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Equity Market Reaction to Green Bond Issuance Announcement

Global Empirical Evidence of Corporate Green Bonds in 2013–2021

Master's thesis
in Accounting and Finance

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Sustainable development (SD) is becoming increasingly prominent in business and finance, and especially environmental challenges are receiving growing concern. What often falls outside the discussion is the substantial amount of capital required to achieve the desired sustainability goals. Assistance to the situation is providing the capital market, which enables the allocation of capital to the desired targets to mitigate and combat sustainability challenges. In particular, the trend is reflected in the debt capital markets, where multiple sustainable debt instruments have emerged. Out of all of the current ones available in the markets, green bonds have become the most popular in recent years. They are bonds whose proceeds must be used to finance or re-finance so-called green projects that aim to promote environmental issues.

This thesis examines the equity market reaction to green bond issuance announcements of listed corporates. The second objective is to evaluate possible linkages between abnormal returns and green bond and issuer characteristics. The scope of the study is global, and the final sample consists of 564 green bond observations from 31 countries and ten economic sectors between 2013–2021. The research methods are an event study and regression analysis. The results are compared between different subsamples and regions to make the analysis comprehensive. In addition to the empirical study, the thesis provides an extensive and timely literature review on the topic.

The results of the event study are not entirely unambiguous but tend to lean more toward a positive equity market reaction. In particular, the positive reaction is visible in the pre-event window suggesting possible information leakage prior to the event, although the results are statistically insignificant. The result is more positive and significant for non-financial corporates, first-time issuances, and issuers from emerging & developing markets. Regionally, the strongest and most positive reaction is for non-financial corporates in Asia-Pacific, with the cumulative average abnormal return (CAAR) of 1.025% over a 10-day event window. The regression analysis suggests no statistically significant links between the abnormal returns and the green bond and issuer characteristics. The same regression results apply to financial and non-financial corporates and different regions.

Key words: green bond, sustainable finance, sustainable debt instrument, event study, regression analysis

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Kestävästä kehityksestä on yhä näkyvämpää liiketoiminnassa ja rahoituksessa. Erityisesti ympäristöhaasteet ovat kasvava huolenaihe. Keskustelun ulkopuolelle jää usein merkittävä pääoman määrä, joka tarvitaan haluttujen kestävyystavoitteiden saavuttamiseksi. Apua tilanteeseen tuovat pääomamarkkinat, jotka mahdollistaa pääoman kohdentamisen haluttuihin kohteisiin kestävyyshaasteiden lieventämiseksi ja torjumiseksi. Suuntaus näkyy erityisesti velkapääomamarkkinoilla vastuullisten velkainstrumenttien kehittymisenä. Kaikista markkinoiden nykyisistä vastuullisista velkainstrumenteista, vihreät joukkovelkakirjat ovat nousseet erityiseen suosioon viime vuosina. Ne ovat joukkovelkakirjoja, joiden tuotot on käytettävä ympäristökysymyksiä edistävien, niin sanottujen vihreiden hankkeiden, rahoittamiseen tai uudelleenrahoitukseen.

Tässä opinnäytetyössä tarkastellaan osakemarkkinoiden reaktiota pörssiyhtiöiden vihreiden joukkolainojen liikkeeseenlaskuilmoituksiin. Toisena tavoitteena on arvioida mahdollisia yhteyksiä epänormaalien tuottojen sekä vihreiden joukkovelkakirjojen ja liikkeeseenlaskijan ominaisuuksien välillä. Tutkimus on maailmanlaajuinen, ja lopullinen otos koostuu 564 vihreästä joukkovelkakirjalainahavainnosta, 31 maasta ja kymmeneltä talouden sektorilta, vuosina 2013–2021. Tutkimusmenetelmät ovat tapahtumatutkimus ja regressioanalyysi. Jotta analyysi olisi mahdollisimman kattavat, tuloksia verrataan eri osanäytteiden ja maantieteellisten alueiden välillä. Empiirisen tutkimuksen lisäksi tutkielma tarjoaa aiheesta laajan ja ajankohtaisen kirjallisuuskatsauksen.

Tapahtumatutkimuksen tulokset eivät ole täysin yksiselitteisiä, mutta ne kallistuvat enemmän kohti positiivista osakemarkkinoiden reaktiota. Positiivinen reaktio näkyy erityisesti tapahtumaa edeltävässä ikkunassa, mikä viittaa mahdolliseen tietovuotoon ennen tapahtumaa, vaikkakin tulokset ovat tilastollisesti merkityksettömiä. Tulos on myönteisempi ja merkittävämpi rahoitusalan ulkopuolisille yrityksille, ensikertaisille liikkeellelaskuille sekä kehittyvien markkinoiden liikkeeseenlaskijoille. Aluekohtaisesti reaktio on voimakkain ja myönteisin Aasian ja Tyynenmeren alueen rahoitusalan ulkopuolisille yrityksille, joiden keskimääräinen kumulatiivinen epänormaali tuotto on 1,025 prosenttia kymmenen päivän tapahtumaikkunan aikana. Regressioanalyysi ei viittaa tilastollisesti merkittäviin yhteyksiin epänormaalien tuottojen sekä vihreän joukkovelkakirjan ja liikkeeseenlaskijan ominaisuuksien välillä. Samat regressio tulokset koskevat rahoitusalan ja rahoitusalan ulkopuolisia yrityksiä sekä eri maantieteellisiä alueita.

Avainsanat: vihreä joukkovelkakirja, vastuullinen rahoitus, vastuullinen velkainstrumentti, tapahtumatutkimus, regressionanalyysi

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LIST OF ABBREVIATIONS

Abbreviation	Definition
AAR	Average Abnormal Return
ABS	Asset-Backed Security
AR	Abnormal Return
CAAR	Cumulative Average Abnormal Return
CAR	Cumulative Abnormal Return
CBI	Climate Bonds Initiative
DCM	Debt Capital Market
EIB	European Investment Bank
EMH	Efficient Market Hypothesis
ESG	Environmental, Social, and Governance
GDB	Green Bond Principle
ICMA	International Capital Market Association
IMF	The International Monetary Fund
IPCC	International Panel on Climate Change
IPSF	International Platform on Sustainable Finance
MPT	Modern Portfolio Theory
MSCI	Morgan Stanley Capital International
OLS	Ordinary Least Squares
RI	Total Return Index
ROA	Return on Assets
SD	Sustainable Development
SDG	Sustainable Development Goal
SIFMA	Securities Industry and Financial Markets Association
SPV	Special Purpose Vehicle
SRI	Socially Responsible Investing
TEG	Technical Expert Group
TRBC	The Refinitiv Business Classification
UN	United Nations
VIF	Variance Inflation Factor

1 Introduction

1.1 Motivation

Sustainable development (SD) has gained a significant role in modern society. According to Brundtland Commission's (1987) report, it is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs.". In general, although not entirely unanimously, the term binds together environmental, social, and economic challenges that the world is facing (Schoenmaker & Schramade 2018, 3). To address these challenges, in 2015, 193 countries in the United Nations (UN) agreed on 17 Sustainable Development Goals (SDGs). The main objective was to encourage governments, corporations, and civil society to tackle the defined broad issues of sustainability with a deadline of 2030. (UN General Assembly 2015; Thompson 2021, 20–23.)

Out of all the areas of SD, the environmental challenges have received considerable attention recently. The concern has been fueled by the UN Climate Report, published by the Intergovernmental Panel on Climate Change (IPCC) on 28 February 2022, stating the devastating consequences of rapid global warming. The trend can also be detected from the increasing amount of pledges to reach net zero carbon emission targets. According to Taking Stock's (2021) global assessment of net zero targets, 61% of nations, 9% of states and regions, 13% of cities, and 21% of corporates have made some form of commitment to net zero. The annual sales of the corporates with net zero commitments included in the assessment account for nearly USD 14 trillion, equivalent to around one-fifth of the sales of the world's 2,000 largest listed corporates. Furthermore, in August 2022, MSCI (2022) reports the cumulative number of listed corporates, with some type of net zero targets, being 3,152. While there may be many disagreements about the motives of pursuing net zero, and many tend to fall short from the claims[1], the increase in its popularity indicates a growing interest in mitigating climate change.

What often falls outside the discussion and news coverage is how much capital is required to achieve the SDGs. According to The New Climate Economy's (2014) estimation, around USD 90 trillion of infrastructure investments are needed between 2015 and 2030 to achieve global sustainable development and climate objectives. (Green Finance

[1] See e.g. New Climate Institute (2022) and UN High-Level Expert Group (2022).

Initiative 2016; Thompson 2021, 13.) In addition, McKinsey & Company's (2022) analysis suggests that a total of around USD 275 trillion in cumulative spending on physical assets is required between 2021 and 2050 to reach the net zero scenario by 2050. It is equivalent to over USD 9 trillion each year. Also, according to Kharas and McArthur's (2019) estimate, in 2015, the global public sector SDG spending was already around USD 20 trillion per year and is expected to reach USD 33 trillion or more by 2030. Although these are just a few examples, and the exact amount is challenging to estimate, the overall consensus is clear: the amount of required capital is substantial.

Assistance to the situation is providing the capital market, which serves as a powerful mechanism to enable the financing of SDGs by providing ease to capital mobilization and deployment. Capital markets can be divided into equity and debt markets, from which debt markets are significantly larger. (World Economic Forum 2019.) What gives debt capital markets a particularly vital role in financing ongoing and new sustainable projects is their financing structure. A typical debt-to-equity ratio of an infrastructure project is 70/30. The proportion of debt is usually even higher for sustainable projects, such as renewable energy, energy efficiency and low-emission vehicle projects, with a ratio of 75/25. (McKinsey & Company 2013; OECD 2015.) In the past, these projects have been funded by general bank loans and balance sheet financing. However, as the transition to a more sustainable world requires a growing amount of capital, the capabilities of post-financial crisis companies are exceeding, and the need for more debt capital is increasing. (Thompson 2021, 239–240.)

The vital role of debt capital markets as an SDG financing enabler is shown well in the development of different sustainable debt instruments. They are used to raise debt capital for SD-aligned operations. Especially one of these instruments has gained broad attention in the past few years. It is called a *green bond*, and it was first introduced to the public in 2007 when European Investment Bank (EIB) issued the world's first green bond (EIB 2022a). Green bonds are virtually equal to conventional bonds, but the proceeds must be used to finance so-called 'green projects'. These projects aim to contribute to the environmental challenges of SD. For the project to be classified as green, it must meet certain criteria. (CBI 2019; ICMA 2022.) Although the use of proceeds is immensely limited for the issuer, the green bond market has only continued to grow exponentially. According to Climate Bonds Initiative (CBI) (2022a), in 2021, the global green bond market reached an annual value of over USD half trillion, maintaining its trend of 10

consecutive years of market expansion. Moreover, the market is expected to reach USD 1 trillion by 2022 and USD 5 trillion by 2025. However, to get to this target, collective actions are needed. For example, policies need to be accelerated, the green project pipeline needs to be expanded, and the capital flow from advanced economies to emerging markets needs to be augmented. (CBI 2022d.)

Green bonds are not only intriguing from the perspective of the corporates and governments issuing them. The growing interest in sustainability is also evident among investors, as they are increasingly more interested in the overall impact of their investments. The mere financial return is no longer enough, as for many, the influence of investment in the environment and climate has reached equal importance. Thus, for investors interested in sustainability, green bonds offer an opportunity to diversify and manage risk while fulfilling the desired sustainable outcomes. (Thompson 2021, 240.) While green bonds may raise concerns about greenwashing[2], for issuers, they also serve as a tool to signal their commitment to sustainability to the investors (Flammer 2021). Consequently, there is some evidence that issuing green bonds would lead to a positive stock price reaction for listed corporates (see e.g. Baulkaran 2019; Wang et al. 2020; Tang & Zhang 2020; Flammer 2021).

The booming market and the growing popularity of green bonds make them a compelling and valuable research topic in the field of finance. Because the green bond is a relatively new financial instrument, market developments and changes are happening rapidly. A continuous examination is needed to keep up with the changes and their effects. By making good use of the constantly growing amount of new data, it is possible to increase the amount of knowledge on which the decisions can be based. This thesis aims to contribute to the finance literature on green bonds, particularly from the point of view of listed corporates and investors.

1.2 Research questions and goals

This thesis examines the impact of green bonds on the stock returns of the listed corporate issuers. In other words, the aim is to study how the equity market reacts to the green bond issuance announcements. In addition, different characteristics of the green bonds and the listed issuers, which could explain the possible abnormal returns, are examined. The focus

[2] See Financial Times (2022).

is on the global green bond market. Although there are some previous studies on the topic, the conclusions are not consistent. By using the new available data, it is possible to find new meaningful observations. The goal is also to make the analysis as comprehensive as possible. Thus, two main research questions for this thesis are:

1. Do green bonds have an impact on the stock returns of the listed corporate issuers?
2. Are there links between green bond and issuer characteristics and abnormal returns?

A two-step empirical analysis is conducted to answer these questions. The first part utilises an event study method. The event study examines whether green bonds create abnormal returns to the issuers and aims to answer the first research question. The date of the first issuance announcement serves as the investigated event. The announcement day, rather than the actual issuance day, represents better the time when the information entered the market. The results are analysed comprehensively between various subsamples, such as regions and sectors. In particular, the focus is on Europe, Asia-Pacific and North America, and the financial and non-financial sectors. Also, a comparison between the effects of the first-time and subsequent issuance is conducted. The comparisons allow a deeper analysis of the results by highlighting key differences between the scrutinised subsamples.

The second part of the empirical analysis is a cross-sectional regression analysis. It is performed to answer the second research question as it allows for highlighting specific characteristics that are linked to the possible abnormal returns. To be precise, the characteristics to be considered are those of green bonds and the listed corporate issuers. In this part also, the results are analysed between regions and sectors. On top of answering the main research questions, the goal is to provide an extensive and up-to-date literature review of green bonds and related concepts.

1.3 Structure

To provide a comprehensive understanding of green bonds and their origins, Chapter 2 contains background to the topic. First, the concept of sustainable finance is outlined. Second, the relationship between the debt capital market and the sustainable finance movement is discussed. Other sustainable debt instruments, excluding green bonds, are also presented in detail. Chapter 3 focuses on green bonds. The green bonds are defined

in depth, and the current green bond types are presented, along with the global green bond market development and current green bond standards. Also, the challenges related to green bonds and their future market development are discussed. Before moving to the chapters covering the empirical study, similar previous studies are summarized. Chapter 4 introduces the data and research methods used in the empirical analysis, and the final results are displayed and discussed in Chapter 5. Chapter 6 summarizes the thesis and provides ideas for future research.

2 Background

2.1 Sustainable finance

The acknowledgement that, through investing, it is possible to impact the world and surroundings beyond the financial benefits is not a newly discovered idea. It has been around for centuries. Even though the modern form of finance can be considered to have started in the 1950s[3], the concept of aligning monetary investments with personal values dates, at least, to the Quakers who aimed to align their purchases and investments with their religious values in 17th century England. (Bugg-Levine & Emerson 2011, 5–6; Boatright 2014, 150.) In modern finance, this ideology is strongly related to the *sustainable finance* movement, which extends to the different dimensions of sustainability. Thus, one major objective of modern sustainable finance is to contribute to sustainable development (SD) by considering the effects of finance, including investing and lending, on economic, social, and environmental issues (Schoenmaker & Schramade 2018, 4).

Sustainable finance has many related terms, which are often treated synonymously, including, for example, green finance; climate finance; responsible banking; and environmental, social, and governance (ESG). However, arguably there are differences between the scopes of the terms as each can be considered to cover diverging dimensions of SD. For example, green finance is usually referred to when only the environmental aspect is in consideration, and thus, green bonds can be classified as green financial products under green finance. ESG, a widely used term in finance, covers almost all dimensions of SD. It also often refers to quantified scores measuring the level of sustainability. Generally, the term sustainable finance is considered to cover all of the dimensions, and it is also treated so in this thesis. (Thompson 2021, 2–3.) ESG is mainly used to refer to measurable scores. Furthermore, this thesis classifies green bonds as sustainable debt instruments to ensure consistency and clarity.

Sustainable finance can be seen to be partly incompatible with traditional finance theory. One big trend among investors is socially responsible investing (SRI), also known as impact investing. It refers to an investing strategy which accounts for the consequences

[3] Miller (2000) refers to the year 1952 as a "big bang" of modern finance, as it is when Harry Markowitz published an article called "Portfolio Selection" in *The Journal of Finance*.

of the investments to SD, and it essentially leads to the pruning of some investees and favouring others. (Bugg-Levine & Emerson 2011, 5; Boatright 2014, 150–151.) From the perspective of Markowitz's (1952) modern portfolio theory (MPT), a rational investor maximizes expected returns at a given level of risk by using diversification, done by selecting various securities for the portfolio. Markowitz argues that for diversification to be optimal, one should utilize all of the available securities in the market. Therefore, excluding non-sustainable securities from the portfolio selection is contrary to the MPT. Although sustainable finance and traditional theories may have some incompatibilities, a valid claim is that the mere financial benefit is not the full power of capital. For some, being able to influence matters far beyond the traditional views is what activates the full potential. (Bugg-Levine & Emerson 2011, 5.) Thus, sustainable finance acknowledges that financial systems have a leading role in allocating capital to sustainable corporates and projects and accelerating the transition to more a sustainable future (Schoenmaker & Schramade 2018, 4).

Many can be perceived to be intrigued by the full power of capital, as sustainable finance has continued to grow in popularity among researchers and financial market participants. According to Luo et al. (2022), the Web of Science (WoS) database contained globally 3,786 research articles on some fields of sustainable finance between 2000 and 2021. They also discovered that the annual number of research papers has continued to grow consecutively almost every year during this period, with the amount being the highest in 2021. Furthermore, according to PwC's (2021) global investor survey, in 2021, 79% of the respondents consider environmental, social, and governance (ESG) risks and opportunities as important factors in making investment decisions. Also, 49% would sell their investments if the target corporation is not showing enough action in addressing ESG issues. The growing demands of investors are also reflected in corporate actions, and KPMG's (2022) global sustainability reporting survey suggests that 96% of G250 corporates and 79% of N100 corporates report on sustainability or ESG matters.[4]

Policymakers and various global organizations are also issuing regulations, standards, and measures to promote the development of sustainable finance. According to European Policy Center (EPC) (2022), global, regional, and local initiatives play a crucial role in

[4] G250 refers to the world's 250 largest corporates by revenue based on the *Fortune 500* ranking, and N100 refers to a worldwide sample of the top 100 corporates by revenue in 58 countries, territories, and jurisdictions providing a more broad-based snapshot of sustainability reporting (KPMG 2022).

achieving the full potential of sustainable finance by providing transparency and efficiency to the markets. A major goal of the initiatives is to ensure that investments classified as 'sustainable' truly contribute to SDG objectives. Another important aim is to prevent greenwashing, where entities make false or misleading claims about the positive environmental impact of a product, service, or activity (Thompson 2021, 30, 249). According to International Shareholder Services (ISS) (2022), globally, the EU is a pioneer in regulatory initiatives, but North America and Australia have also significantly increased their regulatory efforts. Also, Asia has accelerated the growth in new initiatives. Although plenty has already been achieved to promote and reinforce sustainable finance, much remains to be done, especially as geopolitical tensions and other macroeconomic issues have led to increased challenges in 2022. Significant objectives include, for example, reducing complexity and creating harmonization. (ISS 2022; EPC 2022.)

2.2 Debt capital markets and sustainable finance

The sustainable finance movement is reflected particularly in the debt capital market (DCM). It is a place where different debt instruments, mainly bonds, are traded. Debt instruments, also known as fixed-income assets, can be divided into two main categories. These are organization-guaranteed bonds and asset-backed securities (ABS). Organization-guaranteed bonds, typically issued by governments and corporates, are backed (collateralized) entirely by the issuing organization and raise capital for general purposes. The interest payments of ABSs are backed by a specified pool of assets, which are often placed in a corporate structure called a special purpose vehicle (SPV). For example, the issuers can bundle a pool of loans, securitize their revenues, and use that income as collateral for an ABS. On top of these two main categories, a broad range of hybrid structures are available in the DCM. While, for issuers, the debt instruments put up a possibility to borrow debt capital to finance operations, they also provide an opportunity to offset liabilities, generate returns, and diversify portfolios for investors. (Thompson 2021, 238, 273.)

In addition to the DCM, the overall capital markets include the equity market (stock market), where stocks of listed corporates are traded. However, the DCM is substantially larger. According to SIFMA’s (2022) capital market fact book, in 2021, the global equity

market capitalization was USD 124.4 trillion[5], whereas the global debt outstanding was USD 126.9 trillion. Although with this comparison, the markets seem to have a similar size, the issuance volume in the DCM is significantly higher. The SIFMA report augments this statement by disclosing the global debt issuance being USD 26.8 trillion in 2021, whereas the equity issuance was only USD 1,042 billion. One reason for this can be considered to be the pecking order theory, according to which corporates prefer debt financing over equity financing if external capital is needed (Myers & Majluf 1984; Myers 1984).

As a result of the merger of sustainable finance ideology and the DCM, new sustainable debt instruments, including green bonds, have gained conspicuous popularity. Table 1 presents the current sustainable debt instruments and their market sizes and shares as at the end of 2021. For now, green bonds are excluded, as they are presented in depth in the next chapter. After green bonds, the second most popular sustainable debt instrument is a *social bond*, used to finance projects with positive social outcomes such as socioeconomic advancements, food security, or employment generation and thus contribute to the social dimension of SD (ICMA 2021b.). The third most popular is a *sustainability bond*, which has originated from the perception that green projects (typically financed by green bonds) can have social co-benefits and vice versa. The fourth most popular *sustainability-linked bond* is, by contrast with the other instruments, a behaviour-based product.[6] It means that the financial characteristics of the bond are tied to pre-set sustainability targets and can therefore vary according to how the issuer achieves the targets. (ICMA 2020; Bloomberg 2021.) *Transition bonds* are the latest newcomers and are mainly found in highly polluting sectors, such as mining and aviation, which do not fall into the existing definitions of green but are crucial in a transition to net zero (CBI 2022b).

[5] Equivalent to the total market capitalization of the listed corporates globally (SIFMA 2022).
[6] All the other sustainable debt instruments can be classified as activity-based products (Bloomberg 2021).

Table 1 Sustainable debt instruments (modified from ICMA 2020; ICMA 2021b; ICMA 2021c; CBI 2022b)

Instrument	Definition	Market size 2021 (USD billion)	% of total
Social Bond	Proceeds exclusively applied to finance or re-finance so-called 'social projects', which aim to achieve greater social benefits.	223.2	20.87%
Sustainability Bond	Proceeds exclusively applied to finance or re-finance projects that are a combination of both green and social projects with co-benefits in either direction.	200.2	18.72%
Sustainability-Linked Bond	A forward-looking performance-based instrument for which the financial and/or structural characteristics can vary depending whether the issuer achieves predefined sustainability objectives.	118.8	11.11%
Transition Bond	Financing operations that aim to decarbonize an activity or support the issuer in its transition to Paris Agreement alignment.	4.4	0.41%

The market in which the sustainable debt instruments operate can be referred to as the sustainable debt market. In recent years, it has grown exponentially, led by green bonds. According to a global report by Climate Bonds Initiative (CBI) (2022b), the total sustainable debt market reached a value of almost USD 1.1 trillion in 2021. Compared to 2020, the market saw an increase of 46%. At the end of 2021, the cumulative number of all sustainable debt instruments placed on the market was 16,697. From these, 5,999 were issued in 2021, accounting for 35% of the total. Although the share of the sustainable debt in the overall DCM is still relatively small, it has the potential to increase its significance in the future if the same growth trajectory continues. However, challenges to the sustainable debt market, and DCM as a whole, are posed by several factors, such as the continued Ukraine invasion, high inflation, soaring interest rates, and the growing concern of global recession (CBI 2022b; Bloomberg 2022a).

3 Green bonds

3.1 Definition

Of the sustainable debt instruments discussed earlier, green bonds are by far the most popular and subject to particular attention and, thus, the main topic of this thesis. In 2021, they accounted for 49% of the total sustainable debt market, with a market size of USD 522.7 billion (CBI 2022b). Regardless of the recent traction, thus far, there is no globally accepted universal definition for green bonds. Probably the most widely accepted and adopted definition is from International Capital Market Association's (ICMA) (2022) Green Bond Principles (GBPs). They define green bonds as

> any type of bond instrument where the proceeds or an equivalent amount will be exclusively applied to finance or re-finance, in part or in full, new and/or existing eligible green projects.

The eligible green projects can be related to, but are not limited to, pollution prevention, clean transportation, renewable energy, green buildings, climate change adaptation, biodiversity, or sustainable water management. Although there are several possible projects to which the proceeds can be applied, the main requirement is that they are related to the promotion of environmental issues. (ICMA 2022.) According to the CBI, in 2021, the three largest categories for the use of proceeds were energy, buildings, and transport, covering 81% of the whole year's total. Given that in 2022, energy, transport, and production & construction were the world's top 3 most polluting industries[7], capital can be seen to be allocated as desired and expected (The Eco Experts 2022).

Although green bonds have similar features as plain vanilla bonds[8], four generally agreed distinguishing aspects have been specified. Currently, these are (ICMA 2022; Thompson 2021, 241):

1. Use of proceeds: The proceeds should be used to finance projects with green outcomes.

2. Process for project evaluation and selection: The issuers should communicate the environmental suitability objectives, the process of determining the fit of the

[7] The level of pollution is measured by the annual greenhouse gas (GHG) emissions (The Eco Experts 2022).
[8] Plain vanilla bond refers to the most basic version of bonds.

projects, and complementary information on processes used to identify and manage risk associated with the selected projects.

3. Disclosure and management of proceeds: The allocation of funds raised from green bonds should be independently audited and made easily accessible to stakeholders.

4. Reporting: The issuers should evaluate and report the environmental impacts of green bonds.

It is essential to point out that these are only recommendations and not requirements for the issuers. However, they intend to, for example, increase the investors' confidence. In particular, the issuers' transparent communication and reporting will most likely increase the trust of investors favouring sustainable investment strategies. (Thompson 2021, 241.)

To date, ICMA (2022) has identified four distinct green bond types.[9] The types are Standard Green Use of Proceeds Bonds, Green Revenue Bonds, Green Project Bonds, and Secured Green Bonds. They all have specific characteristics and differ by the intended use and risk profiles. Table 2 assembles the current types with their descriptions. *Standard Green Use of Proceeds Bond* is the standard form, and so far, the majority of green bonds issued are this type. In most cases, these types of debt instruments reduce credit risk and the risk of default, as the bond is backed by the issuer’s entire balance sheet, giving rating agencies and investors more confidence. The collateral of *Green Revenue Bonds* is the project-linked cash flows (revenue streams), whereas the *Green Project Bonds* are backed by the green project(s) assets and balance sheet(s). They are similar to the extent that the credit exposure of the investors is linked directly with the success of the project(s) that the bonds are financing. Therefore, they may have a higher risk profile, which is usually acknowledged, with higher return requirements. (Thompson 2021, 241–242; ICMA 2022.)

Secured Green Bonds can be categorised into Secured Green Collateral Bonds and Secured Green Standard Bonds. It depends on whether the net proceeds are exclusively applied to project(s) securing the specific bond only (secured collateral bond) or to project(s) of the issuer, originator or sponsor, where such projects may or may not be

[9] The latest update and specification to the green bond types was done in June 2022.

securing the specific bond in whole or in part (secured standard bond). This category type may include but is not limited to covered bonds, secured notes, securitisations, asset-backed commercial paper, and other secured structures. (ICMA 2022.) There are also similar, but slightly different, green bond type classifications available.[10] However, they will not be covered in this thesis since the classification provided by ICMA is considered widely respected (Refinitiv 2022a).

Table 2 Current green bond types (modified from ICMA 2022; CBI 2022c)

Type	Definition
Standard Green Use of Proceeds Bond	An unsecured full recourse-to-the-issuer debt obligation where the bond is backed by the issuer's entire balance sheet.
Green Revenue Bond	A non-recourse-to-the-issuer debt obligation where the project-linked pledged cash flows of the revenue streams, taxes, fees etc. are collateral for the debt.
Green Project Bond	Can be issued for a single or multiple green project(s), and the recourse is to the green project(s) assets and balance sheet(s) with or without potential recourse to the issuer.
Secured Green Bond	A secured debt obligation collateralized by a pool of eligible green projects (assets).

A few sub-categories have also emerged under green bonds. Practically, they are classified as green bonds but focus more explicitly on the promotion of specific environmental issues. The most notable ones include climate bonds and blue bonds. The proceeds of climate bonds are used to mitigate or adapt to the effects of climate change, and the proceeds of blue bonds are used to support sustainable marine and fisheries projects. Technically, most of the green bonds could be classified as climate bonds since the majority of proceeds have been used to finance projects related to climate change, while blue bonds are a smaller sub-category. (Thompson 2021, 244–245; ICMA 2022.) Overall, as the green bond market, and the sustainable debt market as a whole, continues to develop rapidly, the definitions can see changes shortly.

[10] See e.g. CBI 2022c.

3.2 Global green bond market development

The first-ever green bond was issued in 2007 by a multilateral development bank, European Investment Bank (EIB), and since then, the market has grown immensely. The EIB's green bond portfolio alone had grown to USD 24.5 billion by 2017, covering 160 green projects in 46 countries. (Thompson 2021, 243–244; EIB 2022a.) Figure 1 illustrates the exponential growth of the global green bond market. From 2007 to 2012, the annual issuance was still relatively small, and the growth was limited. During this period, the issuers were mostly multilateral development banks, such as EIB, which are supranational institutions set up by sovereign states (OECD 2015; EIB 2022b). In 2013, the first corporate issuers joined the market, and since then, the growth has been explosive, with 2021 being the record-breaking year with over USD half trillion annual issuance volume. Today, the green bond market issuers include, for example, corporates (financial and non-financial), countries (sovereign issuers), local governments, and development banks. Out of the current issuer types, corporates are the most vigorous, and at the end of 2021, they accounted for 44% of the cumulative green bond volumes. (CBI 2022b.)

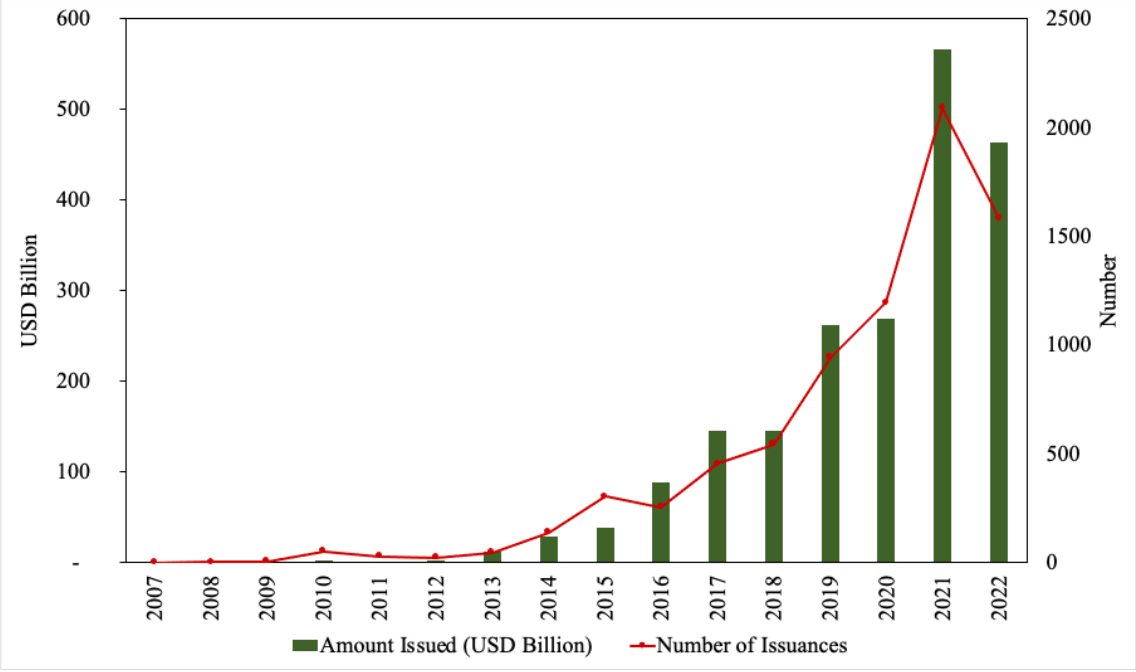

Figure 1 Annual green bond issuances in November 2022 (data retrieved from Refinitiv Eikon)

In 2021, 73% of the total green bond volume originated from developed markets, while the rest came from emerging markets and supranational issuers. Figure 2 displays the geographical distribution of the green bond issuances measured by the USD amount issued, highlighting the current top 3 green bond issuing regions. These are Europe, Asia-Pacific, and North America, out of which Asia-Pacific has experienced the strongest recent growth in green bond issuances, mostly led by China. In 2021, Asia-Pacific was the second biggest region measured by cumulative green bond issuances, surpassing North America for the first time in green bond market history. For now, Europe has been the most dominant region, contributing 50% of the total annual volume in 2021. However, the leading role might be diminishing in 2022 as Asia-Pacific green bond supply has increased. As shown in Figure 2, green bonds have not so far gained popularity in Africa, even though it is one of the territories most affected by climate change. Some of the reasons include, for example, less developed capital markets and smaller-scale loan needs. However, it will be interesting to follow in which direction the green bond market in Africa, as well as in other emerging markets, will develop in the future. (S&P Global 2022a; CBI 2022b.)

Country-wise, at the end of 2021, the US had the largest cumulative green bond issuance volume of USD 304 billion, followed by China with USD 199 billion. However, China will likely surpass the US as the number one green bond issuer shortly, as the supply keeps increasing rapidly in China (Bloomberg 2022b).[11] The US green bond market is typically characterized, by a large number of issuers, with relatively small-sized deals. The market in China has recently seen a rise in non-financial corporate issuers, although one-third of the issuers are still financial institutions which lend money to other corporates' relevant projects. From European countries, France has traditionally been the pioneer, but as also shown in Figure 2, Germany has taken the number one position (Thompson 2021, 242). Germany was also the world's leading green bond issuer in Q3 2022, with a volume of USD 15.89 billion. Recently, Italy has also raised its head with growing green bond volumes on the European market. (S&P Global 2022b; CBI2022b.)

[11] The heat map in Figure 2 suggests that China would have already exceeded the US in the amount issued. The data is retrieved from Refinitiv Eikon at the end of November 2022. However, while writing this thesis, no official records were found.

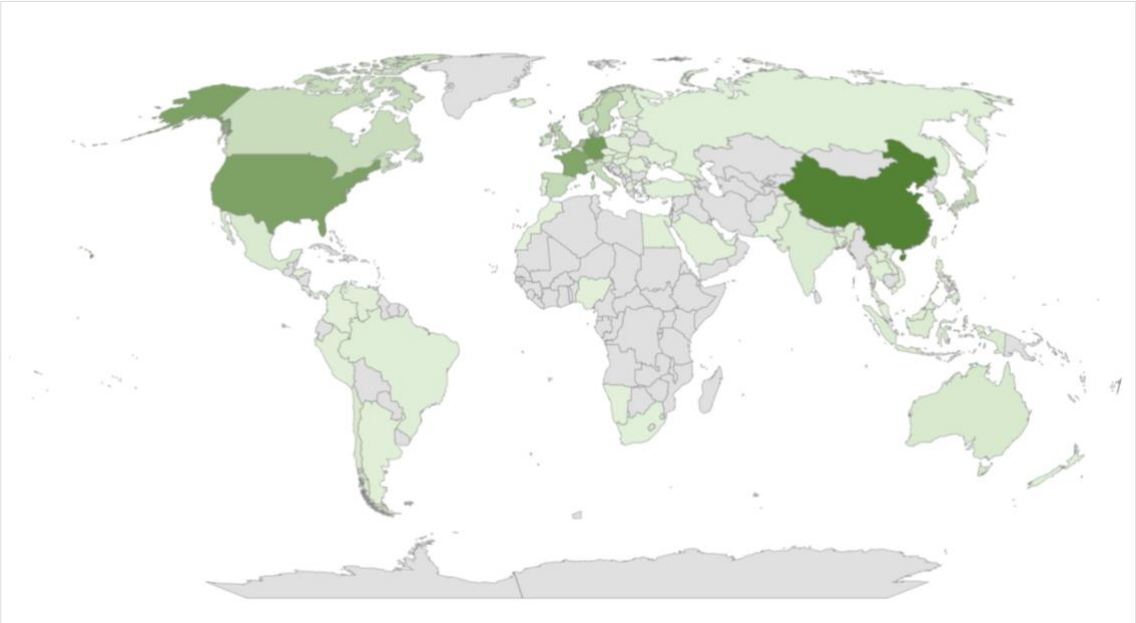

Figure 2 Geographical heat map of green bond issuances in November 2022 (data retrieved from Refinitiv Eikon)

Forecasts and expectations for the green bonds market are high. According to CBI (2022a) forecast, the amount of annual green bond volume is expected to reach a value between USD 900 billion and USD 1 trillion by the end of 2022. After the first annual trillion, the next significant milestone would be to hit an annual volume of USD 5 trillion by 2025. However, this goal is very optimistic, and to reach it, governments, policymakers, investors, and issuers have to contribute to the market development. (CBI 2022a.) Also, the overall market situation is unfavourable to the forecasts and expectations. Macroeconomic factors such as the continued Ukraine invasion, high inflation, hiking interest rates, the European energy crisis, and growing concern about the recession are threatening the entire world economy, including green bonds (Bloomberg 2022a; IMF 2022a; CBI 2022e). Thus, CBI (2022e) has reported a 22% year-on-year (YoY) decline in green bond issuances at the end of Q3 2022.

3.3 Current principles, standards and regulations

To date, there is no uniform global standard for green bonds. However, as the global green bond market keeps growing rapidly, the need for new robust standards, principles and regulations increases immensely. Also, the lack of universal agreement on common approaches can be considered to be holding back the development of the green bond market. One major goal of the standards and principles is to ensure transparency and

create trust and credibility in the market. For the participants, they also enable a better overall understanding and awareness of the market. (Thompson 2021, 245, 249.) Despite the lack of globally harmonized standards and regulations, some regions and nations have supported green bond market development through regional and local approaches. Principles and frameworks are also offered by some associations, namely the International Capital Market Association (ICMA) and Climate Bonds Initiative (CBI).

Probably the most well-known and widely accepted principles for green bonds are the ICMA's (2022) *Green Bond Principles* (GBPs), which have also been referred to several times in this thesis. First published in 2014, the principles offer green bond issuers a collection of voluntary frameworks and outline the best practices. GBPs also serve investors by providing transparent and necessary information to assess the environmental impact of green bond investments. The third group, which they also support, are the underwriters for whom the principles offer vital steps that will facilitate transactions that preserve market integrity. The newest edition of GBPs was published in June 2021 and further developed in June 2022. However, since the GBPs are only a voluntary framework and not a formal regulatory standard, it is evident that different applications of the principles may occur. (Thompson 2021, 250–252, 256; ICMA 2022.)

To supplement the GBPs, particularly the certification of green bonds, the CBI (2019) has developed *Climate Bonds Standards*. The purpose is not to offer competing or alternative practices to GBPs but to build on its principles, providing even more detailed descriptions. Thus, it is fully aligned with the GBPs. One of the reasons for the creation of these complementary standards has been the criticism for the lack of detail of the GBPs. The standard is divided into pre-issuance requirements and post-issuance requirements. The pre-issuance requirements are those that the issuer must meet when applying for a certification ahead of issuance, and the post-issuance requirements are those that the issuer must meet when seeking continued certification following the issuance. If the issuer meets the requirements, they have the possibility for an independent assurance provided by the Approved Verifier. The assurance is beneficial for the relationship between the issuer and the investors. On top of the certification specification, the Climate Bonds Standard also offers detailed criteria for the use of proceeds. Overall, the standard is a more rigorous addition to the GBPs. (CBI 2019; Thompson 2021, 256–257.)

The latest significant news on the development of green bond standards and principles is from China. The China Green Bond Standard Committee published new voluntary *China Green Bond Principles* in July 2022. Like the CBI's Climate Bonds Standard, they refer to and have similar attributes to the GBPs by ICMA but are more directed to domestic green bond issuances. China's green bond principles make four core components for the issuance of green bonds, which are the use of proceeds, management of the proceeds, project evaluation and selection, and duration of information disclosure. Although the principles are aimed at domestic issuances, the intention is partly to make more of the green bonds in China globally recognized. A significant part of this new update is that there have been plans for rule changes that would make these policies mandatory for exchange-traded bonds. There are speculations that if this rule change comes to force, China could become a leader in global green bond regulation. (Sustainable Fitch 2022; Reuters 2022.)

Over the past few years, green bond *taxonomies* have become an increasingly important topic of discussion. According to CBI (2022b, 2022g), a taxonomy is "a classification system that identifies activities, assets or revenue segments that deliver on key environmental objectives". They aim to provide guidance and, more importantly, clarity to the market participants on which activities or assets are eligible for sustainable investments and thus support the development of the green bond market. For decades, the eligibility of assets for inclusion in ESG and other sustainable products has been determined by principles, definitions, and classification systems, such as ESG scores, offered by agents in the private sector. The new taxonomies, however, have been put forward by public actors to form a more top-down approach to determining green activities. The taxonomies are generally publicly available, granular, and science-based. In time, the taxonomies have become more detailed and mandatory for market participants. (CBI 2022b, 2022g.)

Currently, the main actors in the field of green taxonomy are China and the EU. Out of these, China was the first to put forward a mandatory domestic taxonomy for the issuance of green bonds in 2015. It goes by the name of the Green Bond Endorsed Project Catalogue or China Taxonomy.[12] In the EU, the European Commission established a

[12] The latest version of the China Taxonomy was published in April 2021 and was updated to align more closely with global definitions (PBOC 2021; CBI 2022b).

Technical Expert Group (TEG) on sustainable finance in 2018, intending to develop the EU-wide taxonomy and other related action plans.[13] The TEG published the final report on EU Taxonomy in March 2020, containing recommendations related to the overarching design of the taxonomy. However, the taxonomy is still not fully complete and is being developed in several stages. The latest development step is the Climate Delegated Act, which provides taxonomy criteria on climate change mitigation measures, and was put to force in January 2022. (TEG 2020; European Commission 2022a; European Commission 2022b.) Although the EU and China are the two current main taxonomy agents, taxonomies are also either in discussion, development, or draft elsewhere. For example, at the beginning of 2022, taxonomies were in discussion in Australia and Mexico, in development in Brazil, Canada, India, Japan and Kazakhstan, and in the draft in South Africa and the UK. (Thompson 2021, 257–258; CBI 2022b, 2022g.)

3.4 Challenges

At first glance, the proliferation of green bonds appears to be an adequate and good thing. However, there are still various challenges to overcome concerning green bonds. For example, the maintenance of market integrity and transparency becomes an essential factor as the market is growing and developing at a rapid pace. Thus, it is crucial to evaluate the green bond phenomenon from a critical aspect and highlight the current challenges that the market is facing. The previously discussed principles, standards, and regulations play a significant role in ensuring that the development goes in the desired direction. Despite the recent developments, a lot remains to be done. (Thompson 2021, 241; Financial Times 2022.)

One broadly highlighted significant challenge is the increasing risk of greenwashing. It means that the issuers may seek to take advantage of the investors, following the impact investing guidelines, by labelling the issued bonds as ‘green’ but not committing to the promotion of environmental issues (Thompson 2021, 30, 249). This can also be described as a ‘moral hazard’ problem caused by asymmetric information between the issuers and the investors. The rapid expansion of the green bond market has only accelerated the concerns of both regulators and investors. (Financial Times 2022.) Although principles,

[13] The TEG also published a recommendation for a voluntary EU Green Bond Standard (EU GBS) in June 2019 and updated them in March 2020 (European Commission 2022c). However, as of writing this thesis, it is not in application.

standards, and regulations are already widely used, they are not yet sufficient to eliminate the threat of greenwashing altogether. According to CBI (2022f), in 2022, 3 in every 4 dollars from green bond issuances met the best practice climate standards. However, as there still are so-called 'self-labelled' green bonds that are not aligned with the current standards and are not externally verified, the risk of greenwashing persists. Of course, the mitigation of greenwashing also requires greater criticalness on the part of investors, but responsibility cannot be entirely theirs to carry.

One of the problems of the current standards is the voluntary nature of their use, which can lead to governance and legitimacy deficits. Consequently, there have been discussions about whether mandatory standards, instead of voluntary ones, should be applied to prevent greenwashing better.[14] However, there are also fears that mandatory standards would increase the costs of issuing green bonds, and affect the willingness to use them as a source of green financing. (Financial Times 2022.) China's recent reformation of their national green bond principles to make them more globally aligned and the possible update to make them mandatory may serve as a possible benchmark for the best practices in the future. Furthermore, if the new approach is put to force and found to work well, it could also be applied in other nations. Therefore, China has the opportunity to act as a kind of pioneer in the development of the green bond market.

Speaking of China, it has particularly high stakes regarding green bonds. China's president Xi Jinping's government has the twin goals of peaking emissions by 2030 and achieving carbon neutrality by 2060. (Bloomberg 2022b; Reuters 2022.) If these goals are achieved, according to Climate Action Tracker (2020), it would be the biggest single reduction in global warming projections in history. However, the current reality with green bonds, especially in China, is that it is almost impossible to know how the capital is spent and whether it is having the desired impact. This issue is evident, for example, in the case of financial institution issuers that use the proceeds from green bonds to lend capital to relevant projects, meaning that they do not have their own projects to finance directly. In China, financial institutions cover one-third of the issued green bonds. In

[14] See e.g. European Parliament (2021).

addition, the Chinese green bond market also suffers from the risk of greenwashing and general uncertainty.[15] (Bloomberg 2022b.)

Globally, there is a need for better harmonization of the green bond market. For investors, the existence of several diverging standards can lower confidence and increase transaction costs as there is a need to assess multiple different standards. However, global harmonization is easier said than done and requires vigorous dialogue among all the market participants. (German Development Institute 2017.) It would be particularly desirable to standardize the taxonomy globally to have a universal and unambiguous understanding of what green bonds are and what they can be used for. Multiple separate taxonomies can lead to market fragmentation, limit the functioning of the global green bond market and make international mobility of green capital challenging. So far, this has not been achieved, but there are some collective efforts, such as the International Platform on Sustainable Finance (IPSF), developed by the EU and China to serve as a foundation for a common ground taxonomy.[16] (CBI 2022g.) However, as the green bond market grows, the puzzle becomes increasingly complex. Therefore, the action should be as swift as possible.

3.5 Previous studies

As the green bond market evolves at an accelerating pace and in the presence of several challenges, it is interesting to assess how investors view green bond issuances. Besides, the investors who buy the bonds, are the ones lending the money to the issuers. One way to assess this is to examine the impact of green bond issuance announcements on the stock returns of the listed corporate issuers. It essentially describes how the equity market reacts to green bonds and whether investors see the issuance as a positive or negative sign under current market conditions. This research approach also makes it possible to assess whether the listed issuers, on top of gaining debt financing for operations, get extra benefits from issuing green bonds. For example, issuing green bonds might lead to increased investor engagement, as green bonds might serve as a signal for the environmental commitment of the issuer (Flammer 2021). There are some previous studies on this topic, and most of them, although not all, have found green bonds to have

[15] According to Bloomberg (2022b), in a rare interview, even the Chinese PBOC Governor Yi Gang has warned against greenwashing, low-cost arbitrage, and green project fraud in China's green bond market.
[16] IPFS is a forum for dialogue between policymakers to increase the amount of private capital being invested in environmentally sustainable investments (European Commission 2022d).

a positive impact on the stock returns of the issuer. Some studies have also examined whether there are any green bond or issuer characteristics that would be linked to these abnormal returns.

Baulkaran (2019) studied the stock market reaction to green bond issuance announcements with observations mainly from Europe but also from Canada, the US, China, and Australia. The final sample consisted of 54 green bonds issued by public corporates, and the research method was an event study. The issuance announcement dates were had-collected for each observation using news articles and company press releases. The results suggest that the stock market reaction is positive and statistically significant around the announcement date. A regression analysis was also conducted, to further examine the link between abnormal returns and bond and firm characteristics. The only bond characteristic linked with the returns was the coupon, and the result suggested that a higher coupon resulted in lower abnormal returns. Out of the examined firm characteristics, operating cash flows, firm size, and growth opportunities had statistically significant linkage. (Baulkaran 2019.)

Lebelle et al. (2020) examined corporate green bond issuances globally. The initial sample was 2,079 green bond issuances of 190 individual corporate issuers from 2009 to 2018. The final sample for the empirical study contained 475 green bonds issued by 145 individual public corporates. The research method was an event study, and the observed event was the green bond issuance announcement date. Contrary to the majority of the results from similar studies, the results suggest that the market reacts negatively to the green bond issuance announcement. Thus, the results imply that green bond issuances convey unfavourable information about the issuing corporation to the investors. In addition, the negative response was stronger for first-time issuances compared to subsequent issuances, and for issuers in developing markets compared to emerging markets. They also found that financial corporates experienced a stronger negative impact than non-financial corporates, although the magnitude of the differences was small. They also examined the dependency of abnormal returns on issuer characteristics and found leverage, book-to-market ratio, and growth to have a statistically significant linkage. (Lebelle et al 2020.)

Tang and Zhang (2020) examined green bonds globally from the shareholder's benefit perspective. Their initial sample was 1,510 observations from 28 countries from 2007 to

2017. Of these, 241 green bonds were issued by 132 unique public corporates. The chosen research method was an event study, and the observed event was the issuance announcement date. They found green bond issuance announcements to have a positive and significant impact on the stock prices of public issuers. The impact was stronger for non-financial corporate issuers compared to financial institution issuers. Also, the response was stronger for first-time issuances. In addition, they found green bonds to increase institutional ownership and improve stock liquidity after the issuance. They concluded that by issuing green bonds, it is possible to attract more positive media exposure, and through this, investors that follow the guidelines of impact investing are more likely to invest in the issuing company. (Tang & Zhang 2020.)

Glavas (2020) examined stock price reactions to green bond issuance announcements globally. The data consisted of 302 corporate green bonds and 478 conventional bonds, which were added to the analysis to allow comparison. The research method was an event study. The results implied a significant and positive reaction to all bond issuance announcements. However, the reaction was higher for green bond issuances compared to conventional bond issuances. This result suggests that the announcement of the green bond issuance contains value-generation information and is perceived as a value-creating event. In addition, the positive stock reaction was stronger after the Paris Agreement[17] in 2015, suggesting that the agreement has been key to the interest of investors in green bonds. (Glavas 2020.)

Wang et al. (2020) examined the market reaction to green bond issuances in China, the largest emerging debt market. They also studied whether green bonds have a pricing premium over conventional bonds. They constructed a comprehensive sample of Chinese corporate green bonds issued between 2016 and 2019. The final sample consisted of 159 green bonds and 297 conventional bonds. Of these, 48 green bonds and 75 conventional bonds, were issued by publicly listed issuers. The research method for observing the market reaction was an event study. After conducting the event analysis for both green and conventional bonds, they found that the difference in abnormal returns on the announcement date was insignificant. However, for longer time windows around the event, the cumulative abnormal returns were significant, positive and higher for green

[17] The Paris Agreement is a legally binding global treaty on climate change adopted by 196 countries in Paris on 12 December 2015 (UNFCCC 2022).

bonds. Thus, the results suggest that the equity market reacts positively to the green bond issuance announcement in China. In addition, the pricing effect for green bonds was found to be positive and significant. (Wang et al. 2020.)

Flammer (2021) examined corporate green bonds globally between 2013 and 2018. The initial sample consisted of 1,189 corporate green bonds. Of these, 565 were issued by public corporates. An event study method was used to study the equity market reaction to the green bond issuance announcements. The final sample for the event study consisted of 384 issuer-day green bond observations. The results suggest that the market response was positive and significant to the issuance announcement. Also, it was stronger for first-time issuers and green bonds, which were certified by independent third parties. In addition, an interesting finding was that companies that issued green bonds improved their environmental performance, meaning higher environmental ratings and lower CO2 emissions, following the issuance, suggesting that there is no sign of greenwashing. The green bond issuers also experienced an increase in ownership by green and long-term investors. (Flammer 2021.)

As presented above, previous studies suggest largely consistent results from the equity market response to the green bond issuance announcement. Overall, the results imply a positive reaction. However, since not all results are unanimous, further research is necessary. Also, the green bond market is constantly generating new data and the market experiences regulatory changes rapidly. Therefore, examining the equity market response to the green bond issuance announcements remains meaningful, and studying this topic is important for both investors and issuers.

4 Data and research methods

4.1 Data

The data is retrieved from Refinitiv Eikon. The green bonds data in Refinitiv Eikon is originally from Climate Bonds Initiative (CBI) (Refinitiv 2021). For now, there is no centralized database for green bonds. ICMA (2017) provides a summary of the available green bond database providers, the major ones being Bloomberg, Environmental Finance, Dealogic, and CBI. Lebelle et al. (2020) add Trucost, owned by S&P Global, to this list. Out of these, the CBI's database is the oldest, established in 2013, and it is also the most comprehensive provider of green bond data. A green bond has to be aligned with the GBPs to be included in the database, adding credibility to the data. Thus, CBI's database has been utilized in several previous studies on green bonds (See e.g. Tang & Zhang 2020; Lebelle et al. 2020; Tolliver et al. 2020).

The data is global, and the focus is on green bonds issued by listed corporates between 2013 and 2021. The green bonds data is retrieved using Refinitiv's Government Corporate Bonds – Advanced Search app. Issuer Type is set to Corporate, and Bond Type to Bond.[18] Green bond criterion is set to 'Yes', and Prospectus is needed to be available.[19] With these selections, the initial sample retrieved from the app, consisted of a total of 2,761 individual corporate green bonds between 2013 and 2021. Table 3 displays further screening criteria of the green bond sample. Since the study examines the green bond issuance announcements' effect on stock returns, criterion No. 1 is set to exclude private issuers and asset types such as unit trusts and preferred shares from the sample. Criteria No. 2 and 3 are set to ensure that the sample is reliable and allows for a comprehensive analysis. Criterion No. 4 certifies that the data contains only pure green bonds and not, for example, sustainability-linked bonds. Criterion No. 5 is essential for the chosen research method. Since some corporations issue multiple green bonds on the same date, similar to Flammer (2021), criterion No. 6 is set to include only issuer-day observations in the sample.

[18] Certificates of Deposits and Commercial papers are excluded.
[19] Prospectus is a legal document that provides, for example, details of the use of proceeds.

Table 3 Screening criteria for green bonds

Criterion	Description
No. 1	Issuer listed in the stock market with the asset type being ordinary share.
No. 2	Required green bond data: *First announcement date, Issuance date, Amount issued, Coupon, Maturity, Currency & Use of Proceeds*.
No. 3	Required issuer data: *Issuer Name, TRBC Sector Classification, Domicile, Accounting Data (Assets, Liabilities etc.) & Refinitiv ESG score.*
No. 4	Issuer ESG Label, the original label used by the issuer for a green bond in the prospectus or official source, is available and set to 'Yes'.
No. 5	Stock prices are available at least 282 trading days prior and 20 trading days after the First Announced Date.
No. 6	Only unique issuer-day observations are included.

The final green bond sample contains 564 green bond issuances from 31 countries by 272 publicly listed corporate issuers. Table 4 presents the observations by country and economic sector. Regionally, based on the amount issued, Europe is the first (USD 123.4 billion), North America is the second (USD 63.8 billion), and Asia-Pacific is the third (USD 45.9 billion). The regional distribution corresponds fairly well to the volume distribution of the 2021 green bond market, where Europe contributed half of the volume of the year, Asia-Pacific around one quarter, and North America just under one-fifth. At the end of 2021, the cumulative volume of green bonds issued by financial and non-financial corporates was around USD 704 billion. Not all of these corporates are listed. (CBI 2021b.) Given that, in this study, only listed corporates are included, the sample can be considered rather comprehensive, with a total amount of USD 234.3 billion issued. However, it is also good to point out that the data availability has imposed some constraints.

Table 4 Green bond sample by country and economic sector

This table presents the green bond sample used in the empirical study by country and economic sector, sorted by the amount issued. Others row in Panel A includes countries with an amount issued under USD 1 billion, including UAE, Turkey, Hong Kong, South Africa, Switzerland, New Zealand, India, Brazil, and Chile. Panel B presents the sample distribution by The Refinitiv® Business Classification (TRBC) Economic Sectors. In total, there are 13 different TRBC Economic Sectors.

	Amount Issued (USD Billion)	% of Total	# of Green Bonds	% of Total
Panel A: By Country				
US	62.7	26.77 %	98	17.38 %
China (Mainland)	30.6	13.07 %	43	7.62 %
France	25.8	11.03 %	44	7.80 %
Germany	23.1	9.84 %	45	7.98 %
Spain	19.1	8.15 %	39	6.91 %
Italy	14.6	6.24 %	24	4.26 %
Japan	11.0	4.69 %	83	14.72 %
Norway	8.4	3.58 %	24	4.26 %
United Kingdom	7.1	3.03 %	13	2.30 %
Sweden	6.0	2.57 %	57	10.11 %
Denmark	4.7	2.01 %	7	1.24 %
Austria	2.9	1.24 %	11	1.95 %
Ireland	2.3	0.96 %	3	0.53 %
Australia	2.2	0.95 %	4	0.71 %
Belgium	1.8	0.75 %	3	0.53 %
Portugal	1.8	0.75 %	2	0.35 %
Finland	1.7	0.72 %	7	1.24 %
Netherlands	1.6	0.67 %	2	0.35 %
Taiwan	1.4	0.61 %	26	4.61 %
Canada	1.1	0.47 %	3	0.53 %
Poland	1.1	0.46 %	3	0.53 %
Greece	1.0	0.43 %	2	0.35 %
Other	2.4	1.01 %	21	3.72 %
Panel B: By Economic Sector				
Financials	115.7	49.37 %	230	40.78 %
Utilities	53.1	22.67 %	92	16.31 %
Real Estate	34.9	14.90 %	143	25.35 %
Technology	9.5	4.04 %	20	3.55 %
Consumer Cyclicals	8.6	3.68 %	15	2.66 %
Industrials	4.8	2.03 %	34	6.03 %
Basic Materials	3.1	1.34 %	13	2.30 %
Consumer Non-Cyclicals	2.2	0.94 %	8	1.42 %
Energy	2.2	0.92 %	8	1.42 %
Healthcare	0.2	0.10 %	1	0.18 %
Total	**234.3**	**100 %**	**564**	**100 %**

The economic sector classification in Table 4 is based on the TRBC (The Refinitiv Business Classification) Sector Classification, which covers over 250 000 securities in 130 countries to 5 levels of granularity. According to Refinitiv, it is the most comprehensive sector and industry classification available. A significant part of the sample is from the Financials sector. It consists of four different business sectors, which are Banking & Investment Services, Insurance, Collective Investments, and Investment Holding Companies. (Refinitiv 2022b.) A difference between the non-financial and financial sectors is that the non-financial issuers use the proceeds from green bonds to finance green projects directly, whereas financial issuers use the proceeds to finance projects of other corporates' through loans (green lending) (see e.g. Lebelle et al. 2020; Wang et al. 2020; Fatica et al. 2021). Especially in Asia, the green bond market is currently dominated by banks in the financial sector (Taghizadeh-Hesary et al. 2021; Bloomberg 2022b). The majority of the observations from China, Germany, Spain, Japan, Norway, the United Kingdom, Sweden, Denmark, Austria, Taiwan, Canada, and Poland are from the financial sector. Also, Ireland, Australia, Belgium, UAE, South Africa, Switzerland, India, and Chile have observations only from financial corporates. This indicates that the financial sector is also prominent outside of Asia.

Panel A in Table 4 presents the summary statistics of the included green bonds. The mean of the amount issued is USD 415.4 million, but the amounts vary substantially. Compared to the total green bond market, CBI (2022b) reports the average size of a green bond being USD 250 million in 2021. The large mean of the final sample is explained by the large green bond issuances by Chinese financial corporates, with the biggest being USD 4.1 billion. The sample's largest non-financial corporate green bond is issued by an automobile manufacturer Ford Motor Company in the US. An interesting observation is a green bond with 1000-year maturity issued by the Danish energy corporation Orsted in 2019. Orsted is the world's largest offshore wind farm developer and issued a 1000-year maturity bond also earlier in 2017 (Insider 2017). The coupon rates of the green bonds are scattered moderately evenly between the minimum and maximum values. The sample includes 29 zero-coupon green bonds.

Panel B in Table 4 presents summary statistics of the individual issuers. The total amount of issuers is 272. The size of the issuers varies substantially, measured both by market capitalization and total assets, and thus, the variance of the size measures are large. The leverage ratios (debt-to-equity) are overall moderate, with a mean of 0.73. Moreover, all

the ratios are under one, meaning that the issuers have more equity over debt. The return on assets (ROA) is quite low for all the issuers. For some, the ROA is negative, indicating that some issuers may be generating losses. Tobin's Q is used to measure growth opportunities. For many issuers, it is under 1, suggesting that the market value is lower than the book value of assets. (Tobin 1969, 1978; Baulkaran 2019.) Overall, the size measures, leverage, ROA, and Tobin's Q of the issuers in this study are largely in line with those reported by, for example, Baulkaran (2019), Lebelle et al. (2020), and Tang and Zhang (2020). To a large extent, the ESG and pillar scores are high for the issuers, although some are surprisingly low. One could expect the green bond issuers to have a higher environmental rating. However, an interesting finding is that the environmental pillar score does not differ substantially from the other pillars.

Table 5 Summary statistics of green bonds and issuers

This table presents the means, medians, minimums, maximums, and standard deviations of the green bond and issuer characteristics of the final sample observations. Panel A displays the green bond characteristics, and Panel B the issuer characteristics. All the monetary values are in USD. Maturity does not include the entire sample since four of the observed green bonds are perpetual bonds meaning they do not have a maturity date. The issuer characteristics are from the end of the fiscal year 2021. Leverage is defined as total liabilities divided by total assets. ROA (Return on Assets) is defined by income after taxes for the fiscal year divided by the average of total assets. Tobin's Q is a measure of growth opportunities and is defined as the market value of equity plus the book value of debt divided by the book value of assets. ESG score and pillar scores are Refinitiv ESG Scores. All the issuers are listed corporates with publicly traded shares.

USD	N	Mean	Median	Stdev	Min	Max
Panel A: Green Bonds						
Amount Issued (Million)	564	415.406	350.000	479.112	0.006	4143.704
Maturity at Issue (years)	560	10.175	6.669	42.614	0.722	1000.000
Annual Coupon %	564	1.789	1.375	1.557	0.000	8.850
Panel B: Issuers						
Market Cap (Billion)	272	38.878	10.632	159.529	0.237	2403.239
Total Assets (Billion)	272	290.723	39.174	705.855	0.742	5536.969
Leverage	272	0.727	0.736	0.185	0.247	0.967
ROA	272	0.037	0.021	0.056	–0.044	0.557
Tobin's Q	272	0.734	0.653	0.701	0.051	7.156
ESG score	272	66.353	70.202	17.477	17.497	95.392
Environmental Pillar	272	69.211	72.915	21.317	0.000	99.200
Social Pillar	272	67.482	72.845	20.767	10.347	98.315
Governance Pillar	272	61.067	65.773	21.556	6.988	97.004

4.2 Research methods

4.2.1 Event study

The event study method has a long history in finance research. The first forms of event studies can be seen published as early as the early 1930s. However, Ball and Brown (1968) and Fama et al. (1969) can be considered pioneers of its current form. An event study is an applicable way to measure the effects of specific events on different financial variables. The event can be, for example, an announcement related to stock splits, dividends or mergers and acquisitions. (MacKinlay 1997; Brooks 2014, 634.) In this study the event under scrutiny is the *first announcement date* of the green bond issuance available in the Refinitiv Eikon database. The frequency of the data for event study can be weekly, daily, or monthly. However, daily is the most used frequency for studies in the literature as it has been shown to have greater power to detect abnormal performance. (MacKinlay 1997; Brooks 2014, 635.) The frequency of choice for this study is also daily, which comforts the nature of the event.

Figure 3 illustrates the structure of an event study. *0* represents the day of the event, which in this case, is the first announcement date. The *estimation window* determines the expected or normal return for security if the event did not happen. The length of the estimation window for this study is [–281, –30], equivalent to 252 trading days (one trading year) before the event. The *event window* comprises the days to be examined to capture the possible abnormal returns around the event. The length of the event window can vary, and it is typical to examine a few different windows. In this study, the chosen event windows are a 41-day window [–20, +20], 21-day window [–10, +10], 11-day window [–5, +5], and 3-day window [–1, +1]. Out of these, [–5, +5] is considered as the baseline event window. In addition, a 10-day pre-event window [–10, –1] before the event and an 11-day post-event window [+10, +20] after the event are observed. The pre-event window aims to examine whether there is a possible leakage of information prior to the announcement. On the contrary, the post-event window aims to examine whether there is a possible delay in the equity market reaction. (MacKinlay 1997; Brooks 2014, 635–636.)

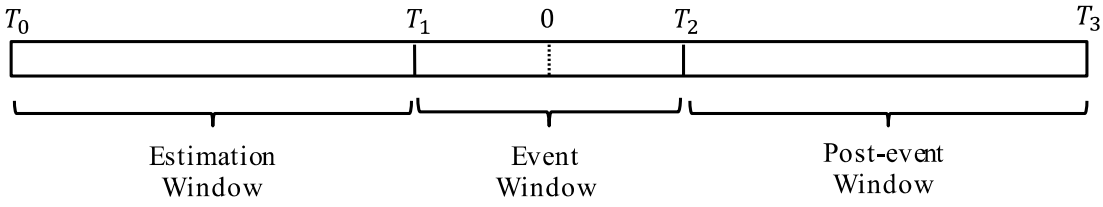

Figure 3 Event study structure (modified from MacKinlay 1997)

The underlying aim of an event study is to determine if the cross-sectional distribution of returns is abnormal at the time of a specific event (Kothari & Warner 2007). According to Efficient Market Hypothesis (EMH), it is impossible to gain abnormal returns if the markets are informationally efficient, as all the asset prices reflect all available information (Pilbeam 2018, 229). Thus, event studies are testing whether the efficient market hypothesis holds. A simple way of calculating abnormal returns is

$$AR_{it} = R_{it} - E(R_{it}), \tag{1}$$

where AR_{it} is the abnormal return, R_{it} is the actual return, and $E(R_{it})$ is the expected or normal return for security i for time period t. This approach can be referred to as the average return model. (Armitage 1995; MacKinlay 1997; Brooks 2014, 636.)

Numerous more sophisticated approaches have also been created for event studies to increase the robustness of the results. In this thesis, the utilized method is a statistical market model. The market model is probably the most common approach for estimating abnormal returns. It is also widely used in previous green bond event studies (see e.g. Baulkaran 2019; Lebelle et al. 2020; Flammer 2021). In the market model, the expected (or normal) return is estimated using a one-factor ordinary least squares (OLS) regression. The market model for security i is defined as

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \tag{2}$$

$$E(\varepsilon_{it} = 0)$$

$$var(\varepsilon_{it}) = \sigma_{\varepsilon_i}^2,$$

where α_i, β_i and $\sigma_{\varepsilon_i}^2$ are the parameters of the market model, R_{it} and R_{mt} are the returns for security i and market portfolio m for time period t, and ε_{it} is the zero mean error term. Typically, major stock indices are used to proxy for the market portfolio. (MacKinlay

1997; Brooks 2014, 637.) In this study, a major stock market index of each country under scrutiny is utilized. The used country-specific indices are listed in the appendices.

Returns for securities and markets are calculated using the Total Return Index (RI) retrieved from Refinitiv Datastream. RI accounts for dividends by assuming that they are re-invested, which mitigates possible large price fluctuations caused by dividend payments. The returns are calculated using a trade-to-trade approach, where the calculation is done from non-missing price days.[20] Another option would be to use lumped returns which consist of trade-to-trade returns on non-missing price days and zero on missing price days. However, Campbell et al. (2010) suggest that using trade-to-trade returns is sufficient in the multi-county setting. If the event day, the first announcement date, is a non-trading day, the event is assumed to be the next trading day. The returns are calculated using both local currencies and USD, and the event study is conducted with both currencies.[21]

The returns are calculated as daily logarithmic returns (log-returns) with the following equation:

$$R_t = 100\% \times \ln\left(\frac{RI_t}{RI_{t-1}}\right), \tag{3}$$

where RI_t is the total return index for trading day t and RI_{t-1} is the total return index for $t-1$. The benefit of log-returns is that they are analytically more trackable and can be interpreted as continuously compounded returns, which is also a crucial attribute for the event study. Also, log-returns are more likely to be normally distributed, which comforts the assumptions of statistical techniques. Thus, they are commonly used in the academic finance literature. (Strong 1992; Brooks 2014, 7–8.)

The OLS estimators for market model parameters $\hat{\alpha}$, $\hat{\beta}$and $\hat{\sigma}^2$ are

$$\hat{\beta}_i = \frac{\sum_{t=T_0+1}^{T_1}(R_{it}-\hat{\mu}_i)(R_{mt}-\hat{\mu}_m)}{\sum_{t=T_0+1}^{T_1}(R_{mt}-\hat{\mu}_m)^2} \tag{4}$$

[20] When using Refinitiv Datastream's RI for calculating returns, it is important to note that it ignores market holidays (non-trading days). One way to deal with this is to use the function X(RI)*IF#(X(P#S),NNA,ONE), which gives a negative value to the non-trading days. After this, the negative values can be highlighted and excluded from the data.

[21] Campbell et al. (2010) report that the use of the local-currency market model abnormal returns is sufficient in a multi-country setting. However, according to Aktas et al. (2004), the use of a common currency, more specifically the USD, does not have a major impact on the inferences of the results.

$$\hat{\alpha}_i = \hat{\mu}_i - \hat{\beta}_i \hat{\mu}_m \tag{5}$$

$$\hat{\sigma}_{\varepsilon_i}^2 = \frac{1}{L_1 - 2} \sum_{t=T_0+1}^{T_1} (R_{it} - \hat{\alpha}_i - \hat{\beta}_i R_{mt})^2, \tag{6}$$

where L_1 is the length of the estimation window, and $\hat{\mu}_i$ and $\hat{\mu}_m$ are means of the returns during estimation window for security i and market portfolio m. After estimating the parameters, the values are used to calculate the abnormal returns. The equation for abnormal return (AR) is

$$AR_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta}_i R_{mt}). \tag{7}$$

In the market model, the abnormal returns are disruptions from normal returns estimated through the market portfolio. By using the ARs it is also possible to calculate average abnormal returns (AAR) by

$$AAR_t = \frac{1}{N} \sum_{i=1}^{N} AR_{it}, \tag{8}$$

where N is the number of the observed events. (Armitage 1995; MacKinlay 1997; Brooks 2014, 637–638.)

To conclude the overall pattern of abnormal returns in the specified event window, a cumulative abnormal return (CAR) over a multi-period window can be calculated. Equation for CAR from time t_1 to t_2 is

$$CAR_i(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_{it}. \tag{9}$$

Thus, CAR sums daily abnormal returns together in the specified event window. In this study, CAR is used to summarize the results of each examined event window. By using CARs, we can calculate cumulative average abnormal returns (CAARs) with the following equation:

$$CAAR_i(t_1, t_2) = \frac{1}{N} \sum_{i=1}^{N} CAR_i(t_1, t_2), \tag{10}$$

where N is the number of individual observations. CAAR can also be calculated as the sum of AARs over a specific window.

In the market model, the null hypothesis, H_0, is that the abnormal return is zero meaning that the event has no impact on the stock returns. That is, the abnormal returns are normally distributed with a zero conditional mean and conditional variance of

$$\sigma^2(AR_{it}) = \sigma_{\varepsilon_i}^2 + \frac{1}{L_1}[1 + \frac{(R_{mt} - \hat{\mu}_m)^2}{\hat{\sigma}_m^2}] \quad (11)$$

where $\sigma_{\varepsilon_i}^2$ is the disturbance variance from Equation (2). (Fama et al. 1969; MacKinlay 1997; Brooks 2014, 638–640) The zero mean null hypothesis also applies for this event study.

Two different statistical tests are applied to test the significance of the event study results. The first is the parametric t-test. The cross-sectional t-test is given by

$$t = \frac{AAR/CAAR}{\sigma/\sqrt{N}} \sim \mathrm{N}(0,1), \quad (12)$$

where the numerator is either AAR or CAAR, and the denominator is the standard error (S.E.) of the numerator, calculated by dividing standard deviation of the observations σ with the square root of the number of observations N. (Brown and Warner 1985, Brooks 2014, 639–640; Stock & Watson 2020, 113.)

Campbell et al. (2010) have reported that in multi-country settings, the non-parametric tests, such as generalized sign and rank tests, appear to be more powerful than the commonly utilized parametric tests such as t-tests. Thus, the second statistical test is the non-parametric generalized sign test introduced by Cowan (1992). It examines whether the number of securities with positive CARs (or ARs) in the event window (or on an observed day) exceeds the number expected in the absence of abnormal performance. The expected number is based on the amount of positive abnormal returns in the 252-day estimation period,

$$\hat{p} = \frac{1}{\mathrm{N}} \sum_{i=1}^{N} \frac{1}{252} \sum_{t=-281}^{-30} S_{it},$$

where

$$S_{it} = \begin{cases} 1 \; if \; AR_{it} > 0 \\ 0 \; otherwise \end{cases}$$

The generalized sign test uses the normal approximation to the binomial distribution with estimated parameter $\hat{p}$. The final test statistic is

$$Z_{GS} = \frac{w - N\hat{p}}{\sqrt{N\hat{p}(1-\hat{p})}}, \quad (13)$$

where w is the number of securities in the event window (or on the observed day) with positive CAR (or AR). (Cowan 1992; Campbell et al. 2010.)

4.2.2 Regression analysis

To further examine the cumulative abnormal returns, a regression analysis is conducted. The aim is to identify possible significant links between the different green bond and issuer characteristics and CARs. In other words, by choosing relevant characteristics, the goal is to explain the positive or negative equity market reaction more comprehensively. Regression analysis also allows us to interpret which type of corporates benefit or disbenefit from the green bond issuance announcements. (Brooks 2014, 640.) A similar approach has also been utilized in previous green bond studies, and some links have been identified (see e.g. Baulkaran 2019; Lebelle et al. 2020). Due to the diverging nature of the use of proceeds in the financial sector, the financial and non-financial corporates are examined as separate groups. Also, this enables highlighting possible differences between the financial and non-financial corporate green bond issuers.

By using ordinary least squares (OLS) regression, the following regression is estimated:

$$\begin{aligned} CAR_i(t_1, t_2) = {} & \beta_0 + \beta_1 AMTISSUED_i + \beta_2 COUPON_i + \beta_3 MATURITY_i + \\ & \beta_4 FIRST\_D_i + \beta_5 SIZE_i + \beta_6 LEVERAGE_i + \\ & \beta_7 PROFITABILITY_i + \beta_8 GROWTH_i + \beta_9 ESG_i + \\ & Country\_FE + Year\_FE + \varepsilon_i, \end{aligned} \quad (14)$$

where the dependent variable CAR_i is the cumulative abnormal return for an event window. For robustness, different event windows for CARs are tested. The explanatory variables are different green bond and issuer characteristics. Green bond characteristics include $AMTISSUED$, $COUPON$, $MATURITY$, and $FIRST\_D$, out of which the last is a dummy variable, also known as a qualitative variable. Issuer characteristics include $SIZE$, $LEVERAGE$, $PROFITABILITY$, $GROWTH$, and ESG. $\beta_0, \beta_1, \dots, \beta_9$ are the coefficient estimates which quantify the effect of each explanatory variable. $Country\_FE$ and $Year\_FE$ are country and year fixed effect dummy variables (Brooks 2014, 529). The fixed effects are added to account for the leftover variation that is due year and country-specific factors. Similar approach was used by, for example, Lebelle et al. (2020).

ε_i is an error term that sweeps up any influences on the CARs that are not captured by the explanatory variables. (Brooks 2014, 135, 157, 684.)

Table 6 Explanatory variables

Green bond characteristics	
AMTISSUED	The natural logarithm of the green bond amount issued in USD million.
COUPON	The coupon rate of the green bond.
MATURITY	The natural logarithm of the maturity of the green bond in years.
FIRST_D	Dummy variable equal to 1 if the green bond is the first for the issuer and 0 if the green bond is subsequent.
Issuer characteristics	
SIZE	The natural logarithm of the issuer's total assets the fiscal year prior to the issuance announcement in USD million.
LEVERAGE	The ratio between issuer's total liabilities and total assets the fiscal year prior the issuance announcement.
PROFITABILITY	Measured by Return on Assets (ROA) the fiscal year prior to the issuance announcement. ROA is calculated as the income after taxes for the fiscal period divided by the average total assets at the beginning and at the end of the year.
GROWTH	Measured by Tobin's Q the fiscal year prior to the issuance announcement. Tobin's Q is calculated by summing up the market value of equity and the book value of debt and dividing it by the book value of assets.
ESG	The Refinitiv® ESG Score.

Table 6 provides detailed descriptions of the explanatory variables. Logarithmic transformation is done to the AMTISSUED, MATURITY and SIZE variables, as it reduces heteroscedasticity and makes skewed distribution closer to a normal distribution (Brooks 2014, 34). The measure used as a proxy for the profitability of the issuer in the PROFITABILITY variable is the return on assets (ROA). Similarly to Baulkaran (2019), Tobin's Q is used as a proxy for the issuer's growth opportunities in the GROWTH variable. The currency for the regression analysis is USD, meaning that the CARs used

as the dependent variable are from an event study conducted in USD.[22] Thus, all the explanatory variables are calculated using USD to make the values more uniform and comparable.

Table 7 Descriptive statistics for regression variables

This table presents descriptive statistics for the regression variables. Panel A displays the descriptive statistics for the group with non-financial corporates. Panel B displays the descriptive statistics for the group with financial corporates.

	Mean	Median	Stdev	Kurtosis	Skewness	Min	Max
Panel A: Non-Financials (N = 332)							
AMTISSUED	5.249	5.365	1.236	–0.950	–0.291	1.920	7.824
COUPON	1.941	1.875	1.444	0.113	0.614	0.000	7.637
MATURITY	2.016	1.900	0.690	10.689	1.610	0.700	6.900
FIRST_D	0.449	0.000	0.498	–1.969	0.207	0.000	1.000
SIZE	9.801	9.597	1.288	0.460	0.684	6.419	13.470
LEVERAGE	0.613	0.606	0.141	–0.510	0.014	0.258	0.948
PROFITABILITY	0.043	0.033	0.040	2.724	0.896	–0.122	0.205
GROWTH	1.080	0.928	0.657	14.812	3.354	0.324	5.816
ESG	60.755	64.905	20.313	–0.318	–0.693	5.861	93.934
Panel B: Financials (N = 228)							
AMTISSUED	5.288	6.215	1.904	6.460	–1.899	–5.139	8.329
COUPON	1.560	0.953	1.692	3.673	1.759	0.000	8.850
MATURITY	1.749	1.700	0.540	4.685	0.487	–0.300	3.500
FIRST_D	0.399	0.000	0.491	–1.844	0.415	0.000	1.000
SIZE	12.752	12.929	1.630	–0.969	–0.405	8.543	15.447
LEVERAGE	0.906	0.932	0.076	6.471	–2.573	0.558	0.967
PROFITABILITY	0.009	0.006	0.010	12.478	2.843	-0.007	0.074
GROWTH	0.289	0.194	0.249	9.070	2.486	0.054	1.836
ESG	71.194	74.982	17.506	0.085	–0.910	20.825	94.811

Table 7 displays the descriptive statistics for the regression variables. The statistics are presented for both non-financial and financial sector groups. The green bond characteristics are similar to both groups, except for the MATURITY variable. The maturity of green bonds issued by non-financial corporates tends to be higher than those by financial corporates. A higher positive kurtosis and skewness of some variables indicates that the distributions have a long and 'fat' right tails (Brooks 2014, 66–67). From the issuer characteristics, the LEVERAGE variable has a notable difference between the two groups. The financial sector corporates are more leveraged than the non-

[22] The descriptive statistics for the used CARs are displayed in appendices.

financial corporates. Higher leverage is common for financial corporates as they typically borrow capital from those with a surplus to invest and lend to those in need (Ingves 2014). Thus, they also typically issue green bonds to lend capital for other corporates' green projects (Lebelle et al. 2020; Wang et al. 2020; Fatica et al. 2021). Other noteworthy differences between the groups are in GROWTH and ESG variables. The non-financial corporates have higher Tobin's Q values indicating bigger growth opportunities. The ESG scores are lower for the non-financial sector, suggesting that ESG creditors see them as less sustainable, although the scores are still relatively high.

Table 8 presents correlation matrices for both financial and non-financial sector regression groups. The correlation matrix serves as one way of estimating multicollinearity in the regression model. An assumption in the OLS estimation is that the explanatory variables are not correlated with one another. If a correlation is present, removing a correlated variable from the regression would cause the coefficients of the other variables to change. However, in practice, the correlation between variables will be non-zero, and a problem occurs only when there is a high correlation. Perfect multicollinearity would arise when two or more variables have an exact relationship meaning that one regressor is a perfect linear function of the other regressor(s). In this case, computing the OLS estimates would be impossible. (Brooks 2014, 217–218; Stock & Watson 2020, 226.) However, this is not the case in this study.

Although perfect multicollinearity is not present, some of the variables have a higher correlation with each other. For the non-financial group, AMTISSUED and SIZE have a correlation of 0.55. It can be explained by the fact that larger corporates tend to issue more sizeable green bonds as they might have bigger-scale green projects that need debt financing. The financial group has a few strong correlations between the issuer characteristics. The highest correlation is between PROFITABILITY and LEVERAGE, which suggests that when financial corporates' leverage increases, the profitability decreases and vice versa. A strong correlation is also detected between GROWTH, LEVERAGE and PROFITABILITY, indicating that when the leverage ratio increase, growth opportunities decrease, whereas an increase in profitability increases growth opportunities. Also, the SIZE variable is positively correlated with LEVERAGE, meaning that the bigger the bank the higher the leverage ratio, and negatively correlated with PROFITABILITY and GROWTH. To further address the multicollinearity, the variance inflation factors (VIFs) are discussed in the result section.

Table 8 Correlation matrices

This table presents correlation matrices for the explanatory variables of the two regression groups. Panel A displays a correlation matrix for the variables used in regressions for non-financial corporates. Panel B displays a correlation matrix for the variables used in regressions for financial corporates.

Panel A: Non-Financials									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) AMTISSUED	1								
(2) COUPON	0.077	1							
(3) MATURITY	0.423***	0.059	1						
(4) FIRST_D	0.009	–0.105*	–0.036	1					
(5) SIZE	0.547***	–0.124**	0.325***	–0.044	1				
(6) LEVERAGE	0.269***	0.023	0.089	–0.003	0.341***	1			
(7) PROFITABILITY	–0.124**	–0.078	–0.095*	–0.079	–0.092*	–0.314***	1		
(8) GROWTH	0.051	–0.095*	–0.001	0.057	–0.044	–0.318***	0.391***	1	
(9) ESG	0.365***	–0.155***	0.205***	–0.061	0.183***	–0.129**	0.205***	0.114**	1
Panel B: Financials									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) AMTISSUED	1								
(2) COUPON	0.016	1							
(3) MATURITY	0.057	–0.063	1						
(4) FIRST_D	0.166**	0.039	–0.009	1					
(5) SIZE	0.169**	–0.229***	–0.032	–0.250***	1				
(6) LEVERAGE	–0.016	–0.043	–0.036	–0.087	0.473***	1			
(7) PROFITABILITY	–0.022	0.191***	–0.051	0.081	–0.517***	–0.853***	1		
(8) GROWTH	0.053	0.055	0.001	0.117***	–0.494***	–0.782***	0.727***	1	
(9) ESG	–0.080	–0.326***	0.296***	–0.279***	0.239***	–0.098	–0.065	0.035	1

Significance levels: * p < 10% ** p < 5% *** p < 1%

5 Results and discussion

5.1 Event study

The event study was conducted using two approaches. The first approach was calculating market model abnormal returns in local currencies, and the second was the same with the difference of converting all the values into USD. Figure 4 illustrates the differences between average abnormal returns (AARs) and cumulative average abnormal returns (CAARs) over the 41-day event window [–20, +20] using local currency and USD approaches. Using USD as a common currency to calculate the abnormal returns in a multi-country setting appears to make the results slightly inflated. Overall, the AARs follow the same pattern between both approaches with only slight differences. The inflated effect of the common currency is illustrated better by the CAARs. CAARs calculated with values converted to the USD are more extreme than the ones calculated using local currencies. However, overall, the results between the two approaches have only minor differences and lead to similar inferences. Therefore, this chapter presents the rest of the event study results from the local currency approach.[23]

In addition to reflecting differences in the use of local and common currency in the event study, Figure 4 illustrates the initial results for the main objective of the event study, the equity market reaction to the green bond issuance announcement. AAR is negative on the announcement date 0. However, AAR spikes nine days before the event and stays positive for a few days after, which might indicate some information leakage before the event. The reason can be that investors in the equity market have received information about green bond issuance from other communication channels and thus anticipated the event before the official announcement. On the other hand, the reason may also relate to the accuracy of the first announcement date available in the Refinitiv Eikon database. Regardless, the equity market reaction appears to be positive. The positive reaction is visualized better with the CAARs over the event window [–20, +20], which stays positive from seven days prior to five days after the event. However, it is important to point out that the positive impact is very short-term, and the cause for the positive CAARs around the event is the positive spike in AARs prior to the announcement.

[23] The overall results from the USD approach are presented in the appendices.

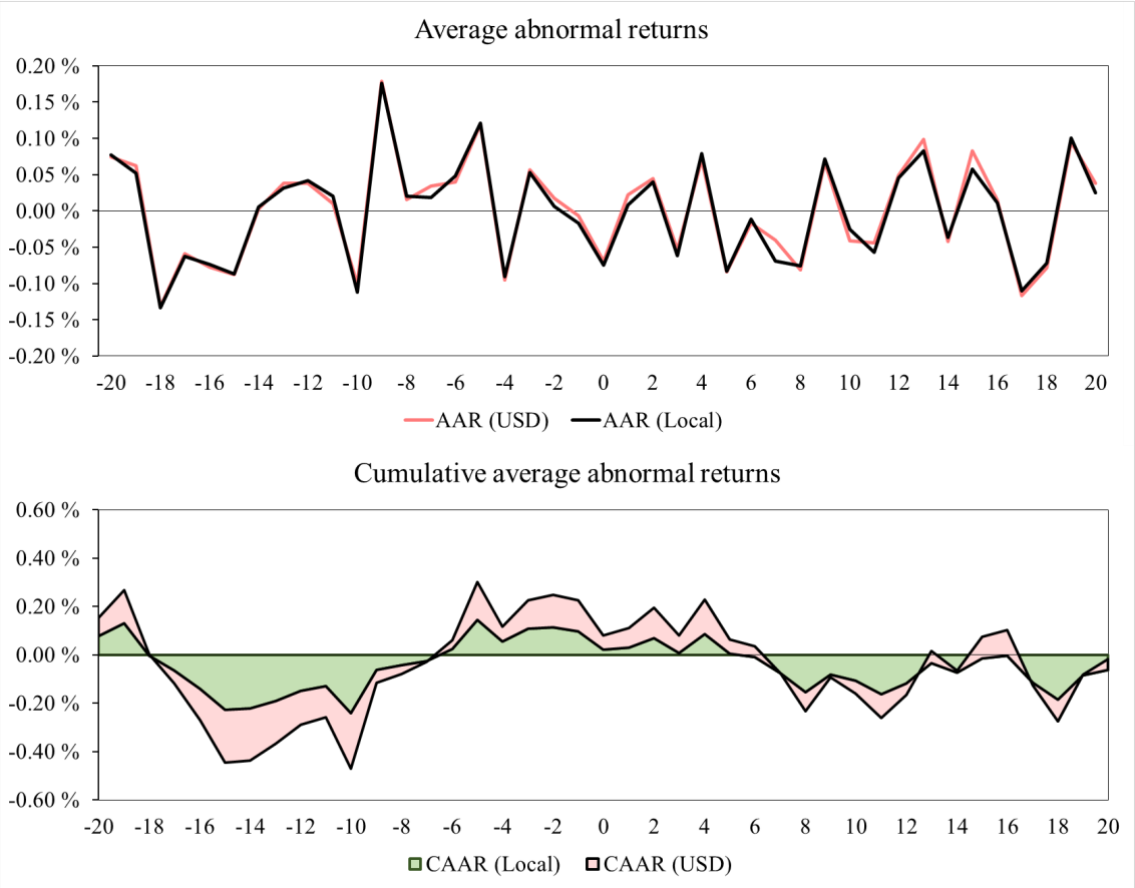

Figure 4 Abnormal returns using local currency vs. USD

Table 9 provides a more in-depth representation of the daily abnormal returns over the 11-day baseline window [–5, +5] for the total green bond sample. Five days before the green bond issuance announcement, the AAR is significant and positive, as indicated in the graphs above, with a value of 0.121%. The parametric t-test for the result is significant at a 10% significance level, and the non-parametric generalized sign test is significant at a 5% level. The sign test practically tests whether the number of positive ARs departs from the expected amount of positive values estimated from the estimation period. Hence, the 'Pos:Neg' column shows that the number of positive values on the day –5 is greater than for the other days. Otherwise, the values for daily AARs are small and statistically insignificant, although, on the event date, the AAR is negative with a value of –0.075%. The standard deviations are similar for all the days and do not suggest significantly different reactions in the daily ARs.

Table 9 Daily abnormal returns

This table presents the daily abnormal returns (ARs) and their means (AARs), medians, standard deviations, minimums, and maximums for the 11-day baseline event window [–5,+5] for the total green bond sample (N=564). The values are displayed in percentages. Additionally, the number of positive and negative abnormal returns for each day is reported in a separate column. The last two columns present the statistical tests for the daily abnormal returns. The t-test is the cross-sectional parametric test, and the sign test is the non-parametric generalized sign test.

Day	AAR	Median	Stdev	Min	Max	Pos:Neg	t-test	Sign test
–5	0.121	0.059	1.559	–10.065	8.820	302:262	1.850*	2.049**
–4	–0.091	–0.105	1.374	–5.378	6.936	265:299	–1.568	–1.067
–3	0.053	–0.070	1.445	–5.344	8.679	270:294	0.868	–0.646
–2	0.006	0.008	1.332	–7.059	6.764	286:278	0.107	0.702
–1	–0.017	0.048	1.458	–8.461	5.903	287:277	–0.278	0.786
0	–0.075	–0.054	1.438	–6.774	7.179	270:294	–1.240	–0.646
+1	0.008	0.047	1.381	–5.641	9.400	294:270	0.136	1.375
+2	0.040	0.047	1.501	–7.255	13.537	293:271	0.628	1.291
+3	–0.061	–0.029	1.500	–12.260	7.695	275:289	–0.973	–0.225
+4	0.079	0.013	1.418	–5.331	10.034	286:278	1.327	0.702
+5	–0.083	–0.062	1.379	–7.602	6.520	268:296	–1.427	–0.815

Significance levels: * p < 10% ** p < 5% *** p < 1%

Table 10 aggregates the AARs in the form of CAARs for four event windows, a pre-event window, and a post-event window. The results are not statistically significant, which is expected as only one result is significant in Table 9. Despite the insignificance, they provide some additional indication of the equity market reaction over different intervals. For example, the potential information leakage before the green bond issuance announcement is supported by and detectable from the 10-day pre-event window [–10, –1]. The pre-event window CAAR is positive with a value of 0.224%. The CAARs of other windows are considerably smaller and range from both sides to zero. However, only one of the actual event windows has a positive CAAR. It is a 21-day window [-10, +10], which also benefits from the possible information leakage. The baseline event window [–5, +5] and the shortest event window [–1, +1] both have negative CAARs indicating a negative equity market reaction near the observed green bond issuance announcement date.

Table 10 Cumulative average abnormal returns

This table presents the cumulative average abnormal returns (CAARs) for different windows for the total green bond sample (N=564). Medians, standard deviations, minimums, and maximums for the cumulative abnormal returns (CARs) are also presented. The values are displayed in percentages. [–10, –1] is the 10-day pre-event window and [+10, +20] is the 11-day post-event window. The other windows are the actual event windows. Additionally, the number of positive and negative CARs is displayed. The last two columns present the statistical tests for the cumulative abnormal returns in each event window. The T-test is the cross-sectional parametric test, and the sign test is the non-parametric generalized sign test.

Window	CAAR	Median	Stdev	Min	Max	Pos:Neg	t-test	Sign test
[–10, –1]	0.224	0.277	4.692	–22.370	25.704	292:272	1.136	1.207
[–20, +20]	–0.061	0.018	9.568	–52.049	33.242	282:282	–0.153	0.365
[–10, +10]	0.021	0.153	6.973	–49.601	37.901	285:279	0.073	0.617
[–5, +5]	–0.020	0.119	4.698	–22.275	27.474	292:272	–0.101	1.207
[–1, +1]	–0.084	–0.082	2.328	–12.672	13.020	272:292	–0.860	–0.478
[+10, +20]	0.021	–0.142	4.406	–23.085	26.021	270:294	0.112	–0.646

Significance levels: * p < 10% ** p < 5% *** p < 1%

Overall, the findings from the event study using the total green bond sample are not unambiguous. However, there is a fairly strong indication that the shares of the issuers experience positive abnormal returns before the green bond issuance announcement date. This suggests that the equity market reacts positively to the issue of the green bond, but there may be some kind of anticipation or information leakage regarding the announcement. Also, as mentioned earlier, the date available in Refinitiv Eikon may be inaccurate. Baulkaran (2019) also reports a negative AAR on the event date, but all the CAARs for observed event windows are positive. Thus, the results resemble the findings of this study in some ways by suggesting information leakage before the announcement.

The results are compared between different subsamples and regions to utilize the full potential of the global dataset and make the event study analysis more comprehensive. First, Table 11 compares the event study results by splitting the total sample in three ways. Panel A displays the results for financial and non-financial sector corporates. Similarly to Tang and Zhang (2020) and Lebelle et al. (2020), the comparison is done due to the diverging natures in the use of proceeds. For the most part, the results are contradictory and suggest a more positive and significant reaction to the green bond issuance announcement for non-financial corporates. It is seen especially over the shortest event window [–1, +1], where financial corporates experience a negative abnormal return of –0.295% at a 10% significance level measured with the t-test. However, a positive reaction, although much more significant for the non-financials, is detectable for both groups in

the pre-event window indicating information leakage. The results resemble the findings by Tang and Zhang (2020), suggesting a stronger positive reaction for non-financial corporates.

Table 11 Comparison between subsamples

This table presents the cumulative average abnormal returns (CAARs) for different subsamples over different windows. The subsamples are formed by splitting the total sample based on different characteristics. Panel A displays the CAARs for financial and non-financial sectors. The split is based on The Refinitiv® Business Classification (TRBC) Economic Sectors. Panel B displays the CAARs for first-time and subsequent green bond issuances. Panel C displays CAARs for green bonds issued in advanced economies and for emerging markets & developing economies. The split is based on International Monetary Fund's (IMF) country classification (IMF 2022b). The CAAR values are displayed in percentages. The T-test is the cross-sectional parametric test, and the sign test is the non-parametric generalized sign test.

Panel A: Financial Sector vs. Other Sectors						
	Financial Sector (N = 230)			Non-Financial Sectors (N = 334)		
	CAAR	t-test	Sign test	CAAR	t-test	Sign test
[–10, –1]	0.066	0.229	–0.231	0.333	1.246	1.760*
[–20, +20]	0.372	0.638	1.088	–0.360	–0.656	–0.429
[–10, +10]	0.214	0.503	0.956	–0.111	–0.277	0.009
[–5, +5]	–0.082	–0.255	–0.231	0.023	0.092	1.760*
[–1, +1]	–0.295	–1.810*	–1.155	0.061	0.505	0.337
[+10, +20]	–0.062	–0.218	–1.287	0.077	0.315	0.228
Panel B: First-time vs. Subsequent						
	First-time (N = 242)			Subsequent (N = 322)		
	CAAR	t-test	Sign test	CAAR	t-test	Sign test
[–10, –1]	0.206	0.663	1.224	0.238	0.932	0.537
[–20, +20]	–0.035	–0.058	–0.062	–0.081	–0.151	0.537
[–10, +10]	0.229	0.521	0.324	–0.135	–0.342	0.537
[–5, +5]	0.267	0.842	1.995**	–0.235	–0.937	–0.132
[–1, +1]	–0.227	–1.605	–0.962	0.023	0.169	0.202
[+10, +20]	0.014	0.051	–0.448	0.026	0.103	–0.467
Panel C: Advanced Economies vs. Emerging & Developing Markets						
	Advanced Economies (N = 502)			Emerging & Developing (N = 62)		
	CAAR	t-test	Sign test	CAAR	t-test	Sign test
[–10, –1]	0.217	1.050	1.453	0.286	0.433	–0.496
[–20, +20]	–0.218	–0.514	–0.332	1.206	0.958	2.050**
[–10, +10]	–0.098	–0.321	0.293	0.990	1.010	1.031
[–5, +5]	–0.161	–0.776	0.293	1.119	1.763*	2.813***
[–1, +1]	–0.103	–1.000	–0.243	0.071	0.232	–0.751
[+10, +20]	0.038	0.196	–0.511	–0.123	–0.210	–0.496

Significance levels: * p < 10% ** p < 5% *** p < 1%

Panel B in Table 11 compares the results between first-time and subsequent green bond issuances. A similar comparison was done by Tang and Zhang (2020), Lebelle et al. (2020) and Flammer (2021). A notable difference is seen over the baseline event window [–5, +5], where the CAAR is positive and significant for the first-time issuances with a value of 0.267% at a 5% significance level measured with the sign test. For the subsequent issuances, the result is insignificant but negative with a value of –0.235%. The results resemble the studies by Tang and Zhang (2020) and Flammer (2021), suggesting a more positive reaction for first-time issuances. It can be expected as the information of green bonds is entering the market for the first time in the first-time issuance. However, the result is the opposite when viewing the window [-1, +1], which may be due to the early reaction. Also, when looking at the pre-event window, the reaction is positive for both groups and even slightly higher for the subsequent issuances. It, again, supports the information leakage finding.

Similarly to Lebelle et al. (2020), Panel C in Table 11 compares the results between advanced economies and emerging & developing markets. Again, both of the groups experience positive CAARs over the pre-event window. However, the event windows reveal a substantial difference. Advanced economies experience negative CAARs over all the event windows, whereas emerging & developing markets have much higher and positive CAARs. In the baseline window [–5, +5], the positive CAAR of 1.119% is also statistically significant at a 10% level measured with the t-test and significant at a 1% level measured with the sign test. Although the figures reported by Lebelle et al. (2020) are negative for both groups, the results are consistent in that the negative reaction was less negative for emerging & developing markets. However, it is also worth noting that the advanced economy group contains 502 observations, while the development & emerging markets group contains only 62. As the number of observations increases in the event study, abnormal returns tend to approach zero, while in smaller samples possible outliers may cause some bias in the result.

To the best of my knowledge, no previous studies have reported regional differences in the equity market reaction to the green bond issuance announcement. Thus, Table 12 presents event study results for the three leading regions involved in the green bond markets. These are Europe, Asia-Pacific, and North America. Since the diverging nature of financial corporates' use of proceeds, on top of providing the total results, the results are also reported excluding the financial sector to add robustness. Panel A displays the

results of the equity market reaction to European green bond issuance announcements. The results are overall insignificant and negative. Even the earlier identified positive reaction over the pre-event window is practically non-existent. Thus in Europe, the equity market seems to react negatively to the green bond issuance announcement. One reason could be investor scepticism considering the validity of green bonds in Europe. Investors may not be confident that the issuers would use the proceeds as they should. It may be due, for example, to the voluntary nature of different standards. On the other hand, Europe can already be seen as a forerunner of the green transition[24] and as a result, investors may not have a particular incentive to find new, sustainable investments from Europe.

The results of North America presented in Panel C are generally in line with the results observed from Europe. The results are not statistically significant and are negative for all event windows. However, there is a great difference between pre-event and post-event windows, with both showing positive reactions. The CAAR over the pre-event window could indicate that investors in North America do react positively to the green bond issuance announcement but with anticipation. Although the CAARs are also positive over the post-event window, the negative sign test value proposes that there are more negative than positive CARs. Thus, the positive mean is likely caused by some exceptionally positive abnormal returns after the issuance. Overall in North America, the equity market reaction is positive over days before and negative around the event, although statistically insignificant.

A significant difference is distinguished in the equity market reaction in Asia-Pacific, reported in Panel B. For Asia-Pacific, the CAAR is positive over all the windows except for the shortest event window for the total sample. The baseline window [–5, +5] indicates a positive CAAR of 0.484% at a 10% significance level measured with the sign test. Furthermore, when excluding the financial corporates, the CAAR jumps to 1.025% at a 5% significance level measured with the t-test and a 10% level measured with the sign test. Also, the CAAR of 1.433% over the event window [–10, +10] for the sample excluding financials is significant at a 10% level measured with the t-test. The results from Asia-Pacific are mostly led by observations from China. It has recently done the most substantial updates to the national green bond standards, and it seems that the investors have more confidence in the Chinese green bond issuer. China is also part of

[24] See e.g. Forbes (2021).

the emerging markets, which partly explains the positive CAAR observations in the emerging & developing markets in Table 11. Overall, the results indicate a strong positive equity market reaction to green bond issuance announcements in Asia-Pacific. Thus, the result is consistent with the findings of Wang et al. (2020), suggesting a positive reaction in China.

Table 12 Comparison between regions

This table presents the cumulative average abnormal returns (CAARs) for different regions over different windows. The results are shown for the total samples and samples excluding the financial sector. Panel A displays the CAARs for Europe, Panel B for Asia-Pacific, and Panel C for North America. The CAAR values are displayed in percentages. The t-test is the cross-sectional parametric test, and the sign test is the non-parametric generalized sign test.

Panel A: Europe						
	Total (N = 289)			Excluding Financial Sector (N = 153)		
	CAAR	t-test	Sign test	CAAR	t-test	Sign test
[–10, –1]	0.047	0.177	0.458	–0.003	–0.008	0.796
[–20, +20]	–0.406	–0.699	–0.013	–1.074	–1.287	–0.175
[–10, +10]	–0.307	–0.722	0.340	–0.885	–1.459	0.149
[–5, +5]	–0.215	–0.775	–0.601	–0.415	–1.188	0.472
[–1, +1]	–0.049	–0.361	–0.484	0.080	0.512	0.472
[+10, +20]	–0.205	–0.766	0.105	–0.174	–0.453	0.957
Panel B: Asia-Pacific						
	Total (N = 162)			Excluding Financial Sector (N = 96)		
	CAAR	t-test	Sign test	CAAR	t-test	Sign test
[–10, –1]	0.406	1.002	0.167	0.893	1.502	0.865
[–20, +20]	0.845	1.149	1.267	1.503	1.372	0.660
[–10, +10]	0.678	1.254	0.167	1.433	1.799*	0.252
[–5, +5]	0.484	1.427	1.739*	1.025	2.082**	1.886*
[–1, +1]	–0.115	–0.609	–0.462	0.198	0.799	0.048
[+10, +20]	0.302	0.903	–0.777	0.367	0.728	–0.565
Panel C: North America						
	Total (N = 101)			Excluding Financial Sector (N = 84)		
	CAAR	t-test	Sign test	CAAR	t-test	Sign test
[–10, –1]	0.444	1.017	1.621	0.230	0.472	1.393
[–20, +20]	–0.528	–0.577	–0.569	–1.159	–1.265	–1.226
[–10, +10]	–0.139	–0.213	0.426	–0.440	–0.657	–0.353
[–5, +5]	–0.368	–0.691	1.223	–0.358	–0.727	0.738
[–1, +1]	–0.158	–0.673	0.227	–0.157	–0.599	–0.135
[+10, +20]	0.290	0.738	–0.768	0.192	0.530	–0.353

Significance levels: * p < 10% ** p < 5% *** p < 1%

5.2 Regression analysis

The regression model was tested with three different event windows for the non-financial and financial groups to highlight possible links between the cumulative abnormal returns (CARs) caused by the green bond issuance announcement and several green bond and issuer characteristics. Additionally, the regression model was tested for the three leading regions in the green bond markets to highlight possible regional differences. White's test was used to test the regressions for heteroscedasticity (White 1980). Heteroscedasticity is present if the variance of the errors is not constant throughout the sample. If this was the case, any inferences made could be misleading. (Brooks 2014, 181, 185.) For the most part, White's test did not suggest an alarming level of heteroscedasticity. However, for a few of the regressions, some heteroscedasticity was detected. The White's test results are reported separately in each result table. Multicollinearity was already addressed with the correlation matrices. However, to further analyse the multicollinearity of the regression models, the variance inflation factors (VIFs) of the independent variables were interpreted. Overall, the VIFs did not show signs of harmful multicollinearity[25].

The regression results for the non-financial group are presented in Table 13. Regression 1 includes all the explanatory variables, whereas Regressions 2 and 3 are conducted to capture the effect of the green bond (2) and issuer (3) characteristics on the CARs. For the most part, the results are insignificant. The GROWTH variable has some significance when using CARs for the event window [–10, +10] as the dependent variable. However, the reported White's tests indicate the presence of heteroscedasticity, and therefore, these results may be misleading. Also, the AMTISSUED, SIZE and LEVERAGE show some significance in Regression 1. However, when the bond and issuer characteristics are regressed separately, the significance of the results diminishes. Also, the R-squared (R^2), which measures how well the explanatory variables explain the variance of CARs, is very low for all the tested regressions (Stock & Watson 2020, 223). Thus, the results in Table 13 suggest that there are no significant links between the CARs and the characteristics of green bond and issuers in the non-financial group.

[25] A general rule of thumb is that a VIF over 10 is a sign of harmful multicollinearity (CFI 2022).

Table 13 Regression results for non-financial group

This table presents the regression results for non-financial sector observations. Regression 1 includes all the variables, Regression 2 includes only green bond characteristics, and Regression 3 only issuer characteristics. T-statistics are in parentheses. χ^2 is the chi-squared test statistic from White's heteroscedasticity test.

	Regression 1			Regression 2			Regression 3		
	[–10, +10]	[–5, +5]	[–1, +1]	[–10, +10]	[–5, +5]	[–1, +1]	[–10, +10]	[–5, +5]	[–1, +1]
Intercept	–0.113	–0.165	–0.010	–0.195	–0.095	0.026	–0.150	–0.285	–0.045
	(–0.243)	(–0.573)	(–0.070)	(–0.435)	(–0.342)	(0.194)	(–0.335)	(–1.024)	(–0.328)
AMTISSUED	–0.004	–0.006*	–0.002*	–0.000	–0.002	–0.001			
	(–0.797)	(–1.927)	(–1.673)	(–0.043)	(–0.687)	(–1.261)			
COUPON	–0.002	0.001	0.000	–0.003	0.000	–0.000			
	(–0.583)	(0.330)	(–0.355)	(–0.882)	(–0.040)	(–0.470)			
MATURITY	0.000	–0.001	0.001	0.002	0.001	0.001			
	(–0.007)	(–0.139)	(0.401)	(0.270)	(0.134)	(0.594)			
FIRST_D	0.005	0.003	–0.004	0.003	0.002	–0.004			
	–0.639	(0.654)	(–1.435)	(0.375)	(0.457)	(–1.493)			
SIZE	0.007*	0.003	0.000				0.006	0.001	–0.000
	(1.661)	(1.331)	(0.245)				(1.573)	(0.356)	(–0.438)
LEVERAGE	–0.008	0.038*	0.010				–0.013	0.033	0.007
	(–0.219)	(1.788)	(0.978)				(–0.367)	(1.547)	(0.702)
PROFITABILITY	–0.019	–0.052	–0.040				–0.005	–0.029	–0.024
	(–0.162)	(–0.711)	(–1.106)				(–0.043)	(–0.404)	(–0.679)
GROWTH	–0.015**	–0.004	–0.001				–0.015**	–0.005	–0.002
	(–2.102)	(–0.842)	(–0.567)				(–2.214)	(–1.185)	(–0.997)
ESG	0.000	0.000	0.000				0.000	0.000	0.000
	–0.293	(1.172)	(1.112)				(0.024)	(0.429)	(0.691)
Observations	332	332	332	332	332	332	332	332	332
R^2	0.032	0.040	0.030	0.004	0.003	0.014	0.027	0.026	0.013
χ^2 (White's test)	18.616*	11.386	13.300	6.068	5.946	6.619	14.792**	6.224	11.333
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Significance levels: * p < 10% ** p < 5% *** p < 1%

Table 14 presents the regression results for the financial corporate group. Similarly to the non-financial group, for the most part, the results are insignificant. However, using the event windows [–10, +10] and [–1, +1] as the dependent variables, the SIZE variable shows significance at a 10% level in Regressions 1 and 3. The positive coefficients for the firm size, measured by the issuer's total assets, indicate that the positive equity market reaction is stronger for the green bond issuance announcements when the financial corporates are larger. Another variable with statistical significance is ESG, measured by ESG scores. The coefficient is very close to zero, suggesting that the ESG scores have no linkage to the CARs whatsoever. Again, however, the R-squared (R^2) is very low for all the tested regressions. It indicates that the chosen characteristics have a low explanatory power over the abnormal returns experienced from the green bond issuance announcements and that the effect size is very small.

Overall, there is a notable lack of statistical significance in Tables 13 and 14. Thus, it seems that for the non-financial and financial groups, the CARs around the green bond issuance announcement have no clear dependency on the chosen characteristics. The finding is somewhat contrary to the previous research. For example, Lebelle et al. (2020) results suggest that issuers with more growth opportunities have reduced negative reactions to green bond issuance. Also, Baulkaran (2019) found growth opportunities to have a positive and statistically significant linkage between the CARs. In addition, Although, from the bond characteristics, a higher coupon was found to have a negative linkage between the abnormal returns. In this study, growth opportunities seemed to have some significance for the non-financial group, but with the presence of heteroscedasticity, the results cannot be interpreted with confidence.

Table 14 Regression results for financial group

This table presents the regression results for financial sector observations. Regression 1 includes all the variables, Regression 2 includes only green bond characteristics, and Regression 3 only issuer characteristics. T-statistics are in parentheses. χ^2 is the chi-squared test statistic from White's heteroscedasticity test.

	Regression 1			Regression 2			Regression 3		
	[–10, +10]	[–5, +5]	[–1, +1]	[–10, +10]	[–5, +5]	[–1, +1]	[–10, +10]	[–5, +5]	[–1, +1]
Intercept	–1.204**	–0.504	–0.062	–0.441	–0.162	0.051	–0.986*	–0.404	–0.125
	(–2.072)	(–1.155)	(–0.270)	(–0.987)	(–0.485)	(0.291)	(1.868)	(–1.015)	(–0.598)
AMTISSUED	0.000	0.002	–0.000	0.001	0.002	–0.000			
	(0.114)	(0.883)	(–0.266)	(0.275)	(1.026)	(–0.111)			
COUPON	0.002	–0.000	–0.001	0.001	–0.001	–0.001			
	(0.798)	(–0.132)	(–0.894)	(0.336)	(–0.616)	(–1.347)			
MATURITY	–0.008	–0.005	–0.001	–0.009	–0.005	–0.000			
	(–0.933)	(–0.818)	(–0.147)	(–1.036)	(–0.809)	(–0.078)			
FIRST_D	0.002	0.007	0.001	0.003	0.007	–0.000			
	(0.173)	(0.989)	(0.369)	(0.297)	(1.090)	(–0.115)			
SIZE	0.007*	0.004	0.002				0.006*	0.004	0.003*
	(1.780)	(1.387)	(1.642)				(1.751)	(1.577)	(1.873)
LEVERAGE	–0.054	–0.110	–0.037				–0.036	–0.120	–0.044
	(–0.431)	(–1.164)	(0.748)				(–0.289)	(–1.294)	(–0.894)
PROFITABILITY	–0.414	–0.366	0.304				–0.274	–0.485	0.250
	(–0.448)	(–0.528)	(0.828)				(–0.306)	(–0.719)	(0.703)
GROWTH	–0.002	–0.018	–0.016				–0.000	–0.013	–0.016
	(0.061)	(–0.831)	(–1.394)				(–0.009)	(–0.620)	(–1.409)
ESG	–0.000**	–0.000	–0.000				–0.001**	–0.000*	–0.000
	(–2.294)	(–1.402)	(–0.212)				(–2.105)	(–1.808)	(–0.627)
Observations	228	228	228	228	228	228	228	228	228
R^2	0.04	0.041	0.036	0.008	0.020	0.009	0.033	0.029	0.032
χ^2 (White's test)	9.494	7.069	12.356	7.955	6.010	6.127	7.107	4.469	10.367
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Significance levels: * p < 10% ** p < 5% *** p < 1%

To analyse the linkage between the CARs and the chosen characteristics further, and to make the regression analysis more comprehensive, the top three green bond regions are examined separately. Table 15 presents the regression for the different regions, with both non-financial and financial groups. The results seem to follow the same trend as the statistical significance for the green bond and issuer characteristics is very low. The only significant results at a 10% significance level are for variables FIRST_D and GROWTH in Europe. First-time issuances have a positive coefficient, and growth opportunities have a negative coefficient for European financial corporates. However, since White's test indicates some heteroscedasticity for the financial group regression, the results need to be interpreted with caution. However, for the non-financial group in Europe, the growth opportunities also have a negative coefficient. That is, non-financial corporates with higher growth opportunities experience lower equity market reactions to green bond issuance announcements in Europe. The reason can be, for example, that investors may have scepticism about the sustainability of growth-oriented corporates. In Asia-Pacific and North America, no significant linkages are detected.

In total, results of 24 different regression models are presented. Overall, if anything, the regression analysis results suggest that there is a very minimal linkage between the CARs from the green bond issuance announcement and the bond and issuer characteristics. In other words, the results suggest that investors are not particularly interested in some characteristics of a green bond or their issuers over others. Thus, even if investors may show some interest in listed corporates that issue green bonds, their interest does not seem to reach other factors which would lead to significantly higher or lower abnormal returns. For robustness, regressions were also tested without fixed effects and with different amounts of explanatory variables. However, there were no great differences in the results that would lead to different inferences. The result applies to all the groups analysed.

Table 15 Regional regression results

This table presents regional regression results for non-financial and financial sectors. (1) represents the non-financial sector regression and (2) the financial sector regression. T-statistics are in parentheses. χ^2 is the chi-squared test statistic from White's heteroscedasticity test.

[–5, +5]	Europe		Asia-Pacific		North America	
	(1)	(2)	(1)	(2)	(1)	(2)
Intercept	–0.030	0.523**	–0.347**	–0.192	0.178	–1.326
	(–0.143)	(2.134)	(–2.488)	(–0.927)	(1.226)	(–0.706)
AMTISSUED	–0.003	0.000	–0.009	0.006	–0.014	–0.011
	(–0.631)	(0.189)	(–1.169)	(1.297)	(–0.851)	(–0.507)
COUPON	–0.001	–0.004	0.009	–0.001	0.001	0.121
	(–0.315)	(–1.130)	(1.451)	(–0.149)	(0.222)	(1.395)
MATURITY	–0.000	0.005	–0.001	–0.008	0.000	–0.123
	(–0.008)	(0.554)	(–0.078)	(–0.944)	(0.030)	(–1.878)
FIRST_D	–0.000	0.018*	0.016	0.006	–0.016	0.143
	(–0.012)	(1.699)	(1.430)	(0.693)	(–1.514)	(1.415)
SIZE	0.003	0.007	0.003	–0.001	–0.008	0.114
	(0.600)	(1.473)	(0.427)	(–0.409)	(–1.139)	(1.943)
LEVERAGE	–0.002	–0.097	0.037	0.119	0.04	–2.262
	(–0.057)	(–0.741)	(0.899)	(0.661)	(0.867)	(–1.153)
PROFITABILITY	–0.118	0.295	–0.190	0.608	0.370	–2.795
	(–1.165)	(0.349)	(–0.975)	(0.384)	(2.326)	(–0.198)
GROWTH	–0.027*	–0.050*	–0.004	0.031	–0.010	–0.124
	(–1.718)	(–1.659)	(–0.473)	(0.915)	(–1.038)	(0.583)
ESG	0.000	–0.000	0.000	–0.000	0.000	0.004
	(0.983)	(–1.206)	(1.243)	(–1.415)	(0.072)	(0.664)
Observations	151	134	96	66	84	17
R^2	0.080	0.108	0.211	0.133	0.134	0.620
χ^2 (White's test)	12.010	17.420*	21.453**	12.051	7.969	12.643
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Significance levels: * p < 10% ** p < 5% *** p < 1%

6 Conclusions

This thesis has examined how the equity market reacts to green bond issuance announcements of listed corporates. In other words, the aim was to see how investors in the equity market react to the information about green bond issuances. The scope of the study was global. The second objective was to investigate possible links between the abnormal returns caused by the green bonds and different bond and issuer characteristics. First, the sustainable finance movement was discussed, to give the reader an explicit background to the topic. Second, the relationship between sustainable finance and the debt capital markets was considered, and after this, the current sustainable debt instruments, other than green bonds, were introduced.

The green bonds were discussed extensively by first giving a detailed definition and then moving on to the global green bond market development. The green bond market has seen considerable popularity growth in recent years. It has also led to an increasing need for better principles, standards and regulations. Thus, to give a better understanding of the current state of green bonds, the most notable green bond principles, standards and regulations were discussed. Since the green bond is still a new and evolving sustainable debt instrument, there are also existing challenges and problems, such as the risk of greenwashing. These were also discussed, by also highlighting the differences in different parts of the world. Before moving to the empirical study, similar previous studies were introduced.

In total, 564 corporate green bond observations from 31 countries and ten economic sectors were selected for the empirical study with specific criteria. The first part of the study was an event study using a market model approach. It was conducted in two ways by using local currencies and USD as a common currency. The results suggest that both approaches lead to similar results with no diverging inferences. The equity market reaction to the green bond issuance announcement is not entirely unambiguous but tends to lean more toward the positive reaction. A key finding is that the listed issuers experience positive CARs over the 10-day pre-event window [–10, –1] when analysing the total sample. The same result was also seen in the examined subsamples, although not statistically significant. A stronger and more positive reaction was detected for the non-financial corporates, first-time issuances, and issuers in emerging & developing markets. Regionally, the most significant finding was a strong positive reaction for the non-

financial corporates in Asia-Pacific. The worst reaction was detected in Europe. The regression results overall showed little to no linkage between the CARs and the green bond and issuer characteristics. The result was the same for non-financial and financial corporates and different regions.

The results of this study had some similarities to the previous studies. However, it also discovered some new findings and highlighted more regional differences. The overall findings suggest that the equity market reaction can be either positive or negative depending on, for example, the issuer's sector and geographical location. In addition, the different characteristics of bonds and issuers do not appear to have a strong link to abnormal returns. However, the results are not yet entirely clear, and the need for future research persists as the amount of available green bond data increases. The rapid changes in the green bond market regulations are also constantly changing the operational environment. Possible improvements in the quality of available data will also likely enhance future research. To date, the data imposes some limitations on the quality, as there are multiple providers with some inconsistencies. In the future, other sustainable debt instruments might also serve as an intriguing research topic in finance as they grow and develop alongside green bonds.

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Appendices

Appendix 1 Used market indices

Country	Used Market Index
Australia	Standard and Poor's / Australian Stock Exchange 300
Austria	Austrian Traded Index
Belgium	Belgium 20
Brazil	Brazil Bovespa
Canada	Standard and Poor's / Toronto Stock Exchange Composite Index
Chile	FTSE Chile
China (Mainland)	Shanghai Shenzhen CSI 300
Denmark	OMX Copenhagen (OMXC)
Finland	OMX Helsinki (OMXH)
France	France CAC 40
Germany	Prime All Share (Xetra)
Greece	Athex Composite
Hong Kong	Hang Seng
India	Nifty 500
Ireland	Iseq All Share Index
Italy	FTSE MIB Index
Japan	TOPIX
Netherlands	AEX All Share
New Zealand	Standard and Poor's / NZX 50
Norway	Oslo Exchange All Share
Poland	FTSE Poland
Portugal	Portugal PSI All-Share
South Africa	FTSE / JSE All Share
Spain	IBEX 35
Sweden	OMX Stockholm (OMXS)
Switzerland	Swiss Market (SMI)
Taiwan	Taiwan Stock Exchange Weighed TAIEX
Turkey	FTSE Turkey
UAE	FTSE United Arab Emirates
United Kingdom	FTSE All Share
US	Standard and Poor's 500 Composite

Appendix 2 Results from event study using USD as common currency

Daily abnormal returns

Day	AAR	Median	Stdev	Min	Max	Pos:Neg	t-test	Sign test
–5	0.119	0.084	1.551	–9.791	8.915	297:267	1.826*	1.643
–4	–0.095	–0.082	1.374	–5.378	6.749	261:303	–1.644	–1.389
–3	0.056	–0.040	1.455	–5.292	9.020	267:297	0.920	–0.884
–2	0.017	0.026	1.341	–6.960	6.764	289:275	0.306	0.969
–1	–0.007	0.060	1.470	–8.343	5.929	289:275	–0.109	0.969
0	–0.069	–0.064	1.468	–6.779	6.729	270:294	–1.123	–0.631
+1	0.022	0.050	1.382	–5.672	9.495	294:270	0.374	1.390
+2	0.045	0.067	1.526	–7.050	13.732	301:263	0.698	1.980**
+3	–0.053	0.002	1.475	–10.264	7.700	282:282	–0.852	0.380
+4	0.070	–0.030	1.409	–5.279	9.318	275:289	1.187	–0.210
+5	–0.084	–0.069	1.388	–7.602	6.933	267:297	–1.439	–0.884

Significance levels: * p < 10% ** p < 5% *** p < 1%

Cumulative average abnormal returns

Window	CAAR	Median	Stdev	Min	Max	Pos:Neg	t-test	Sign test
[–10, –1]	0.258	0.165	4.679	–22.434	25.993	291:273	1.311	1.138
[–20, +20]	0.043	0.178	9.476	–52.436	34.074	283:281	0.108	0.464
[–10, +10]	0.076	0.189	6.975	–49.714	38.345	290:274	0.259	1.053
[–5, +5]	0.022	0.093	4.661	–22.275	27.636	289:275	0.111	0.969
[–1, +1]	–0.054	–0.041	2.337	–12.040	12.755	275:289	–0.553	–0.210
[+10, +20]	0.055	–0.221	4.352	–23.091	25.854	266:298	0.303	–0.968

Significance levels: * p < 10% ** p < 5% *** p < 1%