Signaling sustainability through green bonds: Evaluating its impact on stock returns

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Abstract

When a company issues a green bond, it signals its intent to follow a sustainable approach. This study examines the medium- to long-term implications of green bond issuance on stock returns. Our findings reveal that companies issuing green bonds demonstrate positive abnormal returns compared to their counterparts issuing conventional bonds. However, the abnormal returns diminish over time, suggesting that the market gradually adjusts to the signal sent out by the green bond issuance. Furthermore, our results indicate that the market's response to green bond issuance is stronger for companies that have effectively reduced their CO2 emissions post-issuance, underscoring the strength of the signal when supported by credible actions. This research yields valuable insights into the evolving dynamics of green bonds, highlighting their impact on stock returns of companies.

Keywords— Sustainable finance, Green bonds, Stock returns, Corporate social responsibility (CSR), Environmental social and governance (ESG)
JEL codes— G12, G32, G38, Q56, M14

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1 Introduction

In light of the shift to a more sustainable economy, companies are incentivised to incorporate sustainability concerns into their business processes (Eccles et al., 2014). Integrating sustainability is not only a legal requirement (e.g. the European Green Deal (European Commission, 2019)), it is also increasingly becoming a decision criterion for investors (Renneboog et al., 2008). Whether a company is sustainable or not is often communicated to investors by means of ESG scores (Semenova & Hassel, 2015). An alternative way for companies to signal their environmental intentions is by issuing green bonds (Sangiorgi & Schopohl, 2023).

Green bonds are similar to regular bonds, with the only difference being that the proceeds of green bonds should be used to finance or refinance, in part or in full, new and/or existing green projects (ICMA, 2017). The issuance of green bonds might not only strengthen companies' environmental performance (Flammer, 2021; Fatica & Panzica, 2021; Zheng et al., 2023), it may also reduce their financing costs through the green bond premium (Flammer, 2021; Zerbib, 2019; Zhang et al., 2021; Wu, 2022) and attract new investors valuing the sustainable commitment of companies (Tang & Zhang, 2020; J. Wang et al., 2020).

Following signalling theory (Flammer, 2021), green bonds are meant to finance and signal a company's environmental commitment. Positive medium to long term stock performance could indicate that these efforts are successful, as companies are effectively improving their environmental performance and managing the risks associated with the funded projects. Furthermore, positive stock performance in the medium to long term means that green bonds are valued by investors and could have attracted socially responsible investors (Biktimirov & Afego, 2022; Flammer, 2021; Zerbib, 2019). Additionally, companies issuing green bonds need to report on the use of proceeds and environmental impact. Positive returns could, therefore, also indicate a higher level of transparency and accountability (Lebelle et al., 2022; H. Wang & Jiang, 2023).

Previous literature reveals that investors appreciate the environmental efforts of companies. Multiple studies show short-term abnormal returns after the announcement of a green bond (Flammer, 2021; J. Wang et al., 2020; Tang & Zhang, 2020). The endurance of positive abnormal returns could indicate that the company effectively makes an effort to become sustainable. From an academic as well as a practitioner's point of view, it is interesting to analyse medium to long term, in addition to short-term, abnormal returns following the issuance of green bonds.

We study longer term stock performance for different reasons. First, an examination of medium to long run stock performance can show a complete and objective evaluation of green bond issuance (McWilliams & Siegel, 1997). For instance, because improving environmental sustainability may need a broader timeline to materialise (Hahn et al., 2015). Second, event studies, which measure the immediate market reaction to events like green bond issuance, have limitations. Announcement returns only show investors' expectations regarding the future short-term profitability of green bond issuance, which may not translate into the long term (Edmans, 2011; Orlitzky et al., 2003). The market often (initially) does not incorporate intangible information (Chan et al., 2001; Lev & Sougiannis, 1996), such as the investments made by green bonds on firm value. Furthermore, short-term abnormal returns rely on the efficient market hypothesis. However, market efficiency is not likely to be true at all times (Fama & French, 2007), especially when markets are

in development[1]. In the short term, some information may lead to an over- or underreaction, as market participants are not able to fully grasp its impact (Malkiel, 2003).

In this study, we evaluate the medium (1 year) to long term (3 year) impact of green bond issuance on stock market returns. We address this question by comparing the returns of green bond issuing companies and companies with similar characteristics that issue conventional bonds, using propensity score matching. Thereby, we mitigate the effect of firm-specific characteristics other than the 'green' component of the bond. In particular, we find that a green bond issuing company earns on average 5.8 percentage points more than a conventional bond issuing company over the medium term (1 year) and 5.2 percentage points more on the long term (3 years) using cumulative abnormal returns. Furthermore, we find similar results for buy-and-hold abnormal returns, where green bond issuing companies have an average overperformance of 7.8 percentage points in the medium term and 17.5 percentage points on the long term. However, our findings also indicate that abnormal returns diminish with time, possibly suggesting the market's gradual adjustment to green bond issuance. Subsequently, we explore whether environmental performance, measured by CO2 emissions, could increase the market reaction to green bond issuance. In the sense that, better environmental performance after issuance leads to abnormal returns. Notably, we find that companies with lower CO2 emissions after issuance experience higher medium to long-term stock performance. This indicates that the signal send by green bonds is stronger when the company shows concrete actions.

Our work has several contributions to the green bond literature. First, to the best of our knowledge, our work is the first attempt to investigate medium to long run stock performance following a green bond issue. It provides empirical evidence of the financial implications of sustainable investments and contributes to the understanding of how environmentally responsible initiatives impact companies' financial performance over the longer term. Second, we analyse a potential channel through which green bonds could influence stock performance, namely changes in environmental sustainability through the level of emissions of a company. As such, our study validates the hypothesis that improved environmental sustainability positively affects stock returns after green bond issuance.

The paper is structured as follows: Section 2 provides a review of relevant literature on green bonds, sustainable finance, and their impact on corporate financial performance. Section 3 outlines the methodology and data utilised for the empirical analysis. Section 4 presents the findings from our comprehensive study, emphasising the implications of green bond issuance on medium to long term stock performance. Section 5 discusses the result. Section 6 concludes by offering insights and implications for investors, policymakers, and companies aiming to adopt sustainable financial strategies.

[1] See adaptive market hypothesis by Lo (2004). The hypothesis states that financial markets are not always perfectly efficient; instead, they continuously adapt and evolve. It accounts for the role of psychology, behaviour, and changing market conditions in shaping asset prices.

2 Theoretical framework and hypothesis development

2.1 Sustainable corporate practises: CSR, ESG and SRI

Corporate Social Responsibility (CSR) and Environmental, Social, and Governance (ESG) are intertwined concepts. Corporate Social Responsibility (CSR) refers to voluntary initiatives of a company that positively impact society and the environment beyond its core business activities (McWilliams & Siegel, 2001). It involves actions like charitable donations, community engagement, and sustainable practices, aiming to contribute to the greater good while enhancing the company's reputation. Environmental, Social, and Governance (ESG) is a broader framework that evaluates company performance based on three key criteria (World Bank, 2005). The environmental aspect considers the company's ecological footprint and resource management. The social dimension looks at employee welfare, community involvement, and human rights. The governance factor assesses leadership ethics, transparency, and accountability. In sum, while CSR focuses on activities regarding being more responsible, ESG encompasses a more comprehensive evaluation of a company's sustainability and how corporations and investors incorporate environmental, social, and governance concerns in their corporate valuation models (Gillan et al., 2021).

Aligned with the sustainable approach of firms, investors are increasingly adhering to ethical standards. Sustainable Responsible Investing (SRI) is an investment approach that goes beyond financial considerations. It takes into account environmental, social, and governance (ESG) factors when making investment decisions (Renneboog et al., 2008). By aligning investments with values, SRI seeks both financial returns and positive contributions to a more sustainable and equitable world. Consequently, the relation between ESG criteria and stock performance is a widely discussed topic in the literature (Gillan et al., 2021; Friede et al., 2015; Orlitzky et al., 2003)[2].

Some researchers find that pursuing sustainability practices has a positive impact on the performance of a company's stock. Klassen and McLaughlin (1996), for instance, show that strong environmental performance is correlated with significant positive returns, while environmental crises are associated with significant negative returns. Edmans (2011) analyse the relationship between employee satisfaction and long-term stock returns find that a portfolio of the best "100 Best Companies to Work for in America" outperform industry benchmarks. Pástor et al. (2021) link the findings of high returns for green assets in recent years with unexpectedly strong increases in environmental concerns. This is confirmed by Ardia, Bluteau, Boudt, and Inghelbrecht (2022) who empirically test the predictions of Pástor et al. (2021) for the S&P500 companies and find that on days with an unexpected increase in climate change concerns, the stock prices of green firms rise, whereas the stock prices of brown firms decrease.

Other researchers have more doubts about whether following a sustainable approach would lead to higher returns. Bernal et al. (2021), who compare the returns of publicly-listed impact investments, find a risk-adjusted underperformance of these sustainable investment options compared to mainstream markets.

[2]ESG scores can have a dual impact on stock performance, influencing investor preferences both directly through taste discrimination (Hong & Kacperczyk, 2009) and indirectly through the dissemination of information regarding risks and returns (Bolton & Kacperczyk, 2021).

In other words, investors are sacrificing financial returns to invest in accordance to their values. The same is observed by Barber et al. (2021), who note that investors receive lower returns when allocating their capital to impact funds. Aligning with these results, Hong and Kacperczyk (2009) find that sin stocks (tobacco, gambling and alcohol) earn higher returns. The same applies to investing in companies with higher CO2 emissions (Bolton & Kacperczyk, 2021).

In general, the literature has not reached a consensus on whether SRI will undoubtedly lead to improved financial performance. However, for firms it might be beneficial to follow a sustainable approach for several reasons. First, there is a growing demand within the investor community for 'sustainable investment options'. Therefore, by positioning themselves as sustainable firms, they might attract new investors. This could expand their investor base and lower their cost of capital (El Ghoul, Guedhami, Kwok, & Mishra, 2011). Second, governments are implementing new legislation with more stringent sustainability requirements. By anticipating this legislation, firms can mitigate future legal risks (Krueger, Sautner, & Starks, 2020). Third, by adopting a sustainable approach, firms can mitigate the reputational risks associated with potential environmental disasters (Cowan & Guzman, 2020).

2.2 Green bonds

The findings in the literature on the performance of social responsible investment options are context-specific; they depend on asset class, timing, and methodology. Therefore, this paper investigates one particular asset class, namely green bonds. In particular, we investigate the medium to long term stock market response to green bond issuance. Companies have a greater understanding of their sustainability efforts compared to outsiders. Due to information asymmetry, outsiders often encounter difficulties in distinguishing between firms that implement a sustainable strategy and those that do not (Akerlof, 1970). The challenge that many companies face is, therefore, how to send a credible signal to their stakeholders that they making sustainable efforts. In signalling theory, a signal is considered credible when it is costly for firms with less desirable characteristics to imitate (Riley, 1979; Spence, 1973).

Green bonds can serve as a signal towards sustainability (Flammer, 2021). First, by issuing green bonds, companies make a financial commitment to allocate funds, especially for environmentally beneficial projects. Second, green bonds foster transparency as issuers are required to provide detailed information about the projects they fund. Third, many green bonds are certified by independent external parties to guarantee their alignment with sustainability criteria. In sum, we can conclude that issuing green bonds could serve as a credible signal of a company's commitment to the environment. This is because it involves various requirements that are costly to replicate for companies not pursuing sustainable objectives.

The response to green bond announcements remains a subject of intense debate in the literature (J. Wang et al., 2020; Flammer, 2021; Tang & Zhang, 2020; Wu, 2022). The initial market reaction to green bond issuance is mainly positive (Flammer, 2021; Tang & Zhang, 2020; J. Wang et al., 2020). Tang and Zhang (2020) finds that issuing green bonds increases the number of institutional investors, which leads to increased stock liquidity and in turn to higher price stability. Often the presence of long-term investors,

such as institutional investors, signals confidence in the company's future prospects which could benefit the company in the long-run, with potentially higher stock prices in the medium to long term. Furthermore, Tang and Zhang (2020) and Flammer (2021) do not find evidence that green bonds are issued for the lower cost of capital, this could indicate that green bonds may be issued to signal environmental efforts (Flammer, 2021). Improved sustainability could offer resilience against regulatory risks, such as carbon taxes and other climate related risks. Furthermore, abnormal stock returns in the medium to long term could then show the successful implementation of the green bond financed project.

Wu (2022), on the other hand, finds a negative initial market reaction to green bonds. Negative abnormal returns align with analogous findings in the literature regarding conventional bonds (Ammann et al., 2006; Dann & Mikkelson, 1984). This negative return is not surprising, given that both conventional and green bonds are based on the same underlying operations of a company (J. Wang et al., 2020). In fact, issuing a green bond instead of a conventional bond does not alter a company's default risk (Zerbib, 2019), and green bonds do not mitigate investors' exposure to credit risk.

2.3 Testable hypotheses

In general, sustainable investments introduce potential costs and benefits that could influence medium to long-term abnormal performance. Green bonds serve as a signal of a company's commitment to green initiatives (Flammer, 2021; Sangiorgi & Schopohl, 2023), signalling its intended long term survival[3]. Therefore, green investors and long term investors might become interested in the company (Flammer, 2021; Starks et al., 2023). Furthermore, the increase in long term (institutional) investors and the reporting requirements inherent to green bonds reduce information asymmetry (Piotroski & Roulstone, 2004), fostering investor confidence and potentially increasing stock returns. J. Wang et al. (2020) even states that the stock market reacts more positively to the issuance of green bonds than conventional bonds. In summary, it can be argued that by issuing a green bond the company 'signals' avoiding ESG-related risks thereby signalling long-term survival. As a result, we believe that the long-term performance of companies issuing green bonds will likely outpace that of conventional bond-issuing firms, leading to the formulation of the following hypothesis:

Hypothesis 1 *Green bond issuing firms outperform conventional bond issuing firms in the stock market in the long run.*

We explore factors that influence long-term performance subsequent to green bond issuance and propose that enhancements in environmental performance may impact stock performance (Flammer, 2021; Fatica & Panzica, 2021). Note that higher environmental performance contributes to increased resilience against regulatory environmental risks, thereby potentially improving stock performance. Furthermore, Fatemi et al. (2015) state that higher CSR levels lead to higher firm value, equity returns, and lower risk, which makes the company more attractive. In and Park (2019) find that a portfolio that is long in stock of companies

[3]For example, by investing in green aviation oil, airlines are assuring their survival beyond the use of fossil fuels

with low carbon emissions and short in stock with high emissions generate positive abnormal returns. On the other hand, when a company has less desirable environmental performance and it issues a green bond, it signals to the market that it intends to address environmental concerns. Additionally, note that the impact of lower environmentally performing companies could potentially be bigger by issuing a green bond. A green bond could be the first (and maybe much needed) step in making the company more green and as such avoid (the anticipated) regulatory or environmental risks.

Therefore, we formulate the following hypothesis:

Hypothesis 2 *Levels of emissions influence the long term stock performance following green bond issuance.*

3 Dataset and research design

3.1 Sample selection

Table 1 shows the sample distribution of the green bonds by industry, year of issuance and location. Considering the number of green bonds per industry in Table A, it is evident that the majority of green bonds in our sample were issued in the transportation sector, accounting for 42.7% and 43% for the one- and three-year time frames, respectively. The real estate sector follows, with 24.1% and 19.2%. Moreover, as shown in Panel B, we observe that a significant portion of green bonds were issued in the last couple of years. This trend aligns with the recent growth in the green bond market during this period. Furthermore, Panel C reveals that 45.8% and 43.5% of all green bonds in our sample were issued in Europe for the one- and three-year time frame, respectively. This is followed by Asia accounting for 30.5% and 31.1%, respectively.

3.2 Firm-level data

The firm-level data are obtained from different sources and explained below. Table 2 describes its summary statistics. All variables are winsorised at 1% to account for outliers.

Accounting data. Our accounting data are obtained from Eikon, Compustat and Orbis and are used to construct the matched data sample. The accounting variables are defined as follows. *SIZE* is the natural logarithm of the book value of total assets. *Return on assets (ROA)* is calculated as the ratio of operating income before depreciation dived by the book value of total assets. *Tobin's Q* is defined as the ratio of the market value of total assets (obtained as the book value of total assets plus the market value of equity minus book value of equity) divided by the book value of total assets. *Leverage* is the ratio of debt (long-term debt + current liabilities) to the book value of total assets.

Panel A of Table 2 displays the summary statistics of the accounting variables. The statistics are reported as the value of the fiscal year preceding the green bond issuance to ensure good matching criteria before issuance (see Section 3.3). The average size of the green bond issuing companies before issuance amounts to 23.552 and 23.316 for the one and three-year time frames, respectively. The average return on assets of the firms in our sample is 6.5% and 7.4% in the one and three-year time-frames, respectively, indicating that

Table 1: Sample characteristics

This table reports the sample distribution of the corporate green bonds issued between 2013 – 2021, considering data from both the CBI and Eikon database, with sufficient financial data available for conducting our matching and calculating stock returns. The distribution of the sample is reported in Panel A by industry, in Panel B by year of issuance and in Panel C by location

Panel A: Green bond distribution by industry

		1 year		3 years	
SIC code	Industry	Freq.	%	Freq.	%
0100 - 1499	Mining and Agriculture	2	0.5	0	0
1500 - 1799	Construction	43	10.3	20	10.4
2000 - 3999	Manufacturing	74	17.7	38	19.7
4000 - 4999	Transportation, Communications, Electric, Gas, and Sanitary Service	179	42.7	83	43
5000 - 5999	Wholesale and Retail Trade	9	2.2	5	2.6
6000 - 6799	Real Estate	101	24.1	37	19.2
7000 - 8999	Services	10	2.4	8	4.1
9000 - 9999	Public Administration	1	0.2	1	0.5
Total		419	100.0	192	100.0

Panel B: Green bond distribution by year

	1 year		3 years	
Year	Freq.	%	Freq.	%
2013	1	0.2	1	0.5
2014	11	2.6	10	5.2
2015	8	1.9	6	3.1
2016	31	7.4	19	9.8
2017	51	12.2	34	17.6
2018	82	19.3	48	24.9
2019	111	26.5	74	38.3
2020	108	25.8	0	0
2021	16	3.8	0	0
Total	419	100.0	192	100.0

Panel C: Green bond distribution by location

	1 year		3 years	
Region	Freq.	%	Freq.	%
Europe	192	45.8	84	43.5
Asia	128	30.5	60	31.1
Northern America	67	16	30	15.4
Latin America and the Caribbean	20	4.8	12	6.2
Oceania	8	1.9	4	2.1
Africa	4	1	2	1
Total	419	100.0	192	100.0

the companies are profitable. The average Tobin's Q equals 0.981 and 1.098 for the one- and three year time frames. Tobins Q is on average around one, which means that the market value is reflected by the assets of the company. The average leverage ratio of the firms in our sample is 0.376 and 0.379 for the one- and three-year time frames, which means that the firms are under-leveraged.

Environmental performance. Firm-level environmental performance data are obtained from Eikon. The variable is defined as follows. *CO2 emissions* includes both scope 1 and 2 emissions following the Greenhouse Gas (GHG) protocol and is used to proxy the greenness of a company (Bolton & Kacperczyk, 2021)[4]. Furthermore, emissions are typically reported with a one-year delay; therefore, we follow Ilhan et al. (2021) by lagging the variable of CO2 emission by 12 months. We account for the changing effect of these control variables by taking the average value over the respective time frames, one and three years. Panel B of Table 2 displays the summary statistics of the environmental performance variable. We observe that the average firm yearly emits 13.611 and 12.807 tonnes of CO2 emissions, respectively, on the logarithmic scale for the one and three-year time frames.[5]

Firm-specific control variables. The firm specific control variables for our medium to long-term excess return analysis are obtained from Eikon, Compustat and Orbis. These variables are defined as follows. *Sales growth* is defined as the ratio of change in total revenue over stock market capitalisation. *Earnings growth* is defined as the change in earnings per share. *Momentum* is calculated as the cumulative return from month -12 to month -2 and denotes the velocity of price changes in a stock. *Book to market ratio (B/M)* is defined as the ratio between the book value of equity and the market capitalisation. We account for the changing effect of the control variables by taking the average value over the respective time frames, one and three years.

Panel C of Table 2 shows the summary statistics of the control variables. We observe that the average yearly sales growth over the 1-year time frame is 0.043, while it is 0.035 over the three year time-frame. The average yearly earnings growth is 8.1% and 0.1% over the one- and three year time-frames, respectively. Momentum is positive, with a cumulative return preceding the one- and three-year time frames of 5.8% and 6.9%. The average yearly book to market ratios are 0.889 and 0.916 for the one- and three-year time frames.

[4]The emissions of scope 1 cover all direct emissions from production for a year, and the emissions of scope 2 come from the generation of purchased heat, steam and electricity consumed by the company (Bolton & Kacperczyk, 2021). In this paper, we do not incorporate scope 3 emissions, since these are hard to obtain.

[5]Note that we do not include environmental score as a measure for environmental performance. Environmental score often incorporates the fact that the company has issued a green bond and therefore this variable suffers from endogeneity issues.

Table 2: Summary statistics firm-level variables

This table reports summary statistics (mean and standard deviations) for the variables used. Panel A displays the accounting variables used to construct our matched sample between green and conventional bonds. Size represents the logarithm of total assets. ROA represents the ratio of EBITA to total assets. Tobin's Q is the ratio of the market value of total assets divided by the book value of total assets. Leverage refers to the ratio of debt over total assets. Panel B details the environmental performance. CO2 emissions is the logarithm of CO2 emissions, encompassing both Scope 1 and Scope 2 emissions. Panel C reports the firm-specific control variables. Sales growth is defined as total revenue divided by market capitalisation. Earnings growth refers to the change in earnings per share. Momentum is calculated as the cumulative return from month -12 to month -2. B/M represents the book-to-market ratio, which is the ratio between the book value of equity and stock market capitalisation. To account for outliers all variables are winsorised at 1%.

Panel A: Accounting data

	1 year		3 years	
	N	Mean (Std.)	N	Mean (Std.)
SIZE	419	23.552 (1.655)	192	23.316 (1.700)
ROA	419	0.065 (0.037)	192	0.074 (0.042)
Tobin's Q	419	0.981 (0.663)	192	1.098 (1.031)
Leverage	419	0.376 (0.145)	192	0.379 (0.156)

Panel B: Environmental performance

	1 year		3 years	
	N	Mean (Std.)	N	Mean (Std.)
Log(CO2 emissions)	419	13.611 (3.096)	188	12.807 (3.142)

Panel C: Firm-specific control variables

	1 year		3 years	
	N	Mean (Std.)	N	Mean (Std.)
Sales growth	417	0.043 (0.216)	182	0.035 (0.257))
Earnings growth	393	0.081 (0.596)	177	0.001 (0.693)
Momentum	412	0.058 (0.266)	179	0.069 (0.262)
B/M	417	0.889 (0.764)	182	0.916 (0.982)

3.3 Matching approach

We are studying how green bonds affect the medium to long-run stock returns by considering the financial returns of a company's stock one year (medium) and three years (long) after the green bond issuance. The empirical challenge is that the issuance of green bonds is endogenous in relation to firm-level variables that can also affect stock returns, such as profitability. To ensure unbiased test statistics when analysing the long-run test statistics of companies issuing green bonds, we apply a match-control approach where we match each firm that issues a green bond (treated group) with a similar firm (control group) that issues a conventional bond.

We use several matching criteria to ensure that companies issuing conventional bonds are as similar as possible to companies issuing green bonds. We largely follow the matching approach of Flammer (2021). First, we require that the matched sample consists of firms issuing conventional bonds, which we retrieve from Refinitiv Eikon. Second, the matched firms must operate in the same industry and region as the green bond issuing firm to account for region and industry-specific effects. Third, the green and matched conventional bonds must be issued in the same year to account for year specific effects. Fourth, of the remaining conventional bond issuing firms, the matched firms are selected by matching the propensity score based on four firm-level characteristics: size, ROA, Tobin's Q and leverage. For each of these variables, we consider the values from the year before the bond issuance to ensure that before bond issuance both firms are as similar as possible. Using firm size and leverage ensures that both firms have similar access to capital markets (Barber & Lyon, 1997). ROA and Tobin's Q ensure that firms have comparable profit levels and growth opportunities (Hendricks & Singhal, 2001).

Table 3 displays the results of propensity score matching on size, ROA, Tobin's Q, and leverage following exact matching on industry, location and year of issue for the one and three year time frame. This ensures that both samples are highly comparable in size, profit, market-value, and capital structure and differ only on the type of bond issued (i.e. green vs. conventional). From this table, it is evident that the characteristics of the sample and matched firms have been made as similar as possible, as the mean of each covariate is comparable between treated (green bond issuer) and control firms (conventional bond issuer). Furthermore, the t-test for the difference in means are all insignificant which proves that the treated and control sample are similar in the chosen characteristics.

3.4 Measuring abnormal stock returns

This section describes our approach to test for over(under)performance of green bond issuing firms compared to a benchmark. First, we test whether the over(under)performance of the green bond issuing firms is not a result of risk. Therefore, we control for the Carhart (1997) four factors. The model is estimated using the following equation:

$$R_{it} - R_{bt} = \alpha_i + \gamma_{Mkt}(R_{mt} - R_{ft}) + \gamma_{SMB}SMB_t + \gamma_{HML}HML_t + \gamma_{MOM}MOM_t + \varepsilon_{it} \quad (1)$$

Table 3: Matching

This table reports summary statistics (mean and standard deviations) comparing treated and matched control firms for the one-year and three year time-frame. SIZE represents the logarithm of total assets. ROA represents the ratio of EBITA to total assets. Tobin's Q is the ratio of the market value of total assets divided by the book value of total assets. Leverage refers to the ratio of debt over total assets. All variables are measured in the year before the green bond issuance. To account for outliers all variables are winsorized at 1%. The last column of every time-frame report the p-value of the standardised difference-in-means.

		1 year			3 years		
		N	Mean (Std.)	p-value (diff. in means)	N	Mean (Std.)	p-value (diff. in means)
SIZE	Green bond	419	23.561	0.177	192	23.328	0.163
			(1.659)			(1.692)	
	Matched control	419	23.368		192	23.091	
			(2.414)			(1.633)	
ROA	Green bond	419	0.064	0.078	192	0.074	0.421
			(0.037)			(0.042)	
	Matched control	419	0.069		192	0.078	
			(0.053)			(0.056)	
Tobin's Q	Green bond	419	0.967	0.866	192	1.096	0.799
			(0.676)			(1.034)	
	Matched control	419	0.978		192	1.130	
			(1.106)			(1.528)	
Leverage	Green bond	419	0.372	0.119	192	0.378	0.897
			(0.145)			(0.156)	
	Matched control	419	0.389		192	0.380	
			(0.160)			(1.172)	

where $R_{it} - R_{bt}$ represents the excess return of company i in month t over a benchmark b, either the matched firm or the riskfree rate. α_i is the abnormal risk-adjusted return, R_{mt} is the return of the market index, R_{ft} is the return of the one-month risk free-rate, SMB_t, HML_t, MOM_t are the size, value, and momentum factors[6].

Then, we analyse the medium (1 year) to long (3 years) term performance of green bond issuing firms. Two commonly used metrics to assess long-term performance are cumulative abnormal returns (CAR) and buy-and-hold abnormal returns (BHAR) (Barber & Lyon, 1997; Ritter, 1991; Bessembinder & Zhang, 2013; Edmans, 2011; Sorescu, Chandy, & Prabhu, 2007; Spiess & Affleck-Graves, 1999). The first method, (long run) cumulative abnormal returns (CAR), calculates the abnormal return of stock i as the equally weighted arithmetic sum of the difference in the monthly returns between the green bond issuing companies (R_{it}) and their matched counterpart (R_{m_it}):

$$CAR_{iT} = \sum_{t=1}^{T} R_{it} - R_{m_it}$$

where R_{it} is the return of stock i of the green bond issuing company in the tth month after the bond issue, R_{m_i} denotes the return of the matched counterpart of company i and T is the number of months from the bond

[6]We downloaded the monthly SMB, HML and MOM factors from Kenneth French's online data library from the dataset Developed Factors. We use country-specific market indices returns following Flammer (2021), meaning that we use the leading stock market index per country.

issuance to the end of the period. CAR evaluates how a stock's return deviates from what would be expected in the absence of that event or news, in this case the 'green' component in bond issuance. In that sense, we attempt to isolate the green effect of bond issuance on stock performance. The cumulative approach captures the overall impact of issuing a green bond on stock returns.

The second method, buy-and-hold abnormal returns (BHAR) calculates the abnormal return of stock i as the difference between the geometrically compounded daily returns of the green bond issuing companies (R_{it}) and their matched counterparts (R_{m_i}):

$$BHAR_{iT} = \prod_{t=1}^{T}(1+R_{it}) - \prod_{t=1}^{T}(1+R_{m_it})$$

where R_{it} is the return of stock i of the green bond issuing company in the tth month after the bond issue, R_{m_i} denotes the return of the matched counterpart of company i and T is the number of months from the bond issuance to the end of the period. Conrad and Kaul (1993) advocate that the BHAR (Buy-and-Hold Abnormal Returns) method is superior in terms of statistical accuracy. Our BHAR evaluate how well green bond issuing firms have done compared to their matched counterparts relative to market conditions. In essence, BHAR compares the cumulative returns of the green bond stock to what you would have earned if you had invested in the matched conventional bond stock instead.

CAR and BHAR are used to answer different questions (Ritter, 1991). For example, compare the 12-month CAR and the annual BHAR. The 12-month car consists of 12 monthly abnormal returns; hence testing the null hypothesis that the 12-month CAR is zero is equivalent to testing that each mean monthly abnormal return of the sample firms during that year are zero. On the other hand, the annual BHAR tests the null hypothesis that the mean annual abnormal return is equal to zero. Furthermore, CAR ignore monthly compounding while BHAR includes the compounding effect (Barber & Lyon, 1997).

3.5 Corporate sustainability and long-term abnormal returns

To investigate whether environmental-performance can bolster the credibility of the green signal sent to the market by issuing a green bond, we establish a relationship between the CO2 emissions of a green bond-issuing company and its corresponding medium- to long-term abnormal stock returns. We test this relationship by estimating the following regression:

$$RET_{iT} = \beta_0 + \beta_1 CO2_{iT} + \beta_2 X_{it} + \gamma_1 Industry_T + \gamma_2 Year_T + \varepsilon_{iT} \tag{2}$$

where RET_{iT} represents the long-term abnormal stock return of the green bond-issuing company i over period T. Long-term abnormal stock returns are measured using either CAR or BHAR. $CO2_{iT}$ refers to the logarithm of CO2 emission of firm i. X_i represents the control variables, which encompass various firm-specific factors known to predict long-term returns, such as $Sales growth$, $Earnings growth$, $Momentum$, and B/M. Additionally, we incorporate industry and year-fixed effects. The industry-specific effect is gauged through dummies constructed from the 2-digit SIC codes. The year-specific effect is measured by the year of issuance of the green bond. Our coefficient of interest is β_1. We expect β_1 to be negative for the logarithm of CO2 emissions (hypothesis 2).

4 Results

4.1 Excess return

As mentioned, we first want to test if the excess return of the green bond issuing firms might be the result of risk. Table 4 presents the monthly risk-adjusted excess stock returns of green bond issuing companies over a benchmark for both the one-year and three-year time frames. First, Panel A shows that green bond issuing firms generate excess return over the riskfree rate. The alpha is positive and significant and equal to 0.031% and 0.028% for the one and three year time frame respectively. Furthermore, Panel B shows the monthly excess return over the matched firms. As hypothesised in Hypothesis 1, green bond issuing companies generate excess returns over their matched conventional bond issuing counterparts, while controlling for the Carhart (1997) risk factors. The alpha is equal to 0.022% per month for the one-year time frame and 0.017% per month for the three-year time frame above the returns of their matched conventional bond issuing firm. Alpha is positive and significant, which indicates that the monthly excess returns do not stem from risk. Note that alpha is slightly lower for the three year time frame, this could indicate that the abnormal returns are diminishing over time.

Table 4: Risk-adjusted monthly excess returns

This table reports risk-adjusted monthly excess stock returns of companies issuing green bonds. The dependent variable represents the monthly return of a green bond issuing company minus the return of a matched firm issuing a conventional bond. This variable is regressed against the four Carhart (1997) factors, MKT, SMB, HML, and MOM. The alpha indicates the excess risk-adjusted return, and t-statistics are shown in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Excess return over the riskfree rate		
	1 year	3 years
α	0.031	0.028
	(19.222)***	(18.574)***
γ_{Mkt}	0.260	0.276
	(18.247)***	(21.044)***
γ_{SMB}	0.002	0.005
	(2.381)**	(5.620)***
γ_{HML}	0.001	0.001
	(3.409)***	(1.317)
γ_{MOM}	-0.001	-0.002
	(-3.072)***	(-3.820)***
Panel B: Excess return over the matched firm		
	1 year	3 years
α	0.022	0.017
	(7.867)***	(7.178)***
γ_{Mkt}	0.222	0.199
	(9.049)***	(9.527)***
γ_{SMB}	0.001	0.005
	(0.480)	(3.522)***
γ_{HML}	0.001	0.001
	(1.704)*	(0.887)
γ_{MOM}	-0.000	-0.000
	(-0.291)	(-0.407)

Now we investigate the medium to long term abnormal stock returns based on monthly returns of the companies to identify the (over)underperformance of green bond issuing companies. As discussed in Section 3.4, two measures are frequently employed in the literature to calculate the extended impact of outperformance: Cumulative Abnormal Returns (CAR) and Buy-and-Hold Abnormal Returns (BHAR). Table 5 presents the long-term abnormal stock returns of companies issuing green bonds using these two measures.

Panel A of Table 5 presents the results for the cumulative abnormal returns of firms that issue green bonds over the one-year and three years time frames. The mean CAR is equal to 0.058 and 0.052 for the one-year and three-year time frames, respectively, and is statistically significant. This means that the green bond issuing company earns on average 5.8 percentage points more than the conventional bond issuing company over the one year periods and 5.2 percentage points more on the 3 year period. The median cumulative abnormal return is positive and significant for both time spans, amounting to 0.052 for the one-year period and 0.053 for the three-year period. Hence, we contend that companies issuing green

bonds outperform their conventional counterparts when evaluating long-term performance via cumulative abnormal returns.

Panel B of Table 5 presents the results for the buy-and-hold abnormal returns of firms that issue green bonds over the one-year and three-year time frames. The mean BHAR is 0.078 and 0.175 for the one-year and three-year time frames, respectively, and is statistically significant. This indicates that green bond issuing firms earn on average 7.8 percentage points more than their conventional bond issuing counterparts on the one year time frame and 17.5 percentage points more on the three year time frame. The median buy-and-hold abnormal returns are respectively 0.063 and 0.144 for the respective time frames, and they are significant at the 0.01 level using the Wilcoxon signed-ranks test for both periods. This result suggests that investors value green bonds more than conventional bonds and reward companies issuing green bonds in the medium to long run.

As hypothesised and confirmed by the CAR and BHAR, firms issuing green bonds exhibit significant abnormal returns compared to firms issuing conventional bonds. This observation might indicate that green bonds serve as a credible signal for companies' commitment to sustainability. This means that companies effectively deliver on their sustainable promise and manage the risks associated with the funded projects. Positive abnormal returns also suggest that green bonds are highly valued by investors and could have attracted a larger share of socially responsible investors (Zerbib, 2019) which widens their investor base. Furthermore, positive abnormal returns could be attributed to the higher levels of transparency associated with green bond issuance and the corresponding reports on the utilisation of proceeds (Lebelle et al., 2022).

Table 5: Long term abnormal returns

This table presents the long-term abnormal stock returns of companies issuing green bonds. Panel A displays cumulative abnormal returns (CAR) for these companies. CAR is calculated as the difference between the equally weighted arithmetic sum of the monthly return differences of the green bond issuing companies and their matched counterparts. Panel B displays buy-and-hold abnormal returns (BHAR) form companies issuing green bonds. BHAR is calculated as the geometrically compounded monthly returns of the green bond issuing companies and their matched counterparts. The table provides mean and median abnormal returns for both CAR and BHAR. The BHAR and CAR are winsorised at the 1% level. The statistical significance of the mean abnormal returns is indicated by the t-statistics shown in parentheses. The Wilcoxon signed-rank test, a nonparametric test, evaluates the null hypothesis that the median abnormal return is not different from 0. *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Cumulative Abnormal Returns (CAR)		
	1 year	3 years
Mean abnormal returns	0.058	0.052
	(2.509)**	(0.913)
Median abnormal returns	0.052	0.053
Wilcoxon signed-rank test Z-statistic	37521***	8239***
Panel B: Buy-and-Hold Abnormal Returns (BHAR)		
	1 year	3 years
Mean abnormal returns	0.078	0.175
	(2.918)***	(2.535)**
Median abnormal returns	0.063	0.144
Wilcoxon signed-rank test Z-statistic	35890***	7206***

In the preceding paragraphs, we delved into the influence of the green signal transmitted by companies issuing green bonds. If this phenomenon is primarily a consequence of sustainability being undervalued rather than associated with risk, it is reasonable to anticipate that the drift linked with green bond issuance diminishes over time, for two reasons. First, sustainability is a dynamic concept subject to change. What is considered sustainable today might not hold the same weight in the future. Companies that invest today in state-of-the-art green technologies and neglect to make follow-up investments might become less sustainable in the future compared to their competitors. Consequently, the initial outperformance linked to green bond issuance might erode over time. Second, even if a company continues its green bond issuance and sustains investments in eco-friendly technologies, the initial mispricing could gradually dissipate as the market learns and fully includes the value of sustainability in their valuation models.

Table 6 further investigates the abnormal returns by examining different subperiods. Panel A displays the average cumulative abnormal return of companies issuing green bonds in event month t. The CAR through month T is the arithmetic sum of the abnormal returns from months t through T. We observe that the CAR grows until 1.5 years and then plateaus until 2.5 years; after that, it slightly drops for the three-year time period. In panel B, we calculate the buy-and-hold abnormal returns by compounding the returns from months 1-12, 13-24, and 25-36. We then subtract the matched compounded returns over the same periods. The results in panel B align with those in panel A: during the first two years, the buy-and-hold average returns are positive but gradually dropping, and by the third year, they are virtually zero but negative. Both panels indicate that several years pass before the abnormal returns begin to decline. This suggests that over time, the market learns about the impact of green bonds and the possible improved environmental performance following their issuance. As a result, the market begins to accurately assess the value of green bond issuance, leading to a diminishing of the overperformance.

4.2 Environmental performance and long-term abnormal returns

This paper hypothesises that issuing a green bond is beneficial to firm value, as it serves as a credible signal for green improvements. We believe that tangible improvements in green performance, triggered by issuing a green bond, significantly contribute to the credibility of the signal. As a result, they may have a positive relationship with long-term abnormal returns. Therefore, in this section, we examine to what extent CO2 emissions impact the long-term abnormal stock returns of green bond issuing companies.

Table 7 presents the results of the regression analyses that establish the relationship between a tangible corporate sustainability measure and long-term abnormal returns. The model investigates the relationship between CO2 emissions and long-term abnormal returns after green bond issuance, quantified by BHAR and CAR. The coefficients of the logarithm of CO2 emissions are significantly negative for both time frames in terms of BHAR, as well as for the 1-year CAR. However, no significant impact could be found for the 3-year CAR, possibly because the CAR is typically more sensitive to short-term market events and news. Furthermore, BHAR has greater statistical accuracy (Conrad & Kaul, 1993), which could also explain the difference in significance between the BHAR and CAR result for the three year time frame.

Table 6: Longevity analysis

This table presents the long-term abnormal stock returns of companies issuing green bonds, divided into subperiods. Panel A displays cumulative abnormal returns (CAR) for these companies. CAR is calculated as the difference between the equally weighted arithmetic sum of the monthly return differences of the green bond issuing companies and their matched counterparts. Panel B displays buy-and-hold abnormal returns (BHAR) form companies issuing green bonds. BHAR is calculated as the geometrically compounded monthly returns of the green bond issuing companies and their matched counterparts. The table provides mean abnormal returns for both CAR and BHAR. The BHAR and CAR are winsorised at the 1% level. The statistical significance of the mean abnormal returns is indicated by the t-statistics shown in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Cumulative Abnormal Returns (CAR)		
	1 year	3 years
6	0.033	0.026
12	0.058	0.063
18		0.087
24		0.087
30		0.080
36		0.052
Panel B: Buy-and-Hold Abnormal Returns (BHAR)		
	1 year	3 years
1-12	0.078	0.095
	(2.918)***	(2.655)***
13-24		0.001
		(0.040)
25-36		-0.009
		(0.211)

In this case, for each one-unit increase in the log of CO2 emissions, CAR is estimated to decrease by approximately 0.015 units and BHAR by 0.051 units over one year time frame. Furthermore, each unit increase in log CO2 emissions decreases BHAR by 0.072 units in the three year time frame. The significance of BHAR results for both one-year and three-year calculations suggests that the relationship between green bond issuance, emissions, and stock performance holds over both medium and longer time frames. Therefore, companies with higher emission levels are negatively associated with long-term abnormal returns after green bond issuance. The reverse holds true, of course, for lower emissions. Consequently, hypothesis 2 is true: lower emission levels after green bond issuance are associated with higher long-term abnormal returns.

One could argue that the impact of green bond issuance is amplified when a company has lower CO2 emission levels. In this view, green bonds send a more compelling signal to the market when a company demonstrates superior environmental performance after issuance by emitting less CO2. Essentially, the market reaction to green bond issuance is higher if there is a commitment to sustainability that is the company's CO2 emissions are at a lower level.

Table 7: Corporate sustainability and long-term abnormal returns

This table reports the influence of corporate sustainability on the long-term abnormal returns, where corporate sustainability is quantified by CO2 emissions. CO2 emissions is the logarithm of CO2 emissions, encompassing both Scope 1 and Scope 2 emissions. We control for various company-specific characteristics that could affect long-term returns. Sales growth is defined as total revenue divided by market capitalisation. Earnings growth refers to the change in earnings per share. Momentum is calculated as the cumulative return from month -12 to month -2. B/M represents the book-to-market ratio, which is the ratio between the book value of equity and stock market capitalisation. To account for outliers all variables are winsorised at 1%. *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	CAR 1 year	CAR 3 years	BHAR 1 year	BHAR 3 years
Intercept	0.273	0.550	1.143*	0.791
Log(CO2)	-0.015*	0.004	-0.051***	-0.072**
Sales growth	-0.099	0.238	0.018	0.063
Earnings growth	0.074*	0.266***	0.170***	0.095
Momentum	-0.186**	-0.382	-0.160	0.138
B/M	-0.116***	-0.431***	-0.176***	-0.319***
Year F.E.	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes
F-value	2.747***	2.287***	5.108***	1.658**
R-value	0.109	0.198	0.186	0.164

5 Discussion

Our results indicate that companies issuing green bonds have positive abnormal returns in the medium to long run compared to conventional bond issuing companies. This result aligns with Pástor et al. (2021) and Pedersen et al. (2021), who find that green firms outperform brown firms. There are several reasons why the demand for companies issuing green bonds might increase in comparison to conventional bond issuing firms. First, environmental concerns and sustainability are growing in popularity; investors may increasingly prioritise companies that commit to environmental responsibility. Green bonds could serve as a signal to broadcast the company's environmental intentions (Flammer, 2021; Sangiorgi & Schopohl, 2023; Tang & Zhang, 2020). Therefore, issuing a green bond might attract socially responsible investors, investors with ESG-focused criteria, and long term investors (Starks et al., 2023; Flammer, 2021). Second, companies issuing green bonds enjoy positive reputational benefits that can attract new stakeholders, including customers, investors, and employees (Sangiorgi & Schopohl, 2023). Hence, companies with a reputation for sustainability are perceived to have a competitive advantage (Porter & Kramer, 2006). Finally, projects funded by green bonds could encompass innovative sustainable business practises that might result in cost savings, improved efficiency, and reduced exposure to environmental risks (Fatemi et al., 2015). In addition, these companies could become more resilient to regulatory shifts concerning environmental issues. Consequently, companies issuing green bonds might experience enhanced long-term stock performance.

Further analysis of long run stock returns reveals that the drift associated with green bond issuance declines over time. One possible explanation could be that the initial positive reaction to green bond issuance might lead to a short-term market overreaction. This means that investor enthusiasm temporarily drives prices higher. As the initial excitement fades, the stock price may start to revert to a more reasonable

level, leading to mean reversion. A second explanation is that the market could gradually adjust to the new information, namely the signal sent out by the green bond issuance. As more information on the company's sustainability initiatives and the potential impact of the green bonds becomes available, investors might reassess the company's long-term prospects. This adjustment could result in a gradual returns to the mean as the stock price converges toward a more accurate valuation. A third explanation is that investors might initially focus on the short-term positive impacts of green bond issuance, such as increased positive sentiment and reputation. However, as time passes, they may shift their attention toward the long-term operational implications. This change in perspective then results in the decline of the drift associated with green bond issuance.

The phenomenon of greater (initial) abnormal returns for green bond issuers underscores the market's appreciation for environmental efforts, signalled by green bonds. Investors seem to react positively to companies that commit to addressing ecological challenges through the issuance of green bonds. This finding echoes the increasing influence of Environmental, Social, and Governance (ESG) factors in investment decisions (Renneboog et al., 2008). The initial enthusiasm from investors probably reflects both the alignment of green bond issuers with sustainable practises and the increasing demand for environmentally responsible investments. The convergence of abnormal returns over time does not necessarily diminish the significance of green bond issuances. Rather, it reflects the market's recalibration of expectations as companies navigate the complexities of executing and maintaining sustainability initiatives. The evolving response pattern observed in this study underscores the need for companies to uphold and communicate their environmental commitments effectively throughout the life of the green bonds.

The observed negative correlation between the level of CO2 emissions and long-term stock performance shows that the market reaction to green bond issuance is stronger for lower emitters. Higher levels of CO2 emissions can indicate poor environmental performance, a weaker commitment to sustainability initiatives, and a greater exposure to environmental risks (Fatemi et al., 2015). Consequently, these companies may experience lower investor confidence, leading to weaker stock performance over the long term. Additionally, higher emission levels seem at odds with issuing green bonds. Furthermore, regulatory bodies are rapidly developing new environmental regulations to combat climate change. For example, in Europe, companies are restricted to a certain level of CO2 emissions. Complying with these new standards could lead to additional costs and administrative burdens. Thus, companies with higher emissions may face greater regulatory and market risks, which can negatively affect their medium to long-term stock performance. Moreover, companies with higher CO2 emissions may encounter negative public perception and stakeholder concerns (Porter & Kramer, 2006). This negative perception can result in increased reputational risks and potential loss of business from socially responsible investors and environmentally conscious consumers. Such damage to their reputation can further contribute to the long-term underperformance of these companies in the stock market. Finally, sustainable business practises, including reduced emissions, often contribute to long-term operational efficiency, cost savings, and resilience in the face of regulatory changes.

6 Conclusion

This paper finds that green bond issuing firms generate superior medium to long-term returns compared to conventional bond issuing firms. We argue that green bonds serve as a signal for environmental improvements that might enhance financial performance. The abnormal returns are initially highly significant and positive; however, they diminish over time and lose their significance. This observation suggests that, initially, the market tends to undervalue the influence of green bond issuance on stock valuation. However, this underestimation gradually corrects itself as the tangible effects of green bonds on corporate operations and environmental improvements become more discernible. Our findings also indicate that the market reaction to green bond issuance is stronger for lower-emitting companies. This result aligns with the premise that improved environmental performance positively intersects with financial performance (Flammer, 2013; Klassen & McLaughlin, 1996).

As ESG considerations continue to shape investment landscapes, these findings have implications both for corporate strategies and investor decision-making. Companies aiming to leverage green bonds for financial and sustainability gains should be prepared for an evolving market response that requires an ongoing commitment to meaningful environmental actions, such as reducing emission levels. Furthermore, investors should recognise the multifaceted nature of market reactions, valuing not only the initial enthusiasm, but also the longer-term prospects for sustainable value creation.

In conclusion of this study, we extend an invitation for future research on long-term stock performance after green bond issuance. Recognising the relatively nascent nature of this phenomenon, our study focuses primarily on a constrained time frame with only data up to 3 years after bond issuance spanning a timeframe from 2012 to 2023. Delving into more extensive temporal dimensions could potentially reveal additional nuances and patterns that are currently beyond our scope. Especially since our dataset covers a timeframe when ESG-related instruments were in high-demand, one could argue there was a 'ESG-bubble'[7]. Therefore, out results could be skewed with respect to later timeframes. Furthermore, it would be interesting to investigate the influence of investor sentiment after green bond issuance on the stock market. Previous research has shown that sustainability preferences have an influence on asset prices (Pástor et al., 2021). However, other studies concluded that investors do not seem to reward organisations that engage in sustainable initiatives (Krüger, 2015).

[7]Bloomberg L.P., "The Virtue Bubble Is About to Burst. Good Riddance.," Bloomberg 31/05/2023.

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