysis. To our knowledge, this is the first time a temporal index of climate news has been constructed and used in the asset pricing literature. We choose to construct monthly indices of short-term vs long-term horizons, to align with the availability of our asset pricing data. Indeed, while prices for dividend futures are reported daily, liquidity is low enough that no meaningful result could be derived in that frequency. Similarly, for each firm only a handful of dividend futures of different maturities is traded at each point in time, thus we construct only 2 temporal categories.

Our procedure consists of three steps. In the first step, for each news article we identify all in-text temporal references. These include explicit calendar references (e.g., "by 2022", "in 2040"), as well as relative expressions (e.g., "next month", "in the next two years", "over the coming decades"), which we resolve into calendar dates using the publication date of the article.[7] We then compute, for each reference, its distance from the publication date of the article, and we classify it as short-term (ST) if this distance is less than three years, and as long-term (LT) otherwise. For example, an article published on May 1, 2021 containing the expressions "in the next 2 years", "next month" and "by 2022" would obtain an ST count of three; had the same article also mentioned the 2040 emissions target of our earlier example, this reference – lying 19 years ahead of the publication date – would contribute one unit to the LT count.

In the second step, we convert these counts into *temporal weights*. Denoting by N_j^S and N_j^L the total ST and LT counts of article j, we define

$$w_j^S \;=\; \frac{N_j^S}{N_j^S + N_j^L}, \qquad\qquad w_j^L \;=\; 1 - w_j^S. \tag{1}$$

These weights proxy the *share* of each article that is devoted to short-term and long-term considerations, respectively. Working with relative shares, rather than with raw counts, is important: raw counts depend mechanically on the length and verbosity of an article,

[7] We have built an extensive set of patterns to capture such expressions as accurately as possible, including, among others, references to specific years, quarters, months, and days, as well as vaguer expressions such as "next decade" or "by the end of the century", to which we assign the midpoint of the implied period.

and would thus artificially over- or under-state the temporal component of the news, generating spikes in the index that carry no meaningful information.[8]

In the third step, we combine the temporal weights with the climate-risk scores created before. For each article j, the product of its physical-risk score with its short-term weight, $PRI_j \times w_j^S$, provides the short-term component of physical climate risk conveyed by that article; the remaining components (long-term physical, and short- and long-term transition risk) are constructed analogously. By construction, the decomposition is exact: the short- and long-term components of each index sum to the original index at all times,

$$PRI_j \;=\; PRI_j^S + PRI_j^L, \qquad\qquad TRI_j \;=\; TRI_j^S + TRI_j^L. \tag{2}$$

This additivity is a convenient property of our approach: rather than constructing separate – and potentially inconsistent – indices for each horizon, we decompose the existing measures of climate risk into a short-term and a long-term portion. Finally, we aggregate the article-level components to the monthly frequency by summing the daily values within each month, and we correct the resulting series for the seasonality of news coverage (e.g., news about the year's outlook are concentrated in the beginning of each year). The outcome of this procedure is a set of four monthly time-specific climate-risk indices (PRI^S, PRI^L, TRI^S, TRI^L), which we use of our empirical analysis. For illustration, Figure 2 plots the TRI^S, TRI^L indices over our sample period.

3.2 Dividend data

To conduct our asset pricing analysis, we have downloaded single stock dividend futures and index dividend futures from January 2010 to July 2023 from EUREX, which is a derivatives exchange trading in European derivatives. We have a total of 53,022 observations (corresponding to 2,265 underlying stocks), which are both on and off the book. The

[8] Articles that contain no temporal reference are assigned equal weights, $w_j^S = w_j^L = 0.5$.

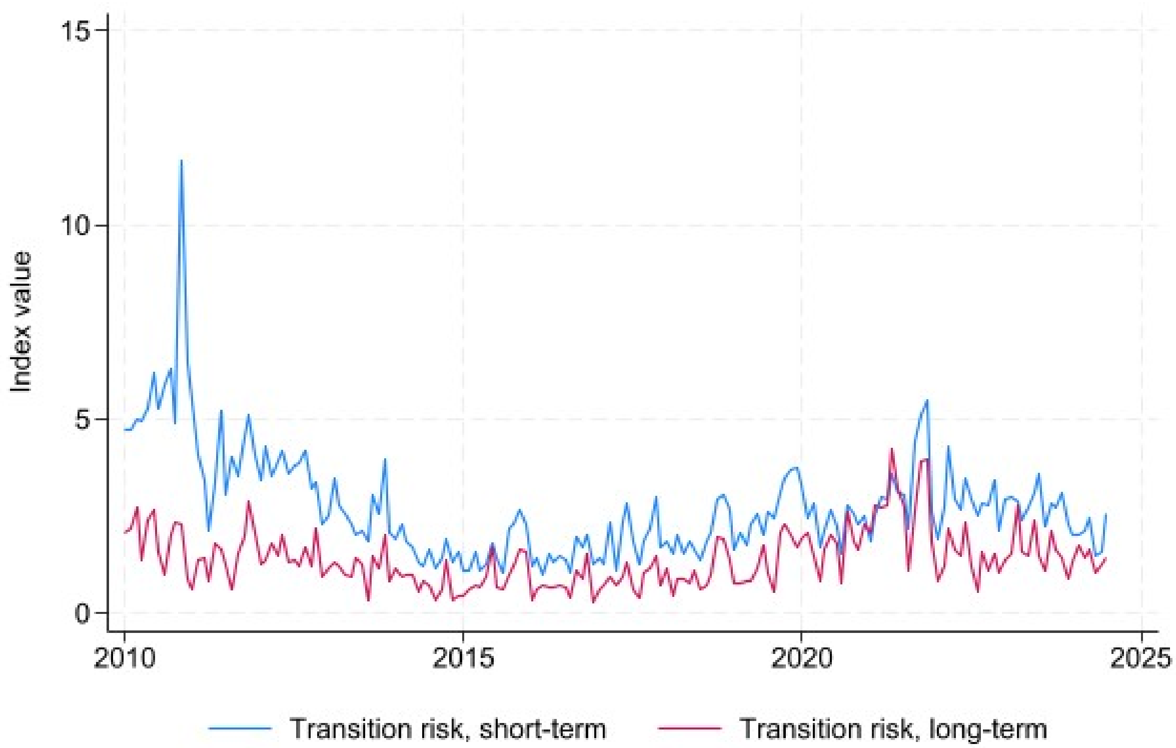

FIGURE 2: The short-term (blue) and long-term (red) Transition risk indices.

total trading volume in the dividend futures market has steadily increased in the recent years; however, the market remains largely illiquid.[9] This increase can be also seen in the Figure 3 (note also that there is also a clear seasonality in the trading of these derivatives as many of them are traded more heavily a few days before the dividend payment dates, and especially in December). The fact that many dividend futures expire in the very short term can be also seen from Figure 4. This concentration of trading near expiration partly reflects structured-product dealers unwinding their dividend hedges as contracts mature, and partly the tendency of thin markets to concentrate liquidity at the front end, where counterparties are easiest to find.

It may still appear that nothing can be said about long-term risks, given the short

[9]This illiquidity also forces us to talk about short-term and long-term effects, rather than talking about the whole term structure; if and when these derivatives are more widely traded in the future, this can allow for an even more granular exploration of the temporal decomposition we are after.

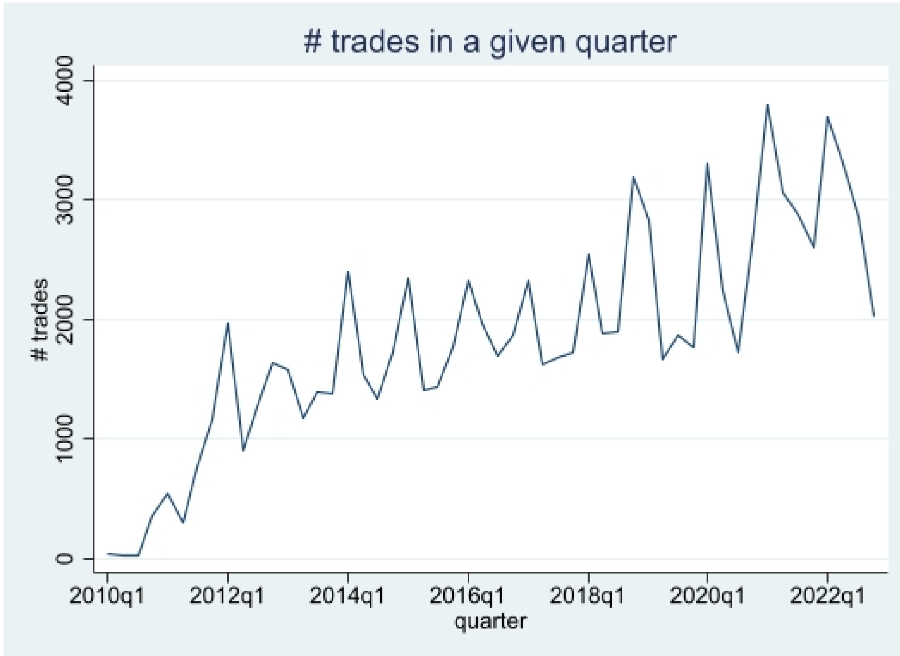

FIGURE 3: The per-quarter trading volume of dividend futures from 2010-2023.

horizon of the traded derivatives that we have in our sample. However, due to the accounting identity presented in Section 2 the combination of the stocks prices and the short-term dividend strips, allows us to extract information about the long-term dividend strips as well (though we recognize that we cannot distinguish between, for example, a 10-year cashflow and a 30-year cashflow). These futures correspond to various underlying firms. Among them, the financial and the energy sectors are represented the most in the stocks that have the greatest trading volume of dividend futures. Few of these underlying stocks with heavily traded dividend futures are presented in Figure 5.

The corresponding data about the European stock prices of the underlying stocks is downloaded from Bloomberg, the information about the European risk-free rates is downloaded from Kenneth French's data library, while the realized dividends are retrieved from ORBIS database. We also use the I/B/E/S database to collect information about analysts' dividend/earnings forecasts data for different maturities. Finally, as an alternative data source we download U.S. dividend swaps data, as well as analysts' dividend forecasts

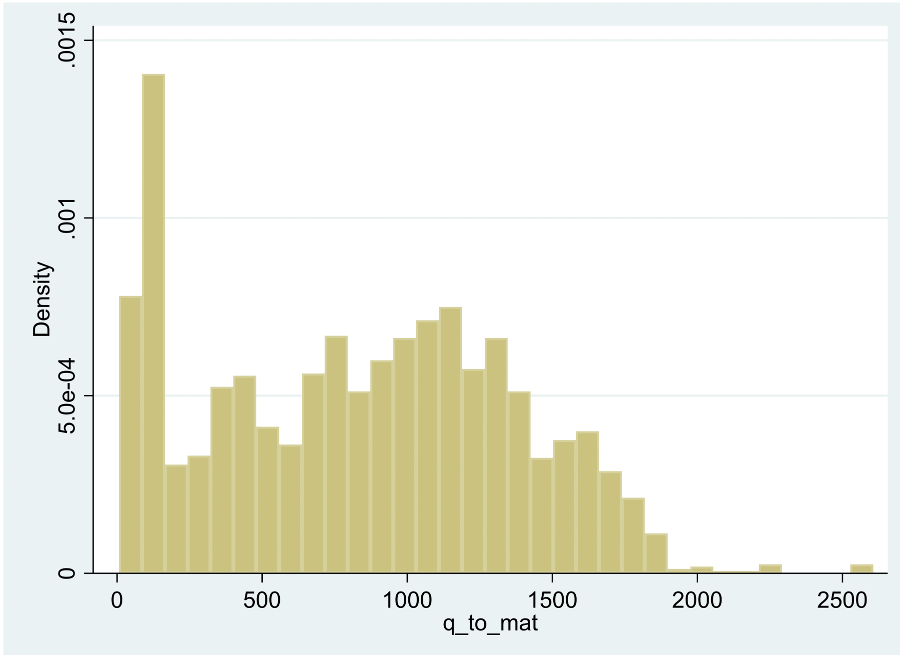

FIGURE 4: Histogram of days to maturity of various dividend futures

from $S\&P$. In a similar spirit, we use dividend swap data to study the same phenomena in US economy. We recognise that the set of legislations and policy relevant news can be different than in Europe, but we use this data for robustness reasons and also because the dividend swaps are slightly more liquid, and we have 1,589,695 observations ranging from February 2014 to June 2023. To further increase robustness we also download the US news-based climate indices from Faccini et al. (2023) and perform our analysis using these indices as well.

The empirical research methodology that we have followed is quite straightforward. We assume that higher climate concerns -presumably because of a new policy that has taken place, or because of a particular physical climate event- are proxied by increases in the text-based indices we have constructed. Then, we try to decompose any price reaction that we can credibly (partially) attribute to climate risk into the corresponding short-term and long-term dividend futures' price movements. Our focus is mostly on the effects of climate regulations and interventions, hence we will conduct our main analysis using only

Name	Freq.	Percent	Cum.
AXA	1,403	25.05	25.05
BASF	956	17.07	42.12
BNP PARIBAS	525	9.37	51.49
ENI	456	8.14	59.63
ING	235	4.2	63.83
INTESA SANPAOLO	835	14.91	78.74
TOTALENERGIES	1,191	21.26	100
Total	5,601	100	

FIGURE 5: This table presents the companies that have dividend futures traded in more than 200 different days in our sample, along with their observed frequencies.

the Transition Risk Index. Since the dividend derivatives are not traded frequently (they are rarely traded in consecutive dates), we prefer to consider monthly data.

We then proceed in the following steps. First, we construct a binary dummy variable that is assigned the value one in days with the top 10% highest climate -transition risk-index (TRI). Second, for each dividend future, we categorise it as short term ($\mathcal{S}$) if its maturity is less than 3 years from the trading date. Third, based on our analysis in Section 2, for each stock at each time t, we construct the weights of its dividend futures $w_{t,n} = \frac{P_{n,t}}{P_t}$. Finally we perform two panel regressions with fixed effects: the first confirms that TRI has a negative relationship with stock prices, while the second examines the effect of TRI on the short-term dividend weights. Our regressions are presented in more detail in the next section.

By conducting the above-mentioned analysis, we will be able to understand which firms get affected in the short-term and which ones are mostly hurt in the longer term (e.g., because they will no longer be able to use any fossil fuels). This finally can allow us to better understand and measure the degree to which assets will be "stranded" because of climate change and of the corresponding environmental interventions.

TABLE 1: Effect of the Transition Risk Index on stock returns

	(1)
Transition Risk Index (TRI) dummy	−0.014***
	(0.005)
Constant	0.002*
	(0.001)
Observations	4,964

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4 Results

We first establish that our climate risk index is relevant. Even if we may think that climate change risk may affect prices, it could still be the case that the policies or the physical risks are so small that they could not have a significant effect on stock returns. For this reason, we want to examine the effect of TRI on returns, using stock fixed effects. Specifically, we estimate the following model:

$$R_{i,t} = \alpha_i + \beta \cdot TRI_t + \epsilon_{i,t} \tag{3}$$

where $R_{i,t}$ denotes the return of stock i in month t, α_i is a stock fixed effect, and TRI_t is an indicator variable equal to one in months in which the transition risk index lies in the top decile of its distribution, signifying months with unusually elevated climate-policy news coverage. Our results are presented in Table 1. We see that indeed the relationship is negative, which consistent with what we would expect, as it is likely that news about the worsening climate affect the prices of stocks negatively.

Table 2 then decomposes the effect of transition-risk news into its short-term and long-term components. The pattern that emerges is striking: the negative price reaction documented above is driven entirely by the short-term-oriented component of climate news, which carries a negative and statistically significant coefficient. By contrast, news

TABLE 2: Effect of short-term and long-term transition-risk news on stock returns

	(1)
Transition Risk Index – short-term	−0.004***
	(0.001)
Transition Risk Index – long-term	0.003*
	(0.002)
Constant	0.007**
	(0.003)
Observations	4,964

Standard errors, clustered by month, in parentheses.
The specification includes stock fixed effects.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

oriented towards distant horizons has no negative effect on aggregate stock prices – if anything, the point estimate is mildly positive, though only marginally significant. This pattern is consistent with standard present-value logic: news concerning imminent policies affects cashflows that are only lightly discounted, and thus passes almost fully into current prices, whereas the price impact of news about distant policies is mechanically attenuated by discounting, as well as by the possibility that such policies are revised or never implemented. We stress, however, that the absence of an aggregate price response does not imply that long-horizon climate news is ignored by investors; as we show below, such news is associated with a significant reallocation of value across the maturity structure of dividend claims. The temporal composition of climate news, therefore, matters for *where* in the term structure repricing occurs, even when it is barely visible in aggregate returns.

Once we establish the above relationships, the next step is to understand whether the price reaction described in Table 1 stems from the pricing of all future cashflows in the same way. Presumably it could well be the case that only short-term or only long-term dividends are affected by the climate change risk. There are two channels through which dividend strips of various maturities may be affected, the first is that the expected dividend may be reduced (because earnings may be predicted to be lower at that horizon) and the second is that the discount rate corresponding to that horizon may move (e.g. because the corresponding risk is higher). Our asset-pricing perspective is not going to allow us to distinguish between the two channels; however, once we incorporate data about analysts' forecasts, perhaps we can isolate the cashflow channel from the discount rate one. In what follows we will try to understand how the weights of different maturities are moving on days with and without climate interest (note that a dummy equal to 1, corresponds to the top 10% of the values of transition risk index).

We are then interested in decomposing the price movement into a short-term and a long-term effect. To do that, we look at the way the dividend weights are moving on days with and without climate interest. Hence we estimate the following regression:

$$w_{i,t}^{\mathcal{S}} = a_i + \beta \cdot TRI_t + \epsilon_{i,t} \tag{4}$$

The results of this regression are presented in Table 3. The coefficient on the transition risk index is positive and statistically significant: in months with elevated transition-risk news, the share of the stock price accounted for by short-term dividend claims rises. Recall that, by the accounting identity of Section 2, the short- and long-term weights sum to one; an increase in the short-term weight therefore means that the present value of long-term dividends falls *relative* to that of short-term dividends. In other words, when climate-policy concerns intensify, the repricing is concentrated at the long end of the equity term structure: investors mark down distant cashflows – in risk-neutral terms, through some combination of lower expected dividends and higher discount rates at long horizons – while near-term dividends, which are typically already announced or easily forecastable, are largely unaffected. This evidence is consistent with the view that most firms do not respond to climate-policy news by adjusting their near-term payout or investment behaviour; rather, the market treats such news as information about earnings in the more distant future – precisely the horizon at which concerns about stranded assets reside. Column (2) of Table 3, decomposes the effect on the short-term dividend weight into the two temporal components of the index ($w_{i,t}^S = a_i + \beta_s \cdot TRI_t^S + \beta_L \cdot TRI_t^L + \epsilon_{i,t}$). The increase in $w_{i,t}^S$ documented in column (1) is driven by the short-term-oriented component of climate news, while long-term-oriented news is associated with a *decrease* in the short-term weight. To interpret this pattern, it is useful to recall that $w_{i,t}^S$ is the ratio of the value of near-term dividend claims to the total stock price, and that near-term dividends – which are typically already announced, or forecastable with considerable accuracy – constitute the most rigid component of this ratio. News about imminent climate policies therefore operates primarily through the denominator: it marks down the stock price, and in particular the long-term values that dominate it, while leaving near-term dividends largely untouched, so that the short-term weight rises. Notably, this implies that even short-horizon policy news is priced as news about *long-run* profitability; had firms responded to imminent policies by immediately adjusting payouts or accelerating green investment, near-term dividends would fall and the short-term weight would decline – which is not what we observe. By contrast, long-term-oriented news leaves the aggregate price essentially unchanged (consistent with Table 2), and its negative coefficient instead points to a relative markdown of near-term dividends. One interpretation is that credible long-horizon commitments – the announcements most likely to be expressed in long-term language – are precisely the news that induces some firms to begin adapting today, retaining earnings and investing in the transition at the expense of near-term payouts. Taken together, the two coefficients suggest an inversion of the naive horizon-matching intuition: short-term news is priced at the long end of the term structure, while long-term news, to the extent that it moves the term structure at all, is reflected at the short end.

We also extend our results to a more granular analysis for each stock: the coefficient of the above regression, performed in each stock, gives us a measure of its short-term dividend sensitivity. Negative/low sensitivity is associated with a firm that is likely to

TABLE 3: Effect of transition-risk news on short-term dividend weights

	(1) $w_{i,t}^S$	(2) $w_{i,t}^S$
Transition Risk Index (total)	0.001***	
	(0.000)	
Transition Risk Index – short-term		0.003***
		(0.000)
Transition Risk Index – long-term		−0.001***
		(0.000)
Constant	0.037***	0.037***
	(0.000)	(0.000)
Observations	7,086	7,086

Standard errors in parentheses.

The specification includes contract fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

have lower short-term dividends as a result of the climate change concern. These firms, may be the ones who are willing to *retain earnings*, perhaps invest in *R&D* and try to adopt new "green" technologies. Alternatively, it could be the case that these firms are facing short-term reputational costs related to their climate change responses. Our approach allows us to identify such firms. We can outline a few examples of such firms here: Adecco, Apple, IBM, Pepsico, Philip Morris, KBC Group etc. The reverse is true for firms which have a very positive coefficient on the above regression (which is also the most common outcome, as the coefficient on the panel regression is positive overall). The market believes that such a firm is more likely to wait more passively, until any climate-change policy actually affects the firm's earning, which may only happen in the long-run. It is reasonable to assume that these firms face higher risk of *stranded assets*. Examples of such firms include: McDonalds, Citigroup, Morrisons, Orange, Vivendi, ACS etc.

4.1 Dividend swaps

To enhance the external validity of our results, and provide more robust conclusion, we provide preliminary evidence using dividend swap data to study the same phenomena in the US. When using swaps there is no one-to-one correspondence between the dividend strips and the dividend swap prices, because the swaps are usually structured so that there is an exchange of a floating and a fixed leg up to maturity, and not just at maturity. However, we choose to use the same methodology as before, since we are simply interested in the short-term/long-term horizons, without distinguishing between specific maturities. We first confirm that a higher TRI index is associated with a drop in the US stock returns (even though the index is constructed through European news). The results are presented in Table 4. Indeed when climate concerns increase the prices of US equities seem to fall, indicating that investors perceive as bad news for future cashflows (or they use higher discount rates).

TABLE 4: Effect of Transition Risk Index on stock returns

	(1)
Transition Risk Index (TRI)	-0.015***
	(0.001)
Constant	0.001
	(0.000)
Observations	1589648

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We then examine the temporal dimension of this effect, by regressing the short-term dividend weights (price of short term swap dividend by the stock price) on the TRI index. Almost the same pattern reappears. Short-term dividends are not affected as much by the TRI, indicating that most firms (and their investors) only view the climate policy concerns as *long-term problem*. The results appear in Table 5.

TABLE 5: Effect of Transition Risk Index on dividend swap weights

	(1)
Transition Risk Index (TRI)	963.428
	(3311.671)
Constant	63.495
	(85.567)
Observations	1203341

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5 Conclusion

Our study aims to bridge a gap in understanding the temporal dimension of climate risks and their impact on financial markets. Using textual analysis of European news articles, we construct indices of physical and transition climate risk, and we decompose them according to the horizon, short-term or long-term, implied by the wording of the underlying news. We then link these indices to the prices of dividend futures and dividend swaps, which allow us to observe how climate news is priced across the maturity structure of equity cashflows.

Our results paint a consistent picture. Months with elevated transition-risk news are associated with lower stock returns, and this effect is driven by the short-term-oriented component of the news; long-term-oriented news has no detectable effect on aggregate prices, consistent with the heavy discounting of distant cashflows. At the same time, elevated climate concerns shift the composition of stock prices towards short-term dividend claims, indicating that the repricing is concentrated at the long end of the equity term structure. Notably, this holds even for news about imminent policies: near-term dividends remain essentially untouched, suggesting that the market expects the typical firm to maintain its current payout and investment policies, and to absorb the consequences of climate policies only when these eventually materialise. Our firm-level estimates allow us, however, to also identify the exceptions – firms whose short-term cashflows are more sensitive to climate concerns, and which the market appears to view as more likely to adapt early, for instance by retaining earnings to invest in the transition. The remaining firms, whose valuations rest on long-term cashflows that investors mark down when climate concerns intensify, are naturally the ones most exposed to the risk of stranded assets.

We also hope that our work can motivate additional research in this area. On the empirical side, one could apply our approach in an event study around key legislative or regulatory surprises, without any reference to text-based indicators. This could allow for a more disciplined concept of stranded assets and of their effects on firm behaviour. Combining our pricing evidence with data on realized dividends and analysts' forecasts could, moreover, help separate the cashflow channel from the discount-rate channel, which our asset-pricing perspective cannot distinguish. On the theoretical side, a model capturing the sensitivity of individual firms to climate risks would be valuable: such a model could identify which firms should be investing in the transition and which should be paying out or shutting down. Understanding market views on this question would likely require a heterogeneous-firm, endogenous-growth model that incorporates climate change and regulatory shifts.

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