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Do Investors Care About the Credibility of Green Commitments?

A study of stock market reactions to corporate green bond announcements and the credibility of firms' commitment

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Abstract

We study stock market reactions to firms' announcements of first-time green bond issuances in two major markets, the US and Japan. Specifically, we attempt to answer two research questions: 1) whether green bond announcements provide stock-price relevant information and 2) whether stock price reactions are associated with the credibility of firms' commitment to green investments.

Our data set consists of 36 announcements from US firms and 31 announcements from Japanese firms from January 2013 to September 2021. We apply event study methodology and find evidence of green bond announcements providing stock-price relevant information in the US. Specifically, we find evidence of negative stock market reactions. By dividing the bonds into subgroups based on the credibility of issuing firms' commitments to green investments, we find that the negative reaction is driven by groups of bonds with relatively low credibility. For Japan, we find no such evidence.

We also apply OLS regression analysis with assumed measures of credibility as regressors. For the US market, we find a positive correlation between firms' environmental performance and stock price reaction following announcement. For the Japanese market, we find no correlation between measures of credibility and stock price reaction.

Preface

This thesis is written as part of the MSc in Economics and Business Administration at the Norwegian School of Economics (NHH). One of the authors majors in Business Analytics and the other in Financial Economics.

The opportunity to work independently and develop our analytical skillset while gaining deeper knowledge on the corporate green bond market has been rewarding and educational.

We would like to thank our supervisor, Tommy Stamland, for his valuable insights and guidance. Finally, we want to thank lecturers and fellow students for formative years at NHH.

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1 Introduction

Over the previous years, and especially since the launch of UN's sustainable development goals (SDG) in September 2015, we have seen governments, corporates and other organizations taking actions to combat climate change and its impact, trying to reach SDG 13 (United Nations, 2015). The financial sector is an important part of the solution as they provide the opportunity to allocate capital towards activities that contribute to mitigating climate change.

A relatively new financial instrument intended to facilitate this shift towards green investments is corporate green bonds (Flammer, Corporate green bonds, 2018). A corporate green bond is a bond where the proceeds are invested in projects that generate environmental benefits, such as green buildings or renewable energy (United Nations Development Programme, 2016). However, there are no regulations governing green bonds today. This provides an opportunity for firms to issue a bond with a green label but not allocate the entire proceeds to green investments, which is a form of greenwashing (Flammer, Corporate green bonds, 2018). With no regulations, they can therefore market themselves as environmentally friendly without being fully committed.

Previous literature finds a positive relationship between announcements of corporate green bond issuances and stock market reactions for the global market (Flammer, 2018; Tang & Zhang, 2018). However, as corporate green bonds are a relatively new financial instrument, there is limited research on this topic. Additionally, even though event studies have been conducted on this topic for the global market, insufficient attention has been paid to examine the relationship solely for the US and Japanese markets, two of the markets with highest number of corporate green bonds issuances. Most studies also mainly focus on the stock market reaction itself, rather than the characteristics related to the issuance. In particular, the heterogeneity in green bonds' provisions for use of proceeds is often overlooked.

Thus, this study is set out to answer if announcements of corporate green bonds issuances provide stock price relevant information, and if stock market reactions are associated with the credibility of firms' commitment to green investments.

We focus on firms' first-time issuances of corporate green bonds in the US and Japan. Our final data sets consist of 36 events in the US and 31 events in Japan respectively. We apply event study methodology to calculate cumulative abnormal returns (CAR) across days around bond announcements. To analyze stock market reactions on group level, we use two different measures: average cumulative abnormal returns (ACAR) and median cumulative abnormal returns (MCAR) across events. We calculate these measures for both the full samples and for subgroups of bonds arranged according to assumed level of credibility of firms' commitment to green investments, for each market separately. For the sample of US bonds, we find evidence of negative stock market reactions, driven by bonds with relatively lower credibility. For the sample of Japanese bonds, we find little to no evidence of any reaction.

We also conduct OLS regressions to investigate whether stock market reactions are associated with the credibility of firms' commitment to green investments. The CAR of firms' stock prices is regressed on three assumed measures of credibility. For the US sample, we find a significantly positive correlation between firms' documented environmental performance, measured by E-score, and the stock market reaction measured by CAR. For the Japanese sample, we find no evidence of correlation with measures of credibility.

We contribute to the literature by investigating whether stock market reactions vary with the assumed level of credibility of commitments to green investments. As such, we can provide insight on the ability of corporate green bonds to fulfill their purpose as a financial instrument. If investors care about the credibility of bonds contributing to mitigate climate change, this is positive for the allocation of capital toward such projects. A key insight is that many bonds labelled as green by Bloomberg allow for proceeds to be allocated to non-green purposes, even when certified by independent third parties. Additionally, we contribute to literature by looking at the US and Japan as individual markets.

The structure of this thesis is as follows: In section two, we first present an overview of the green bond market before presenting both historic and recent literature on green bonds. Section three will elaborate on the research questions and hypotheses for our study. In section four, we introduce the event study methodology that is applied to measure the stock market reactions of announcements, before presenting the data collected for the empirical analysis in section five. Section six presents the inference tests used for the event study. Then, we present the empirical finding and analysis in section seven. Lastly, section eight provides a conclusion before we briefly touch on the limitations of our study in section nine.

2 Literature review

Most studies find a positive market reaction to green bond announcements. However, the issuance of corporate green bonds has not been exercised for a long time, as it is a relatively new financial instrument.

Historically, literature related to green bonds has primarily focused on the cost of capital of green bonds compared to conventional bonds. Moreover, researchers (Zerbib, 2017) have mainly focused on whether the green bond displays a negative or positive market premium relative to a conventional bond. A negative market premium involves a lower yield on a green bond than a conventional bond. More recent literature such as Flammer (2018) and Thang & Zhang (2018) focuses on the effects of green bond announcement on enterprise value. As this is more relevant to our research questions, presented in section 3, this section will emphasize literature that describes how corporate green bond announcements affect stock market returns.

2.1 Overview of the green bond market

As noted by the United Nations Development Program (2016), there is minimal difference between a green bond and a conventional bond. The only unique characteristic is that the proceeds are invested in projects that generate environmental benefits. In the absence of regulations determining what constitutes environmental benefits, several guidelines have been developed. The Green Bond Principles (GBP), formulated by the International Capital Market Association[1] (ICMA), clarify the approach for issuance of a green bond by recommending a clear process for issuers. Another guideline is created by the Climate Bond Initiative (CBI), which defines eligible criteria for the use of proceeds. To be certified as a green bond by the CBI, the prospective issuer must appoint an independent third-party to verify that the bond meets the CBI's standards (Climate Bonds Initiative, u.d.)

The first green bond was issued in June 2007 by the European Investment Bank. However, the corporate green bond market did not start its development before 2013. The volume of green bond issuance has almost doubled each year, and the share of corporate green bonds is growing steadily (Bachelet, Becchetti, & Manfredonia, 2018). In 2020, the recorded green bond issuance was USD 1.1trn, which is a 9% growth from the previous year. The biggest market for green bonds in 2020 was Europe with a total value of USD 156 bn (Harrison & Muething, 2021). United States has since the outset of the green bond market been a region with high

[1] The International Capital Market Association is a self-regulatory organization and trade association for participants in the capital markets.

activity. Outside Europe and the US, China and Japan have the highest number of green bonds issued.

2.2 Green bond premiums

Zerbib (2017) is a relatively early study on the cost of capital on green bonds compared to conventional bonds. The author researched the effect of pro-environmental preferences on bond prices. Zerbib applied a matching method and then a two-step regression to estimate the yield difference between green and conventional bonds from July 2013 to December 2017. The author found that the green bonds had a small negative premium of, on average, –2 basis points compared to a conventional bond - indicating that investors' pro-environmental preferences have a low impact on bond prices. The main reasons for the relationship were the rating and the issuer type. The lower the rating of the green bond, the lower green premium. In addition, the level of premia differs between governmental-related bonds and financial bonds – the premia on financial bonds are lower than the premia on governmental-related bonds.

Hyun, Park & Tian (2019) also conducted a study on the cost of capital of green bonds relative to conventional bonds. They find that, on average, there is no robust and significant yield premium or discount on green bonds. This finding is different from Zerbib (2017). However, it is the same result as Larcker & Watts (2019) who find that the green bond premium is essentially zero. Moreover, they filter the green bonds certified by an independent third-party and find that they have a coupon discount of 6 basis points. They further filter the green bonds who earned a certification mark by the CBI, finding a discount of 15 basis points.

2.3 Stock market reactions to green bond announcements

This thesis researches the announcement of corporate green bonds. Previous literature on the impact of green bond announcements on firm value are thus highly relevant.

Flammer (2018) used an event study methodology to measure how stock prices of corporates react to green bond announcements. She found that investors respond positively to the green bond issuance announcement, with a CAR of 0.49% for the event window [-5,10], significant at 5% level. In addition, she finds that there is a larger stock market reaction for certified green bonds. The sample includes 384 issuer day-observations from January 1, 2013 to December 31, 2018. Flammer extracted data on corporate green bonds from Bloomberg's fixed income database and the stock market data were obtained from the daily stock file of Compustat North America and Compustat Global.

Tang and Zhang (2018) also conducted an event study to examine the relationship between stock price movement and announcements of corporate green bonds. As Flammer, they also find that the market responds positively to such announcements. The study is based on corporate green bond data from 132 unique public firms in 28 countries during 2007-2017. Additionally, they find no premium for green bonds – indicating that the positive market reaction is not driven by the lower cost of debt. Tang and Zhang also find that institutional ownership increases in the aftermath of the green bond announcement, especially from domestic institutions.

(Flammer, 2012) also conducted an earlier study where she investigated how the stock market reacted to corporate news regarding environmental responsibility, which is similar to an announcement of a corporate green bond as it signals a firms' environmental commitment. She finds that the companies that have high degree of environmental responsibility experience a significant stock price increase, while firms with less responsible environmental policies face a significant decrease. The study is based on US public firms from 1980 to 2009.

Glavas (2018) uses event study methodology to analyze how equity investors react to announcement of green bonds before and after the Paris Agreement. Overall, he finds a positive stock price reaction. Moreover, he finds an increase in stock price reaction after the Paris Agreement – indicating a different behavior from the equity investors after the climate summit. The study is based on a sample of 780 corporate bond issuance announcements in 22 countries between January 2013 and August 2018. Additionally, Glavas uses a regression analysis to explain the drivers of cumulative abnormal return, controlling for both bond and firm characteristics. Here, he finds that green bond issuance is a significant driver of return.

Based on the mentioned literature, we learn that investors tend to react positively on announcements of corporate green bonds. However, as corporate green bonds are a new financial instrument there is limited research on this topic. Thus, further research is needed.

3 Research questions and hypotheses

This section presents the research questions and hypotheses for our study.

3.1 Research questions

To investigate the role of corporate green bonds in mitigating climate change, our thesis poses two main research questions. We do not only want to find out whether investors react in a particular manner to green bond issuances, but also whether investors care that firms are credibly committed to contribute to accelerate the transition towards a sustainable future. The latter is an important question, as the ability of green bonds to allocate capital towards the most sustainable projects is increased if investors see beyond the green label.

Research question 1: Do announcements of corporate green bond issuances provide stock price relevant information?

Research question 2: Are stock price reactions to corporate green bond issuance announcements associated with the credibility of firms' commitment to green investments?

3.2 Hypotheses

To be able to answer our research questions, we have formulated two hypotheses that will be tested in this study.

Hypothesis 1: Announcements of corporate green bond issuances are associated with abnormal stock price returns.

This hypothesis assumes that an announcement of a first-time corporate green bond issuance will provide new and valuable information to investors, resulting in a stock market reaction. Such an announcement might be relevant as it can inform the market about a change of behavior from the firm.

The research covered in the literature review suggests that green bond announcements are followed by positive stock market reactions. However, as mentioned in section 2.3, there is limited research on this topic. Thus, we do not hypothesize the direction of the stock market reaction.

Hypothesis 2: Cumulative abnormal return around a corporate green bond issuance announcement is correlated with assumed measures of credibility.

This hypothesis tests if the credibility of firms' commitment to green activities can explain some variation in abnormal return around the announcement. Flammer (2018) highlights the importance of green bonds as credible signals of the firms' environmental commitment. Our measures of credibility will be presented in section 7.

4 Event study methodology

This section will introduce the event study methodology and present the theoretical framework this study is based on. The purpose of this section is to provide the reader an understanding of how to measure the effects of an economic event on firm value.

An event study is conducted to measure the impact of a certain event on the firm value (MacKinlay, 1997). This methodology estimates a model for stock price returns during an estimation window and uses this to predict normal returns in the event window. It defines the difference between the actual and normal return in event window as abnormal return. Inference tests are conducted on the abnormal returns to examine if they are significantly different from zero.

There are three assumptions that apply for an event-study. These are: 1) efficient markets 2) unanticipated event and 3) no confounding events during the event window (McWilliams & Siegel, 1997). An efficient market is defined as a market where the prices "fully reflect" available information (Fama, Efficient Capital Markets: A Review of Theory and Empirical Work, 1970). Moreover, the event-study is based on the semi-strong form of the efficient market hypothesis where prices should reflect all available information – i.e., past prices and new, publicly available information – immediately. Due to the semi-strong form, impacts of an economic event can be quantified by observing stock prices over a relatively short time period.

For this thesis, the announcement of a corporate green bond issuance is viewed as the economic event. The intuition is that information regarding the corporate green bond will be publicly available to the market through the announcement of the issuance, as the date of the announcement is prior to the issuance date.

4.1 Estimation window

The estimation window is used to estimate the normal return in the event window. It is common to choose an estimation window prior to the event window. There is a trade-off between choosing an estimation window which is long or short. The advantage of a long estimation widow is that it will strengthen the statistical precision and the advantage of a short window is that will only include the latest, most relevant movements in price (Strong, 1992). The event study literature does not define an exact estimation window to be used.

When choosing the length of the estimation window it is important to make sure that it is not overlapping with the event window. Overlapping windows will lead to returns around the event affecting the normal performance model parameter estimates (MacKinlay, 1997). In other words, variations from the event window will result in biased normal returns. Usually, the abnormal return will capture the effects of the events. However, in the case of overlapping windows, both the abnormal and normal returns will be affected by the event.

We set the estimation window to [-220, -21]. The days are set relative to the event day and only consist of trading days. Thus, -220 means that the estimation window starts 220 trading days before the announcement of the corporate green bond issuance, and -21 means that the estimation window leaves 20 days between the last day of the estimation window and the event date.

4.2 Event window

An event window consists of the days that are coincident with the economic event (McWilliams and Siegel, 1997). Like the estimation window, there is a trade-off between choosing a long or short window around the event. A long event window increases the chance to seize the potential effect of the event, and a short event window will make it easier to exclude confounding events. Ryngaert & Netter (1990) state that the length of the event window should be set according to the nature of the event. McWilliams and Siegel (1997) argue in favor of a short event window.

A long event window might violate the aforementioned assumptions regarding efficient markets. Long event windows can indicate that the effects of events are not captured quickly by the stock prices. They make it seem like the stock prices need a long time to realize the effect of the economic event, which strides against the efficient market hypothesis.

Furthermore, a long event window increases the difficulty of controlling for confounding events. It is highly important to control for confounding events as the whole methodology is based on measuring the abnormal returns that are caused by the event in question (McWilliams and Seigel, 1997). The data set applied in this study consists mainly of large, public firms. It is therefore a higher probability that confounding events occur regularly relative to samples with smaller, less diversified firms. With a short event window, it is easier to control for confounding events, ascertaining that the abnormal returns are indeed caused by the economic event, and not a confounding event.

In addition to the arguments above, Brown & Warner (1980; 1985) found that long event windows diminish the explanatory power of a test statistic, which leads to a higher likelihood of committing type two errors. That is, it will increase the likelihood of failing to reject the null hypothesis when it is false (Wooldridge, 2013).

Moreover, Ryngaert and Netter (1990) prove that short event windows are effective in capturing significant effects. Nonetheless, in order to measure the abnormal returns caused by a potential leakage of information in a short event-window, it is important to include some days prior to the announcement (McWilliams and Siegel, 1997).

Following the arguments above, we apply short event windows. To ensure robustness in the analysis, multiple event windows are applied. The pre-event windows [-1,0], [-2,0] and [-5,0] are used to capture the effects of a potential leakage of information. The post-event windows [0,1], [0,2] and [0,5] are used to capture the effects following the corporate green bond announcement. The symmetrical windows [-1,1], [-2,2] and [-5,5] are applied to capture the effects both before and after the green bond announcement.

The timeline of our event-study is illustrated in the figure below.

Figure 4.1: Event study timeline

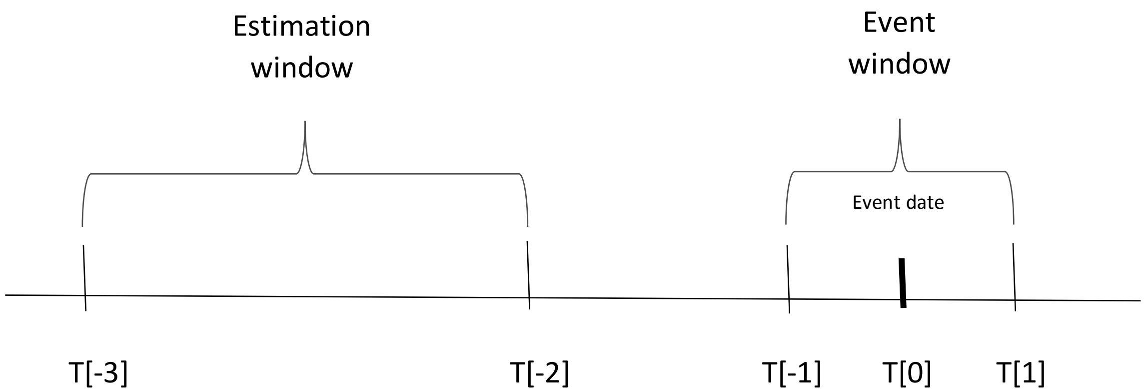

Figure 4.1 displays the event study timeline. T[0] defines the event date – i.e., the announcement of a corporate green bond issuance. The event window equals the time period around the event date, and is limited by the lower limit T[-1] and the upper limit T[1]. The estimation window is illustrated as a given period before the event window, and is in the time interval between T[-3] and T[-2]. This corresponds to our estimation window of [-220, -21]. There is no exact time period defined for the event window as we apply multiple event windows.

4.3 Model to measure normal returns

There are both statistical and economic return models that can be applied to estimate normal returns. The constant mean return model and the single-factor market model are two examples of statistical return models (MacKinlay, 1997). Two examples of economic models are the capital assets pricing model (CAPM) and the arbitrage pricing theory (APT).

We use the single-factor market model to estimate normal returns. It is considered better than the constant mean return model as it reduces the variance of the abnormal return by filtering out the share of return that is connected to market variance (MacKinlay, 1997). Binder (1998) also found that the other models do not prove to be as good as the market model.

The equation for the market model (MacKinlay, 1997) is expressed as:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \epsilon_{it}, \tag{4.1}$$

$$E(\epsilon_{it}) = 0, \qquad Var(\epsilon_{it}) = \sigma^2_{\epsilon_i}, \tag{4.2}$$

where R_{it} is the return of the security i at time *t* and R_{mt} is the market portfolio's return at time *t*. ϵ_{it} is the error term. The error term is also an estimator of abnormal returns. It contains information that is not controlled for in the regression, as for instance firm specific information (Fama, Fisher, Jensen, & Roll, 1969). The market model applies an Ordinary Least Squares (OLS) regression to estimate both α_i and β_i, which are two parameters in the model. β_i is a measure of how volatile each stock is relative to the market index. According to MacKinlay (1997) it is reasonable to believe that the general OLS assumptions hold.

Abnormal returns for security i equals the difference between its actual return and its estimated normal return. It is calculated for all days in the event window. The derived abnormal returns are normally distributed with a zero conditional mean and conditional variance (MacKinaly, 1997). Its equation is expressed as:

$$AR_{it} = R_{it} - (\widehat{\alpha_i} - \widehat{\beta_i} R_{mt}). \tag{4.3}$$

Furthermore, we aggregate the abnormal returns, across time and securities, to conduct inference tests. For this aggregation, an assumption of no clustering is required. In the presence of clustering – overlapping of event windows of the included securities – the abnormal returns can be dependent across securities (MacKinlay, 1997).

AR_{it} is defined as the abnormal return of security i at time *t* in the event window. The abnormal returns are aggregated over the event window, which is denoted as the period between T_{-1} and

T_1, for each event. It is defined as the cumulative abnormal return and its equation is the following:

$$CAR_i(T_{-1}, T_1) = \sum_{t=T_{-1}}^{T_1} AR_{it} \,. \tag{4.4}$$

In order to study a group of events, we derive the average cumulative abnormal return. This is expressed by the following formula:

$$ACAR(T_{-1}, T_1) = \frac{1}{N} \sum_{i=1}^{N} CAR_i\,(T_{-1}, T_1), \tag{4.5}$$

where N is the number of events.

4.4 Proxy for return of the market portfolio

MacKinlay (2013) suggests a broad-based stock index as a proxy for the market portfolio. The author states that indexes such as the S&P 500 Index, the CRSP Value Weighted Index and the CRSP Equal Weighted Index are often used to replicate the market. Value-weighted indexes are indexes where the individual stocks are weighted according to their market capitalization. Campbell, Cowan, & Salotti (2010) state that a value-weighted national market index is a sufficient proxy for the market portfolio when using the market model.

5 Data

This section will describe the data used in this study. We first elaborate on the data collection and treatment process before presenting descriptive statistics. The data presented is used for both the event study and the regression analysis.

5.1 Data collection and cleaning

5.1.1 Corporate Green Bonds

Data on corporate green bonds from January 2013 to September 2021 were retrieved from the Bloomberg fixed income database. It was possible to identify green bonds as Bloomberg uses a green instrument indicator to label bonds as such. The main reason for using Bloomberg is the comprehensive coverage of its fixed income database (Flammer, 2018). The following data were extracted from the database: Issuer name, announcement date, issuer date, ticker, coupon, maturity, currency, amount issued, industry[2] , enterprise value, shareholder value, total debt and country of issuance.

We only include bonds issued by companies that are either publicly traded themselves or have a public mother company. For the private firms that have public parent companies in our data set, we follow Tang and Zhang (2018) and use the stock market data of the parent company.

We also exclude financial institutions based on the BICS Level 1 code. Fatica, Panzica, & Rancan (2019) note that financial institutions issue green bonds to finance their clients' projects, and do not use the proceeds for green investments themselves. Hence, investors might assume that green bond issuance by financial institutions does not indicate environmentally friendly behavior and therefore not react to the event.

To examine if the proceeds of the green bonds are actually allocated to green projects, they were looked up in the Climate Bonds Initiative database. The Climate Bond Initiative (CBI) is an international organization that mobilizes capital for climate change solutions, and their Climate Bonds Standard is a labeling scheme used globally to prioritize investments that contribute to improving the climate (Climate Bonds Initiative, 2021). The key criterion in their Climate Bond Standard is that 100% of the proceeds are dedicated to green activities that are in line with their Climate Bonds Taxonomy. Their taxonomy features eight categories for use

[2] Industries are defined by BICS-code (Bloomberg Industry Classification Systems). BICS Level 1 and BICS Level 2 are both used (Bloomberg, 2016). An overview of the classification system is provided in Table A1.1 in Appendix A.

of proceeds[3]. None of the US bonds and only 7% of the Japanese bonds in the data set earned a certification as a green bond by the CBI. Firms might be reluctant to get their bond certified by an independent third-party as it requires extensive managerial efforts and resources, which is costly for the issuing firm (Flammer, 2018). Another plausible reason might be that a share of the bonds in our data set, although labeled as green by Bloomberg, do not meet the requirements of the Climate Bond Standard. As a low percentage of the sample is certified by CBI, we wanted to investigate the bonds further and observe to what extent their proceeds are actually used to finance green projects.

As part of the data treatment process, all prospects of the issuing bonds have been examined. The prospects for the US corporate green bonds are retrieved from the Edgar database at the U.S. Securities and Exchange Commission. The prospects for the Japanese corporate bonds are not gathered in a similar database. Thus, they were retrieved by web search. Following the examination, the bonds were classified as either "truly green" or "quasi-green" based on information regarding the share of proceeds allocated to green projects. The criterion for being classified as truly green is that 100% of the proceeds are allocated to such projects. If less than 100% of the proceeds are directed to green investments, or there was insufficient information on allocation, they were classified as quasi-green. The chosen criterion for being classified as truly green or quasi-green is inspired by the criterion in the aforementioned Climate Bond Standard.

We observed that the announcement dates in Bloomberg for corporate green bond issuances in Japan do not correspond to the initial announcement. Bloomberg's announcement date for the Japanese green bond market is based on the presentation of the official prospect. However, the first announcement from the issuing firms in Japan is often an announcement in conjunction with the release of a preliminary prospect. Thus, we found the initial announcements in Japan by web search. Finding the correct event date is not a problem for the corporate green bond market in the US as the Bloomberg data base's announcement dates here correspond to the initial announcement for each firm.

Furthermore, we exclude bond announcements from firms with confounding events within the window [-1,1] for both markets. Excluding confounding events for a longer window will considerably reduce the number of observations. Since there are few observations, we prioritize keeping observations above the potential issue of confounding events being present further

[3] The eight categories for use of proceeds in the Climate Bonds Taxonomy are: energy, buildings, transport, Water, waste, land use, industry and Information and Communications Technology (ICT).

away from the event date. The confounding events include dividend announcements, dividend payments, stock repurchases, M&As, earnings announcements and changes in credit rating or top management.

Moreover, we only conduct an event study for first-time issuances of corporate green bonds. Previous studies such as Flammer (2018) have analyzed both first- and second-time issuances. Flammer (2018) analyzed second-time issuances to test if they also signal firms' commitment to green projects. This paper focuses only on first-time issuances as we want to investigate if the market reacts in the same way for first-time American and Japanese green bond announcements as it does in other global markets. Additionally, Flammer (2018) did not find a significant stock market reaction for second-time issuances, indicating that these issuances do not provide stock price relevant information. We want to analyze the stock market reaction to novel information, and thus we restrict the focus to first time issuances. After excluding subsequent issuances and issuances with confounding events, the sample consists of 36 unique events in the US and 31 unique events in Japan.

5.1.2 Stock prices

Yahoo Finance is used to collect stock price data for the publicly listed firms. Specifically, adjusted daily stock prices[4] have been retrieved to calculate logarithmic returns across different windows.

5.1.3 Market indices

The market portfolio we use to derive the market return for both the US and Japan is the leading value-weighted stock market index in each country. Campbell, Cowan & Salotti (2010) found that using a national market index will provide well-specified and powerful tests of average stock price effects in an event study. Kempf & Osthoff (2007) use a value-weighted index for their market portfolio. Following the methodology in both studies, this paper uses the value-weighted S&P 500 index to calculate the market return in the US and the value-weighted Nikkei225 index for Japan.

5.1.4 Explanatory variables for regression analysis

The firm characteristics used as explanatory variables in the regression analysis are extracted from the Refinitiv database by Thomson Reuters. Like Bradshaw, Richardson, & Sloan (2006),

[4] Daily adjusted stock prices are stock prices adjusted for dividends, share splits, right offerings and other corporate actions.

we retrieve total assets to create a measure for firm size[5]. We retrieve firm data for the fiscal year before the bond issuance announcement (Glavas, 2018).

Environmental score (E-score) is a part of the ESG-score and is also retrieved from the Refinitiv database by Thompson Reuters. The E-score is on a scale from 0 to 100, where a score between 0 and 25 equals the grade D, between 25 and 50 equals the grade C, between 50 and 75 equals the grade B, and a score between 75 and 100 equals the grade A (Refinitiv, 2021). The E-score is based on three categories: emissions, innovation and resource use. Each category consists of different environmental themes, listed in appendix B.

We apply the aforementioned (section 5.1.1) classification of bonds as truly green or quasi-green as a dummy variable. This is the only bond characteristic applied as an explanatory variable.

It would have been interesting to apply other firm characteristics such as shareholder equity, operating income (EBIT), interest expense and net income, as is done by both Bradshaw et al. (2006) and Spiess & Affleck-Graves (1999). By applying these firm characteristics, it would have been possible to derive explanatory variables such as equity to total assets, EBIT-to-interest expense and return on assets (ROA). These financial ratios would have made it possible to examine if solvency and profitability characteristics explain the variation in CAR around the event (Godlewski, Turk-Ariss, & Weill, 2013). However, including all these explanatory variables when we have few observations will lead to overfitting. A solution to limit overfitting is to restrict the regressions to few explanatory variables. The same rationale is applied for not examining other interesting bond characteristics such as coupon, maturity and bond size. We restrict our choice of explanatory variables to E-score, firm size and the dummy for truly green, as they are the most important to test hypothesis 2 regarding credibility.

5.2 Descriptive Statistics

This section presents an overview of the collected data. First, we present firm and bond characteristics, before we show which industry the issuing firms belong to. Followingly, we present how the green-labeled bonds are spread across time. Lastly, we present the distribution between truly green and quasi-green bonds. The US green bond market comprises of 36 green-labeled first-time issuances, while the Japanese market consists of 31 issuances.

[5] Firm size is computed as the natural logarithm of total assets.

In some instances, firms issue multiple bonds on the same date. This is known as a tranche. We treat tranches by aggregating the bond sizes into one single bond. Furthermore, we calculate the value-weighted maturity and coupon rate of the multiple bonds issued on the same date.

Table 5.1: Descriptive statistics of firm and bond characteristics for the US sample

Table 5.1 displays firm characteristics for the issuing firms and bond characteristics for the green bonds in the US from January 2013 to September 2021. E-score is the firms' environmental score, on a scale from 0-100. Total assets represents the firm size in USDm. Equity to assets and Return on assets (ROA) are two of the firms' financial ratios. Bond size is the amount issued in USDm. Maturity is the date when a bond's principal must be repaid, given as years from issuance to deadline date. Coupon is the annual interest rate paid on a bond, expressed as a percentage of the face value. Number of observations, unit, the mean, the median, minimum and maximum value is presented for all characteristics.

Firm characteristics	*N*	*Unit*	*Mean*	*Median*	*Min*	*Max*
E-score	36	0-100	58.58	60.50	7.00	96.00
Total assets	29	USDm	37,850	15,459	660	290,345
Equity to assets	29	ratio	0.34	0.34	-0.20	0.80
Return on assets	29	ratio	0.031	0.032	-0.230	0.184
Bond characteristics	*N*	*Unit*	*Mean*	*Median*	*Min*	*Max*
Bond size	36	USDm	838.4	695	40	3,600
Maturity	36	years	13.86	10.00	4.85	31.00
Coupon	36	percent	3.31	3.20	0.00	9.75

Table 5.1 presents the green-labeled bonds in the US, arranged by firm and bond characteristics. The firm-level data are extracted from the Refinitiv database by Thomson Reuters. We observe that the average of total assets of firms is 37 850 USDm. Notice that there is a large discrepancy in the US data between the mean and median of the total assets, with the median being only 15 459 USDm. This indicates that there are some firms that have a much higher level of total assets than the rest of the firms in the data set, driving up the mean. We observe a similar trend for bond size. The mean is at 838.4 USDm while the median bond size is 695 USDm, representing a 21% larger mean than median bond size.

The mean maturity of bonds is 13.9 years, and the mean coupon rate is 3.31%. The solvency and profitability ratios such as equity to assets and ROA have means of 34% and 3.1%

accordingly. Interestingly, we observe that the mean E-score for the issuing firms is 58.58 of 100, resulting in grade B. This indicates that the average firm in our data set has taken measures and actions to maintain and create a better environment. We notice that the there is a low discrepancy between the average and median E-score.

Table 5.2: Descriptive statistics of issuing firms by industry

Table 5.2 illustrates how the issuing firms in the US are spread across industries.

Industry	*N*
Communications	1
Consumer Discretionary	1
Consumer Staples	1
Energy	4
Industrials	2
Materials	3
Technology	2
Utilities	22

Table 5.2 is presented to illustrate how the firms that issue green-labeled bonds in the US are spread across industries. We observe that, in our data set, most issuers operate within utilities.

Table 5.3: Descriptive statistics of US green bonds by year

Table 5.3 shows how the first-time, green bonds issuances are spread across the time period January 2013 to September 2021.

Year	*N*
2013	1
2014	2
2015	2
2016	3
2017	2
2018	4
2019	6
2020	8
2021	8

Table 5.3 illustrates how the first-time issuances of green bonds are spread across time. As mentioned in section 2.1, the development of the corporate green bond market started in 2013. We observe one first-time issue in 2013 and a steady increase over the years, where 2020 and 2021 are the years with most first-time issuances. This is aligned with the global trend in the green bond market (Harrison & Muething, 2021).

Table 5.4: Descriptive statistics of US green bonds by classification

Table 5.4 illustrates the distribution of the green bonds in the US between truly green and quasi-green.

Classification	*N*
Truly green	15
Quasi-green	21

Table 5.4 shows the distribution of the green-labeled bonds between truly green and quasi-green. We observe that 15 of 36 (42%) green-labeled bonds are classified as truly green while

21 of 36 (58%) are classified as quasi-green, meaning that the majority of the green-labeled bonds in the US between 2013 and 2020 were not fully allocated to green investments.

Table 5.5: Descriptive statistics of firm and bond characteristics for the Japanese sample

Table 5.5 displays firm characteristics for the issuing firms and bond characteristics for the green bonds in Japan from January 2013 to September 2021. E-score is the firms' environmental score, on a scale from 0-100. Total assets represents the firm size in JPYm. Equity to assets and Return on assets (ROA) are two of the firms' financial ratios. Bond size is the amount issued in JPYm. Maturity is the date when a bond's principal must be repaid, given as years from issuance to deadline date. Coupon is the annual interest rate paid on a bond, expressed as a percentage of the face value. Number of observations, unit, the mean, the median, minimum and maximum value is presented for all characteristics.

Firm characteristics	*N*	*Unit*	*Mean*	*Median*	*Min*	*Max*
E-score	20	0-100	64.37	69.47	0.00	89.90
Total assets	28	JPYm	1,326,976	863,855	171,686	4,948,063
Equity to assets ratio	28	Ratio	0.35	0.35	0.08	0.66
Return on assets	28	Ratio	0.032	0.036	-0.062	0.078
Bond characteristics	*N*	*Unit*	*Mean*	*Median*	*Min*	*Max*
Bond size	31	JPYm	16,716	9,948	4,728	101,350
Maturity	31	Years	6.26	5.00	3.00	10.00
Coupon	31	percent	0.28	0.25	0.00	1.23

Table 5.5 presents green-labeled bonds in Japan, arranged by firm and bond characteristics. We observe that the mean of total assets for the Japanese firms is 1 326 976 JPYm, while the median of total assets is 863 855 JPYm. As in the US, there are some large firms driving up the mean. The trend is also similar for the bond size, where the mean is 16 716 JPYm and the median is 9 948 JPYm.

Furthermore, the bond characteristics show that the mean maturity for the green-labeled bonds in Japan is 6.3 years. Comparing to the US, the mean maturity is around 7.6 years shorter. Additionally, the mean coupon rate is 0.28%, 3.03 percentage points lower than the mean coupon rate for the US green-labeled bonds. This is considerably lower than for the US sample. Moreover, mean equity to assets and mean ROA are 35% and 3% respectively. The mean E-score is 64.37, which corresponds to grade B. We observe that the mean E-score in Japan is higher than in the US (58.58). This means that, on average, the Japanese firms have a slightly better environmental performance than the American firms.

Table 5.6: Descriptive statistics of issuing firms by industry

Table 5.6 illustrates how the issuing firms in Japan are spread across industries.

Industry	*N*
Communications	1
Consumer Discretionary	6
Consumer Staples	2
Energy	0
Industrials	13
Materials	3
Technology	3
Utilities	3

Table 5.6 is presented to illustrate how the firms that issue green-labeled bonds in Japan are spread across industries. It shows that the industry which has issued the most green-labeled bonds in Japan is industrials. The industry which has issued the second most first-time, green-labeled bonds in Japan is consumer discretionary.

Table 5.7: Descriptive statistics of Japanese green bonds by year

Table 5.7 shows how the first-time, green bonds issuances in Japan are spread across the time period from January 2013 to September 2021.

Year	*N*
2016	1
2017	1
2018	8
2019	7
2020	9
2021	5

Table 5.7 illustrates how the first-time issuances of green-labeled bonds in Japan are spread across time. We observe that the growth of the green bond market in Japan started a couple of years later than in the US, as the first bond was issued in 2016. The number of issuances has been stable since 2018.

Table 5.8: Descriptive statistics of Japanese green bonds by classification

Table 5.8 illustrates the distribution of the green bonds in Japan between truly green and quasi-green.

Classification	*N*
Truly green	19
Quasi-green	12

Lastly, table 5.8 shows the distribution of the green-labeled bonds that are classified as truly green and quasi green in Japan. We observe that approximately 61% (19 of 31) of the green-labeled bonds are classified as truly green, while 39% (12 of 31) are classified as quasi green. As for the US, there is a large share of green-labeled bonds where the proceeds are not fully allocated to green investments.

6 Inference tests

This section will first discuss the choice of inference tests, before elaborating on the fundamental structure of the chosen tests.

6.1 Choice of inference tests for abnormal returns

Parametric and non-parametric tests are two types of inference tests used to test a hypothesis. Different distributions of data require different tests. Parametric tests assume that the sample is approximately normally distributed, while non-parametric tests do not have any stringent assumptions about the shape of the underlying population distribution (Campbell & Wasley, 1992). Subsequently, it is recommended to use a non-parametric test if the data set consists of categorical or continuous data that is not normally distributed. However, if the sample is normally distributed, a non-parametric test will have a lower explanatory power than a parametric test. Thus, conducting hypothesis testing on normally distributed data with a non-parametric test will lead to a higher probability of type two errors.

The distribution of cumulative abnormal returns for both US and Japan is illustrated in figure A4.1 and A4.2 respectively in Appendix D. As there are few observations it is difficult to judge whether the data is normally distributed or not. Thus, we apply both a parametric and a non-parametric test. If the two tests yield different results it is important to interpret them with caution.

The parametric test that we apply is a standard t-test (MacKinlay, 1997). This parametric test is not robust against clustering, but this is not a problem for us as we do not have extensive overlapping event windows (MacKinlay, 1997). An advantage of applying such a standard test is its simple interpretation.

We use the Wilcoxon signed-rank test as the non-parametric test (Wilcoxon, 1945). This test accounts for both the magnitude and sign of abnormal returns. This is an advantage relative to other non-parametric tests such as the rank tests suggested by Corrado (1989) and Corrado & Zivney (1992). The rank tests suggested in these two papers rank the abnormal returns, but do not to consider their sign.

To summarize this section, we apply both a parametric and a non-parametric test to ensure robustness in the analysis, as we have few observations which causes uncertainty regarding the form of the data's distribution. The parametric test used is a standard t-test and the non-parametric test is the Wilcoxon signed-rank test.

6.2 Inference tests

This section will explain the fundamental structure of the two inference tests presented above: the standard t-test and the Wilcoxon signed-rank test.

6.2.1 Standard t-test

We follow the method of MacKinlay (1997) and use a standard t-test to test our hypothesis. It tests if the average cumulative abnormal return is significantly different from zero.

The parametric t-test is expressed by the equation:

$$t_{ACAR} = \frac{ACAR(T_{-1}, T_1)}{var(ACAR(T_{-1}, T_1))^{1/2}}, \tag{6.1}$$

where $ACAR$ is calculated for the event period, limited by T_{-1} and T_1. The standard deviation is the square root of the variance of ACAR in the event period, which is defined as:

$$var(ACAR(T_{-1}, T_1)) = \frac{1}{N^2}\sum_{i=1}^{N} \sigma_i^2(T_{-1}, T_1), \tag{6.2}$$

where N is the sample size, and σ_i^2 is the variance for each security i in the event period. This variance is expressed as:

$$\sigma_i^2(T_{-1}, T_1) = (T_1 - T_{-1} + 1)\sigma_{\epsilon_i}^2, \tag{6.3}$$

where $(T_1 - T_{-1} + 1)$ is the length of the event window. $\sigma_{\epsilon_i}^2$ is defined in equation 4.2 - section 4.3 as the variance of the error term, ϵ_{it}, in the market regression model. However, in practice, $\sigma_{\epsilon_i}^2$ is unknown (MacKinlay, 1997). Thus, an estimator is applied to derive the variance of the error term, which is equal to the variance of the abnormal returns. The estimator is expressed as:

$$\hat{\sigma}_{\epsilon_i}^2 = \frac{1}{L_1 - 2}\sum_{t=T_{-3}+1}^{T_{-2}} (AR_{it})^2, \tag{6.4}$$

where L_1 is defined as the length of the estimation window, limited by T_{-3} and T_{-2}. AR_{it} is here defined as the abnormal return of security i at time *t* in the estimation window.

6.2.2 Wilcoxon signed-rank test

As mentioned in section 6.1, the Wilcoxon signed-rank test is a non-parametric test that accounts for both the magnitude and sign of abnormal returns. The Wilcoxon signed-rank test relies partially on the rank-order statistics (Gibbons & Chakraborti, 2003). The null hypothesis in this test is that the median cumulative abnormal return is zero. The test statistic is based on a Z-score for samples with observations above 15. The formula for this statistic is:

$$Z = \frac{MAX(T^{+},T^{-}) - N(N+1)/4}{\sqrt{\frac{N(N+1)(2N+1)}{24}}}, \tag{6.5}$$

where N is number of observations, T^{+} is the sum of the positive ranks of the absolute values of the cumulative abnormal returns, and T^{-} is the sum of the negative ranks of the absolute values of the cumulative abnormal returns. Followingly, $MAX(T^{+},T^{-})$ is the largest value of these rank sums. The sum of the ranks is initially derived from the following expression:

$$D_i = X_i - M_0, \tag{6.6}$$

where X_i is the observation of security i and M_0 is the hypothetical median. In the case of cumulative abnormal returns, X_i equals the cumulative abnormal return for each security i and M_0 equals 0. D_i is thus equal to the cumulative abnormal return for each security i. In order to derive the rank, one has to calculate the absolute value of D_i, denoted as $|D_i|$. The absolute differences are then arranged in ascending order and assigned ranks according to their relative position in the order. Thereafter, they are labeled according to the original sign of the difference D_i. In our case, the sign reflects whether returns are negative or positive. When calculating the positive and negative rank sum it is important to sum the absolute values of the positive and negative ranks.

7 Empirical analysis

The overall purpose of the empirical analysis is to test our hypotheses about how investors react to corporate green bond announcements. The specific purpose of the event study is to test hypothesis 1 of whether the announcements are associated with an abnormal return. This allows us to answer research question 1 of whether the announcements contain stock-price relevant information. The purpose of the regression analysis is to delve deeper into the analysis of investors' reactions by testing hypothesis 2 of whether certain assumed measures of credibility are correlated with the cumulative abnormal stock-price return around the announcement. As such, we can answer our second research question related to whether stock price reactions are associated with the credibility of firms' commitment to green investments.

A central part of our analysis relies on two proxies which we assume to be informative measures of said credibility. The first proxy is whether the bond is classified as truly green or quasi-green. As mentioned in section 5.1.1., certain green-labeled bonds allow for the allocation of proceeds to non-green projects. We assume that this weakens the credibility of the firms' signaled commitment to green investments. The second proxy is related to the firms' track record of environmental performance, measured by the E-score part of ESG ratings. We assume that a higher E-score strengthens the credibility that the firm will realize the green investments promised in the bond prospect.

These proxies are used both in the event study and in the regression analysis. In the event study, we divide the full samples of green bond announcements into sub-groups based on the proxies. This approach is similar to the approach used by Berrone, Fosfuri & Gelabert (2017) to study reactions to firms' environmental actions. In addition to studying the full sample, this allows us to isolate the stock market reactions for each group of bond announcements. As such, we test hypothesis 1 both for the full sample and for each sub-group individually. In the regression analysis, the proxies are used as explanatory variables to test hypothesis 2 regarding the correlation between credibility and cumulative abnormal return.

7.1 Results from Event Study

This section presents the results from the event studies performed for the US and the Japanese market.

7.1.1 Full sample of green bond announcements in the US

Table 7.1: Results of inference tests for the full sample of US green bond announcements

Table 7.1 summarizes the results from both the standard t-test (MacKinlay, 1997) and the Wilcoxon signed rank test (Wilcoxon, 1945). The inference tests are conducted on the full sample of green bond announcements in the US. The null hypothesis for the standard t-test is ACAR = 0, and MCAR = 0 for the Wilcoxon signed rank test. ACAR: Average cumulative abnormal return, in percent. T: t-statistic of standard t-test. MCAR: Median cumulative abnormal return, in percent. Z: z-statistic of Wilcoxon signed rank test. N: Number of observations.

	Symmetrical windows			*Pre-event windows*			*Post-event windows*		
Event window	[-1,1]	[-2,2]	[-5,5]	[-5,0]	[-2,0]	[-1,0]	[0,1]	[0,2]	[0,5]
ACAR	-2.23***	-1.38	-3.33**	-2.37**	-1.16	-1.30**	-2.04***	-1.34*	-2.08*
T	(-3.05)	(-1.47)	(-2.39)	(-2.29)	(-1.59)	(-2.19)	(-3.43)	(-1.84)	(-2.02)
MCAR	-0.34	-0.34	-0.81	-0.50	-0.01	-0.23	-0.58	-0.50	-0.91
Z	(1.24)	(0.91)	(1.19)	(1.12)	(0.80)	(0.35)	(1.53)	(0.52)	(1.37)
N	36	36	36	36	36	36	36	36	36

Note ***p<0.01; **p<0.05; *p<0.10

For the overall sample of US bonds with the Bloomberg green label, we find a significantly negative average CAR (ACAR) in multiple event windows according to the standard t-test. However, none of the median CARs (MCAR) are found to be significantly different from zero according to the rank test. The MCAR is negative for all windows when rounded to three decimal places.

The difference in magnitude between ACAR and MCAR indicates that our data is skewed, meaning it deviates from the normal distribution. This has consequences for the interpretation of the results. We present a histogram of CARs across the event window [-1,1] to illustrate the skewed distribution of CARs.

Figure 7.1: Distribution of CARs of all green bonds in the US

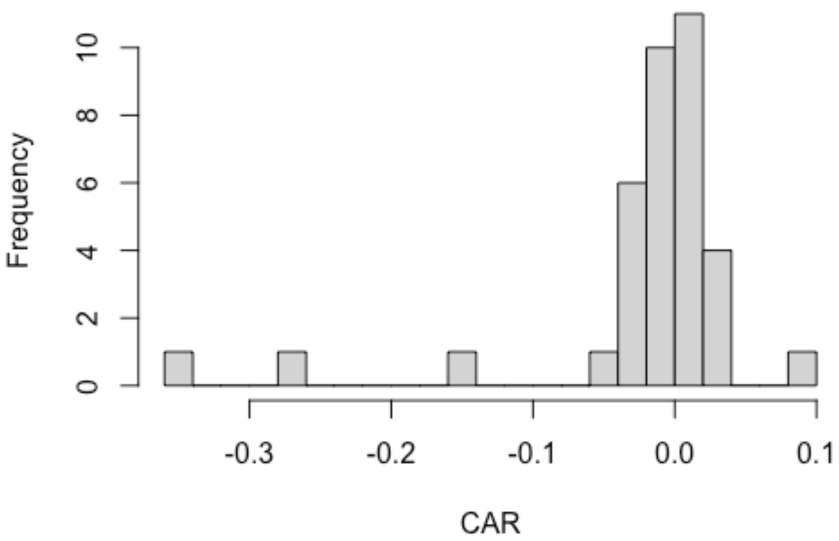

Figure 7.1 illustrates the distribution of CARs of all green bonds in the US in the event window [-1,1]. Number of observations: 36. X-axis: CAR. Y-Axis: Frequency

Three companies experience a negative cumulative abnormal return in excess of 10%, 20% and 30% respectively during the three-day symmetrical window around the bond announcement. These three observations contribute heavily towards a negative ACAR, which explains the difference in magnitude from the MCAR. This in turn affects the results of the significance tests. Note that the non-parametric test for MCAR considers the relative magnitudes of the CARs by ranking them according to order, while the absolute magnitude beyond its effect on the rank is not considered.

Looking at ACAR in isolation, there is reason to assume that our first hypothesis is correct, as there is an abnormal stock market reaction. However, due to the few observations that cause uncertainty about the normal distribution of the CAR's, we are reluctant to claim a correct hypothesis based solely on the parametric test.

7.1.2 Truly green and quasi-green bonds in the US

Table 7.2: Results of inference tests for US truly green bonds

Table 7.2 summarizes the results from both the standard t-test (MacKinlay, 1997) and the Wilcoxon signed rank test (Wilcoxon, 1945). The inference tests are conducted on the sample of truly green bond announcements in the US. The null hypothesis for the standard t-test is ACAR = 0, and MCAR = 0 for the Wilcoxon signed rank test. ACAR: Average cumulative abnormal return, in percent. T: t-statistic of standard t-test. MCAR: Median cumulative abnormal return, in percent. Z: z-statistic of Wilcoxon signed rank test. N: Number of observations.

	Symmetrical windows			*Pre-event windows*			*Post-event windows*		
Event window	[-1,1]	[-2,2]	[-5,5]	[-5,0]	[-2,0]	[-1,0]	[0,1]	[0,2]	[0,5]
ACAR	-0.23	-0.13	0.20	0.96	0.17	0.03	0.00	-0.02	-0.49
T	(-0.32)	(-0.14)	(0.14)	(0.91)	(0.23)	(0.06)	(0.01)	(-0.04)	(-0.47)
MCAR	0.00	-0.22	-0.44	0.98	-0.07	0.16	-0.69	0.52	-0.76
Z	(0.25)	(0.00)	(0.03)	(1.20)	(0.19)	(0.08)	(0.25)	(0.08)	(0.86)
N	15	15	15	15	15	15	15	15	15
Note									***p<0.01; **p<0.05; *p<0.10

Table 7.3: Results of inference tests for US quasi-green bonds

Table 7.3 summarizes the results from both the standard t-test (MacKinlay, 1997) and the Wilcoxon signed rank test (Wilcoxon, 1945). The inference tests are conducted on the sample of quasi-green bond announcements in the US. The null hypothesis for the standard t-test is ACAR = 0, and MCAR = 0 for the Wilcoxon signed rank test. ACAR: Average cumulative abnormal return, in percent. T: t-statistic of standard t-test. MCAR: Median cumulative abnormal return, in percent. Z: z-statistic of Wilcoxon signed rank test. N: Number of observations.

	Symmetrical windows			*Pre-event windows*			*Post-event windows*		
Event window	[-1,1]	[-2,2]	[-5,5]	[-5,0]	[-2,0]	[-1,0]	[0,1]	[0,2]	[0,5]
ACAR	-3.65***	-2.27	-5.85***	-4.74***	-2.11*	-2.26**	-3.50***	-2.28*	-3.22*
T	(-3.23)	(-1.56)	(-2.70)	(-2.97)	(-1.87)	(-2.45)	(-3.79)	(-2.01)	(-2.01)
MCAR	-0.38	-0.48	-1.06	-1.40**	0.05	-0.26	-0.47	-0.53	-1.38
Z	(1.31)	(1.10)	(1.56)	(2.18)	(1.13)	(0.44)	(1.63)	(0.68)	(1.20)
N	21	21	21	21	21	21	21	21	21
Note									***p<0.01; **p<0.05; *p<0.10

For the sample of truly green bonds, neither ACAR nor MCAR is significantly different from zero in any of the event windows studied. However, for the sample of quasi-green bonds we find a significantly negative ACAR for all windows. In the event window [-1,1] we observe a negative ACAR of 3.65%, significantly different from zero at the 1% level. MCAR, on the other hand, is only significantly different from zero in the pre-event window [-5,0], at the 5% level. For quasi-green bonds, we observe the same pattern as with the overall sample, where the negative ACAR is much larger in magnitude than the MCAR. The three negative outliers in Figure 7.1 above are all bonds classified as quasi-green, contributing to the same discrepancy between ACAR and MCAR as observed for the full sample.

Regarding hypothesis 1, we find no evidence that it is true for the sub-group of truly green bonds. For quasi-green bonds, we find a significantly negative ACAR, which shows support for hypothesis 1. However, we encounter the same challenge as for the full sample, where mainly the parametric test indicates a significantly negative abnormal return.

7.1.3 Above and below median E-score in the US

We divide the overall sample into two equally sized groups based on whether the issuing firms' E-score is above or below the sample median. For the US, this sample median is 60.5 of 100.

Table 7.4: Results of inference tests for US firms with E-score above median

Table 7.4 summarizes the results from both the standard t-test (MacKinlay, 1997) and the Wilcoxon signed rank test (Wilcoxon, 1945). The inference tests are conducted on the sample of green bond announcements in the US where the issuing firms have an E-score above median. Sample median E-score: 60.5. The null hypothesis for the standard t-test is ACAR = 0, and MCAR = 0 for the Wilcoxon signed rank test. ACAR: Average cumulative abnormal return, in percent. T: t-statistic of standard t-test. MCAR: Median cumulative abnormal return, in percent. Z: z-statistic of Wilcoxon signed rank test. N: Number of observations.

	Symmetrical windows			*Pre-event windows*			*Post-event windows*		
Event window	[-1,1]	[-2,2]	[-5,5]	[-5,0]	[-2,0]	[-1,0]	[0,1]	[0,2]	[0,5]
ACAR	0.50	1.04	0.67	0.29	0.69	0.29	0.47	0.61	0.64
T	(0.94)	(1.52)	(0.66)	(0.38)	(1.31)	(0.68)	(1.08)	(1.15)	(0.86)
MCAR	0.66	0.81**	1.44**	1.04	0.84*	0.71	0.24	0.81	1.02
Z	(1.07)	(2.12)	(1.96)	(1.20)	(1.74)	(1.03)	(1.16)	(1.52)	(1.03)
N	18	18	18	18	18	18	18	18	18

Note ***p<0.01; **p<0.05; *p<0.10

Table 7.5: Results of inference tests for US firms with E-score below median

Table 7.5 summarizes the results from both the standard t-test (MacKinlay, 1997) and the Wilcoxon signed rank test (Wilcoxon, 1945). The inference tests are conducted on the sample of green bond announcements in the US where the issuing firms have an E-score below median. Sample median E-score: 60.5. The null hypothesis for the standard t-test is ACAR = 0, and MCAR = 0 for the Wilcoxon signed rank test. ACAR: Average cumulative abnormal return, in percent. T: t-statistic of standard t-test. MCAR: Median cumulative abnormal return, in percent. Z: z-statistic of Wilcoxon signed rank test. N: Number of observations.

	Symmetrical windows			*Pre-event windows*			*Post-event windows*		
Event window	[-1,1]	[-2,2]	[-5,5]	[-5,0]	[-2,0]	[-1,0]	[0,1]	[0,2]	[0,5]
ACAR	-4.95***	-3.80**	-7.32**	-5.02**	-3.01**	-2.90**	-4.55***	-3.28**	-4.80**
T	(-3.65)	(-2.17)	(-2.82)	(-2.62)	(-2.22)	(-2.62)	(-4.10)	(-2.42)	(-2.50)
MCAR	-1.52***	-2.56**	-2.71***	-2.02**	-1.77**	-0.61	-1.42***	-0.85*	-2.74
Z	(2.61)	(2.51)	(2.88)	(2.31)	(2.31)	(1.61)	(2.88)	(1.65)	(2.57)
N	18	18	18	18	18	18	18	18	18

Note ***p<0.01; **p<0.05; *p<0.10

For announcements from firms with above-median E-score, we observe no significant ACAR. However, the MCAR in two symmetrical event windows, [-2,2] and [-5,5], is significantly positive at the 5% level. Additionally, in the pre-event window [-2,0] we find a positive MCAR, significant at the 10% level. In the sample of bonds from firms with below-median E-score, we observe negative abnormal returns across the board. ACAR is significantly negative in all event windows, at least at the 5% level. The ACARs are in line with what we find for the sample of quasi-green bonds, with even greater magnitudes of abnormal return for this sample. However, in contrast to the sample of quasi-green bonds, we also observe a significantly negative MCAR for several windows. This indicates that the negative stock market reaction observed is not just driven by the three negative outliers previously referred to.

With reference to hypothesis 1, we find marginal evidence of a positive stock market reaction for the group of bonds from firms with above-median E-score. For the other sub-group, we find strong evidence of a negative stock market reaction. In sum, we find evidence that hypothesis 1 is true for both sub-groups, with stock market reactions in opposite directions. Additionally, given our assumption that E-score is a proxy for the credibility of firms' commitment to green investments, this difference in direction of returns may suggest that our second hypothesis is true. This will be formally investigated in the regression analysis.

7.1.4 Discussion of US event study

For the full green bond sample, we find some evidence for our first hypothesis that green bond announcements are associated with abnormal stock returns. The negative direction of the reaction nonetheless contrasts other studies which find a positive stock market reaction to green bond announcements (Flammer, 2018; Tang & Zhang, 2018).

The division of bonds into subgroups based on proxies for credibility enhances our understanding of the results for the full sample. While investors seem indifferent to the announcement of truly green bonds, there is some evidence that they react negatively to quasi-green bonds. The results for the subgroups of relatively high and low E-score paint a similar picture. In fact, the negative stock market reaction for firms with below-median E-score is significant not only when testing for ACAR, but also for MCAR. Given the assumption about use of proceeds (truly and quasi-green) and E-score as proxies for credibility, this may indicate that investors punish companies for announcing green bonds without a certain level of credibility attached to their commitments.

A relevant concept related to credibility is “greenwashing”, whereby firms make misleading or unsubstantiated claims about their environmental impact (Huang & Chen, 2015; Laufer, 2003; Ramus & Montiel, 2005). This widely accepted definition is useful in the context of our proxies of credibility. Issuing quasi-green bonds can be thought of as making misleading claims about environmental impact, as the green bond label signals green investments, while in reality the proceeds may be allocated to non-green purposes. Firms with relatively low E-score issuing green bonds may be thought of as making unsubstantiated claims about environmental impact, as there is a lack of evidence that the firm will follow through on their commitments related to green investments. As such, our two measures of credibility can be used to highlight two different forms of greenwashing, both misleading claims and unsubstantiated claims. This is line with what is argued by both Berrone et. al (2017) and Flammer (2012).

Lastly, we note that the negative ACARs observed for both subgroups with lower assumed credibility are heavily influenced by the three negative outliers. Yet, the fact that all these three outliers are both classified as quasi-green bonds and are issued by firms with a relatively low E-score is in itself an observation which suggests that credibility is important.

7.1.5 Full sample of green bond announcements in Japan

Table 7.6: Results of inference tests for the full sample of Japanese green bond announcements

Table 7.6 summarizes the results from both the standard t-test (MacKinlay, 1997) and the Wilcoxon signed rank test (Wilcoxon, 1945). The inference tests are conducted on the full sample of green bond announcements in Japan. The null hypothesis for the standard t-test is ACAR = 0, and MCAR = 0 for the Wilcoxon signed rank test. ACAR: Average cumulative abnormal return, in percent. T: t-statistic of standard t-test. MCAR: Median cumulative abnormal return, in percent. Z: z-statistic of Wilcoxon signed rank test. N: Number of observations.

	Symmetrical windows			*Pre-event windows*			*Post-event windows*		
Event window	[-1,1]	[-2,2]	[-5,5]	[-5,0]	[-2,0]	[-1,0]	[0,1]	[0,2]	[0,5]
ACAR	-0.72	-0.01	1.09	0.16	-0.47	-0.51	-0.44	0.24	0.70
T	(-1.49)	(-0.01)	(1.19)	(0.24)	(-0.99)	(-1.29)	(-1.11)	(0.50)	(1.03)
MCAR	0.13	0.96	1.80	0.84	0.20	-0.40	-0.61	0.58	0.47
Z	(1.00)	(0.00)	(1.18)	(0.61)	(0.55)	(1.24)	(0.49)	(0.71)	(1.32)
N	31	31	31	31	31	31	31	31	31

Note ***p<0.01; **p<0.05; *p<0.10

We find no significant abnormal returns for the overall sample of Japanese announcements of green-labeled bonds, neither for ACAR nor MCAR, illustrating that this is the case for most of the firms. The results show no evidence for the hypothesis that green bond announcements are associated with abnormal stock price returns. We continue by dividing the bonds into sub-groups following the same procedure as for the sample of US bonds.

7.1.6 Truly green and quasi-green bonds in Japan

Table 7.7: Results of inference tests for Japanese truly green bonds

Table 7.7 summarizes the results from both the standard t-test (MacKinlay, 1997) and the Wilcoxon signed rank test (Wilcoxon, 1945). The inference tests are conducted on the sample of truly green bond announcements Japan. The null hypothesis for the standard t-test is ACAR = 0, and MCAR = 0 for the Wilcoxon signed rank test. ACAR: Average cumulative abnormal return, in percent. T: t-statistic of standard t-test. MCAR: Median cumulative abnormal return, in percent. Z: z-statistic of Wilcoxon signed rank test. N: Number of observations.

	Symmetrical windows			*Pre-event windows*			*Post-event windows*		
Event window	[-1,1]	[-2,2]	[-5,5]	[-5,0]	[-2,0]	[-1,0]	[0,1]	[0,2]	[0,5]
ACAR	-1.44**	-0.76	-0.01	-0.37	-0.91	-0.77	-1.09**	-0.28	-0.07
T	(-2.28)	(-0.93)	(-0.01)	(-0.41)	(-1.44)	(-1.49)	(-2.12)	(-0.44)	(-0.08)
MCAR	-1.82*	-1.76	-0.47	0.22	-0.28	-0.40	-1.05	-0.40	0.02
Z	(1.67)	(0.97)	(0.06)	(0.26)	(0.93)	(1.13)	(1.21)	(0.10)	(0.10)
N	19	19	19	19	19	19	19	19	19
Note							***p<0.01; **p<0.05; *p<0.10		

Table 7.8: Results of inference tests for Japanese quasi-green bonds

Table 7.8 summarizes the results from both the standard t-test (MacKinlay, 1997) and the Wilcoxon signed rank test (Wilcoxon, 1945). The inference tests are conducted on the sample of quasi-green bond announcements in Japan. The null hypothesis for the standard t-test is ACAR = 0, and MCAR = 0 for the Wilcoxon signed rank test. ACAR: Average cumulative abnormal return, in percent. T_1: t-statistic of standard t-test. MCAR: Median cumulative abnormal return, in percent. Z_1: z-statistic of Wilcoxon signed rank test. N: Number of observations.

	Symmetrical windows			*Pre-event windows*			*Post-event windows*		
Event window	[-1,1]	[-2,2]	[-5,5]	[-5,0]	[-2,0]	[-1,0]	[0,1]	[0,2]	[0,5]
ACAR	0.43	1.18	2.84*	1.01	0.21	-0.09	0.60	1.06	1.92*
T	(0.59)	(1.25)	(2.03)	(0.97)	(0.29)	(-0.15)	(1.01)	(1.45)	(1.85)
MCAR	0.65	1.31	2.00**	1.28	0.54	-0.25	0.71	1.14*	1.53**
Z	(0.72)	(1.27)	(2.31)	(1.27)	(0.49)	(0.19)	(1.19)	(1.77)	(2.21)
N	12	12	12	12	12	12	12	12	12
Note							***p<0.01; **p<0.05; *p<0.10		

For truly green bonds, we observe a negative ACAR in the narrowest symmetrical window [-1,1], significant at the 5% level. In the same window, a negative MCAR is marginally significant at the 10% level. None of the other windows show any significant effects. Contrastingly, for the sample of quasi-green bonds, we observe a positive ACAR in the widest symmetrical event window [-5,5], however only marginally significant at 10% level. In the same window we find a positive MCAR significant at the 5% level. We also see some positive reactions in the post-event windows.

In sum, we find some evidence for hypothesis 1 for both sub-groups. The abnormal returns for the two groups draw in opposite directions. Interestingly, we find some negative abnormal returns for truly green bonds, while the quasi-green bonds show a tendency towards positive abnormal returns. This contrasts our findings for the US market and the intuition regarding credibility. We bear in mind, however, that the contrasting directions of abnormal return occur in different event windows.

7.1.7 Above and below median E-score in Japan

Table 7.9: Results of inference tests for Japanese firms with E-score above median

Table 7.9 summarizes the results from both the standard t-test (MacKinlay, 1997) and the Wilcoxon signed rank test (Wilcoxon, 1945). The inference tests are conducted on the sample of green bond announcements in Japan where the issuing firms have an E-score above median. Sample median E-score: 69.5. The null hypothesis for the standard t-test is ACAR = 0, and MCAR = 0 for the Wilcoxon signed rank test. ACAR: Average cumulative abnormal return, in percent. T: t-statistic of standard t-test. MCAR: Median cumulative abnormal return, in percent. Z: z-statistic of Wilcoxon signed rank test. N: Number of observations.

	Symmetrical windows			*Pre-event windows*			*Post-event windows*		
Event window	[-1,1]	[-2,2]	[-5,5]	[-5,0]	[-2,0]	[-1,0]	[0,1]	[0,2]	[0,5]
ACAR	-0.40	0.38	1.30	-0.27	-0.37	-0.73	0.25	0.67	1.49
T	(-0.48)	(0.36)	(0.82)	(-0.23)	(-0.44)	(-1.08)	(0.37)	(0.80)	(1.26)
MCAR	-0.31	0.78	0.83	0.18	-0.10	-0.82*	0.71	1.24	1.76
Z	(0.39)	(0.29)	(0.59)	(0.00)	(0.79)	(1.73)	(0.10)	(0.99)	(1.30)
N	10	10	10	10	10	10	10	10	10

Note ***p<0.01; **p<0.05; *p<0.10

Table 7.10: Results of inference tests for Japanese firms with E-score below median

Table 7.10 summarizes the results from both the standard t-test (MacKinlay, 1997) and the Wilcoxon signed rank test (Wilcoxon, 1945). The inference tests are conducted on the sample of green bond announcements in Japan where the issuing firms have an E-score below median. Sample median E-score: 69.5. The null hypothesis for the standard t-test is ACAR = 0, and MCAR = 0 for the Wilcoxon signed rank test. ACAR: Average cumulative abnormal return, in percent. T: t-statistic of standard t-test. MCAR: Median cumulative abnormal return, in percent. Z: z-statistic of Wilcoxon signed rank test. N: Number of observations.

	Symmetrical windows			*Pre-event windows*			*Post-event windows*		
Event window	[-1,1]	[-2,2]	[-5,5]	[-5,0]	[-2,0]	[-1,0]	[0,1]	[0,2]	[0,5]
ACAR	0.29	0.43	2.09	0.93	-0.14	0.32	0.04	0.65	1.24
T	(0.36)	(0.42)	(1.37)	(0.82)	(-0.18)	(0.48)	(0.06)	(0.81)	(1.09)
MCAR	1.03	1.95	3.29	1.49	0.01	0.26	-0.58	0.84	0.25
Z	(0.00)	(0.29)	(1.09)	(0.79)	(0.00)	(0.39)	(0.10)	(0.99)	(0.89)
N	10	10	10	10	10	10	10	10	10
Note							***p<0.01; **p<0.05; *p<0.10		

Except for a marginal effect in window [-1,0] for firms with above-median E-score, none of the event window show a significant ACAR or MCAR for either of the two groups of bonds. Moreover, the directions of returns vary between windows within the same group of bonds, for both subgroups. As such, we cannot say that we find evidence for hypothesis 1 being true, neither for firms with above-median E-score nor those with scores below median.

7.1.8 Discussion of Japanese event study

For the complete sample of bonds, we find no evidence for our first hypothesis that green bond announcements are associated with abnormal stock returns in Japan. This differs from what is observed in large-scale international studies such as Flammer (2018) and Tang and Zhang (2018). It is however somewhat in line with what we observe for the complete sample of US bonds, where no significant MCAR is found despite a significantly negative ACAR. A possible explanation for the lack of abnormal returns may be that the information offered by the initial announcements does not provide new, price-relevant information to investors. This may either be because the information is not relevant to the stock price, or it may be because the information is not new. If Japanese investors do care about companies' commitment to the environment, this information may already be reflected in the stock price prior to the announcement. Moreover, the fact that dates for initial announcements deviate from the announcement dates registered in the Bloomberg fixed income database may suggest that identifying correct event dates is difficult for the Japanese market.

For the subgroups of bonds with different levels of assumed credibility, the results are mixed. It seems that investors react differently to truly green bonds than quasi-green bonds, but for subgroups arranged according to E-score, we find no reaction. If Japanese investors care about the credibility of companies' commitment to green investments, we expect to observe a relatively more positive reaction to truly green bonds than quasi-green bonds. What we observe is the opposite. As such, our impression is that Japanese investors do not value the credibility of firms' commitment. The fact that we see no (difference in) reaction to announcements for groups with different levels of E-score strengthens this impression. Thus, we believe that the abnormal returns observed for announcements of truly green and quasi-green are driven by other factors.

7.2 Regression analysis

The event study has already given some suggestions that US investors value credibility, while we find no evidence of this for the Japanese market. We want to delve deeper into the investors' reactions to green bond announcements by testing if measures of credibility can explain the variance of stock market returns. We do this for each market separately as well as on a combined data set with observations from both markets. We expand our range of proxies of credibility and apply them as explanatory variables in OLS regressions to test hypothesis 2. In the following sections, we elaborate on the methodology behind the regression analysis before presenting the results.

7.2.1 Regression analysis methodology

Previous literature on the relationship between bonds and financial markets tells a story of how both firm and bond characteristics impact the stock market reaction (Bradshaw et al., 2006; Godlewski et al., 2013; Spiess and Affleck-Graves,1999). In order to analyze how cumulative abnormal return varies with changes in assumed credibility, we use a multiple regression model (Wooldridge, 2013). A multiple regression model is an OLS regression with several explanatory variables.

7.2.1.1 Dependent variable

We choose the CAR for window [-1,1] for both the US and Japan as the respective dependent variables for the regression analysis. Applying this narrow window minimizes the risk of capturing abnormal returns caused by confounding events.

7.2.1.2 Explanatory variables

As mentioned in section 5.1.4 we retrieve the following firm-specific characteristics: total assets and E-score (part of ESG-score). Our distinction between truly and quasi-green is used a categorical bond characteristic.

We retrieve firm data for the fiscal year before the bond issuance announcement. Full year accounting data is applied as it has been revised by auditors, while this might not be the case, for instance, for quarterly data (Glavas, 2018).

Firm size is a potential driver of market reaction to bond issuances (Glavas, 2018). We expect a positive relationship between firm size and CAR. Large firms with more resources can provide comprehensive information and thus be more transparent than smaller firms. This transparency can lower the risk of not committing to green investments, and thus increase the firms' credibility. An announcement of a green bond issuance by a large firm can therefore send a credible signal of their commitment to green investments.

Environmental score (E-score) is one of the metrics in the ESG ranking. As mentioned in section 5.1.4, a high E-score indicates that a firm takes positive action for the environment. An announcement from a firm with a higher E-score can to a greater extent be viewed as a credible signal than announcements from firms with lower E-scores. As such, a positive relationship can be expected between E-score and abnormal return.

On the other hand, one can argue that green bond announcements from firms with high E-scores do not provide new information. The high E-score itself and the public reports related to their ESG-ranking might already signal the firms' commitment to green investments. Thus, one doesn't necessarily need to expect a positive relationship between E-score and abnormal return.

The last proxy for credibility included as an explanatory variable is our classification of bonds as either truly green or quasi-green. We expect a relatively more positive relationship between CAR and truly green bonds than quasi-green bonds, following our previous rationale regarding credibility.

7.2.1.3 Applied regressions

In order to test hypothesis two, if the stock market reaction is affected by the credibility of the firms' commitment towards green investments, we apply the regression in equation 7.1 below. We present three main regressions; one for the US market, the Japanese market and a regression that includes both these markets. Moreover, we present three models for each of these three markets. The regressions are partially based on the findings from Glavas (2018) and Godlewski et al. (2013):

$$CAR_i = \alpha_i + \beta_i \times TrulyGreen.dummy_i + \beta_i \times E - score_i + \beta_i \times Firmsize_i + \varepsilon_i \tag{7.1}$$

In this multiple linear regression model, the dependent variable CAR_i is the cumulative abnormal return of firm i in the main event window. $TrulyGreen.dummy_i$ is a dummy variable equal to one if firm i has issued a truly green bond based on use of proceeds outlined in the prospect. $E - score_i$ represents the environmental score for firm i and $Firmsize_i$ represents the natural logarithm of total assets for firm i. ε_i is the error term. It has a variance equal to $\sigma^2_{\epsilon_i}$ and an expected value of zero.

Since the dependent variable CAR (in percent) is calculated as the sum of logarithmic returns for each firm across the event window, coefficients of explanatory variables are only interpreted as the percentage point increase of the dependent variable associated with a one unit increase in the explanatory variable. For small values of CAR, this is approximately equal to the percentage point increase in simple return across the event window.

7.2.1.4 Statistical challenges in our regression analysis

A key challenge to our analysis is the presence of outliers in our data set. This is particularly challenging for regressions with small data sets such as ours, as OLS estimates are sensitive to the inclusion of outliers (Wooldridge, 2013). As can be seen from Figure 7.1, four US observations stand out in terms of CAR for the window [-1,1]. Since the approach used by OLS regression is to minimize the sum of squared residuals, large residuals receive a lot of weight (Wooldridge, 2013). Our estimations are likely to be heavily influenced by the outliers, especially since three of four are extremely negative and will as such draw in the same direction. This was also noted previously as a concern regarding the event study, where we used the median CAR to give a more nuanced picture of the stock market reaction to the announcements.

Dealing with these outliers is not straightforward. After investigating in detail, we have no reason to exclude them due to confounding events or incorrect data collection. As such, they are equally relevant to our analysis as all the other observations. However, due to their potentially large effect on the OLS estimates, we include, where relevant, one regression model without extreme outliers[6]. This allows us to illustrate the effect of outliers without excluding them from our analysis.

Omitted variable bias is when we omit an explanatory variable from the regression, and it is correlated with another explanatory variable which is included in the regression. A correlation between an explanatory variable and the error term results in all OLS estimators being biased (Wooldridge, 2013). Our regressions might have omitted variable bias, but we choose to have few explanatory variables to avoid overfitting as we have few observations in our data set. The same rationale is applied for not preventing time-invariant omitted variable bias with fixed effects. We therefore only apply country fixed effects for the last set of regressions, which has more observations, since it includes both the US and Japanese market.

[6] We define extreme outliers using the inter-quartile range rule (Dunn, 2021). See appendix F for details.

7.2.2 Regression analysis: US

Table 7.11: Regression models for the US green bond market

Table 7.11 summarizes the regressions results for the full sample of green bonds issued by US firms. The sample period is from January 2013 to September 2021. It displays the results of three different regression models with CAR (in percent) per bond announcement in the main event window [-1,1] as the dependent variable. TrulyGreen.dummy: Dummy variable equal to 1 if firm i has issued a truly green bond, 0 otherwise. E-score: Environmental score for firm $i. Firmsize$: Natural logarithm of total assets for firm i. Constant: Regression constant. Outliers excluded: Notes if the extreme outliers of observations of the dependent variable are excluded. Observations: Total number of observations. R^2: Ratio of the explained variation compared to the total variation. Adjusted R^2: Goodness-of-fit measure that punishes additional explanatory variables by applying a degrees of freedom adjustment when estimating the error variance (MacKinlay, 1997). Residual Std.Error: The standard error of the error term in the OLS regression. F statistic: Statistic of inference test. Coefficients of each explanatory variable are noted without parenthesis. Standard errors are noted in parentheses. Model 1 excludes Firmsize and includes all extreme outliers. Model 2 includes all the mentioned explanatory variables and includes all extreme outliers. Model 3 includes all the mentioned explanatory variables but excludes the extreme outliers.

	Dependent variable: CAR [-1,1]		
	Model 1	*Model 2*	*Model 3*
TrulyGreen.dummy	3.54	2.61	1.04
	(2.36)	(2.85)	(0.79)
E-score	0.16***	0.18***	0.041**
	(0.05)	(0.06)	(0.02)
Firmsize		1.30	-0.17
		(0.98)	(0.29)
Constant	-13.33***	-27.67***	-1.70
	(3.266)	(7.97)	(2.68)
Outliers excluded	No	No	Yes
Observations	36	29	26
R^2	0.29	0.48	0.21
Adjusted R^2	0.24	0.42	0.11
Residual Std. Error	6.98 (df = 33)	6.60 (df = 25)	1.82 (df = 22)
F statistic	6.66 (df = 2; 33)	7.67*** (df = 3; 25)	1.98 (df = 3; 22)
Note			***p<0.01; **p<0.05; *p<0.10

TrulyGreen.dummy is not significant for either of the three models above. An insignificant dummy shows that we cannot observe if investors in the US green bond market value announcements of truly green bonds differently from those of quasi-green bonds. In the event study, we observed a significantly negative ACAR for the subgroup of quasi-green bonds, but no significant reaction to truly green bonds. The results from the regression models above shows that there is no significant difference in CAR between truly and quasi-green bonds when also accounting for E-score.

E-score is significant with a positive coefficient at the 1% level for model 1 and 2. The relationship weakens in model 3 when excluding the three outliers but is still significantly positive at the 5% level. We observe the strongest relationship between E-score and CAR in model 2, where an increase of one E-score point (on a scale from 0-100) is associated with a 0.18 percentage point higher CAR. This indicates that credibility is valued by investors, as measured by E-score. As mentioned in section 7.2.1.2, this might be due to a history of sustainable operations that clearly signals the firm's intentions behind issuing a green-labeled bond.

A possible explanation for observing that investors do not value truly green bonds differently from quasi-green bonds is that the "greenness" of the bond is difficult to assess. E-score, however, is a measure of credibility that is more easily observed by investors, as it is generally readily available for US firms. The fact that investors seem to react more in line with E-score than the greenness of the bond may be due to the limited application of high-quality standards of greenness such as those from the CBI. As mentioned in section 5.1.1., none of the US green bonds in our data set are CBI-certified. Hyun, Park & Tian (2019) also note that investors tend to rely on independent information enhancers due to the limited information on environmental impact. Given that investors care about credibility, the lack of direct information on the environmental impact of green bonds may impede effective allocation of capital to firms with activities that actually contribute to mitigating climate change. This could be improved by adopting a universally accepted greenness measure, as is also argued by Hyun, Park & Tian (2019).

In models 2 and 3 we have included Firmsize as an explanatory variable. Model 2 shows a positive coefficient for Firmsize. In section 7.2.1.2 we expected that larger firms with more resources can provide comprehensive information and thus send out a more credible signal of their commitment to green investments. However, as the relationship is insignificant it is not possible to claim that it holds. In model 3, the relationship disappears completely, indicating that it is in large part driven by the three extreme negative CARs, which all have a relatively small firm size.

In sum, we find evidence of hypothesis 2 being true for the US market. Specifically, we find that cumulative abnormal return is positively correlated with the issuing firm's E-score, a proxy for credibility.

7.2.3 Regression analysis: Japan

Table 7.12: Regression models for the Japanese green bond market

Table 7.12 summarizes the regressions results for the full sample of green bonds issued by Japanese firms. The sample period is from January 2013 to September 2021. It displays the results of three different regression models with CAR (in percent) per bond announcement in the main event window [-1,1] as the dependent variable. TrulyGreen.dummy: Dummy variable equal to 1 if firm i has issued a truly green bond, 0 otherwise. E-score: Environmental score for firm $i. Firmsize$: Natural logarithm of total assets for firm i. Constant: Regression constant. Outliers excluded: Notes if the extreme outliers of observations of the dependent variable are excluded. Observations: Total number of observations. R^2: Ratio of the explained variation compared to the total variation. Adjusted R^2: Goodness-of-fit measure that punishes additional explanatory variables by applying a degrees of freedom adjustment when estimating the error variance (MacKinlay, 1997). Residual Std.Error: The standard error of the error term in the OLS regression. F statistic: Statistic of inference test. Coefficients of each explanatory variable are noted without parenthesis. Standard errors are noted in parentheses. Model 1 excludes Firmsize. Model 2 includes all the mentioned explanatory variables and Model 3 excludes E-score. There are no extreme outliers observed of the dependent variable.

	Dependent variable: CAR [-1,1]		
	Model 1	*Model 2*	*Model 3*
TrulyGreen.dummy	-0.93	-1.15	-2.02*
	(1.01)	(1.17)	(1.16)
E-score	-0.02	-0.01	
	(0.02)	(0.02)	
Firmsize		-0.09	0.42
		(0.87)	(0.62)
Constant	1.58	2.72	-5.30
	(1.57)	(11.91)	(8.54)
Outliers excluded	No	No	No
Observations	20	18	28
R^2	0.08	0.09	0.13
Adjusted R^2	-0.03	-0.11	0.06
Residual Std. Error	2.25 (df = 17)	2.44 (df = 14)	2.94 (df = 25)
F statistic	0.73 (df = 2; 17)	0.46 (df = 3; 14)	1.84 (df = 2; 25)
Note			***p<0.01; **p<0.05; *p<0.10

TrulyGreen.dummy is not significant for either model 1 or model 2 but is marginality significant for the third model. In model 3, a truly green bond is associated with 2.02 percentage points lower CAR than quasi-green bonds. The negative difference is in line with what we find in the event study, where we argue in section 7.1.8 that we cannot attribute the disparate reactions to investors caring about credibility as we would then expect the opposite to occur.

E-score is not significant for either of the two models where it is included. We exclude E-score from the third model to increase the number of observations, as there are ten Japanese firms without an E-score. In short, we find no evidence of investors valuing credibility, measured by E-score, in Japan. This result is aligned with the event-study where we separated the Japanese bonds based on above-median and below-median E-score.

Firmsize is included as an explanatory variable in model 2. In section 7.2.1.2 we discussed the possibility of firm size conveying a credible signal as larger firms can provide more comprehensive information and be more transparent than smaller firms. However, we find that firm size does not explain variation in cumulative abnormal return of Japanese bonds. The finding supports the story told by an insignificant E-score and truly green-dummy (model 1 and 2) – we cannot observe that investors in the Japanese green bond market value the credibility of firms' commitment to green investments.

In sum, we find no evidence that supports hypothesis 2 for the Japanese market.

7.2.4 Regression analysis: US and Japan combined

Table 7.13: Regression models for the US and Japanese green bond market

Table 7.13 summarizes the regressions results for the combined sample of green bonds issued by US and Japanese firms. The sample period is from January 2013 to September 2021. It displays the results of three different regression models with CAR (in percent) per bond announcement in the main event window [-1,1] as the dependent variable. TrulyGreen.dummy: Dummy variable equal to 1 if firm i has issued a truly green bond, 0 otherwise. E-score: Environmental score for firm i. $Firmsize$: Natural logarithm of total assets in USD for firm i. US.dummy: Dummy variable equal to 1 if green bond is issued in the US, 0 otherwise (issued in Japan). Constant: Regression constant. Outliers excluded: Notes if the extreme outliers of observations of the dependent variable are excluded. Observations: Total number of observations. R^2: Ratio of the explained variation compared to the total variation. Adjusted R^2: Goodness-of-fit measure that punishes additional explanatory variables by applying a degrees of freedom adjustment when estimating the error variance (MacKinlay, 1997). Residual Std.Error: The standard error of the error term in the OLS regression. F statistic: Statistic of inference test. Coefficients of each explanatory variable are noted without parenthesis. Standard errors are noted in parentheses. Model 1 excludes US.dummy, includes all extreme outliers. Model 2 includes all the mentioned explanatory variables and includes all extreme outliers. Models 1 and 2 include 29 US observations and 18 Japanese. Model 3 includes all the mentioned explanatory variables but excludes the three US extreme outliers.

	Dependent variable: CAR [-1,1]		
	Model 1	*Model 2*	*Model 3*
TrulyGreen.dummy	1.15	0.69	-0.05
	(1.86)	(1.87)	(0.69)
E-score	0.09**	0.09**	0.01
	(0.04)	(0.04)	(0.02)
Firmsize	1.69**	1.76**	-0.01
	(0.77)	(0.76)	(0.30)
US.dummy		-2.37	-0.10
		(1.79)	(0.68)
Constant	-24.05***	-22.82***	-0.67
	(6.53)	(6.54)	(2.78)
Outliers excluded	No	No	Yes
Observations	47	47	44
R^2	0.31	0.34	0.01
Adjusted R^2	0.26	0.27	-0.09
Residual Std. Error	5.92 (df = 43)	5.87 (df = 42)	2.16 (df = 39)
F statistic	6.41*** (df = 3; 43)	5.33*** (df = 4; 42)	0.14 (df = 4; 39)
Note			***p<0.01; **p<0.05; *p<0.10

TrulyGreen.dummy is not significant for any of the models. This is in line with the results for the country-specific models, where only a weak negative effect is observed in model 3 for Japan. Moreover, the event studies performed on the sub-groups of truly green and quasi-green bonds show conflicting evidence for the US and Japan. As such, it is not surprising that we do not observe a significant effect for the combined data. Overall, thus, there is no clear evidence that bonds with proceeds exclusively allocated to green projects are associated with a more positive stock market reaction than bonds that allow for allocation to non-green projects.

E-score is, on the other hand, significantly positive in both model 1 and 2. This is in line with what we find for the US models. Moreover, since we find no significant effect of E-score for Japanese bonds, it is likely that the effect is driven by the US bonds in the combined sample. The coefficient is lower for the combined data set than for US bonds alone. In model 1, an increase of one E-score point (on a scale from 0-100) is associated with a 0.09 percentage point higher cumulative abnormal return. The coefficient is stable across the two models, meaning that this relationship is observed even when controlling for the difference in average CAR for each country. As E-score is insignificant in model 3, the relationship is likely to be driven in large part by the three negative outliers in the US sample. We observe a similar dynamic for the models performed on the US data set alone, where model 3 shows a weaker relationship between CAR and E-score, albeit still significantly positive at the 5% level. As the relationship disappears completely for the combined sample of US and Japanese bond announcements, it seems that the lack of relationship with E-score of Japenese companies dilutes the overall effect, causing it to lose its significance in the absence of three influential US observations.

Firmsize is significantly positive in models 1 and 2 at the 5% level. Based on these two models, our expectation of a positive relationship between CAR and Firmsize seems to be true. Given that firmsize is a proxy for credibility, this indicates that investors value credibility. However, since we do not observe any relationship in model 3, this effect seems to be driven by the three extremely negative CARs in the US sample, which are all from firms with a relatively small firm size.

US.dummy is included in models 2 and 3 to control for the difference in average CAR between countries. We see that this dummy is not significant for either model. We therefore cannot conclude that there is a difference in CAR between green-labeled bonds issued in the US and Japan.

Regarding hypothesis 2 about measures of credibility being correlated with CAR, we find no strong additional evidence in the combined analysis compared to what we find for the two markets separately. E-score and Firmsize are significantly positive for the combined data set when including outliers. The effect is driven by the US observations generally and the extreme outliers particularly.

8 Conclusion

The main purpose of this paper is to answer two research questions; 1) whether green bond announcements provide stock-price relevant information and 2) whether stock price reactions are associated with the credibility of firms' commitment to green investments.

As the results of the analyses of the two markets differ considerably, we present a conclusive discussion for each market.

US green bond market

The results from the event study indicate that green bond announcements from US firms do provide stock price relevant information. We find some evidence of a negative reaction both for the full sample and the subgroup of quasi-green bonds. Stronger evidence is found for the sample of bonds from firms with below-median E-score, where both the median and average CAR are significantly negative. The fact that the negative reactions are driven by the subgroups of quasi-green bonds and bonds issued by firms with below-median E-score suggests that investors punish companies for announcing green bonds without a certain level of credibility attached to their commitments.

The direct correlation between measures of credibility and abnormal stock returns is formally investigated in the regression analysis. For the US, we find a significantly positive relationship between E-score and CAR, indicating that investors care about the credibility of commitments. However, no significance is found for the dummy variable for truly green bonds. We argue that this disparity might be a result of E-score being more available to investors as a measure of credibility than the provisions for use of proceeds.

The purpose of corporate green bonds as a financial instrument is to allocate capital toward firms with green projects, thereby contributing to climate change mitigation. The limited application of high-quality standards for labelling green bonds according to their environmental impact impedes such allocation of capital. The Bloomberg green instrument indicator allows bonds used to finance non-green projects to be labelled as equally "green" as bonds that are truly green, potentially misleading investors. As such, there is a need for high-quality, universally accepted measures of greenness to enhance the allocation of capital to activities that mitigate climate change.

Japanese green bond market

The results from the event study on the sample of Japanese bonds show little evidence that green bond announcements provide stock-price relevant information. For the subgroups of truly and quasi-green bonds, we see some significant reactions. However, the significance is marginal, and the direction of reactions is counterintuitive to the argument regarding credibility of firms' commitments to green investments.

Similarly, we find little to no evidence of a correlation between measures of credibility and the stock market reaction for each announcement. A marginally negative correlation with the truly green dummy is observed in one model, but here too the marginality and direction of the correlation leads us to believe that the effect is not driven by investors' preferences for credibility.

There could be different reasons for the lack of observable stock market reactions for the Japanese market. Information conveyed by the green bond announcements needs to be both new and valuable to affect the stock price. It may be that information is either not new, not valuable, or a combination of both.

9 Limitations of the study

As mentioned in the introduction, corporate green bonds are a relatively new financial instrument and there is thus limited research on this topic. This weakens the ability to compare our findings to previous literature. Another consequence is that, despite being two of the largest markets for green bonds in the world, the number of unique, publicly listed issuers is low. As we focus on first-time issuances only, this means that we are left with a relatively small number of observations. With more available data, future research can provide more insight on stock market reactions and the importance of credibility of firms' commitment to green investments.

Furthermore, our analysis of the association between credibility and stock market reactions assumes that our proxies for credibility reflects the credibility of firms' commitment to green investments. Lastly, we do not compare green bonds to conventional bonds. As such, we are not able to say whether stock market reactions to green bond announcements differ from reactions to conventional bond announcements.

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Appendix

A1 Appendix A

Table A1.1: Industry Segmentation

Table A1.1: Industry segmentation by Bloomberg Industry Classification Systems

Table A1.1 displays the Bloomberg Industry Classification Systems by sector (Level 1) and industry group (Level 2). Sector (Level 1) is noted in *italics* and industry group (Level 2) is noted under each sector.

Communications	*Consumer Staples*	*Financials*
Cable & Satellite	Consumer Products	Banking
Entertainment	Food & Beverage	Commercial Finance
Media Non-Cable	Retail Staples & Supermarkets	Consumer Finance
Wireless Telecom Services	Tobacco	Financial Services
		Life Insurance
		Property & Casualty
		Real Estate
Consumer Discretionary	*Energy*	*Health Care*
Airlines	Exploration & Production	Health Care Facilities & Services
Apparel & Textile Products	Integrated Oils	Managed Care
Automotive	Oil & Gas Services	Medical Equipment & Devices
Casinos & Gaming	Pipeline	Pharmaceuticals
Consumer Services	Refining & Marketing	
Distributors	Renewable Energy	
Educational Services		
Entertainment Resources		
Home & Office Products		
Home Builders		
Home Improvements		
Leisure Products		
Restaurants		
Travel & Lodging		

Industrials

Aerospace & Defense

Electrical Equipment

Industrial Other

Machinery

Manufactured Goods

Railroad

Transportations & Logistics

Waste & Environment Services

Equipment & Facilities

Utilities

Materials

Chemicals

Construction Materials

Construction & Packaging

Forest & Paper Products

Metals & Mining

Government

Sovereign

Government Agency

Governmental Region/Local

Supranational

Development Bank

Winding Up Agency

Technology

Communications Equipment

Hardware

Software & Services

A2 Appendix B

Table A2.1: Refinitiv environmental matrix

Table A2.1: Refinitiv environmental matrix

Table A2.1 displays the Refinitiv environmental matrix arranged by categories and themes. It shows which categories their environmental score is based on, and the themes covered in each category. The categories are noted in *italics* and the themes are noted under each category.

Environmental score		
Emission	*Innovation*	*Resource use*
Emissions	Product innovation	Water
Waste	Green revenues, Research and Development (R&D) and Capital Expenditures (CapEx)	Energy
Biodiversity		Sustainable packaging
Environmental management systems		Environmental supply chain

A3 Appendix C

Table A3.1: List of US firms

Table A3.1: List of US firms

Table A3.1 presents an overview of the firms in the sample of US corporate green bonds and characteristics of each firm. Note that CAR for the event window [-1,1] is given in percent.

Firm	Industry	CAR [-1,1]	Truly/quasi-green	E-score
AES Corp	Utilities	-2.65	Quasi-green	51
Ameren Illinois Co	Utilities	-1.22	Quasi-green	35
Analog Devices Inc	Technology	2.37	Truly green	88
Apple Inc	Technology	-1.33	Truly green	60
Avangrid Inc	Utilities	-2.47	Truly green	77
Bloom Energy Corp	Industrials	-15.91	Quasi-green	37
Clearway Energy Operating LLC	Utilities	-4.23	Truly green	58
Consolidated Edison Co of New York Inc	Utilities	9.06	Quasi-green	54
Dominion Energy Inc	Utilities	1.33	Quasi-green	80
DTE Electric Co	Utilities	0.30	Quasi-green	87
Duke Energy Carolinas LLC	Utilities	3.18	Quasi-green	77
Enphase Energy Inc	Energy	-0.29	Quasi-green	46
Evergy Kansas Central Inc	Utilities	0.42	Quasi-green	44
Georgia Power Co	Utilities	-1.69	Quasi-green	78
Interstate Power and Light Co	Utilities	-0.43	Truly green	69
Livent Corp	Materials	-27.87	Quasi-green	33
MidAmerican Energy Co	Utilities	0.00	Truly green	26
MP Materials Corp	Materials	-34.65	Quasi-green	7
Niagara Mohawk Power Corp	Utilities	0.55	Truly green	50
Norfolk Southern Corp	Industrials	3.10	Truly green	68
Northern States Power Co/MN	Utilities	1.43	Truly green	87
NSTAR Electric Co	Utilities	1.02	Truly green	66
Owens Corning	Materials	-2.96	Quasi-green	96
PacifiCorp	Utilities	-1.72	Truly green	26
PepsiCo Inc	Consumer Staples	-0.38	Quasi-green	80
Plug Power Inc	Energy	-3.67	Quasi-green	28
Public Service Co of Colorado	Utilities	2.78	Truly green	87
Public Service Co of Oklahoma	Utilities	0.03	Quasi-green	61
Solar Star Funding LLC	Utilities	-1.01	Quasi-green	26
Southern Power Co	Utilities	1.75	Quasi-green	78
Southwestern Public Service Co	Utilities	-0.26	Quasi-green	87
Sunnova Energy Corp	Energy	0.27	Truly green	39
Terraform Global Operating LLC	Utilities	-2.81	Truly green	13
Tesla Energy Operations Inc (Previously Solar City)	Energy	1.07	Quasi-green	70
Verizon Communications Inc	Communications	-2.04	Truly green	58
VF Corp	Consumer Discretionary	-1.22	Quasi-green	82

Table A3.2: List of Japanese firms

Table A.3.2: List of Japanese firms

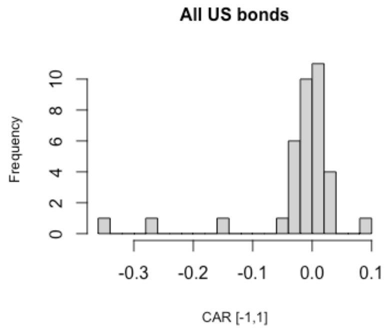
Table A3.2 presents an overview of the firms in the sample of Japanese corporate green bonds and characteristics of each firm. Note that CAR for the event window [-1,1] is given in percent.

Firm	Industry	CAR [-1,1]	Truly/quasi-green	E-score
ANA Holdings Inc	Consumer Discretionary	-2.25	Truly green	82
Asahi Group Holdings Ltd	Consumer Staples	-3.68	Truly green	88
Chubu Electric Power Co Inc	Utilities	0.98	Quasi-green	35
Daio Paper Corp	Materials	-2.07	Truly green	16
Daiwa House Industry Co Ltd	Consumer Discretionary	3.45	Truly green	88
Hitachi Zosen Corp	Industrials	-6.90	Truly green	NA
Kajima Corp	Industrials	-2.92	Truly green	67
Kaneka Corp	Materials	-2.37	Quasi-green	66
Kirin Holdings Co Ltd	Consumer Staples	-0.77	Quasi-green	82
Kyushu Electric Power Co Inc	Utilities	0.15	Quasi-green	72
Kyushu Railway Co	Consumer Discretionary	2.76	Truly green	NA
Marui Group Co Ltd	Consumer Discretionary	-7.87	Truly green	NA
Meidensha Corp	Industrials	1.07	Truly green	NA
Mitsui OSK Lines Ltd	Industrials	3.63	Quasi-green	64
Mitsui-Soko Holdings Co Ltd	Industrials	-4.18	Truly green	NA
Nidec Corp	Technology	-3.21	Truly green	86
Nippon Yusen KK	Industrials	0.35	Quasi-green	75
Nomura Research Institute Ltd	Technology	-1.32	Quasi-green	64
Obayashi Corp	Industrials	1.69	Truly green	85
Odakyu Electric Railway Co Ltd	Consumer Discretionary	1.94	Truly green	0
Penta-Ocean Construction Co Ltd	Industrials	0.12	Truly green	NA
RENOVA Inc	Utilities	-1.82	Truly green	NA
Seiko Epson Corp	Technology	1.21	Quasi-green	90
Senko Group Holdings Co Ltd	Industrials	1.80	Quasi-green	NA
Shimizu Corp	Industrials	-0.97	Truly green	73
Sumitomo Forestry Co Ltd	Materials	-5.52	Truly green	NA
Takasago Thermal Engineering Co Ltd	Industrials	-1.41	Quasi-green	NA
Toda Corp	Industrials	1.95	Truly green	65
Toyota Finance Corp	Consumer Discretionary	0.95	Quasi-green	NA
Yaskawa Electric Corp	Industrials	1.94	Quasi-green	46
Z Holdings Corp	Communications	1.09	Truly green	42

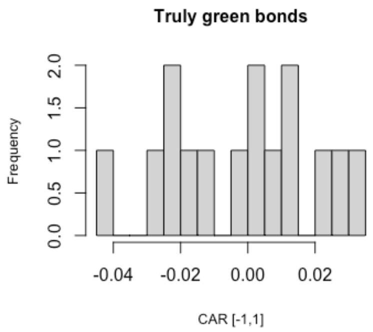
A4 Appendix D

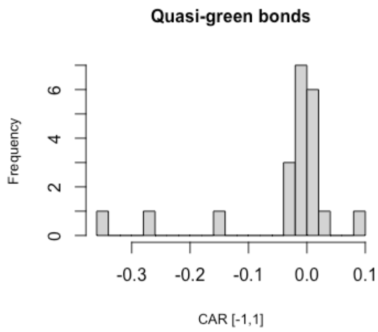
Figure A4.1: Histogram of CAR [-1,1] for US bonds

Panel A: All US green bonds

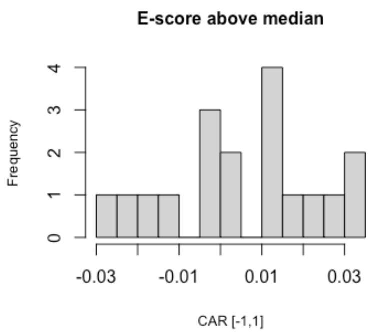


Panel B: US truly green and quasi-green bonds





Panel C: US bonds filtered by E-score above and below median



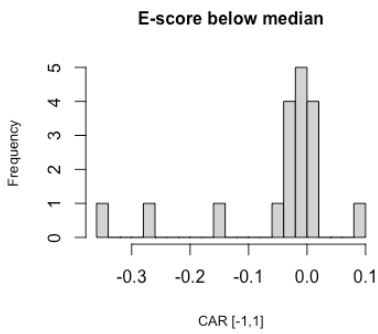
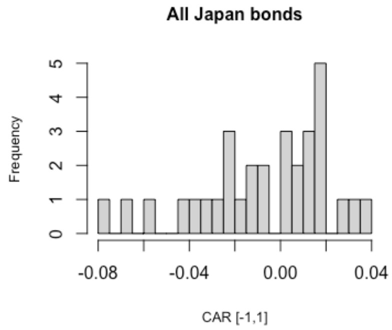


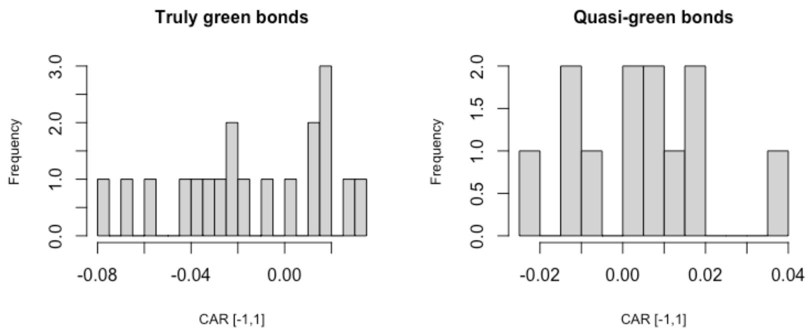
Figure A4.1 illustrates the distribution of the cumulative abnormal returns in the event window [-1,1] for all US green bonds, and its subgroups: truly green, quasi-green, E-score above median and E-score below median.

Figure A4.2: Histogram of CAR [-1,1] for Japanese bonds

Panel A: All Japanese green bonds



Panel B: Japanese truly green and quasi-green bonds



Panel C: Japanese bonds filtered by E-score above and below median

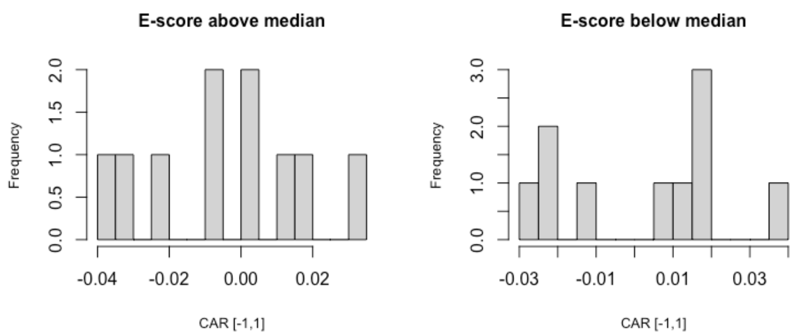


Figure A4.2 illustrates the distribution of the cumulative abnormal returns in the event window [-1,1] for all Japanese green bonds, and its subgroups: truly green, quasi-green, E-score above median and E-score below median.

A5 Appendix E

A5.1 Inter-quartile range rule

Since the distribution of CARs is not symmetrical, we use the interquartile range instead of the standard deviation as a method for identifying outliers among observations of the dependent variable in the regression analyses. An extreme outlier is defined as an observation that lies further away from Q1 or Q3 than three times the interquartile range (Q3 - Q1), following the approach of Dunn (2021). For each data set (US, Japan and combined), we identify extreme outliers among observations of dependent variables included in model 2. After applying the inter-quartile range rule, we remove three extreme negative observations of CAR from regression model 3 performed on the US and combined data sets. For these two regression analyses, model 3 is intended as a direct comparison to model 2, with the exclusion of outliers being the only difference.

A6 Appendix F

A6.1 Correlation matrices

Tables A6.1, A6.2 and A6.3 below illustrate the Pearson correlation coefficient for each pair of explanatory variables for models 1, 2 and 3 of the regression analysis performed on the US, Japanese and combined set of green bonds respectively. The correlation coefficient, r_{xy} for a pair of variables x and y, is defined as:

$$r_{xy} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Table A6.1: Correlation matrices for US regression models

Table A6.1: Correlation matrices for US regression models

Table A6.1 show correlation matrixes between the explanatory variables used in the US regression models. TrulyGreen.dummy: Dummy variable equal to 1 if firm i has issued a truly green bond, 0 otherwise. E-score: Environmental score for firm $i. Firmsize$: Natural logarithm of total assets for firm i. The Pearson correlation coefficient is used to calculate the correlation.

Model 1 N=36

	TrulyGreen.dummy	Escore
TrulyGreen.dummy	1.00	
Escore	-0.02	1.00

Model 2 N=29

	TrulyGreen.dummy	Escore	Firmsize
TrulyGreen.dummy	1.00		
Escore	0.06	1.00	
Firmsize	0.44	0.43	1.00

Model 3 N=26

	TrulyGreen.dummy	Escore	Firmsize
TrulyGreen.dummy	1.00		
Escore	-0.11	1.00	
Firmsize	0.37	0.19	1.00

Table A6.2: Correlation matrices for Japanese regression models

Table A6.2: Correlation matrices for Japanese regression models

Table A6.2 show correlation matrixes between the explanatory variables used in the Japanese regression models. TrulyGreen.dummy: Dummy variable equal to 1 if firm i has issued a truly green bond, 0 otherwise. E-score: Environmental score for firm i. $Firmsize$: Natural logarithm of total assets for firm i. The Pearson correlation coefficient is used to calculate the correlation.

Model 1			N=20
	TrulyGreen.dummy	Escore	
TrulyGreen.dummy	1.00		
Escore	-0.07	1.00	

Model 2			N=18
	TrulyGreen.dummy	Escore	Firmsize
TrulyGreen.dummy	1.00		
Escore	0.02	1.00	
Firmsize	0.13	0.28	1.00

Model 3			N=28
	TrulyGreen.dummy	Firmsize	
TrulyGreen.dummy	1.00		
Firmsize	-0.07	1.00	

Table A6.3: Correlation matrices for combined models

Table A6.3: Correlation matrices for combined models

Table A6.3 show correlation matrixes between the explanatory variables used in the combined regression models. TrulyGreen.dummy: Dummy variable equal to 1 if firm i has issued a truly green bond, 0 otherwise. E-score: Environmental score for firm i. $Firmsize$: Natural logarithm of total assets for firm i. US.dummy: Dummy variable equal to 1 if green bond is issued in the US, 0 otherwise (issued in Japan). The Pearson correlation coefficient is used to calculate the correlation.

Model 1 N=47

	TrulyGreen.dummy	Escore	Firmsize
TrulyGreen.dummy	1.00		
Escore	0.05	1.00	
Firmsize	0.35	0.37	1.00

Model 2 N=47

	TrulyGreen.dummy	Escore	Firmsize	US.dummy
TrulyGreen.dummy	1.00			
Escore	0.05	1.00		
Firmsize	0.35	0.28	1.00	
US.dummy	-0.17	-0.03	-0.15	1.00

Model 3 N=44

	TrulyGreen.dummy	Escore	Firmsize	US.dummy
TrulyGreen.dummy	1.00			
Escore	-0.06	1.00		
Firmsize	0.27	0.21	1.00	
US.dummy	-0.13	0.06	0.10	1.00