Master Thesis: 'Unlocking Corporate Green Bonds'

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Abstract
This paper provides a quantitative examination of corporate green bonds – bonds whose proceeds are earmarked to finance environmental and climate-friendly projects. It uses a global sample of more than 600 corporate green bonds, issued between 2013 and 2020, to assess the credibility of the main rationales identified in the literature to date for issuers to issue green bonds (signalling commitment to the environment to stakeholders, improving operational efficiency and attracting more capital from the green and long term investor pool). It analyses the extent to which issuers in fact achieve these goals using a matching approach and difference-in-differences specification. It then looks at corporate green bonds from the investor's perspective, discussing the implications this analysis has for understanding the motivations of participating investors (whether ethically or financially-driven), and for assessing whether those motivations are supported by the performance results delivered to date by issuers. The results show that the signal issuers provide by green bond issuance does appear to succeed in attracting green and long term investors, but that the signal effect is limited and short lived. The same is true of internal environmental performance improvements - limited improvements coincide with first issuances but fade over time and with subsequent issuances. So, thus far, there is a clear suggestion of diminishing returns for issuers and investors. In addition, there was no evidence for a relation between green issuance and operational performance improvements. Overall, this implies that, to date, the corporate green bond market has grown largely in response to a first or one-off signal from issuers and largely on faith. Investors have responded to the new information and promises contained in first issuances with a willingness to participate, giving first issuers the benefit of the doubt based on largely unproven and uncertified promises. How long this faith will hold remains to be seen and will depend on the extent to which regulation, certification and transparency develop.

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1. Introduction

'Climate change widespread, rapid and intensifying' is the headline conclusion of the latest Intergovernmental Panel on Climate Change (IPCC) report issued in August 2021. The scientists writing the IPCC report are unequivocal that a dramatic and sustained further reduction in emissions of carbon dioxide (CO_2) and other greenhouse gases is needed, starting now, to keep the change within the 1.5 degrees Celsius level, and so limit the severest impacts of climate change on human well-being and the environment (IPCC, 2021). Even before the report was issued, over 80% of the 750 executives surveyed in a major global study by Deloitte said their organisations were registering deep concern about climate change and its impact on their businesses (Deloitte, 2021). However, avoiding and mitigating the worst physical and economic impacts of climate change is an extremely complex challenge, requiring transformative systemic changes not only in the global energy system but in how (and which) goods and services are produced and consumed. One thing is clear: enormous flows of capital will need to be redirected to finance these changes. Already in 2017, the OECD had estimated that $93 trillion in climate friendly infrastructure investment would be needed over the subsequent 15 years to achieve a low carbon future. Even that estimate now looks conservative. Additionally, it has become clear that the climate crisis is feeding a crisis of trust in companies. In an interview with Bloomberg Green, Ben van Beurden, CEO of Shell, nicely captured today's challenge of trust (Akshat and Hurst, 2020):

> 'My children span the ages of 10 to 25. On the 25 end of things, we have deep philosophical discussions. My son understands what we're doing. He may be critical, but I have convinced him on my fundamental understanding. What you can do with a 10-year-old is to say "Do you trust Papa to do the right thing for you?" And she will say, "Yes, I trust you. I know you love me. I know you will do the right thing for me, and therefore I believe in you." That's the nice thing about a 10-year-old. We can't have that attitude with society. If I asked society, "Do you trust me to do the right thing?" I think I know what the answer is. So we have to work harder to reestablish trust where we have lost it and to strengthen it where we haven't.'

This growing alarm over the climate threat, the recognition by companies that they will be impacted and need to act, and the huge amounts of capital that will be involved, have all fed the rapid growth of a new financial debt instrument: green bonds.

Green bonds are fixed income securities whose proceeds are fully earmarked to finance or re-finance new and/or existing, environmentally sound projects (ICMA, 2021). Like

traditional bonds, they can be issued by governments, banks or corporates.[1] The only difference with traditional bonds is the commitment to use the proceeds for (long term) environmental improvement projects, including projects responding to the climate crisis (e.g. renewable energy, energy efficiency, wastewater management, pollution prevention, green buildings, clean transportation, biodiversity, circular economy adapted products, climate change adaption). No more technically complex than conventional bonds, green bonds merely require additional information to confirm the use of funds and to assess and track the environmental impact of the activities for which the proceeds are used (Shishlov et al., 2016).

Since the first green bond was issued by the European Central Bank in 2007, the use of this new financial instrument has grown explosively, especially after companies joined the fray. This happened in 2013 when Vasakronan, a Swedish property firm, issued the first corporate green bond (Climate Bonds Initiative, 2020). New corporate green bond issuances grew more than fifty fold over the next five years. Issuance volumes doubled again in 2019. In that year, more than 170 billion US dollars in green corporate bonds were issued (Climate Bonds Initiative, 2020). Green bonds issued by corporates represented nearly 70% of the more than $270 billion green bonds issued in that year (Cheong & Choi, 2020). Despite the COVID-19 pandemic, new corporate green bond issuances rose again in 2020, reaching more than $188 billion.[2]

This strong growth has occurred despite a continuing lack of clarity on definitions and criteria for inclusion. According to Maia Godemer, a sustainable finance associate at Bloomberg New Energy Finance (BNEF): 'It is hard to know how green bonds' proceeds are being used because there is no mandatory requirement to do so and no standardized manner to do it' (Quinson, 2021).[3,4] The same is true for tracking claims about environmental or operational improvements post issuance. As a result, the environmental integrity of green bonds remains a work in progress (Shishlov et al., 2016). Currently, issuers claims about the

[1] Note that this study focuses on the green bonds issued by corporates globally.
[2] Corporate green bond volume levels are all based on issuances registered in Thompson Reuters' Datastream (see Table 1).
[3] There are various competing voluntary guidelines established for the issuance of green bonds - with the Green Bond Principles (GBP) of the International Capital Market Association (ICMA) the most widely cited. However, there are no binding, or even fully agreed, international guidelines to determine what fund end uses qualify for the green bond label. Nor is there an agreed process in place to track fund use (Park, 2018; Wang, 2018).
[4] Maia Godemer refers in this quote to the lack of requirements, and standardized procedures, in the definition and communication of the 'greenness' of a project (Quinson, 2021).

'greenness' of the projects being funded by green bonds are largely unverified, with individual investors left to judge the veracity of these claims.[5]

Despite these limitations, the growing popularity of green bonds suggests they could become a permanent and material instrument for funding the corporate response to the climate change (and other environmental) challenges.[6] Hence the importance of understanding the motivations of and the impacts on both the firms issuing them and the investors buying these instruments. Yet academic analysis of this new financial instrument is still in its infancy. The studies to date on the motivations of green bond issuers and green bond investors rely heavily on qualitative research. They also generate varying, and in some cases conflicting, results.[7] In short, the basic questions of why firms choose to issue green bonds instead of traditional ones – and why investors choose to buy them – have not been answered in any depth. Why did Apple for example, with its extraordinary ability to raise capital through conventional routes, choose to issue a 1.5 billion US dollar green bond in 2016? The answer is not immediately obvious, since green bonds have lower flexibility (their proceeds are locked into green projects) and at least marginally higher administrative and compliance costs (for tracking and reporting use of funds). And why did investors choose to purchase that bond, given that conventional Apple bonds of similar price and duration were also readily available? Further, did issuers and investors actually achieve what they intended by issuing or buying those bonds?

This thesis paper aims to shed new light on these questions. It first focusses on green bond issuers. It qualitatively describes the range of motivations stated by green bond issuing firms. It then quantitatively examines whether these motivations appear justified based on firm level outcomes to date, and if so, whether this justification strengthens or diminishes over time and with subsequent issuances. For this, three main rationales are identified in the literature to date for the issuance of corporate green bonds: i) signalling commitment to the environment, ii) improving operational efficiency and iii) extending the green and long term investor pool. The first refers to the idea that, due to their constraining nature, green bonds allow firms to

[5] While the GBP encourages organisations to adopt the relevant practices of the GBP (ICMA, 2021), the principles remain non-binding. There is no governance control to enforce or confirm compliance. At the moment, some firms decide to undergo third-party verification to demonstrate that the proceeds are financing projects that credibly contribute to the environment.

[6] To give an idea of the scale of the green financing challenge, Jessica Alsdorf, Head of Morgan Stanley's Global Sustainability Research Team, estimated that about 90 trillion US dollars in infrastructure in the period 2017 to 2032 is needed to achieve the goals outlined by the Global Commission on Economy and Climate. She makes the case that, with a finance ask this large, a wide variety of debt and equity instruments will be required including widespread use of green bonds (Morgan Stanley, 2017).

[7] The literature review in section 2.1.1. and 2.1.2 lays out the specific claims of the academic studies on corporate green bond issuers and investors to date.

credibly signal to the market their commitment to the environment, to undertake green investments and to improve environmental performance. If borne out, this rational would undermine the speculations and concerns that green bonds represent just another form of 'greenwashing' (Flammer, 2020).[8] The second rationale highlights how, by credibly signalling intent to their employees and suppliers, issuers expect to improve their operational efficiency. Signalling a green ambition through issuing green bonds is hoped, by companies, to be a way to both attract high quality employees and motivate employees and suppliers to increase focus on energy and resource savings that save time and costs. The third rationale also builds on the signal effect, highlighting environmental commitment to the market to attract environmentally focused and/or long term investors, both to purchase the issued bonds themselves and, more importantly the equity of the issuing company (Maltais and Nykvist, 2020; Shislov et al., 2016). The time-effect of firm-level outcomes - at different time lapses post first issuance and after subsequent issuances - is also analysed. It sheds additional light on two things, not yet well explored in the literature. First, whether firms continue to improve their environmental contribution in the immediate aftermath of a first green bond issuance and so indeed live by their signalling motivation (and do not 'greenwash'). Second, whether subsequent issuances provide new information or stimulus for improvement to issuing firms above and beyond that provided by a firm's first green bond issuance or instead whether there is talk of diminishing returns or fading effects after the initial first issuance boost.

Next, this paper turns to investors, contributing to the immature body of academic literature on green bond investors' motivations by examining the two broad groupings of ESG investors identified in the qualitative literature to date: those driven by mainly ethical and those by mainly financial considerations.[9] The former are presumed willing to forego some level of return to invest in line with their ESG principles. The latter group are not, they are operating on the belief that better ESG performance will result (at least over time) in higher risk adjusted returns. This study then looks whether these reasons for investing appear justified by firm level outcomes to date, and which of these groups of investors to date appears most likely to be investing in green bond issuing companies (both in their green bonds and their equity). This is done against a background of recent academic analysis on stock market performance that has

[8] Greenwashing is defined as the practice of making unsubstantiated or misleading claims about the company's environmental commitment.

[9] ESG investors are defined in the literature as investors who apply a form of socially responsible investing in which they consider non-financial factors – Environmental, Social and Governance (ESG) - as part of their investment analysis.

found significant stock price upticks only for issuers of independently certified green bonds.[10] Again, the inclusion of the time-effect analysis on firm level outcomes helps shed light on the question of whether these investors are seeing sustained effects over time and new information with each new issuance, or instead whether the information and effects are concentrated in the brief period around the first issuance.

The quantitative core of this study is a difference-in-difference analysis, performed on a matched set of green and non-green corporate bond issuers. This analysis finds only limited support for the credibility of the main stated rationales of green bond issuers. In line with previous literature, it does find a short term improvement in environmental performance (measured by environmental rating and CO_2 emissions) for green issuers post issuance relative to non-green issuers. However, in an addition to the literature, it finds that this green issuer advantage quickly erodes and is not significant after a second, third or other subsequent issuances. These results imply that first green bond issuances do provide a credible short term signal (up to one year after issuance), with the relative outperformance bump fading beyond that time period and with subsequent issuances. The analysis also shows a change in ownership mix post green bond issuance, in line with previous studies, with green issuers successfully getting green and long term investors to increase their ownership share of these companies. In other words, the signal effect cited as a primary motivation for green bond issuers seems to be at least somewhat effective in meeting their goals – both in prompting the environmental performance gains and in attracting the intended investors. However, the results go on to show that the effect is significant only one year after the first bond issuance, with limited ownership mix improvements seen in the longer term and for subsequent issuances. No supporting evidence is found for greater than peer group firm-level operational performance gains after a first or any subsequent issuance, in contrast to a previous analysis done in the Chinese market (Zhou and Cui, 2019).

This study then considers possible implications of these firm-level findings for investors. Without empirically being able to check which investor group is the more active in corporate green bond investing, it speculates that the newly attracted investors in these companies post issuance have likely been largely ethically motivated rather than financially. This former group will have been undeterred by the lack of operational improvements seen to

[10] While Flammer (2020) finds a positive stock market reaction after green bond issuances in general (and a slightly stronger positive reaction for certified bonds), research by Yeow et al. (2021) more recently suggests that positive stock price effects are only significant for certified green bonds – and not certified green bonds, the vast majority of green bonds to date.

date in green bond issuers and by the lack of significant sustained stock market uptick for the majority of these issuers.[13] The possibility remains that any financially motivated investors in the mix are either concentrated in certified bond issuers (and realizing the documented market gains for this small subset of green bonds) or are taking a longer term perspective, hoping and/or expecting financial outperformance in the long run (in part due to their influence as shareholders). Overall, it observes, based on its firm level analysis, that investors prompted to invest in green bond issuers are still, in this early stage of the market development, largely acting on faith rather than observed firm performance. And as a result, that the future of this potentially promising instrument is far from assured. Time and significantly increased transparency (through consistent and widely used certification, performance reporting etc.) will be critical for corporate green bonds to grow into mainstays of climate finance.

The remainder of this paper is structured as follows: Section 2 provides the theoretical framework and describes the hypotheses tested. Section 3 describes the data on corporate green bonds, as well the issuer-level data. In addition, it explains the methodology in detail. Section 4 presents the results of the difference-in-differences analysis and section 5 discusses these findings, considering the study's limitations, potential wider implications, and further research the results points to. Finally, section 6 draws a series of summary conclusions.

2. Theoretical Framework

2.1. Theoretical background

The theoretical framework for understanding the recent and rapid rise in the use of corporate green bonds is still emerging. This section describes the pieces of that framework now in place in the academic literature, to understand both the firms issuing green bonds and their investors.

2.1.1. Firms issuing green bonds

As Agrawala et al. (2011) rightly state, quantitative academic studies on the reasons why firms have chosen to issue green bonds and subsequent firm-level impacts have been limited. This remains the case. Most of these quantitative studies have focussed on the more mature municipal green bond market (e.g. Baker et al., 2018; Karpf and Mandel, 2017; Zerbib, 2019) and the question of comparative yields between green and 'brown' municipal bonds. The results of these studies vary, but overall no statistically significant differences in prices (either premiums or discounts) have been found. Tang and Zhang (2020) recently published the first

[13] See footnote 9 – note that the majority of corporate green bonds issued remain uncertified by third parties.

quantitative study on corporate green bond market yields. Focused on China, they found no market premium for green bond issues. They did find a short term positive stock market price effect for green bond issuers post issuance. Lebelle et al. (2020) in their quantitative study focussed entirely on stock market reactions immediately post green bond issuance globally and by contrast, found a negative impact on stock prices.

Shishlov et al. (2016) were one of the first to focus specifically on the nascent corporate green bond market and firm-level outcomes, rather than financing impacts. Published only three years after the first green issuance, they relied on existing literature and expert interviews rather than quantitative analysis and argued that green bond issuance did (or in the future would) benefit issuers in three main ways: helping issuers signal and draw attention to their sustainability strategy, improving their relationships with debt providers and broaden the investor base, and creating internal synergies between financial and sustainability departments.[18] Building on these insights, Maltais and Nykvist (2020) later interviewed players in the Swedish green bond market to understand company stated rationales – so why companies say they issue green bonds. They found issuers' ex post facto explanations for entering the green bond market in Sweden to be dominated not by direct financial incentives (e.g. greater access to or lower costs of capital), but by what they called 'business-case incentives'. Simply put, this comes down to two main things. First signalling effects, in which highlighting their environmental projects through issuing green bonds would allow companies to attract different – environmentally sensitive and/or long term – investors. And second, the expectation of operational efficiency improvements created through a range of internal changes - including attracting and motivating employees to increase focus on energy and resource savings that also save time and costs. These two motivations – signalling resulting in attracting more green and long term investors as well as operational efficiency improvements – reappear in subsequent, qualitative and quantitative studies and will be tested in this paper.

In terms of quantitative analyses, Zhou and Cui (2019) were one of the first to analyse firm-level changes in performance after corporate green bond issuance, limiting themselves to the Chinese market. They undertook a matching study to compare changes in profitability (return on assets), operational performance (gross profit margin) and corporate social responsibility performance (based on a qualitative score they assigned) of green bond issuers compared to non-green issuing corporates. They show a positive correlation between the

[18] The article is unclear as to whether the authors were speculating and/or advocating for future benefits or claiming actual benefits to have been realized in practice to date.

issuance of green bonds and greater improvements in these elements of firm-level performance in the period 2016-2019. Zhou and Cui's Chinese green bond market study limited itself to these performance outcomes, with no check on Maltais and Nykvist's highlighted ownership impacts or signaling effects.

Flammer (2020), by contrast, presents a first systematic quantitative assessment of the signalling effect motivation for green bond issuance Maltais and Nykvist (2020) posit, as well as testing the credibility of that motivation by examining firms' environmental performance post issuance.[19] And she does so on a sample of issuers covering all major geographies. Her matching approach and difference-in-differences analysis of corporate green bond issuers in the period 2013-2018 shows evidence that green issuers do in fact improve their environmental performance more and sustainably over time. Consequently, she finds a greater gain in green and long term investors for green issuers compared to non-green issuers. This lends support to Maltais and Nykvist's signaling argument (and also undermines widespread concerns that corporate green bond issuance is a form of greenwashing, not backed up by real environmental improvements).[20] In addition, the attraction of investors by corporate green bonds, creating a broad base of interested actors aimed to invest in green bonds, reveals the importance that this instrument has for both the companies and the environment (Flammer, 2019).

Note that Flammer (2020) does not examine the potential increase in operational efficiency Maltais and Nykvist (2020) postulated. Flammer's study did examine 'bond yields'. And like Tang and Zhang (2020) in the Chinese market, she finds no material pricing difference globally between green and non-green bonds, casting further doubt on reduced cost of capital as an incentive for green bond issuances.

An even more recent global matching study by Yeow & Ng (2021) comes to a more nuanced conclusion when it comes to greenwashing. Their results, which unlike Flammer (2020) distinguish certified versus non-certified green issuances, point to green bond issuers improving environmental performance post issuance only when those issuances are certified by third parties.[21]

2.1.2. Investors purchasing green bonds

[19] The methodology used in this paper is based on Flammer (2020).
[20] Greenwashing is defined by the Cambridge Dictionary as: 'to make people believe that your company is doing more to protect the environment than it really is'.
[21] As certification has thus far been led by the industry, third party certifiers range from a selection of financial institutions to associations like the International Capital Market Association and the Climate Bond Initiative

It obviously takes two to tango – issuers need buyers for these novel instruments. The rapid growth in take up of green corporate bonds by investors, as well as the share price bounce and increased equity stakes in green bond issuers by green and long term investors post issuance found by Flammer (2020) confirm investor willingness to buy green bonds and the stock of green bond issuers.[23] The volume of ESG investment (on both the equity and bond side) has become sizeable.[24] However, to date, the academic literature examining the investor perspective has been limited and high level. That literature, based on interviews with participants, describes stated institutional investor rationales for investing in ESG in general, often combined with advocacy arguments for how those investors should be justifying this move (e.g. Boffo & Patalano, 2020; Novethic, 2015; Dyck et al., 2019). From this work, a high level picture emerges of two main types of ESG institutional investors – those driven by direct financial motives and those investing primarily because of ethical considerations (either their own or their target client group).

The first group is acting on a belief that an ESG investment focus generates higher risk adjusted returns. It sees high ESG ratings as a useful proxy or signal for better firm-level performance both in terms of higher expected long-term returns (both from operational efficiency and branding, as well as market advantages) and in terms of lower financial and operational risks (Jansson & Biel, 2011; Maltais & Nykvist, 2020; Shishlov et al., 2016).[27] These financially-driven ESG investors are, according to the literature, investing on their belief in the mantra 'Doing well by doing good'. They are following a conviction that, far from ESG distracting or costing firms money, corporate green bonds are a source, at least in the longer term, of lower risk and higher risk-adjusted returns (Barman, 2016; RBC, 2019; Wang et al., 2020). This belief is driven by their concern about future climate regulations and customer (and employee) acceptance of firms, which could lead to stranded assets by rendering those companies' product offerings and business models obsolete (Carbon Tracker, 2011; Caldecott, 2013). In addition, for the largest institutional investors with a long term outlook (e.g. pension funds), the financial drive to ESG investment is also about future macro economic and sectoral risks. Climate risk is the big focus here. It is argued that, as these investors are broadly exposed

[23] Note that the positive share price is found to be strongest for first time issuers and bonds certified by third parties (Flammer, 2020).
[24] The US SIF Foundation's Biennial 'Trends Report' found that sustainably invested assets reached 17.1 trillion US dollars in 2020 – covering one third of the total US assets under professional management (SIF, 2020). Note that the United States is one of the largest players in the field of sustainable investing.
[27] More quantitively expressed, a 2019 survey from BNP of institutional investors and asset managers notes that over half of the respondents are seeking to integrate ESG due to improved long-term returns, and 37% due to decreased investment risk (BNP, 2019).

to economic conditions (and in some cases large allocators of capital in their own right), they are increasingly seeing investment in the low-carbon transition as a way to both contribute to maintaining long term economic sustainability, and allowing them to offset long-term climate-related risks associated with their investment portfolios (Novethic, 2015; Hawley & Williams, 2007). ESG investing fits their long-term perspective and conservative risk appetite. These financially driven ESG investors are undeterred by the academic studies to date that have so far failed to find consistent financial outperformance by ESG investments compared to conventional investments (Galema et al., 2008; Renneboog et al., 2008; Derwall et al., 2005; De Lucia et al., 2020; Lee et al., 2014; Alonso-Conde & Rojo-Suárez, 2020). Instead, they believe their view will be borne out over time as ESG risks (climate change most prominently) continue to grow sharply in the financial materiality of firms. These ESG investors perceive their investment as a sound long term strategy, not as a way to change the world to fit a moral vision or live by their or their customers' principles (Duuren et al., 2015).

The second group, by contrast, are ethically-driven institutional ESG investors, whose primary motivation is some mix of doing good for its own sake (as part of their core purpose, values and sometimes customer given investment mandate), and signalling this commitment to sustainability to their end customers, employees or regulators (Barman, 2016). There is no claim here of superior financial returns. Some qualitative studies have even found a stated willingness by institutional and other investors to accept lower returns from investments that contribute to sustainability (Honura et al., 2020; Maltais & Nykvist, 2020; Riedl and Smeets, 2017). This stance is not without its economic logic. For at least some of these ethically-driven institutional ESG investors, there is a second order financial motivation at play – namely responding to their end customers' growing demands and tapping into a fast growing market for ESG responsible investment products (Wheeler, 2012).[28]

Overall, there has been little academic work specifically on green bond investors. Only Maltais & Nykvist (2020) and Shislov et al. (2016) focus on this investor group, offering (qualitative) surveys of their varied motivations. In addition, Flammer's (2020) issuer-level study of the pricing difference between traditional and green bonds gives rise to several implications for corporate green bond investors. Intuitively, she argues that the finding of no green bond premium, in combination with the stock market outperformance of green bonds,

[28] Khorana and Servaes (1999) have underlined how new fund types in high demand (in this case ESG responsible investment products) are a valuable source of capital inflows and incremental revenue for fund managers.

poses the expectation that green bond investors are willing to trade off financial returns for societal benefits. However, she then claims, based on interviews with various industry practitioners, that investors would not invest in green bonds if the returns were not competitive.

2.2. Hypotheses

Building on the literature to date, this paper aims to provide a deeper understanding of the motivations of firms issuing green bonds and investors, and examines whether these underlying rationales appear justified based on firm-level outcomes to date. More specifically, it quantitatively examines the credibility of the main rationale identified for the issuance of green bonds (signalling commitment to the environment), as well as the extent to which issuers achieve the firm-level improvements motivating this signal (improving operational efficiency and attracting more green and longer term investors). [29] In addition, this research discusses the possible implications of the firm-level outcomes for those investing in green bonds, and their motivations. To this end, four hypotheses have been generated for empirical testing:

> *Hypothesis I*: That green bond issuers actually do improve their environmental performance following the issuance of green bonds, meaning that the issuance of a green bond is a credible signal by the issuer of its commitment towards the environment.

Note that this does not imply that green bonds themselves (e.g. the funds raised and earmarked) cause improvements in environmental performance. As Flammer (2020) notes, the size of the green bond funds raised remain small compared to the size of the issuers' overall asset size and thus, green bonds themselves, are unlikely to bring material firm level improvements (Flammer, 2020). The argument instead is that, by issuing green bonds, companies draw positive attention to their broader environmental commitment and to the improvement efforts planned or underway across the company above and beyond the specific projects being funded. They are advertising upcoming expenditures on more sustainable activities to signal a more general commitment to environmental performance. However, referring to the rapid growth of the green bond market, industry practitioners are starting to question the value of these bonds (e.g. additional value to the issuers' environmental performance) and whether they are not just

[29] It builds on the quantitative analysis of Flammer (2020), and the survey research and conceptual framing of Maltais & Nykvist (2020) and Shislov et al. (2016).

another case of greenwashing (Grene, 2015). In an attempt to provide further clarification on these concerns, this hypothesis tests whether or not that signal is credible – mainly judged on whether it is backed up by genuine improvements in environmental performance (in the short and long term) post issuance. Due to time, this paper is able to contribute to the existing literature by providing a longer term assessment of the issuers' environmental performance through 2020. This time element is important in understanding the soundness of the green issuers' signal. If the signalling motive is only a short term objective, one would not expect any improvement in environmental performance in the long run, and the greenwashing motive prevails.

> *Hypothesis II:* That green bond issuers in fact improve their firm-level operational performance following the issuance of green bonds, supporting these companies' expressed belief in the link between investing in greener activities and overall operational improvement.

This quantitatively tests whether a core motivation for green bond issuance identified by Maltais and Nykvist (2020) in their qualitative analysis – the expectation of operational improvements - is actually realised by companies that invest in green projects and issue green bonds to advertise and finance them. The rationale is based on the idea that by credibly signalling commitment to the environment, companies will be able to attract high quality employees, impact the productivity of employees motivated by the firm's green commitment and identify innovative operational efficiency gains – which in turn improves the overall operational efficiency (Ali et al., 2010). Note that this hypothesis at a minimum claims co-occurrence not causality. It does not assert that green bond issuance directly cause improvements in operations, for example, by focussing attention on saving energy or materials costs (KPMG, 2015). Instead, what is being tested here is simply whether operational improvements above and beyond those of non-green bond issuing matching firms can in fact be found.

> *Hypothesis III*: That following the issuance of green bonds, the ownership share of issuing companies by green investors and long term investors does in fact increase, supporting one firm level justification for issuing green bonds.

In other words, green bond issuance results in the change in ownership mix posited by Maltais and Nykvist (2020) and Shislov et al. (2016) as a motivation for issuance and for which Flammer (2020) found empirical evidence. The idea is that highlighting environmental commitment through the issuance of corporate green bonds would make firms more appealing to investors sensitive to the environment, and allow them to attract environmentally and long term investors. Note that Deloitte (2021) adds a second layer of thought to this by underlying the longer term importance of this shift in ownership. It highlights how much firms' environmental sustainability initiatives are driven by stakeholder pressure and investor demands. In other words, once the investors are in, they could further nudge these firms towards change and environmental outperformance – linking back to *Hypothesis I*. This longer term perspective is key in the following, and last, hypothesis:

> *Hypothesis IV:* That these three firm-level outcomes (signalling commitment to the environment, improving operational efficiency and attracting more green and longer term investors) post green bond issuance are greatest for first-time green bond issuers, with additional improvements diminishing with subsequent issuances.

This last hypothesis has not yet been tested in the literature. If borne out by the data, it could support and provide further nuance to the signalling argument. It would suggest that, once firms signal their commitment to the environment with a first green bond issuance (accruing any benefits in terms of operational efficiency or ownership changes), the news is then incorporated into the market (investors) and employee behaviour. More specifically, driven by the lack of regulation mentioned earlier, employees and investors' key challenge is accessing ESG data and determining issuers' ESG performance (Capital Group, 2021). Both groups are therefore left constrained by the market and their personal judgement, in which case subsequent issuances would provide them with minimal new information or stimulus (save from their intrinsic motivation) to engage with these specific firms. In turn, with subsequent issuances, green issuers would have a harder time achieving a positive impact on their ability to source high quality employees (achieving their higher operational efficiency objectives) and green or long term investors (diversifying their investor pool). In other words, the gain is concentrated in the initial signal to labour and financial markets that comes with the first green issuance. Issuances after that at best reconfirm or remind one of a firm's commitment, and at worst are just disregarded as 'old news' or ' more of the same'. A final possible, second order implication of this hypothesis concerns issuers' environmental performance. If indeed the benefits and

signal to the markets fade, then so too could issuing firms environmental outperformance in response to the diminishing insistence of sustainable sensitive investors.

The empirical predictions for green bond issuers contained in these hypotheses are analysed in section 4. Section 5 then discusses the questions posed by these hypotheses for investor identity, motivation and justification.

3. Data and Methodology

This chapter describes the data set and methodology used to empirically test these four hypotheses. It is divided into three sections:

- Corporate green bond issuance data
- Firm-level performance and outcomes data
- Methodology, including control group matching

3.1. Corporate green bond issuance data

To understand the market and identify corporate green bond issuers, a database was compiled of corporate green bonds issued globally between 2013 and 2020. Thomson Reuters' global database Datastream was used to build this data set. All bonds were extracted from Datastream for which the 'Green bond indicator' variable was labeled 'Yes' and 'the issuer type' was labeled 'corporate'. Note that any bonds labeled 'Sukuk' in the Datastream 'instrument type' field were excluded, in light of these Shari's law based instruments' distinct equity like structure and their use of non ESG criteria.[30] Given that Datastream provides data on financial instruments traded on 60 markets and covers companies in 175 countries, the issuances contained here can be expected to provide a representative overview of the global universe of corporate green bonds, covering the vast majority of global issuances.

The resulting data set consisted of 2,304 corporate green bond issuances in the period and included a range of information about the issuer (e.g. company identity, industry and country) and the bond issued (e.g. issue date, amount, currency, credit rating, coupon and maturity). The following sections provide initial insights from this data.

3.1.1. Corporate green bonds over time

[30] Sukuks are financial instruments used in Islamic finance and designed to comply with Shariʿa law. They involve a direct asset ownership and is banned from interest bearing lending (this would make it no longer halal). Datastream includes sukuks as corporate bonds.

The explosive growth in the corporate green bond market since 2013 is shown in Table 1, based on the sample dataset drawn. The new issue amounts registered per year in Datastream rose by more than one hundredfold over the seven year period after the market's launch, from $1.42 billion in 2013 to $188 billion in 2020. The number of bonds issued annually jumped almost fiftyfold, with 794 bonds issued in 2020.[32] Corporate green bond issuances continued to grow in 2020 despite the COVID-19 pandemic, which started in February 2020.

Table 1: Corporate green bonds over time
This table reports the number of corporate green bonds issued as well as the issuance amount (in US dollar billions) on an annual basis over the period 2013-2020, using all corporate green bonds registered in Datastream.

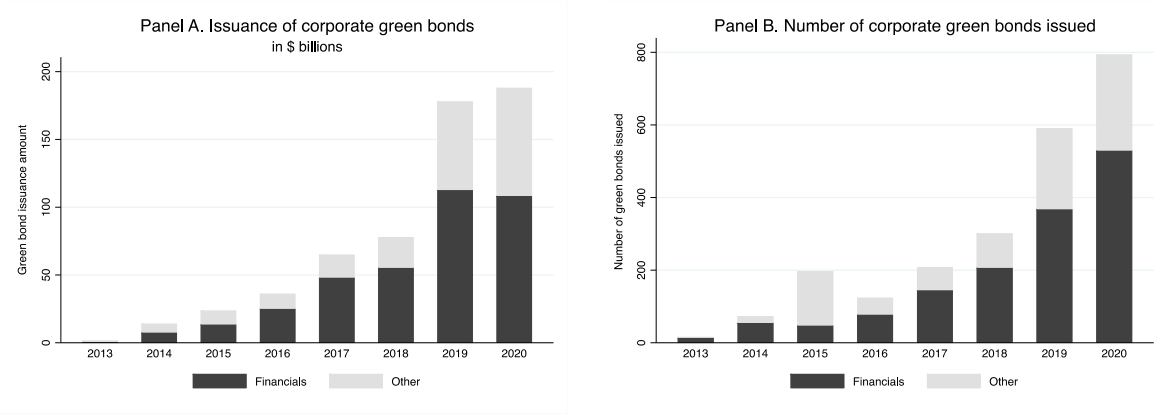
Year	# Bonds	$ Amount (billions)
2013	16	1.42
2014	73	14.03
2015	197	23.66
2016	124	36.08
2017	208	64.98
2018	301	77.94
2019	591	177.97
2020	794	188.02
Total	2,304	584.09

3.1.2. Corporate green bonds by industry

Corporate issuers of green bonds captured in Datastream were distinguished by industry, using the major divisions of the Standard Industrial Classification (SIC) system.[33] Financial institutions have been the largest group of green bond issuers from the outset, as Figure 1 underlines.[34] The majority of non-finance industry issuances were by companies in the transportation, communications and electricity major SIC division. And more than seventy percent of these bonds were issued by power companies.[35] This is not surprising, given these companies' substantial environmental impact and high visibility to regulators and customers.

[32] Note that the spike in number of corporate green bonds issued in 2015 was caused by 113 separate issuances in that year by Tesla subsidiary SolarCity (Flammer, 2020).
[33] The SIC codes provide a standard categorisation of companies' industry, based on primary business activities. The SIC system contains 11 major divisions (see Table 2), which are then divided into 83 two-digit groups, and further subdivided into 416 three-digit and over a 1,000 four-digit industries.
[34] Note that SolarCity (a Tesla subsidiary) issued 131 green bonds in 2015. This explains the uptick in the number of non-financial green bonds in Figure 1, Panel B.
[35] Power companies issued 417 of the 574 green bonds from non-financial firms between 2013 and 2020. See Table 2 in appendix section 8.1 for the full breakdown of the corporate green bonds by major SIC-division over the period 2013-2020.

Figure 1: Evolution of finance industry and other sector corporate green bonds
This figure plots the total issuance amount of corporate green bonds in US dollar billions (Panel A) and the number of green bonds issued (Panel B) on an annual basis over the period 2013-2020 by companies in the financial sector and other sectors, using all corporate green bonds in the sample drawn from Datastream.



3.1.3. Corporate green bonds by region

Table 3a provides a regional breakdown of corporate green bonds. The seven regions follow the World Bank's regional classification and are used later for the matching of green and non-green bond issuers in the data sample (see section 3.4). Corporate green bond issuances to date have been concentrated in heavily industrialised Europe, China and the United States, with Europe being the largest issuer and responsible for approximately half of all green bond issuances by number and value.[36]

Table 3a: Corporate green bonds by region
This table reports the number of corporate green bonds issued as well as the issuance amount (in US dollar billions) by region (as categorized by the World Bank), using all corporate green bonds from 2013-2020 in the sample from Datastream.

Country	# Bonds	$ Amount (billion)
East-Asia and Pacific	683	126.52
Europe and Central Asia	1,163	312.54
Latin America & Caribbean	82	20.31
Middle East and North Africa	7	2.10
North America	315	109.75
South Asia	28	5.28
Sub-Saharan Africa	25	6.89
Total	2,304	584.09

3.1.4. Corporate green bond data summary statistics

Table 4 below, provides an overview of the green bond data set used. The 2,304 corporate green bonds extracted from the Datastream database are issued by 872 unique firms – meaning

[36] See Table 3b in appendix, section 8.1 for a more detailed breakdown of corporate green bonds by country.

that each corporate that opted to use a green bond, on average, undertook nearly 2.7 green bond issuances over the period. Note that firms can, and do, issue multiple bonds in a day or a year, something considered in the subsequent analysis. The differences in issuances by public and privately owned firms are slight, both in terms of maturity (slightly more than 7 years on average) and coupon (more than two thirds being variable-rate rather than fixed in both cases). While public corporate green bond issuers have a slightly worse credit rating and lower fixed coupon rate, the difference is not material.

In the remainder of this paper, the analysis focusses on publicly traded corporate green bond issuers. This is due to the limited data available on firm-level ownership, operational and environmental performance information for private corporate issuers. Public corporate issuers represent slightly more than a quarter of all issuances by number, but, given the far larger size of their issuances, more than 60% of the total green bond issuance amount in the period.

This data set of public corporate issuers contains 638 green bonds issued by 293 unique firms in 430 unique issue years.

Table 4: Summary statistics
This table provides an overview of all corporate green bonds (column 1), corporate green bonds issued by private firms (column 2) and by public firms (column 3) over the period 2013-2020 in the Datastream database. *# Green bonds* is defined as the number of discrete corporate green bond issuances; *# Green bond issuer-days* is defined as the number of unique days on which a firm issues green bonds, summed across all firms; *# Green bond issuer-years* refers to the number of unique years in which a firm issues green bonds, summed across all firms; *# Green bond issuers* includes the number of unique firms that issued a green bond; *Amount* is the issuance amount in US dollar millions; *Maturity* is the duration, in years, until the bond matures, measured from the year of issuance; *Fixed-rate bond* is a dummy variable equal to one if the bond has a fixed coupon payment; *Coupon* refers to the coupon rate for fixed-rate bonds; *Credit rating* refers to the rating of the green bond and includes three different ratings (based on Standard & Poor's, Moody's and Fitch's rating scales). For each characteristic, save credit rating, the table provides sample means and standard deviations.

	All	Private	Public
	(1)	(2)	(3)
# Green bonds	2,304	1,666	638
# Green bond issuer-days	1,906	1,370	536
# Green bond issuer-years	1,306	876	430
# Green bond issuers	872	579	293
Amount (in US dollar millions)	253.754	224.525	330.016
	(374.017)	(322.157)	(475.753)
Maturity (in years)	7.213	7.259	7.092
	(5.919)	(5.783)	(6.262)
Fixed-rate bond (1/0)	0.693	0.700	0.676
	(0.461)	(0.458)	(0.469)
Coupon (for fixed-rate bonds)	0.027	0.031	0.022
	(0.024)	(0.023)	(0.024)
Credit rating			
S&P rating (median)	AAA	AAA	AA-
Moody's rating (median)	Baa1	Baa1	Baa1
Fitch's rating (median)	BB+	BB+	BB

3.2. Firm-level data

With this data set of green bond issuances by public firms built, a second data set was then compiled consisting of the public firm issuers themselves and a sample of comparable public firms in terms of geography and industry that issued non-green corporate bonds in this period. Note that the public firms issuing standard (non-green) bonds were also selected from Datastream and its data on non-green bond issuances. The information for these firms consists of firm-level data (financial, environmental and operational performance, and institutional ownership), collected from a variety of sources for the period 2010 through 2020.[39] This data set makes a comparison of firm-level performance possible, before and after the issuance of green bonds for green bond issuing public firms. It also allows for a comparison between firms issuing green and non-green bonds during the period once those firms are 'matched' in terms of geography and industry. This section provides a description of the firm-level data used in the analysis.

3.2.1 Financial performance

The financial data for these green and non-green bond issuing public firms was obtained from Standard & Poor's Compustat database.[41] Both Compustat North America and Compustat Global were used since the scope of this study covers public firms issuing green bonds globally. Compustat provides a wide range of financial data and was supplemented by annual share price information from Thomson Reuter's Datastream. For this analysis, the Compustat annual fundamental data file and Datastream were used to compute the following variables at fiscal year end for each of the years in the period 2010-2020:

- *Size* – the natural logarithm of the book value of total assets (in US dollars).
- *Return on assets (ROA)* – the ratio of operating income before depreciation to the book value of total assets, providing an indication of profitability.
- *Tobin's Q* - the ratio of the market to book value of total assets (in US dollars), with the stock market data on common share close prices obtained from Datastream (in US dollars) and data on common shares outstanding as well as the book value of total assets (in US dollars) coming from Compustat Global and North America.

[39] Data was included from 2010 to create a treatment window before the first issuance in 2013 to allow analysis of potential trends in the period prior to issuance. Note that, in the case of parents and subsidiaries, the direct green issuer is considered not the parent company since the green bond has the most impact on the actual issuer.
[41] Further details on the matching procedure are outlined in section 3.3.1.

- *Leverage* - the ratio of debt (long term debt plus debt in current liabilities) to the book value of total assets.

The ratios were then winsorized at the 1st and 99th percentile to control for the impact of outliers. These statistics are included below in Tables 5 (green/non-green issuer full sample overview) and 6 (green/non-green issuer matched sample overview).

3.2.2. Operational performance

The same Compustat databases were also the source for the firm level operational performance data. Two measures were used to assess operational performance:

- *Asset turnover* – the ratio of total revenue to book value of total assets, which is the most broadly used measure of operational efficiency (Baik et al., 2013; Soliman, 2008; Bhullar, 2017).
- *Gross profit margin* – the total revenue minus the cost of goods sold divided by the total revenue, which reflects both current and potential future profitability of a firm (Zhou & Cui, 2019). It is a relevant comparison for firms within an industry sector and is not used for cross-sectoral comparisons.[42]

Summary statistics for these measures are also provided in Tables 5 and 6 below.

3.2.3. Environmental performance

The firm level Environmental, Social and Governance (ESG) data used was obtained from Thomson Reuter's ASSET4. ASSET4 is specialized in providing corporate ESG information. It contains summary scores per firm for the three pillars of environment, social and governance. *The environmental score* considers emission reduction and product innovation. *The social score* is built up from seven categories: community, diversity, employment quality, health-and-safety, human rights, product responsibility and training-and-development. *The governance score* is a composite of five elements: board functions, board structure, compensation policy, shareholders policy and vision-and-strategy (Thomson Reuters, 2013).[43]

The social and governance scores are used for matching, meaning these scores are compared between green and non-green issuers in comparable regions and industries to find

[42] Note that this data was available from Compustat (North America and Global) only for a subset of 258 of the 293 public corporate green bond issuers. It is used for assessing the performance of these issuers before and after issuance.

[43] See Thomson Reuter's Corporate Responsibility Ratings (TRCRR) (2013) for the variables and rating methodology used by ASSET4 analysts.

best fit pairs of green and non-green issuing firms. They are not used to compare green issuers performance before and after issuance.

By contrast, the Thomson Reuters annual environmental pillar score is used to assess green issuers' environmental performance before and after issuance, as well as for matching. To account for the possibility that ASSET4 analysts are influenced in their judgement of a firm's environmental performance by the issuance of a green bond itself (seeing issuance as an environmentally good practice in its own right worthy of a rating upgrade), a second environmental variable was used – *CO_2 emissions score*. This is the ratio of CO_2 emissions (in tonnes), as provided by ASSET4, to the book value of total assets (in US dollars) from Compustat.[44,45]

Summary statistics for these measures are also included in Table 5 and 6 below.

3.2.4. Ownership structure

To test the third hypothesis concerning changes in investor mix post green bond issuance, equity ownership data was analysed for companies in the United States.[46] Four measures of ownership were used:

- *Institutional ownership* - the percentage of shares owned by institutional investors, with data from Thomson Reuters holding company database.
- *Ownership by green investors* - the percentage of shares owned by 'green' institutional investors, the latter identified as 'green' if members of the Ceres Investor Network on Climate Risk and Sustainability.[47]
- *Ownership by long term investors* - the percentage of shares owned by long term investors. These were calculated based on data from Thomson Reuters. Working back from the investor base per year for all issuing firms in the sample (green and non-green issuers) investors were categorised as long term or not. This was done based both on the holding duration metric used by Cremers and Pareek (2016) which measures holding horizons and, following Gaspar et al. (2005), using the churn rate across their full portfolio in the period.[48] All

[44] Just like the financial performance ratios, the CO_2 emissions ratio is winsorised by the 1st and 99th percentile.
[45] More specifically, the 'total CO_2 and CO_2 equivalent emissions in tonnes' variable from ASSET4 is used.
[46] Due to data availability, it was not possible to conduct a global analysis on the changes in ownership structure.
[47] Ceres is a nonprofit organization aiming to transform the economy to build a sustainable future for people and the planet. Their investor network includes over 195 institutional investors, managing more than $37 trillion in assets, advancing leading investment practices, corporate engagement strategies, and key policy and regulatory solutions (Ceres, 2021).
[48] See appendix section 8.1, Eq. (2) and section 8.2, Eq. (3) for further details.

investors in the sample with above median holding duration or below median churn rate were tagged as long term.

These ownership structure variables are used for analysis of green issuers before and after issuance, not for matching comparisons with non-green issuers, so are reported in Table 6.

3.2.5. Firm-level data summary statistics

As seen in Table 4 above, the 638 green bonds issued by public firms in the period correspond to 293 issuing public firms and 430 unique issue-years. Sufficient financial, operational and environmental performance data was available for 258 of these firms - representing 372 of the 430 unique issue-years. Table 5 reports a first set of firm-level summary statistics for these green bond issuing firm-year observations. For a high level first cut comparison it also provides, in column 2, the same summary aggregate statistics for a set of public firms, obtained from Datastream, that issued non-green bonds during the same 2013-2020 period, are domiciled in the same regions, and operate in the same industry sectors as the green bond issuers.[49] All the firm-level characteristics are computed in the fiscal year end preceding the green bond issuance.[50]

Compared to the set of non-green corporate bond public issuers, green bond issuers, as would be expected, have a higher ESG rating. Noticeable is that the Tobin's Q score is higher for non-green bond issuers, arguably stating that these firms are less undervalued then their green peers. Other comparative measures are broadly similar, although green issuers are slightly larger and more leveraged.

Table 5: Summary statistics at issuer level
This table provides summary statistics of public firms issuing green bonds during the 2013-2020 period (column 1). For a first, high level comparison, summary statistics for public non-green bond issuers who domiciled in the same regions (as defined by the World Bank, see section 3.1.3.), two-digit SIC industry codes and year are also provided (column 2). The statistics in each column are the means and standard deviations covering the entire group of firms, in the year prior to issuance. *Log(assets)* is the natural logarithm of the book value of assets in US dollars, *Return on assets* is the ratio of operating income before depreciation to the book value of total assets, *Tobin's q* refers to the ratio of the market value of total assets to the book value of total assets, *Leverage* is the ratio of debt to book value of assets. *Asset turnover* is the ratio of total revenue to the book value of total assets. Environment, social and governance rating are the ESG ratings. Last, column 3 states the *p*-value of the difference-in-means test, where *, ** and *** denote significance at the 10%, 5% and 1% level.

	N	Green bond	Non-green bond	*p*-value

[49] Note that this comparison set of non-green issuers has not yet been subject to the Mahalanobis distance single best matched firm matching process described in 3.3.1. It is instead the average mean data for all non-green issuers that share a region, and industry and issuance period with the green issuer set of firms.
[50] Note that, due to data availability, the number of observations differ across firm-level characteristics.

		issuers	issuers in same region, industry and year	(difference in means)
		(1)	(2)	(3)
Log(assets)	372	10.153	8.091	0.000***
		(2.219)	(1.365)	
Return on assets	372	0.066	0.040	0.268
		(0.046)	(0.451)	
Tobin's Q	372	0.495	0.872	0.051*
		(0.93)	(3.598)	
Leverage	372	0.332	0.309	0.035*
		(0.162)	(0.133)	
Asset Turnover	372	0.312	0.377	0.009*
		(0.366)	(0.313)	
Environment rating	241	66.680	42.15	0.000***
		(24.242)	(16.304)	
Social rating	241	66.387	49.218	0.000***
		(21.364)	(14.227)	
Governance rating	241	60.621	49.076	0.000***
		(22.228)	(8.650)	

3.3. Methodology

This section describes the methodology applied to test the four hypotheses, which is based on Flammer's empirical research on corporate green bonds in 2020. It also presents the final data sample used throughout the analysis.

3.3.1. Matching

A core analytical challenge in examining firm-level outcomes after the issuance of a green bond concerns endogeneity – dealing with the possibility that there might be factors independent of the act of green bond issuance driving change in the performance or ownership mix of these firms. As Flammer (2020) rightly states, endogeneity concerns cannot, in this case, be addressed with a statistical instrument.[51] Instead, Flammer (2020) applies a matching approach to manage this issue. This paper follows the same approach, in which a 'control' firm that has issued a non-green bond in the period is identified per issuer for each of the 372 unique green issue year observations.[52] The control firm is selected from the same Datastream database as the green issuing firms. To ensure this (non-green) bond issuer is as similar as possible to the green bond issuer, the following matching criteria are used:

[51] More specifically, Flammer recognizes that, since the issuance of green bonds is not a random event, finding a controlled empirical setting - in which companies randomly issue green bonds - is not possible. As a result, no statistical instrument can be created to account for endogeneity (Flammer, 2020).
[52] Note that the control sample only includes those non-green bond issuing firms that have not issued green bonds.

- Geography - that they operate in the same region. [53]
- Industry - that they have the same two-digit SIC industry code.
- Year – that they operate in the same year preceding green bond issuance.
- Nearest neighbour – that the matching control firm has the smallest Mahalanobis distance from the green issuer.[54] The distance measure was calculated based on eight firm-level characteristics drawn from the different data sources described in section 3.1: *size, ROA, tobin's q, leverage, asset turnover* and the three ESG pillars. For each characteristic, the value in the year preceding the green bond issuance (t-1) and the 'pre-trend' (change from t-2 to t-1) is considered. Sixteen metrics, drawn from these eight characteristics, were used to establish the Mahalanobis distance.[55]

These matching criteria were selected to identify a single control firms as similar as possible to each green issuer, in the period preceding the bond issuance. The criteria cover a variety of firm-level elements, in the period before bond issuance, that could potentially be expected to impact the operational and environmental performance post issuance.

Using a control firm that operate in the same region, industry and year helps control for business environment, ensures that the matched and green firm experience the same economic conditions at and after green bond issuance. Using size, ROA, tobin's q and leverage controls for the possibility that the result is impacted by a green issuer having differentiated access to capital or being more or less profitable, or being better or worse able to seize growth opportunities in the years leading up to the bond issuance. Asset turnover follows a similar logic, ensuring that a green issuer and matched control firm have similar operational efficiency prior to the green bond issuance.[56] Finally, ESG ratings are used as matching criteria to align green and control firm performance in this area prior to green bond issuance.

3.3.2. Final data sample

[53] In contrast with Flammer (2020), I require the control firm to operate in the same region instead of the same country due to sample size. A matching group based on country was also created and tested. It was smaller, with matches found for 302, rather than 372, green issue years matched. The smaller sample delivered similar results to using the regionally matched sample. Given the level of statistical significance, the research is presented here based on the larger control sample based on region.

[54] The formal definition of the Mahalanobis distance measure is the distance between treated firm *i* and control firm *j*, given by: $[(Xi - Xj)' \Sigma^{-1} (Xi - Xj)]^{1/2}$ where X is a (14 x 1) vector containing the 14 matching variables and Σ is the (14 x 14) covariance matrix of these matching variables.

[55] Note that if no ESG data was available for a green issuer, the remaining financial- and operational characteristics were used to establish the Mahalanobis distance.

[56] Since this analysis goes beyond Flammer (2020) in examining operational performance following the issuance of a green bond, asset turnover (as measure of operational efficiency) - which Flammer did not include - has been added to the matching procedure.

Table 6 provides summary statistics for the resulting data sample of green issuers and their matched control firms.[57] It is this sample of firms that will be used throughout the subsequent analysis of firm-level performance and ownership changes post green bond issuance.

The table reports the matching characteristics for green bond issuers and their non-green issuers pairs in section A. It also provides other firm-level characteristics in section B (CO_2 emissions, gross profit margin and ownership), that will be used later to test all four hypotheses (see section 4). For each characteristic, both the mean, median and standard deviation of the value in the year preceding the green bond issuance and the 'pre-trend' change from two years to one year before issuance are shown. In addition, the *p*-value of the difference-in-means test and the difference-in-medians test are provided.

Table 6 shows green issuers and control firms are broadly similar along the majority of the matching characteristics, with the exception of log(assets) and ESG ratings. Though across the pre-trend characteristics log(assets) and Environmental and Governance rating due appear to be similar between the two groups of companies. Overall, these statistics confirm that the matched control firms are similar to the green issuers. This suggests that the sample provides a reliable set of firms to compare green issuers' performance (environmental and operational) and ownership structure to non-green bond issuers in the period.

Table 6: Matching
This table presents the summary statistics of the matched sample, meaning both the green issuers and matched control (non-green issuers) firms. All characteristics (both matching and other) are measured in the year preceding the green bond issuance (t-1), as well as over the pre-trend (change from t-2 to t-1). The *p*-values represent the difference-in-means and difference-in-medians test. *, ** and *** denote the significance at the 10%, 5% and 1% level.

		N	Mean	Median	Std. dev.	p-value (diff. in means)	p-value (diff. in medians)
Panel A. Matching characteristics							
Log(assets)	Green issuer	372	10.153	9.677	2.219	0.009*	0.021*
	Matched control	372	9.731	9.425	2.145		
Return on assets	Green issuer	372	0.066	0.059	0.046	0.747	0.262
	Matched control	372	0.067	0.068	0.044		
Tobin's Q	Green issuer	372	0.495	0.338	0.930	0.667	0.529
	Matched control	372	0.471	0.330	0.472		
Leverage	Green issuer	372	0.332	0.332	0.162	0.183	0.084*
	Matched control	372	0.316	0.280	0.174		
Asset Turnover	Green issuer	372	0.312	0.140	0.366	0.706	0.154
	Matched control	372	0.322	0.179	0.333		
Environment rating	Green issuer	241	69.190	76.910	23.350	0.000***	0.000***
	Matched control	241	60.140	68.208	26.321		
Social rating	Green issuer	241	69.659	72.205	19.190	0.001***	0.001***
	Matched control	241	62.358	66.031	22.740		
Governance rating	Green issuer	241	63.852	64.710	20.260	0.056*	0.0665*

[57] Note that the number of observations varies depending on data availability.

	Matched control	241	60.176	62.663	19.161		
Δ Log(assets)	Green issuer	372	0.066	0.048	0.145	0.158	0.794
	Matched control	372	0.053	0.047	0.089		
Δ Return on assets	Green issuer	372	-0.001	0.000	0.027	0.522	0.518
	Matched control	372	0.000	-0.001	0.019		
Δ Tobin's Q	Green issuer	372	0.003	0.004	0.368	0.989	0.290
	Matched control	372	0.004	0.002	0.149		
Δ Leverage	Green issuer	372	0.002	0.000	0.039	0.239	0.560
	Matched control	372	-0.001	0.001	0.030		
Δ Asset Turnover	Green issuer	372	-0.006	-0.001	0.057	0.701	0.624
	Matched control	372	-0.004	-0.002	0.035		
Δ Environment rating	Green issuer	241	1.703	0.000	10.188	0.740	0.058*
	Matched control	241	2.004	0.366	8.340		
Δ Social rating	Green issuer	241	3.448	1.101	8.114	0.003***	0.006***
	Matched control	241	1.404	0.029	5.856		
Δ Governance rating	Green issuer	241	0.327	-0.457	10.637	0.532	0.368
	Matched control	241	0.922	0.293	8.857		
Panel B. Other Characteristics							
CO_2 emissions	Green issuer	211	88.866	5.374	232.206	0.011**	0.113
	Matched control	211	191.114	3.893	534.631		
Gross profit margin	Green issuer	202	0.424	0.348	0.244	0.492	0.308
	Matched control	202	0.441	0.396	0.236		
Institutional ownership	Green issuer	24	0.593	0.690	0.267	0.104	0.114
	Matched control	24	0.713	0.745	0.234		
Ownership by long term investors (duration)	Green issuer	24	0.499	0.564	0.231	0.144	0.096*
	Matched control	24	0.591	0.624	0.195		
Ownership by long term investors (churn rate)	Green issuer	24	0.232	0.253	0.098	0.022	0.039*
	Matched control	24	0.297	0.320	0.093		
Ownership by green investors	Green issuer	24	0.143	0.140	0.074	0.644	0.280
	Matched control	24	0.151	0.150	0.044		
Δ CO_2 emissions	Green issuer	183	-9.115	-0.033	42.140	0.480	0.248
	Matched control	183	-13.150	-0.031	64.592		
Δ Gross profit margin	Green issuer	202	0.004	0.000	0.051	0.423	0.844
	Matched control	202	-0.001	0.002	0.070		
Δ Institutional ownership	Green issuer	24	-0.093	0.007	0.215	0.954	0.067*
	Matched control	24	-0.097	-0.005	0.213		
Δ Ownership by long term investors (duration)	Green issuer	24	-0.078	-0.012	0.166	0.970	0.228
	Matched control	24	-0.077	0.008	0.178		
Δ Ownership by long term investors (churn rate)	Green issuer	24	-0.035	-0.014	0.054	0.171	0.109
	Matched control	24	-0.063	-0.031	0.080		
Δ Ownership by green investors	Green issuer	24	-0.005	0.002	0.026	0.958	0.810
	Matched control	24	-0.006	0.000	0.027		

3.3.3. Difference-in-differences analysis

Continuing to follow the approach used by Flammer (2020), a difference-in-differences analysis has been performed for all firm-year observations over the period 2010-2020 for both

the green issuers and their matched control firm, to examine how firm-level performance and ownership structures change after the issuance of corporate green bonds. The following regression was used:

$$Y_{it} = \alpha_i + \alpha_c \times \alpha_t + \alpha_s \times \alpha_t + \beta \times \text{Green bond}_{it} + \varepsilon_{it} \quad (1)$$

Here *Y* is the dependent outcome variable (e.g. environmental rating, CO_2 emissions, asset turnover, gross profit margin, institutional ownership, green ownership and long term ownership), α_i are firm fixed effects, $\alpha_c \times \alpha_t$ are country-year fixed effects, $\alpha_s \times \alpha_t$ are industry-year fixed effects and ε is the error term. Note that *i* defines firms, *t* defines years and *c* defines countries. The coefficient β measures the difference-in-differences outcome of the dependent variable between the green issuers and the control firms. For example, β measures the change in environmental performance following the issuance of a green bond, while accounting for changes in environmental performance at control firms who did not issue a green bond. Finally, the *Green bond* variable is a dummy equal to one if the firm has issued a green bond in the 2013-2020 period and zero otherwise.[58]

To further extend the difference-in-differences specification in Eq. (1) and better understand the effects of the treatment (i.e. issuing a green bond), a second analysis is run in which the single *Green bond* dummy is replaced with three variants: i) *Green bond (pre-issue year)* is equal to one in the year preceding the green bond issuance, ii) *Green bond (short term)* is equal to one in the year after the green bond issuance, iii) *Green bond (long term)* is equal to one for the subsequent years after the green bond issuance (up to 2020). This extension provides a distinction between the short (first year after issuance) and longer term (2+ years after issuance), and thus helps to better understand the timing of the impact. It also provides a formal way of testing for trends in the data prior to the green bond issuance. Both difference-in-differences specification are examined for each firm-level measure (e.g. environmental and operational performance, and ownership structure).

4. Results

[58] The Green bond dummy variables does not flag individual years before or after issuance, it merely analyses the green bond issuers over the entire 2010-2020 period.

This section presents the results of the difference-in-differences analysis on the firm-level environmental performance, operational performance and ownership structure following the issuance of a green bond. This analysis test the paper's four hypotheses.[59]

4.1. Environmental performance

Table 7 below summarizes the comparative results of green versus non-green bond issuers for environmental performance. It thus tests hypothesis I - that green bond issuance provides a credible signal of a firm's commitment to environmental performance improvement. As can be seen, green bond issuers' environment ratings improve less than the matching set of non-green issuers (by 9.95 points less on the 100 point rating scale on average) over the entire period 2010-2020 but more than non-green issuers (by 1.19 points) one year post issuance. That one year improvement represents a peak in the positive performance difference of green bond issuers. After that first year, the initial improvement difference erodes. Note, as Table 6 showed, that environmental ratings improve in absolute terms over the period for both groups of bond issuers. And green bond issuers' environmental ratings remain significantly higher than those of conventional bond issuers throughout the period. The relevant point for *Hypothesis I* however, is the comparative change in environmental rating of green versus non-green bond issuers post issuance. On average, green bond issuers' environmental ratings rose more than non-green issuers in that first year after green bond issuance, but more slowly than non-green issuers in all years after that. Specifically, green bond issuers' environmental rating advantage narrowed by 3.73 rating points between the first year after issuance and subsequent years relative to non-green bond issuers.[60] While these results are not fully statistically significant, they could imply partial quantitative support for *Hypothesis I* in the short run but not in the long. In other words, the fact that a bump up in environmental ratings is observed in year one after the first green bond issuance, relative to non-green issuers, suggests the act of issuance is indeed offering the market a credible signal of a firm's above market level commitment to the environment for the short term. That this rating advantage then erodes in subsequent years suggests that this firm level commitment is short lived and not credible for later years.

[59] As mentioned in section 2.2, the changes in firm-level outcome are unlikely to be directly caused by the projects financed with the green bond proceeds, as the raised amounts are small compared to the size of the issuer (see Table 5 and 6).

[60] The environmental rating is shown to increase in absolute terms for both green and non-green issuers over the period – isolating the possibility of an overall decrease in rating (similar checks have been done for all firm-level outcomes).

The results of the actual CO_2 emissions (so controlling for the possibility of green bond issuances influencing ASSET4's rankings) support this conclusion. In this case, while CO_2 emissions per US dollar million in assets decrease in absolute terms for both groups throughout the 2010-2020, green bond issuers' emissions decrease by more than those of non-green bond issuing firms (by 22.37 tonnes CO_2 emissions per million of firm assets, in US dollars). Importantly, the improvement gap in favour of green issuers again widens in the first year post issuance, with green issuers reducing their emissions by 4.69 tonnes CO_2 per US dollar million in assets more than non-green issuers. That gap then reverses in the long term (2+ years after bond issuance), with green issuers' CO_2 emissions decreasing 0.60 tonnes less than non-green issuers in that later period – imposing potential acts of greenwashing. These results, again, give support for *Hypothesis I* only in the short term, and suggest that the credibility of the commitment to environmental performance improvement signalled by issuing a green bond fades over time post issuance.

Table 7: Environmental performance
This table presents the results of the difference-in-differences analysis, explained in Eq. (1). Here, *Green bond* is a dummy equal to one if the firm has issued a green bond. *Green bond (pre-issue year)* is a dummy equal to one in the year preceding the green bond issuance. *Green bond (short term)* is a dummy equal to one in the first year after the green bond issuance. *Green bond (long term)* is a dummy equal to one in all years subsequent. *Environment rating* is as described in Table 5 and *CO_2 emissions* is defined as the total CO_2 emissions in tonnes from ASSET4 divided by the book value of total assets in US dollars. The sample includes all firm-year observations of the treated and matched control firms over the period 2010-2020 with the standard deviations clustered at the two-digit SIC industry level. *, ** and *** denote significance at the 10%, 5% and 1% level.

	Environment rating		CO_2 emissions	
	(1)	(2)	(3)	(4)
Green bond	-9.948***		-22.372	
	(2.689)		(16.803)	
Green bond (pre-issue year)		-0.345		-1.288
		(0.953)		(3.629)
Green bond (short term)		1.190		-4.685
		(1.290)		(5.001)
Green bond (long term)		-3.725		0.595
		(2.463)		(6.934)
Observations	2939	2939	2305	2305
R-squared	0.495	0.494	0.374	0.374
Firm fixed effects	Yes	Yes	Yes	Yes
Country-year fixed effects	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes

4.2. Operational performance

Table 8 shows the comparative evolution of operational performance of green bond and non green bond issuers. As can be seen in columns 1 and 2, asset turnover increases only slightly

more for green issuers over the entire period 2010-2020. However, this small difference is likely driven by a 'pre-trend', as the post-issuance years show a negative difference in asset turnover between the two groups of firms.[61] These results do not support *Hypothesis II* or the claims made by Maltais and Nykvist (2020) based on qualitative research, that issuers' motivation for engagement with the green bond market is in part driven by pursuit of operational efficiency improvements.

The difference-in-differences analysis on gross profit margin, by contrast, does show a slightly higher improvement for green issuers post-issuance compared to their non-green issuing cohorts, in line with Hypothesis II. In the first year post issuance, this results in green issuers having a slightly more positive change (0.008 percentage points) in their gross profit margin than non-green issuers, a difference that narrows but remains positive in the long run (0.002 percentage points).[62]

Overall, the results for operational performance and green bond issuance thus are two-folded between the asset turnover and gross profit margin measures. This analysis provides only weak (and insignificant) support at best for the second hypothesis concerning a connection between firm-level operational performance and the issuance of green bonds.

Table 8: Operational performance
Below the results of the difference-in-difference analysis on operational firm performance, explained in Eq. (1), are shown. *Green bond* is a dummy variable equal to one if the firm has issued a green bond. *Green bond (pre-issue year)* is a dummy variable equal to one in the year preceding the green bond issuance. *Green bond (short term)* is a dummy variable equal to one in the first year after the green bond issuance. *Green bond (long term)* is a dummy variable equal to one in all years subsequent. *Asset turnover* is calculated as the total revenue divided by the book value of total assets, and *Gross profit margin* is defined as the ratio of total revenue minus the cost of goods sold divided by the total revenue (only for firms operating in the industrial sector). The sample includes all firm-year observations of the treated and matched control firms over the period 2010-2020 with the standard deviations clustered at the two-digit SIC industry level. *, ** and *** denote significance at the 10%, 5% and 1% level.

	Asset turnover		Gross profit margin	
	(1)	(2)	(3)	(4)
Green bond	0.011		0.007	
	(0.016)		(0.026)	
Green bond (pre-issue year)		0.008		0.002
		(0.008)		(0.005)
Green bond (short term)		-0.006		0.008
		(0.008)		(0.002)
Green bond (long term)		-0.006		0.002
		(0.012)		(0.012)
Observations	5298	5298	3263	3263

[61] Table 11 in appendix section 8.5. provides a more detailed analysis on the 'pre-trend'.
[62] Note that the analysis of gross profit margin only includes firms operating in the industrial sectors.

R-squared	0.029	0.032	0.268	0.268
Firm fixed effects	Yes	Yes	Yes	Yes
Country-year fixed effects	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes

4.3. Ownership structure

Table 9 below summarizes the comparative evolution of ownership structure for green and non-green bond issuers during the period. Overall, it does support a connection between the act of issuing a green bond and attracting green, institutional and long term investors compared to the non-green bond issuing peer group. This effect appears stronger for green investors than for long term investors, and is found for institutional investors only for the first year after issuance. Note that, somewhat counterintuitively, in absolute terms, the ownership share of green, institutional and long term investors in the sample set is lower for green bond issuers than non-green bond issuers. That negative difference in ownership share actually widens between 2010 and 2020. This despite the former group's stronger environmental performance. This is the result of a pre-trend in the data (see appendix 8.5 for the pre-trends robustness check). The data shows the gap in the ownership share by these investor groups in green versus non-green issuers growing in the period before a green bond is issued. Once a green bond is issued, that pre-trend reverses. In support of *Hypothesis III*, following the issuance of green bonds, the ownership share of issuing companies by green and long term investors (and institutional investors in the short term) appears to increase, albeit slightly, relative to non-green issuers.

Table 9: Ownership

This table shows the results of the difference-in-differences analysis of Eq. (1) where *Green bond* is a dummy variable equal to one if the firm has issued a green bond. *Green bond* is a dummy variable equal to one if the firm has issued a green bond. *Green bond (pre-issue year)* is a dummy variable equal to one in the year preceding the green bond issuance. *Green bond (short term)* is a dummy variable equal to one in the first year after the green bond issuance. *Green bond (long term)* is a dummy variable equal to one in all years subsequent. The dependent variables in this table are only available for US companies and are defined as following; *Institutional ownership* is the percentage of shares owned by institutional investors. *Ownership by green investors* is the percentage of shares owned by 'green' institutional investors (investors who are members of the Ceres Investor Network of Climate Risk and Sustainability*). Ownership by long term investors (duration)* is the percentage of shares held by long term investors whose holding duration (defined as the holding duration computed by Cremers and Pareek, 2016). *Ownership by long term investors (churn rate)* is the percentage of shares held by long term investors whose churn rate (computed as in Gaspar et al., 2015) is below the median across all investors. The sample includes all firm-year observations of the treated and matched control firms over the period 2010-2020 with the standard deviations clustered at the two-digit SIC industry level. *, ** and *** denote significance at the 10%, 5% and 1% level.

	Institutional ownership		Ownership by green investors		Ownership by long term investors (duration)		Ownership by long term investors (churn rate)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Green bond	-0.044***		-0.051***		-0.055***		-0.075***	

	(0.000)		(0.000)		(0.000)		(0.000)	
Green bond (pre-issue year)		-0.040		-0.008		-0.042		0.006
		(0.092)		(0.011)		(0.070)		(0.027)
Green bond (short term)		0.050**		0.012**		0.041*		0.038
		(0.017)		(0.005)		(0.022)		(0.022)
Green bond (long term)		-0.009		0.041***		0.006		0.019
		(0.056)		(0.008)		(0.048)		(0.028)
Observations	362	362	362	362	362	362	362	362
R-squared	0.539	0.542	0.509	0.498	0.830	0.829	0.827	0.828
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

4.4. Seasoned issuances

In Table 10, the regressions of Table 7-9 are revisited to analyse more closely any differences in results between a firm's first green bond issuance and subsequent green bonds they may issue in later years. Subsequent bonds refer to bond issuances in the years after the first year of issuance and are named 'seasoned issues'.[63]

To do this analysis, the *Green bond (short term)* market is extended with four dummies that measure the change of the firm-level outcomes one year after the second, third, fourth and fifth green issue takes place.[64]

The results in column 1 confirm that the substantial short term (one year post issuance) improvement in environment ratings post issuance by green bond issuers compared to non-green bond issuers found in section 4.1 disappears when comparing firms that have issued a subsequent green bond for a second, third or fourth time to non-green bond issuers in those years. Non-green bond issuer's environmental ratings improve significantly faster than those of these second, third or fourth time round green bond issuers. Only the four green firms issuing for a fifth time show a larger improvement in environmental rating relative to non-green issuers. These results pose concerns about a potential greenwashing motive in the longer run.

The results for CO_2 emissions in column 2 tell a slightly different story. Here there is still a larger decrease of CO_2 emissions for green issuers compared to non-green issuers when comparing issuers after their second green issuance. And this advantage is actually larger than after the issuances they made in their first issuance year. However, this positive gap for green

[63] Due to the limited data availability (ownership data is only available for US companies), the change of ownership in the one year after issuance is only measured for the first and second issuance. All other performance variables include US and global firms and are done for all five subsequent issue years.

[64] Note that the number of green firms issuing in a third (N=22), fourth (N=8) or fifth (N=4) year is limited and thus merely gives an implication on the development of firm-level outcomes across seasoned issues.

bond holders reverses sharply for issuers issuing new rounds of green bonds for a third or fourth time. Again, this shift might be driven by greenwashing motives in the long run.

The results for asset turnover in column 3 show that the negative gap between green and non-green bond issuers post issuance is found throughout the issuance years. The same is true for gross profit margins for all years, save the second bond issuance.

The four measures of ownership, albeit based on a very small sample set, all show a significant negative change in the ownership share for green versus non-green bond issuers after issuers have issued green bonds again for a second time.

Overall, this check on season issuances suggest diminishing (and variable) performance compared with the non-green bond issuers for issuances in subsequent years – is broadly in line with *Hypothesis IV*. In other words, the strongest impact by far comes from the first green bonds issued. There is, generally, diminishing impact (and sometimes negative impact) from additional issuances in subsequent years.

Table 10: Seasoned issuances

This table presents variants of the regressions in Tables 7, 8 and 9. *Green bond (short term)* is equal to one in the year after the first green bond issuance. *Green bond (short term, 2)* is equal to one in the year after the second green bond issuance. *Green bond (short term, 3)* is equal to one in the year after the third green bond issuance. *Green bond (short term, 4)* and *Green bond (short term, 5)* are equal to one in the year after the fourth and fifth green bond issuance. The sample includes all firm-year observations of the treated and matched control firms over the period 2010-2020 with the standard deviations clustered at the two-digit SIC industry level. *, ** and *** denote significance at the 10%, 5% and 1% level.

	Environ-ment rating	CO2 emissions	Asset turnover	Gross profit margin	Institu-tional ownersh.	Ownersh. by green investors	Ownersh. by long term investors (duration)	Ownersh. by long term investors (churn)
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Green bond (short term)	1.190	-4.685	-0.006	0.008	0.050**	0.012**	0.041*	0.038
	(1.290)	(5.001)	(0.008)	(0.008)	(0.017)	(0.005)	(0.022)	(0.022)
Green bond (short term, 2)	-5.716*	-7.710	-0.012	-0.021	-0027***	0.023**	-0.007***	0.023***
	(2.910)	(10.763)	(0.014)	(0.022)	(0.000)	(0.000)	(0.000)	(0.000)
Green bond (short term, 3)	-3.658	5.270	0.007	0.015				
	(4.488)	(4.853)	(0.027)	(0.017)				
Green bond (short term, 4)	-11.438***	20.489	-0.027***	0.057*				
	(3.123)	(16.203)	(0.007)	(0.035)				
Green bond (short term, 5)	4.667***	-12.412***	-0.026**	0.071***				
	(0.000)	(0.000)	(0.012)	(0.019)				
Observations	2,939	2,305	5,298	3,263	362	362	362	362
R-squared	0.494	0.374	0.382	0.268	0.539	0.495	0.482	0.827
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-year fixed effects	Yes	Yes	Yes	Yes	No	No	No	No
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

5. Discussion

5.1. Implications

This paper sheds light on the credibility of the main rationales of companies issuing corporate green bonds (signalling commitment to the environment, improving operational efficiency and attracting more green and long term investors), and the possible implications of the firm-level outcomes to date for those investing in green bonds. It also contributes to the nascent literature by examining whether these firm-level outcomes show diminishing additional improvements with subsequent issuances, and thus provide further nuance to the signalling argument.

Overall, the results provide partial quantitative support for the signaling rationale by issuing firms and for the claims that this rationale is connected to real firm level environmental performance improvements above and beyond those achieved by non-green bond issuers. As such, it supports *Hypothesis I* and undermines the argument of green bonds being entirely greenwashing. Green issuers in this analysis have a significantly bigger environmental performance improvement in the year post-issuance than issuers of non-green bonds and, in absolute terms, have still improved more at the end of the period compared to before issuance. However, in contrast with the literature to date, this analysis also finds that the green issuer advantage quickly erodes. All of this relative gain for green issuers occurs in year one after the first issuance, with non-green issuers improving faster than green issuers in the subsequent years and with subsequent issuances, in line with *Hypothesis IV*. Note that non-green issuers do not fully close this environmental performance gap. At the end of the period green issuers have still outperformed in absolute terms. Furthermore, the analysis finds evidence of the change in ownership mix post green bond issuance that green issuers are aiming for and posited by *Hypothesis III*. The data indicates an increase in ownership in shares of green bond issuing companies by green and long term investors. It finds no evidence of the operational performance gain compared to non-green issuers post issuance that Maltais & Nykvist (2020), Shislov et al. (2016) and *Hypothesis II* posited.

These results point to several possible implications. Focussing first on the confirmation of *Hypothesis III* and the ownership shift, one implication is that investors are proving willing to 'buy the dream.' They are responding to the signal by not only buying up green bonds but also the shares of issuing companies. The lack of certification, guidelines or formal government regulation of green bond labelling claims and the limited transparency on outcomes (and short time frame to judge) all raise the question of why at least some investors remain willing to give issuers the benefit of the doubt, and whether this is justified.

For ethically driven investors, the relative short term environmental performance gain of green bond issuers and their overall absolute environmental outperformance over the period could be part of the answer. It suggests that these ethical investors' belief that by buying green bond issuers' debt and equity, they are investing in better environmentally performing firms does not appear to be entirely or grossly misplaced - at least at this stage. However, in the longer term, the fading environmental outperformance of green issuers compared to non-green issues does open the possibility of these investors becoming disillusioned. If the promised improvement advantage is truly short-lived and over a longer time period non-green issuers continue to improve environmental performance faster, or if performance transparency and certification of claims do not materialize (intensifying the 'greenwashing' concerns), then the credibility of the signal from green bond issuance may well fade. This could result in ethically-driven investors no longer buying equity on the signal of a green bond issuance.

This first year only comparatively better environmental performance by green bond issuers leads to the wider question of what ultimately will determine the buy/sell behaviour of these ethical investors. If they are ultimately driven by their intrinsic principles (or the need to credible market funds to their end investors who are), then a lack of sustained rather than one off environmental outperformance could be expected to trigger divestment over time. In reality, awareness and transparency on this comparative performance gap will likely determine investor behaviour. Since getting line of sight on this relative performance over time is easier said than done and may be too complicated or difficult for investors to process. For one, the lack of consistent and accessible data on firm's environmental performance over time makes the assessment difficult. So does the need for a difference-in-difference matching analysis with a non-green issuing peer group to actually reveal these data trends. It is only when issuers and non-issuers are systematically compared that the claim of longer term improvement is undermined. In other words, there is a real chance that the doubts sown by this more sophisticated analysis concerning the value of the signal on environmental performance from green bond issuance will be lost on ethical investors and their clients. This may leave them unknowingly entering greenwashing schemes (Capital Group, 2021), with the (admittedly small) risk of public exposure.

On the other hand, some ethical investors investing in corporate green bonds could, at this stage, be driven by second order considerations. These could include a desire to burnish their reputation and marketing position with ESG sensitive clients in the short term; or to give a vote of confidence for the general idea of green finance. In this case, they may well be willing to discount or overlook the lack of underlying environmental outperformance to date. More

specifically, they might be willing to engage in a bit of wishful thinking and not probe performance claims too deeply in order to support their overall narrative and achieve a wider strategic aim.

Deloitte (2021) added another dimension to this discussion by underlining the importance of activist shareholder pressure in driving companies' environmental performance. This Deloitte work suggested that the shift in ownership – irrespective of the long term credibility of the original green bond signal - could in itself become a strong force driving further environmental improvements in those firms. In this scenario, irrespective of how credible the initial promise was that got these ethical investors into the ownership tent, once in the tent, these investors become a force for change and environmental outperformance of these firms in the future. It becomes a self-fulfilling prophecy.

It is also worth noting that the lack of evidence of any advantage for green bond issuers in terms of firm-level operational performance to date makes it likelier that it is mainly ethical, rather than financially-driven green investors that have invested in these green bond issuing companies. That is something worthy of investigation in a subsequent study. In any case, this study confirms that the rationale financially driven green investors offer publicly for investing in green finance is not supported to date for green bond issuers. The fact that the academic literature to date has found a significant stock market uptick post-issuance only for the minority of certified green bond issuers and no further evidence of financial outperformance by green bond or ESG profiled firms (Galema et al., 2008; Renneboog et al., 2008; Derwall et al., 2005; De Lucia et al., 2020; Lee et al., 2014; Alonso-Conde & Rojo-Suárez, 2020) also makes it likelier, if understood, that it is ethically rather than financially driven green investors fueling corporate green bond demand. If that turns out not to be the case (and these financially driven investors are indeed investing on the signal provided by green bond issuances), then they are either investing on the back of a bad assumption (so assuming something that is not turning out to be true) or they are expecting these operational improvements to materialize beyond the available time period studied. In other words, they might be staking out a longer term position, expecting that either the financial improvements will materialize further down the road or that as owners they can drive the needed improvements in the long run through their equity stake position.

Note that all these possible behaviours based on longer than study period performance do not, at first glance, sit comfortably with *Hypothesis IV* and the findings about diminishing returns to date after first issuance. But they are not completely undermined by this evidence to date of short term only impacts. Over the still short history of corporate green bond issuance,

the first issuance has proven to provide the big bang. The possibility of a later wave of improvement, once this new wave of shareholders (and employees) have had time to make their impact felt, is certainly possible.

But likely more important than their long term impact for the future credibility and development of this green bond market, is how much and how quickly certification, transparency and accountability in environmental disclosures connected to green bond issuances are strengthened. This study reaffirms that this is urgently needed, not only for the sake of investors, but to underpin the future viability and growth of this new market. As previously mentioned, there are currently no binding (or fully agreed) international guidelines to determine what fund end uses should qualify for the green bond label (Park, 2018; Wang, 2018). Thus far, investor participations seem to be largely driven by faith. However, it is unclear if, and more importantly how long, this faith will hold. The environmental performance results to date of green issuers suggest that, in the long run, the green bond market's credibility and sustainability will depend on certification and regulations that drive transparency. Flammer's (2020) analysis of stock market performance post green bond issuance support this thought, as it shows a significant positive reaction for certified green bonds, and no significant bump up for non-certified green bonds. This gives rise to the idea that in the medium to longer term, investors' leap of faith into corporate green bonds will need to be underpinned by reliable performance data and standards. The recent study by Yeow & Ng (2021) reconfirms this and argues that green bond certification could make a real difference in a sustainable investor traction. These findings drive the urge for clear, and binding, certification guidelines and transparency – no longer leaving individual investors to judge 'greenness' themselves.

5.2. Limitations

This paper has three main limitations worthy of note. The first concerns the relative immaturity of the corporate green bond market itself. Despite its rapid growth, corporate green bonds remain a new financial instrument. As a result, the analysis has been done using a relatively small number of (annual) issuance observations. With the bulk of new issuances occurring in the last three years of the sample period, as volumes ramped up, there were a limited number of firm-level performance year data available post issuance. These limitations will gradually ease over time as the market matures. It does mean that, at this stage, no longer term relationships can be examined or confirmed.

The second limitation concerns potential bias in the environmental data. Since companies are not obliged to publish their CO_2 emissions, there is the chance of a positive bias

in the CO_2 emissions measure – as firms with poor performance could disproportionately choose to withhold their data.[65] In addition, the lack of a single global reporting standard for ranking firms' environmental performance poses limitations. The underlying data is provided voluntarily by firms and the methodology used for comparing parameters and arriving at an overall score per firm varies widely between sources. The Thomson Reuter's ASSET4 rankings used here (and by Flammer) will not be directly comparable to studies using other sources (for example Morgan Stanley Capital International ESG rankings or those of the World Bank databank).

The final limitation concerns endogeneity. While the matching approach used in this paper helps reduce the endogeneity issue as much as possible, it does not completely control for it, the way a quasi-experimental research design approach would. The quasi-experimental approach, by using an instrument to control for the treatment condition (in this study: green bond issuance) and by fully eliminating characteristic differences between groups due to chance, remains the gold standard. However, green bond issuance is not a statistically random event, making this approach impossible to apply in this instance. As a result, it remains possible that firm-level and/or socio-economic market factors, other than green bond issuances, could be influencing the results.

Note that another potential limitation – referring to this paper's use of regional rather than country characteristics to match green and non-green issuers – was addressed in the analysis. A country level matching run was also done, with the results being directionally the same as those from the larger sample size regionally matched.[66]

5.3. Suggestions

In addition to testing existing claims, this paper contributes to the still immature body of literature on corporate green bonds by quantitatively assessing operational performance post issuance and firm improvements over subsequent issuances. The results, combined with the limitations identified in section 5.2, give rise to several suggestions for future research.

First and most obviously, future research is recommended to continue to test and replicate this paper's findings as more data years become available. This would not only check

[65] While many governments encourage firms to report their carbon emissions (CO_2), this largely remains voluntary – save the United States for example, where since 2009 facilities emitting at least 25,000 metric tons or more of carbon dioxide are required to report their greenhouse gas emissions to the Environmental Protection Agency every year.

[66] The matched sample based on country characteristics included 302 green issue-years, and is thus relatively smaller than the matched sample based on regional characteristics (holding 372 green-issuer years).

the robustness of the results, but continue to track the hypotheses as the market further develops and grows. It would also make more vigorous analysis on the long term firm-level, as well as investor-level, implications of the issuance of corporate green bonds possible. More specifically, the potential long term changes in operational efficiency, the relation between environmental performance and green issuance (for example as certification and reporting standards mature) as well as the relationship between companies' environmental performance and changing investor mix posed by Deloitte (2021) would be valuable areas to further analyse.

Next, a further testing of the signalling hypothesis could usefully be conducted by using bond issue announcement dates (instead of actual issue dates as done here) to compare subsequent firm level performance and ownership. This data could provide insight into the extent to which investors and firms are responding to the signalled intent to issue or to the issuance itself.

This study also points to the value of deeper analysis of investors in green bonds and in the equity of green bond issuing firms. For example, quantitatively examining the mix and motivations of financially and ethically driven ESG investors in this market. Any changes in investors' behavior over time, as the market matures, could shed helpful light on whether or not, and how quickly, green bonds will become a permanent and material contributor to meeting to financing efforts to tackle the climate change challenge.

Lastly, given the current lack of regulation in the corporate green bond market, an interesting gap remains around the governance design of the green bond market and the impact of this design on firm-level and investor-level behavior and outcomes. In other words, as the current regime develops over time - and expands hopefully to international and legally bounded regulations – it will be important to understand what impact further regulation and different regulatory designs have on the corporate green bond market, the performance changes of green bond issuers and the stakeholder dynamics.

6. Conclusion

It is becoming painfully clear to companies, their employees and their investors that climate change has serious social and economic implications for the near and longer term that go well beyond the direct effects of extreme weather events. Businesses will be hugely impacted. Transformative systemic change will be needed to avoid the worst impacts – requiring huge amounts of capital, much of it coming from private sector capital markets. It is now recognised that this crisis will create enormous opportunities for the companies developing and deploying the needed technology and the new business models. It will represent an existential threat to

those that fail to change in the right ways and at the needed pace. The same is true for players in financial markets. The corporate green bond market has sprung up as one in response to this financing challenge. It is early days for this market and the body of empirical literature studying this phenomenon of corporate green bonds is still in its infancy.

To contribute to that nascent literature, this paper quantitatively investigated the credibility of the main rationale identified for the issuance of green bonds (signalling commitment to the environment), as well as the extent to which issuers achieve the firm-level improvements motivating this signal (improving operational efficiency and attracting an extended green and long term pool of investors). Using a matching approach and a difference-in-differences specification, it found that the signal provided by green bond issuance does appear to attract green and long term investors, but that the credibility of this signal (as measured by improved environmental performance) is nonetheless limited and short lived. In addition, there was no evidence for a relation between green issuance and operational performance improvements. Second, this study considered the possible implications for investor participation and whether their underlying stated rationales are justified by the firm level outcomes to date. The lack of support for the financial motivations makes it likely that the newly attracted ESG investors post issuance have been largely ethically motivated rather than financially motivated. This former group is most likely to have been undeterred by the lack of operational improvements and stock market uptick seen to date and particularly motivated by the (at least short term) evidence of greater environmental improvement in green bond issuing firms. The possibility remains that any financially motivated investors in the mix are taking a longer term perspective, expecting financial improvements in the long run and/or that as owners they can drive firm-level improvements further down the road.

In short, to date the corporate green bond market has grown largely on faith, with bond buyers and equity investors in green bond issuers willing to participate based on issuers' largely unproven and uncertified promises. How long this faith will hold remains to be seen and will depend no doubt on the extent to which regulation, certification and transparency on performance standards for this new instrument fill the gap. Already though corporate green bonds are changing the shareholder mix of issues - attracting green and long term investors. This in itself could well prove to be a valuable legacy, creating momentum and support for further firm level change.

7. References

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8. Appendix

8.1. Corporate green bonds by industry

Table 2: Corporate green bonds by industry
This table displays the number of corporate green bonds issued and issuance amount (in US dollar billions) by industry, using all corporate green bonds from 2013-2020. The industries are partitioned according to the major divisions of the Standard Industrial Classification (SIC) system.

Industry	# Bonds	$ Amount (billions)
Financials	1,445	372.04
Finance	629	151.61
Insurance	17	8.90
Real Estate	293	29.62
Other	506	181.91
Other	859	212.06
Agriculture, Forestry and Fishing	15	2.09
Mining	10	1.87
Construction	68	14.37
Manufacturing	112	39.13
Transportation, Communications, Electric	574	136.28
Wholesale Trade	14	3.41
Services	52	12.10
Public Administration	14	2.81
Total	2,304	584.09

8.2. Corporate green bonds by country

Table 3b provides a detailed breakdown of the corporate green bond issuances by country over the period 2013-2020. In addition to discussion on the regional breakdown in section 3.1.3., note that Sweden has issued more green bonds than anyone else, albeit often relatively small amounts. In addition to its early start, Bjorn Bergstramd, head of sustainability at the local government funding agency (LGFA) Kommuninvest, highlights several reasons for this widespread use of green bonds in Sweden: including the fruitful ecosystem of issuers, banks and investors, coupled with high climate awareness and a history of innovation throughout society, industry and the banking system (Johansson, 2019).

Table 3b: Corporate green bonds by country
This table reports the number of corporate green bonds issued as well as the issuance amount (in US dollar billions) by country and region (as categorized by the World Bank), using all corporate green bonds from 2013-2020. Note that the United Kingdom includes the issuance of corporate green bonds on overseas British Land: the Cayman Islands, British Virgin Islands and Jersey.

Country	# Bonds	$ Amount (billion)
East-Asia and Pacific	*683*	*126.52*
Australia	19	5.74
China	283	52.24
Hong Kong	72	20.18
Indonesia	8	3.42
Japan	141	19.24

Malaysia	12	0.13
Macau	4	1.50
New Zealand	12	1.14
Philippines	5	1.29
Singapore	20	5.14
South Korea	34	11.13
Taiwan	48	3.77
Thailand	25	1.59
Europe and Central Asia	*1,163*	*312.54*
Austria	20	7.16
Belgium	5	1.07
Denmark	19	13.59
Estonia	1	0.06
Finland	15	5.89
France	199	52.03
Germany	190	36.79
Guernsey	4	0.64
Greece	2	0.50
Hungary	1	0.11
Ireland	5	2.95
Italy	34	15.26
Latvia	3	0.18
Liechtenstein	1	0.11
Luxembourg	25	14.02
Poland	3	0.25
The Netherlands	88	63.33
Norway	71	16.79
Portugal	5	3.19
Spain	49	20.65
Slovenia	1	0.09
Sweden	329	28.29
Switzerland	10	1.79
Turkey	4	0.20
United Kingdom	79	27.60
Latin America & Caribbean	*82*	*20.31*
Argentina	4	0.08
Brazil	39	2.81
Chile	9	2.21
Colombia	2	0.08
Mexico	9	12.71
Panama	13	0.58
Peru	6	1.84
Middle East and North Africa	*7*	*2.10*
United Arab Emirates	6	2.08
Morocco	1	0.02
North America	*315*	*109.75*
Canada	39	15.71
United States	276	94.04
South Asia	*28*	*5.28*
India	28	5.28

Sub-Saharan Africa	*25*	*6.89*
South Africa	9	0.47
Mauritius	14	6.37
Nigeria	1	0.04
Namibia	1	0.01
Total	2,304	584.09

8.3. Duration measure

The duration for stock *i* that is included in the fund portfolio *j* at time (in quarters) T – 1 is calculated for all stocks *i* = 1 ...I and all institutional investors j = 1 ...J , by using the following equation:

$$\text{Duration}_{i,j,T-1} = d_{i,j,T-1} = T-1 \sum_{t=T-W}^{T-1} \frac{((T-t-1)\alpha_{i,j,t}))}{(H_{i,j} + B_{i,j})} + \frac{(W-1)H_{i,j}}{(H_{i,j} + B_{i,j})}, \quad (2)$$

where $B_{i,j}$ = total percentage of shares of stock *i* bought by fund *j* between t = T-W and t = T −1. $H_{i,j}$ = percentage of total shares outstanding of stock *i* held by fund *j* at time t = T −W. $\alpha_{i,j,t}$ = percentage of total shares outstanding of stock *i* bought or sold by fund j between time (quarter) t −1 and t , where $\alpha_{i,j,t} > 0$ for buys and < 0 for sells.

8.4. Churn rate

The churn rate measures for each institutional investor how frequently he rotates his positions on all the stocks of his portfolio (churn rate). The set of companies held by investor *i* is denoted by *Q* and so the churn rate of investor *i* at quarter *t* is calculated using the following equation:

$$CR_{t,i} = \frac{\sum_{j \in Q}[N_{i,j,t}P_{j,t} - N_{j,i,t-1}P_{j,t-1} - N_{j,i,t-1}\Delta P_{j,t}]}{\sum_{j \in Q} \frac{N_{i,j,t}P_{j,t} - N_{j,i,t-1}P_{j,t-1}}{2}}, \quad (3)$$

Where $P_{j,t}$ and $N_{j,i,t}$ represent the price and the number of shares, respectively, of company *j* held by institutional investor *i* at quarter *t.*

8.5. Pre-trend checks

Table 11 presents the results of an extended check on 'pre-trends' in the data. This robustness check was done to identify and isolate any changes in the operational or environmental performance, or ownership structure of the green bond issuing firms that were already evident

from the data prior to the year of green bond issuance. To do this the *Green bond* dummy variable in all years from 2010 prior to issue is set to one and the comparative performance and ownership structure of green bond issuers are again compared to that of the matched non-green issuers.

As can be seen, a relevant pre-trend potentially impacting conclusions is evident for asset turnover – where the overall increase of 0.011 percentage point across the whole period looks likely to have been driven by jumps in asset turnover for green bond issuers before they first issued green bonds. This further strengthens the conclusion above that this variable does not support *Hypothesis II* linking green bond issuance and operational performance.

In addition, as noted in 4.3, the negative pre-trends for ownership by green, institutional and long term investors (defined by duration and churn rate) explain why this negative gap persists for the full 2010-2020 period. It is a gap that grows before green bond issuance. Once a bond is issued, the institutional, green and long term investor ownership share of green bond issuers grows faster, at least in the short term, after issuance – just not fast or long enough to make up for the full difference that emerged pre-issuance. No other noteworthy pre-trends were found and this pre-trend check does not qualify or undermine the conclusions on the four hypotheses from the difference-in-differences analyses described above.

Table 11: Pre-trends
This table presents variants of the regressions in Tables 7, 8 and 9. Here, the *Green bond, Green bond (short term)* and *Green bond (long term)* are similar to the dummies used in the previous regression tables. In addition, *Green bond (pre-trend)* is equal to one for all the years previous to the green bond issuance. The sample includes all firm-year observations of the treated and matched control firms over the period 2010-2020 with the standard deviations clustered at the two-digit SIC industry level. *, ** and * denote significance at the 10%, 5% and 1% level.

	Environ-ment rating	CO_2 emissions	Asset turnover	Gross profit margin	Institu-tional ownersh.	Ownersh. by green investors	Ownersh. by long term investors (duration)	Ownersh. by long term investors (churn)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Green bond	-9.948***	-22.372	0.011	0.007	-0.044***	-0.051***	-0.055***	-0.075***
	(2.689)	(16.803)	(0.016)	(0.026)	(0.000)	(0.000)	(0.000)	(0.000)
Green bond (pre-trend)	1.140	1.187	0.008	-0.003	-0.047	-0.009	-0.047	-0.046*
	(1.451)	(5.704)	(0.008)	(0.007)	(0.039)	(0.009)	(0.033)	(0.021)
Green bond (short term)	1.190	-4.685	-0.006	0.008	0.050**	0.012**	0.041*	0.038
	(1.290)	(5.001)	(0.008)	(0.002)	(0.017)	(0.005)	(0.022)	(0.022)
Green bond (long term)	-3.725	0.595	-0.006	0.002	-0.009	0.041***	0.006	0.019
	(2.463)	(6.934)	(0.012)	(0.012)	(0.056)	(0.008)	(0.048)	(0.028)
Observations	2,939	2,305	5,298	3,263	362	362	362	362
R-squared	0.495	0.374	0.382	0.268	0.539	0.495	0.483	0.827
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-year fixed effects	Yes	Yes	Yes	Yes	No	No	No	No
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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