Investors in Green Bonds*

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Abstract

Using data on the universe of holdings in bonds traded in Norway 2010-20, we describe the characteristics of real-world green investors. We do so by comparing investors of Norwegian green bonds to those of similar non-green bonds by the same issuers. Although green bonds only constitute a small fraction of portfolios, their investors exhibit a distinct investment strategy. Theory describes green preferences as a trade-off with financial preferences, where the presence of green preferences shields investors, allowing them to take on more financial risk. Consistent with this prediction, we find that green investors hold riskier portfolios with more defaults. They invest in smaller, but more profitable issuers with higher financial leverage. Their portfolio firms have lower ESG ratings and higher CO2 emissions, which supports a consequentialist rather than a warm-glow motive of investment.

Keywords: Sustainable finance, Climate change, Green bonds, Impact investing

JEL: G14, G32, Q56, M14

1. Introduction

The demand for sustainable and impact investing has been increasing dramatically recently, by more than 40 % since 2015, and represents 33 % of the $ 51 trillion in US assets under management in 2020 (US SIF 2020). The theory literature usually models

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such demand explicitly as heterogeneity in preferences, where some investors derive utility from investments in green assets (Pástor et al., 2021; Pedersen et al., 2021; Baker et al., 2018; Green and Roth, 2021; Gupta et al., 2022; Piatti et al., 2022; Davies and Van Wesep, 2018). Such preferences affect equilibrium pricing and corporate behaviour. How important they are is therefore an important empirical question. Yet, preference heterogeneity in non-financial returns is difficult to estimate. The most direct prediction of such preferences is that investors with green preferences are willing to forego financial returns when investing in greener assets. However, realized returns are driven by aggregate demand and do not represent expectations. While surveys have documented that investors profess to take environmental effects of their investments into account (Krueger et al., 2020), it is unclear how these map into their portfolio choice. After all, investors may choose green assets for traditional reasons if such investments yield higher returns or help investors to diversify, and view green motives merely as a way to attract investor flows.

Instead of returns, we test the risk-taking predictions of theories of non-financial preferences. Investors with separable utility from financial as well as non-financial sources are less risk-averse in terms of financial risk (Piatti et al., 2022). This is because investors are shielded by the non-financial benefits of their investments as long as they are not perfectly correlated with their financial performance. We compare bond portfolios of investors in green assets to those without. In our data, investors in green assets indeed exhibit more financial risk-taking in the remainder of their portfolios.

Realized portfolio volatility may differ from expected volatility. To make inferences about investor preferences on risk, we study bond portfolios, for which ex-ante risk assessment is easier to measure than for equity portfolios. Studying green preferences in bond portfolios has the additional advantage that we abstract from engagement motives as in Edmans et al. (2022). We use data from the Oslo Stock Exchange on the universe of non-sovereign bond holdings and trading in Norway between 2010 and 2020. The Norwegian bond market is large: its size is about 79% of the stock market, and 58% of the Norwegian economy (2018).

We identify green investors as investors in Green bonds. These are assets for which proceeds are earmarked for climate-friendly projects (Flammer, 2021). Using them as a marker for revealed environmental preferences is thus more straightforward than using ESG ratings, which often disagree (Berg et al., 2019; Serafeim and Yoon, 2021), or names, which may serve marketing purposes. Our data comprises holdings and transactions of 73 bn NOK of 94 Green bonds. While Green bonds constitute only a subset of the emerging green assets, it is a market important in its own right: between 2013 and 2018 the amount outstanding in Green bonds increased from $5bn to over $95bn (Flammer, 2021). Our dataset allows us to track investors in Green bonds and describe their remaining Norwegian bond portfolio and trading patterns.

To identify a comparison group to investors in Green bonds, we exploit the fact that firms often issue both “regular” and Green bonds. These bonds have the same underlying default risk profile because they stem from the same issuer, and often mature at the same time. To document preferences of investors specifically interested in green assets, we compare holders of Green bonds who do not hold or trade the matched regular bonds to those that hold or trade regular but not their matched Green bonds. Our procedure yields 124 investors with Green, but no matched regular (non-Green) bonds (henceforth "Green investors"), and 152 that hold regular (non-Green) bonds, but no matched Green bonds (henceforth "regular investors"). Although we match on bonds, not investors, the match removes most differences in observable investor characteristics, with the only exception that Green investors are more likely to be related to the government, and less likely to be banks.

First, we document differences between green and regular investors in terms of portfolio risk. Consistent with the predictions of theories of green preferences, their portfolios are smaller and more volatile. The bonds in their portfolio are less likely to be rated, have lower ratings, higher coupons, and experience more credit events. Green investors generally make more and larger trades and are more likely to invest at the emission, but less likely to hold securities until maturity. These results are not driven by the matched se-

curities, but also pertain to the rest of their portfolio. Indeed, Green bonds only constitute a very small fraction of below 5% in bond portfolios.

We also document lower ESG ratings and higher carbon emissions in portfolios of green, compared to regular investors. Most of the corporate finance theory on ESG investing assumes that investors are consequentialist - that they care about the impact of their investment (Heinkel et al., 2001; Hart and Zingales, 2017; Oehmke and Opp, 2022; Green and Roth, 2021). In contrast, most asset pricing theory green investors derive utility from investing in more sustainable firms, no matter their impact (Pástor et al., 2021; Pedersen et al., 2021; Goldstein et al., 2022). Although the ultimate goal of channeling capital towards greener firms is to lower their cost of capital (see (Gormsen et al., 2023)), most of the literature do not model such consequences, with the exception of Hartzmark and Shue (2014) and Edmans et al. (2022), who describe unindended consequences of investing into greener firms. Our evidence is more supportive of a consequentialist motivation.

Our work contributes to the growing empirical literature on sustainability-related preferences, which has focused on equity investment. We add to this literature by directly testing the implications of theories of non-financial preferences on risk-taking, and, thus, proving the existence of such preferences. Previous literature has used surveys to document the existence of sustainability-related preferences: Krueger et al. (2020) indicate that institutional investors consider climate risk implications for their portfolios and advocate disclosure. Another strand of the literature uses flow-performance sensitivity to sustainability funds to show those with ESG motives are more tolerant of poor returns (Bollen, 2007; Renneboog et al., 2011). Hartzmark and Sussman (2019) provide causal evidence from trading after the introduction of sustainability ratings that US mutual fund investors value sustainability. Gantchev et al. (2022) show that green funds specifically, and Chen et al. (2021) that mutual funds generally divest from firms after environmental and social incidents. We are the first to compare the portfolios of green and regular investors instead of only their investments into green assets. Indeed, in our sample, we

document that green assets only constitute a very small fraction of their portfolios.

We also contribute to the literature on sustainability footprints vs. impact. Vaska Atta-Darkua (2023) document that investors that join the Carbon Disclosure Project or Climate Action 100+, climate related investor initiatives, re-weight their portfolios towards less carbon-intensive firms, but that their portfolio firms do not improve their emissions, except for the firms that emit the most. Similar to our results that green investors have portfolios with higher emissions and lower ESG ratings, Gibson et al. (2021) document that many US investors that publicly commit to sustainable investment with the UNPRI invest in firms with wore sustainability ratings. Their interpretation is that these investors use sustainability as a marketing tool rather than show actual preferences for it. An alternative interpretation is that green investors have consequentialist rather than warm-glow preferences and therefore prefer to invest in firms that have the highest potential to become greener (Hartzmark and Shue, 2014; Edmans et al., 2022) or need funding for their green projects (Oehmke and Opp, 2022; Piatti et al., 2022; Green and Roth, 2021; Gupta et al., 2022). Our results are more consistent with the presence of consequentialist preferences, as the Green bonds in the portfolios of our green investors are too small a fraction to be meaningful for marketing or greenwashing purposes and more likely to indicate a genuine interest in impact.

We are one of very few empirical papers on the relevance of sustainability in the bond market. The only papers to our knowledge on the portfolios of Green investors are Baker et al. (2018) and Fatica and Panzica (2021), who show that ownership of Green bonds is more concentrated than for other bonds. We contribute to this literature with a rich description of the ownership patterns of green investors and their portfolios.

While our focus is on the investors in Green bonds, we also contribute to the literature on Green bonds themselves. The research studying the sustainability of fixed income securities relies on issuances (e.g., Baker et al. (2018); Flammer (2021)), and the evidence about bond performance in the medium- and long-term is limited (see the review by Gerard (2019)). Bhojraj and Sengupta (2003) study default risk (inferred from credit ratings for

around 1,000 issuances), but they only evaluate the impact of corporate governance. Amiraslani et al. (2021) focus on E&S factors and track credit spreads on the secondary markets. A larger literature uses equity prices to assess the effect of ESG policies on downside risk (e.g., Konar and Cohen (2001); Kim et al. (2014); Lins et al. (2017)). Our focus is on ownership.

We start by describing the market for Green bonds in section 2 and our data in section 3. We then explain our empirical strategy and how we match our Green investors in section 4. Section 5 describes their portfolios. We discuss our results in light of the theory literature in section 6 and conclude in section 7.

2. The Norwegian market for Green bonds

Green bonds are fixed income instruments which earmark proceeds for specific projects that have positive environmental and climate benefits (Flammer, 2021). Issuers commit to use the funds raised exclusively to finance or re-finance green projects (Barbalau and Zeni, 2022). Issuers obtain a green label from a number of certification providers, most of which adhere to the Green Bond Principles (GBPs). The GBPs provide issuers with guidance on the key components involved in launching a Green bond, and place particular emphasis on ex-ante verification that all the necessary processes are in place to ensure that the proceeds will be used for the stated projects while making no reference to outcomes delivered by the projects.

The first Green bond was issued in 2007, by the European Investment Bank, and the first Corporate Green bond in 2013, by the Swedish firm Vasakronan. The Green bond market has grown significantly over the past ten years. In Table I A, we report the evolution of listed Green bonds in the Nordics over the years (the corresponding statistics are in Figure I). In 2014, the total issuance of listed Corporate Green bonds in the Norwegian market was NOK 3bn (see Table I A, approximately USD 300 million), for five bonds.[1]

[1]The overall issuance including also non-listed bonds is larger. However, the observed time trends discussed later in the paper are similar both for listed and un-listed bonds. We focus on the secondary

Growth accelerated in recent years to over NOK 30B (corresponding to 44 bonds) in 2020.

Green bonds are concentrated in industries where environmental considerations are central to company operations (e.g., utilities, transportation, industry). Table I B presents a breakdown of Green bonds of our sample by industry.

In Table I C, we show a breakdown of the market by country. While the majority of issuers in our sample are from Norway, the Norwegian bond market serves also other regional and international issuers, with Swedish companies representing almost 4% in terms of issuance value.

3. Data

Our main data is provided by the Euronext VPS - Norwegian Central Securities Depository. It contains the complete universe of bond transactions and annual holdings in Norway 2010 to 2020. The data is confidential and supplied with a fictitious investor identifier. The transaction data include the date of the transaction, bond identifier, transaction type, transaction value, number of shares, and the fictitious identifier of the investor. In total, the data set contains 7.6 K buy transactions in Green bonds with a value of NOK 28.3 trillion (approximately USD 2.85 trillion).

We use issuance data from Nordic Trustee, the main bond trustee in the Nordics, for information on the bonds. Our sample contains all listed non-government bonds in the Nordic Trustee data set issued between 2010 and 2020. The main focus of our analysis is on the subset of bonds that are labeled as "Green" (more precisely, bonds for which the field "Green" is "Yes").

Firm-level data are obtained from the Centre for Corporate Governance Research (CCGR) database. It contains financial accounting data for public and private Norwegian companies. The main variables include revenues, total assets (size proxy), leverage (defined as long-term liabilities over total assets), the share of bonds in total liabilities,

market in order to study investors in Green bonds.

and share of financial liabilities in total liabilities. Level variables are deflated to year 2015 with annual CPI when necessary.

Firm-level carbon emissions data are from Trucost. Trucost covers around 30% of the issuers of the listed bonds in Scandinavia and follows the Greenhouse Gas Protocol that sets the standards for measuring corporate emissions. The Greenhouse Gas Protocol distinguishes between three different sources of emissions: scope 1 emissions, which cover direct emissions over one year from establishments that are owned or controlled by the company; these include all emissions from fossil fuel used in production. Scope 2 emissions come from the generation of purchased heat, steam, and electricity consumed by the company. Scope 3 emissions are caused by the operations and products of the company but occur from sources not owned or controlled by the company. These include emissions from the production of purchased materials, product use, waste disposal, and outsourced activities.

The ESG scores are from Thomson Reuters' ASSET4, as in Flammer (2021). ASSET4 rates companies along three dimensions ("pillars"): we use the rating for the environment. Note that the ASSET4 universe does not cover all firms.

The above data source and sample choice criteria yield 8,768 bonds for which we have issuance and trading data, of which 94 bonds are Green.

It's important to point out that our data does not represent the complete portfolio of investors. While it represents the universe of corporate bonds listed in Norway, it misses any other investments, notably equity investment and bonds listed outside Norway. As a result, our findings must be interpreted within these restrictions. Our objective is to compare between investors in Green assets to investors in similar assets. To that extent, we focus on the differences that become evident in their trading behaviour in Norwegian bonds.

3.1. Summary statistics: bonds

In Table II A, we provide summary statistics on the bonds in our sample. The average issuance amount is NOK 420 M. The average maturity is 11.2 years, 24% have a fixed rate,

and of those with information, the coupon at issuance was on average 3.95%. The median Universal Credit Rating is A. It is not uncommon that a given company issues several bonds on a given day - the 8,768 Green bonds correspond to 7,894 unique issuer-days, 4,143 issuer-years, and 1,144 unique issuers.

In Table II B, we provide summary statistics on the 94 listed Green bonds. Green bonds are larger than the average bond - the mean issuance amount is NOK 620 M (approximately USD 78.4 M). This compares to an average Green bond issuance of USD 253 M in the international sample of Flammer (2021). The average maturity is shorter than average, with 6.4 years (comparable to an average 7.7 in the international sample), 33% have a fixed rate, more than the average bond (but fewer than the 75% in the international sample), and the average first coupon after issuance was lower than average, with 2.86% (and also lower than the international average of 3.7%). The median Universal Credit Rating is CCC. The 94 Green bonds correspond to 81 unique issuer-days, 61 issuer-years, and 44 unique issuers.

In Table III A, we more formally compare Green and regular bonds in a regression with all bonds in our sample, where the dependent variable is an indicator for Green bonds. Green bonds are more likely to have a fixed rather than a floating rate. Their coupons are lower, albeit for fixed rate bond only significantly on a 10% level. They are more likely to be senior. In the short history we have, Green bonds experience fewer distress events, but not significantly so once we control for whether the rate is fixed and seniority.

3.2. Summary statistics: issuers

In Table II C, we provide summary statistics on the issuers in our sample, taken from the year before issuance. The average issuer has 4 bn NOK of bonds outstanding and on average nine securities. They own total assets of 9.5 bn NOK on average, have an average leverage ratio of 13%, of which 5% are bonds and 12% are to financial institutions. Half of the issuers are in Finance, 13% are Municipalities, 10% in Oil, and 9% in Real Estate. We only obtain ESG scores for 125 of the issuers. Their average score is 0.72. Carbon

emissions data is available for 192 issuers. The average issuer produces 0.75 million tons of scope 1 emissions, and is tied to 0.84 million tons of scope 3 emissions. The quantity of scope 2 emissions is relatively smaller, at 0.07 tons of CO2 equivalent. The average scope 1 intensity (tons of CO2 equivalent divided by the company's revenues in million U.S. dollar units) in our sample equals 3.01 tons/million, while the respective intensities for scope 2 and scope 3 are 0.23 tons/million and 2.54 tons/million. The Trucost estimates of the impact of the carbon emissions are 1.29 for direct and 0.56 for indirect impact on average.

Next, we formally compare Green to other bonds, starting with table III B. Green bond issuers are less likely to be financial companies and municipalities. They are larger, in terms of outstanding bond portfolios, as well as assets and revenues. We do not find differences in coupons they pay for fixed rate bonds in our sample. Including floaters, however, the coupons on their bonds are generally lower. Leverage is higher before an issue of the Green bond, with a higher share of bonds in total liabilities and more a higher share of financial liabilities.

Green bond issuers have similar ESG scores to other issuers. Table III C shows regressions where the dependent variable indicates a Green bond and the independent variables are Refinitiv ASSET4 ESG scores from the year preceding the issue. We have ESG scores for issuers of 287 bonds. Each row corresponds to a different score: overall, economic, environmental, corporate, or social. While they are positively correlated, each of them put different weights on ESG factors. If anything, Green bond issuers have lower ratings, but significantly so only for the corporate governance score.

In Table III D, we show a similar regression for carbon emissions. Issuers of Green bonds produce significantly lower CO2 emissions in absolute terms. When expressed as tons of CO2 equivalent divided by the company's revenues in million U.S. dollar units (intensity), however, issuers of Green bonds are only tied to fewer scope 3 emissions. The same applies to Trucost's estimate of the cost of emissions (impact).

4. Matched sample

4.1. Methodology

Sustainability concerns are only one dimension that investors use to make decisions. As a result, an observed investment in Green assets can reflect sustainability concerns as well as traditional reasons, notably the risk-return trade-off. To disentangle sustainability concerns from others, we proceed in two steps: we create a set of comparable assets, of which some are Green and others are not, but the two groups are comparable along almost all other dimensions. We then identify investors that only invest into the Green set of assets but not the other one, and compare them to those that only invest into the matched, non-Green assets.

In the first step, we match two similar bonds from the same issuer, for which most of the factors explaining investment are identical. The only exceptions are the sustainability-related impact of the proceeds and the yield; the underlying fundamental risk is the same between the matched bonds. This matching method has been used to assess the additional return of Green bonds (Zerbib, 2018), the offer spread and demand (Wang and Wu, 2023) of Green bonds, ethical funds in comparison with identical conventional funds or indices (Kreander et al., 2005; Renneboog et al., 2011; Bauer et al., 2005), as well as the cost of liquidity by matching and comparing pairs of bonds issued by the same firm (Helwege et al., 2014). To be more precise, we follow Helwege et al. (2014) and Zerbib (2018) and impose an exact match in terms of issuer, currency, seniority, and rating. Within such strata, we match, with replacement, bonds with the smallest differences in terms of issuance year and maturity. We begin by excluding any matches in which the difference between issuance years is greater than three. Among the remaining, we discard any pairs except the one with the smallest difference in maturity. For any bonds with multiple remaining matches, we then keep those for which the distance in issuance years are the smallest. Finally, for equally well matched pairs we use the one with the smallest difference in the outstanding (deflated) amount at issuance.

In the second step, we categorise investors as 'Green' and 'regular'. In order to

construct a sample of comparable 'Green' and 'regular' investors, we focus only on investors that hold or trade bonds from the matched sample of bonds described in the previous paragraph. We do not include investors in our 'Green' sample if they hold or trade only Green bonds outside our matches, since we do not have an adequate comparison group for them. For our classification, we disregard holdings and trades in 'regular' bonds before the focal issuer issues their first Green bond. We classify those who trade or hold only regular but no Green bonds from our matched sample as 'regular' investors. These investors constitute the comparison group underlying further analysis of investors' behavior in this paper. At this stage we exclude investors holding both Green and non-Green bonds from our matched sample. In Appendix A, we show that these investors are very different from our focus investors and notably hold more securities.

We further exclude investors that are likely to be market makers. To do so, we restrict the sample to investors with less than three average trades per bond and day on active trading days. We identify 97 market makers in the overall sample; 13 of them in the pool of green and regular investors. While we have comprehensive data on all bond transactions including emissions, in-kind interest payments, calls, conversions, etc., in the transaction counts we include only trades.

4.2. Matched bonds

The resulting matched set of assets consists of 123 bonds: 73 Green and 50 regular. There are only 21 Green bonds that we are not able to match, despite our strict restrictions.

Table IV A presents the summary of the matched sample of bonds. The average difference between matched securities is small. None of the listed characteristics is significantly different between the matched assets.

Next, we compare liquidity between the matched bonds. This is important as Helwege et al. (2014) shows differences in liquidity between their matched bonds. We measure liquidity at the bond level by counting the percentage of days without trade within each quarter in our sample period. For each bond-quarter, we calculate the percentage of days

with no reported trade[2] relative to business days in a quarter. To compute bid-ask spreads, we use price data from Bloomberg and Oslo Stock Exchange. For each bond-quarter, we calculate the average bid-ask spread and average relative spread.

Table IV B presents the comparison between matched Green and regular bonds. Neither type of bonds is frequently traded, on average less than twice per month. This is a characteristic feature of the Nordic bond market whose primary sub-section is relatively more active than the secondary sub-section. Green bonds have on average 3bp lower bid-ask spreads than regular bonds of similar characteristics.

4.3. Investors in matched bonds

Our primary categorisation yields a sample of 276 investors in matched bonds, 124 Green and 152 regular. We exclude 249 investors that trade both green and regular securities from the main analysis. Although our sample is small compared to the total universe of over 24K investors in our data, only 564 of these hold any non-government green assets. In Appendix A, we show that our matched green investors are representative and similar to the non-matched. In total, the average matched investor has a Norwegian bond portfolio of NOK 76 million (around USD 8 million), has been investing for seven years, and entered our sample end of 2012 (see Table V A). Most investors, 76%, are Norwegian. A significant fraction, 7%, are individual investors. The average portfolio return volatility is 48bp. Portfolios are closely correlated with bond market indices, with an average beta of 0.77 to the Bloomberg Euro corporate bond index, 0.74 to the MSCI Green bond index, 0.75 to the US corporate bond index, and 0.76 to the Bloomberg global bond index.

Next, we compare green to regular investors (Table V B). Green and regular investors are comparable in all dimensions except that local governments constitute 9% of Green, but only 1% of regular investors. In Table V C, we present an more detailed industry breakdown of non-individual investors. The largest groups among are private non-

[2]Note, that this definition excludes transactions involving calls, interest payments, etc.

financial enterprises (19% of Green and 18% of regular investors), banks, (11% of Green and 17% of regular investors), and mutual funds (11% of Green and 10% of regular investors).

The matched investors are only a small fraction of all bondholders. In Table VI A, we show that green investors only own 3% of the average issuer's bonds. Of these, 2% are owned by financial investors, 0.02% by individual investors, and 0.1% by local governments. Regular matched investors own 7% of the average issuers' oustanding bonds. Of these 5% are financial investors, 0.03% individual investors, and another 0.03% affiliated with local governments.

5. Portfolio characteristics

5.1. Bonds

In Table VII A, we compare the portfolios of green and regular investors. Portfolios of regular investors are more than ten times larger than those of Green investors. Within the portfolios of Green investors, Green securities constitute a very small fraction, reflecting the only recent popularity of Green bonds. By construction, the share of Green bonds in a portfolio is higher for green investors, but Green investors not only hold more matched, but also more unmatched Green bonds. Regular investors hold a significantly greater number of distinct bonds.

We then provide statistics for the overall portfolios, including non-matched bonds. Green investors hold significantly more bonds with fixed interest, higher coupons, and higher seniority. Bonds in their portfolio are less likely to be rated, and those rated have worse ratings. Consistent with the worse ratings, the bonds in Green investor portfolios experience more credit events and defaults.

5.2. Issuers

In Table VII B, we present univariate statistics comparing issuers of securities in Green and regular investor portfolios. First, Green investors hold bonds by fewer issuers,

reflecting their smaller portfolios. These issuers held by Green investors are more likely to be in Real Estate and oil, and less likely to be in renewable energy and finance industries.

Green investors hold bonds of issuers that are significantly smaller in terms of total assets compared to regular investors, but similar in terms of revenues. Issuers in Green investor portfolios are significantly more profitable and more levered, consistent with the prediction that Green investors in general prefer riskier investments. Of the liabilities, issuers with Green investors have a higher proportion in bonds. These results are not driven by the matched securities themselves: the patterns are almost the same when we exclude the matched securities (Table VII C).

Issuers with Green investors are less likely to have an ESG score. (Where the issuer does not have a score, we use the one of their ultimate parent if available.) They also have a lower social score on average, but only significantly so on a 10% level. The other scores are comparable. Issuers with Green investors also have marginally higher scope 1 CO2 emissions (also only on a 10% level, and only for intensity, not for the absolute volume), leading to a marginally higher cost from emissions. The cost from emissions is significantly higher in Green investor portfolios once we exclude the matched securities. The scope 2 and scope 3 CO2 emissions do not differ significantly between the portfolios of Green and regular investors.

5.3. Risk-taking

Next, we report average portfolio volatility and betas, in Table VIII A. Green investor portfolios are significantly more volatile. In contrast, their portfolios do not differ significantly from the ones of regular investors in terms of their average sensitivity to bond indices. Green investors are more likely to hold portfolios with extremely high or low betas. These results are not driven by the matched securities: they are almost the same if we exclude those (Panel B).

To compare risk-taking behaviour in a multivariate setting, we estimate this regression:

$$Volatility_{it} = \alpha + \beta I_i^G + FEs + Controls_i + \epsilon_{it} \tag{1}$$

The variable $Volatility_{ijt}$ is the portfolio variance of investor i at time t. The benchmark set of control variables in the regression includes fixed effects for the calendar year and the number of years that the investor has been investing in our dataset. We also include indicators for the quintile of the portfolio value in that year. We cluster errors at the investor level.

The results are presented in Table VIII C. Green investors have significantly more volatile portfolios. This is true controlling for the type of investor, but not conditioning on industry: in particular, investment in the oil and gas industry, which Green investors tend to hold more, drive portfolio volatility.

To see how much the higher volatility is driven by default risk, we directly regress the fraction of defaulted securities on investor types. The results, in Table in Table VIII D, shows that portfolios of Green investors have more defaults - significantly at a 10% level. This result holds controlling for the type of investor as well as their industry.

Neither of these results are driven by the matched securities - when we exclude them (in Panel E), the results are almost entirely unchanged. In the Appendix, we also show that the results are similar if we exclude investments in the oil sector.

5.4. Trading

In Table IX A, we document the trading behaviour of green and regular investors. Green investors trade significantly more often: on average 1.71 times, excluding issuance and redemption events, in the years in which they trade a given bond, compared to 1.24 for regular investors. Their trades are significantly larger, at NOK 178 million vs. 80 for regular investors. Green investors are more likely to hold an asset since its issuance, and less likely to hold assets until redemption.

To compare trading behaviour in a multivariate setting, we use this regression:

$$Hold_{ijt} = \alpha + \beta I_i^G + \gamma^G B_i^G + \gamma^R B_i^R + \iota^G I_i^G x B_i^G + \iota^R I_i^R x B_i^R + FEs + Controls_i + \epsilon_{ijt} \quad (2)$$

The variable $Hold_{ijt}$ is a dummy that equals 1 if a bond i that investor j held in his

portfolio at time t is in his portfolio also at time $t+1$. The variables of interest are I_i^G, which indicates a Green investor, B^G and B^R, which indicate Green and regular matched bonds, and their interactions with I^G and I^R, which indicate Green and regular investors. The benchmark set of control variables in the regression includes year and issuer fixed effects, indicators for the first two years of the issuance ('just issued') and the last two years before maturity ('close to maturity'), and rating fixed effects. We control for bond liquidity with a variable that counts the fraction of days without trades, fixed rates, issuer size, and leverage. We cluster errors at the investor level.

The results are presented in Table B.12 B. Green investors are less likely to hold any given bond for another year, consistent with the univariate statistics. Regular investors, in contrast, are more likely to hold any given bond for another year. This is not driven by the Green bonds that our green matched investors hold. In the Appendix, we also show that the results are similar if we exclude investments in the oil sector. In general, investors hold Green bonds longer, both compared to all other securities and compared to their matched securities similar in terms of credit risk, issuance and maturity characteristics.

6. Warm-Glow vs. Consequentialist Preferences

Asset pricing theories of sustainable investment aim to derive equilibrium securities prices in the presence of investors with ESG-related preferences. The key assumption in these theories is either that one set of (Green) investors derives extra utility from investing in Green assets (Pástor et al., 2021; Pedersen et al., 2021) or that one set of firms does not meet their criteria for investment and is therefore excluded (Heinkel et al., 2001; Berk and van Binsbergen, 2021; Luo and Balvers, 2017). The underlying assumption is that such investors aim to lower the cost of capital of greener firms by channeling capital towards them (see Gormsen et al. (2023) or Brav and Heaton (2021)). These preferences are also consistent with the institutional restrictions of sustainability-linked funds, which are typically rated based on the current ESG ratings of their portfolios (Hartzmark and Sussman, 2019) or market themselves as excluding certain sectors (Berk

and van Binsbergen, 2021).

The equilibrium consequences of a strategy that invests into the greenest firms are subject to debate. For example, Hartzmark and Shue (2014) argue that green firms have much less margin to improve emissions and that tilting capital away from brown firms makes it more expensive for them to invest into greener technology. Gupta et al. (2022) make a similar argument but point out that investing into "reformable" dirty firms also drives up their prices, giving firms an incentives to be even dirtier. Consistent with a more active ownership model, Edmans et al. (2022) shows how the threat of selling can improve firm decisions more in brown firms.

In a similar spirit to Edmans et al. (2022) and Gupta et al. (2022) , a second set of theories models explicitly how investors should invest to affect the sustainability of firms (Oehmke and Opp, 2022; Piatti et al., 2022; Landier and Lovo, 2021; Green and Roth, 2021). This set of papers aims to understand under which conditions such effects can take place. As such, the focus of this class of models is the production decision of firms with possibly negative externalities under different ownership and capital.

When taking impact into account, the prediction on the investment of investors with Green preferences differs from the asset pricing models. Oehmke and Opp (2022) conclude that Green investors should aim to invest in issuers that have the greatest potential to become greener, not in the greenest issuers. This effect is even stronger in Green and Roth (2021), where investing into greener firms crowds out non-green capital into dirtier firms.

To test whether Green investors are more likely to invest in dirtier and/or improving firms, we regress their ownership fraction on issuers' current and future ESG performance. The first set of results are in Table B.13 A, where the dependent variable is the issuer's current CO2 emissions and the key explanatory variable the fraction of Green investors. We control for the issuance of Green bonds, as Flammer (2021) has documented that those improve in their ESG performance after issuance, and an interaction of Green bond issuance with the fraction of Green investors. Consistent with our results in the Portfolio

section, issuers with more scope 1 emissions have a significantly greater fraction of Green investors. This is both compared to non-matched investors and matched regular investors: the coefficient of the fraction of Green investors is also significantly greater than the one for the fraction of regular investors. In column 2, we show that this relationship between emissions and more green investors holds also when we only look at individual investors, financial investors, or government-linked investors. In column 3, we control for industry fixed effects: these absorb the significance of the green investors coefficient. That is, the higher carbon emissions in green investor portfolios are completely explained by the choice of industries by green investors. Scope 2 and 3 emissions (column 4 and 5) are significantly higher for firms with more green investors compared to those with more regular investors, but not significantly so compared to the unmatched sample. The results are similar for carbon intensity (column 6).

In Panel B, we instead regress the next-year change in emissions on the fraction of Green investors. Note that this variable is not well populated. Here, the coefficient is negative for all emissions except for intensity, albeit not significant at an 10% level. These results are broadly consistent with the idea that Green investors in our sample care about potential impact more than about the current state of portfolio firm ESG.

In Panel C and D, we repeat these tests, but with ESG scores as dependent variables. The results are consistent with the ones for emissions. Issuers with a greater current share of green investors have significantly lower ESG scores, both the overall and the environmental scores. This is the case both significantly so in comparison with the regular matched group and with unmatched investors. In contrast to the ones for carbon emissions, these results persist once we control for industry fixed effects. None of the results are statistically significant for future scores. In the Appendix, we also show that the results are similar if we exclude investments in the oil sector.

Our results are consistent with the existence of consequentialist preferences within our sample of green investors. They do not rule out the existence of warm-glow preferences; indeed, our research design more likely identifies mostly consequentialist investors

because Green bonds are directly linked to impact.

7. Conclusion

In this paper, we compare the characteristics of portfolios of real-world investors in Green assets to their counterparts in ESG investment theory, using the portfolios of investors in Norwegian Green bonds. The Green bonds in our focus differ from other bonds in many ways; to focus on investors that consciously choose to invest because of their greenness as opposed to their default risk or maturity profile, we compare investors in Green bonds to those in bonds by the same issuers that are similar in terms of maturity.

Theory distinguishes Green investors from others by linking their utility function to the Greenness of their investments, and then derives predictions about their portfolios based on the precise form of this link. We describe and measure the Greenness and risk-return profile of Green investors. We then interpret our results in relation to existing theories.

Overall, we confirm that investors in Green bonds exhibit behaviour consistent with theory. They invest in riskier bonds with lower ratings from smaller issuers, resulting in a more volatile portfolio with more defaults. This is consistent with the argument that their environmental preferences reduce aversion to financial risk. Investors in Green bonds are more likely to choose firms with higher carbon emissions. This is consistent with the idea that they care more about the impact of their investment than about the current imprint of their portfolio. Most of the patterns in volatility and ESG performance of green portfolios are driven by the industry of their investments, suggesting that our results are not driven by differences in information between investors.

The theory literature on environmental preferences is still in its infancy. We hope that our results provide stylized facts for future theory. Our results are necessarily based on the Norwegian bond portfolios of investors; their equity investments or investments in non-Norwegian assets may differ. In the very least, Norwegian Green bonds provide a in-depth snapshot especially of the Oil and Gas industry and a convenient empirical

setting to identify green investors and observe their remaining portfolios.

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Figure I. Green bonds issuance over time

This figure shows the value of listed Green bonds issued over the years in billion NOK. The sample is the universe of listed Green bonds traded in Norway between 2010 and 2020.

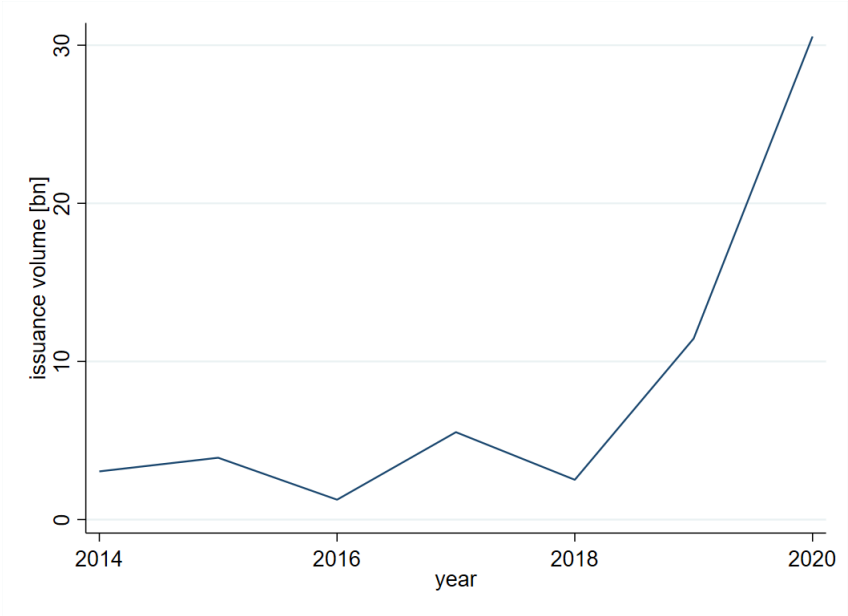
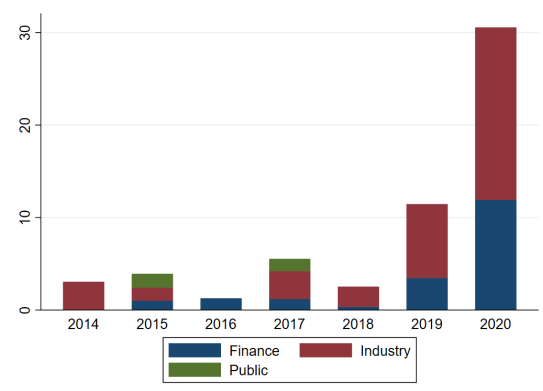


Figure II. Green bonds issuance by industry

This figure shows trends in the issuance of Green bonds by industry in billion NOK. The sample is the universe of listed Green bonds traded in Norway between 2010 and 2020. Panel A presents the value of bonds issued in billion NOK. Panel B presents the number of bonds issued.

Panel A. Outstanding amount by industry



Panel B. Count by industry

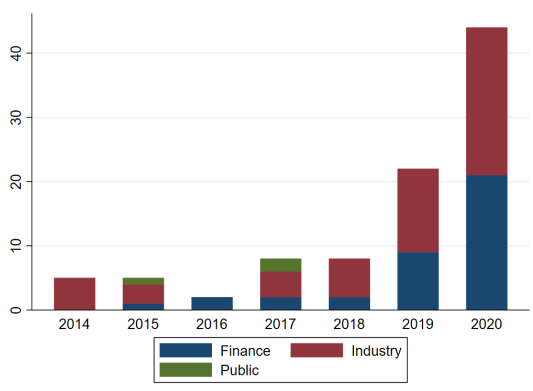


Table I. Green bonds

The table presents trends in the Nordic Green bond market. The sample is the universe of listed Green bonds traded in Norway between 2010 and 2020. The unit of observation is one bond. Panel A displays the value and the number of Green bonds issued over the years. Panel B displays the value and the number of Green bonds issued by the industry. Panel C displays the percentage breakdown of the Green bond issues by the country of the issuer.

Panel A.
Listed Green bonds by issuance year

Year	(1) Outstanding amount (bn)	(2) Count
2014	3.05	5
2015	3.91	5
2016	1.26	2
2017	5.53	8
2018	2.52	8
2019	11.45	22
2020	30.55	44
Total	58.27	94

Panel B.
Listed Green bonds by issuer's industry

Industry group	(1) Outstanding mount (bn)	(2) Count
Bank	4.75	6
Consumer services	2.62	4
Finance	1.70	4
Industry	4.58	7
Public sector	2.85	3
Real estate	12.72	27
Seafood	3.49	3
Shipping	1.81	2
Transportation	5.60	8
Utilities	18.16	30
Total	58.28	94

Panel C. Listed Green bonds by issuer's country

Country	(1) Percentage
Norway	75.5
Sweden	17.0
Netherlands	2.1
Denmark	1.1
Estonia	1.1
Germany	1.1
Other	2.1

Table II. Univariate statistics

The table presents univariate statistics of bonds and their issuers. The sample is the universe of listed bonds and their issuers traded in Norway between 2010 and 2020. The unit of observation is one bond apart from the bottom part of Panel A where the unit of observation is bond times quarter. Panel A displays summary characteristics of all bonds and Panel B of Green bonds. Panel C presents characteristics of the bond issuer in the year before the issuance. Accounting data are available for years 2001–2020, while environmental performance data are available for years 2010-2020.

Panel A. Summary statistics for listed Scandinavian bonds

	Mean	Std.dev.	Median	Count
Outstanding amount (bn)	0.42	1.16	0.20	8657
Maturity	11.2	21.1	5	8768
Fixed rate	0.24	0.42	0	8768
First coupon	3.95	3.11	3.03	8335
Universal rating[1]	3.39	2.27	3	2766
Rated	0.32	0.46	0	8768
Credit event	0.048	0.21	0	8768
Default	0.032	0.18	0	8768
Senior	0.76	0.43	1	8768
Junior	0.12	0.32	0	8768
InvGrade	0.74	0.44	1	8768
% no-trade days	0.96	0.062	0.98	113558
Bid-ask spread	0.57	0.84	0.22	18743
Relative bid-ask spread	0.0091	0.027	0.0023	18464
# Bonds	8768			
# Bond-Quarters	113558			
# Issuers	1144			

[1]Universal rating codes: 1=AAA, 2=AA, 3=A, 4=BBB, 5=BB, 6=B, 7=CCC, 8=CC, 9=C.

Panel B. Summary statistics for listed Green bonds

	Mean	Std.dev.	Median	Count
Outstanding amount (bn)	0.62	0.44	0.50	94
Maturity	6.38	2.58	6	94
Fixed rate	0.33	0.47	0	94
First coupon	2.86	2.10	2.26	86
Universal rating[1]	4.75	2.40	7	55
Rated	0.59	0.50	1	94
Credit event	0.011	0.10	0	94
Default	0	0	0	94
Senior	0.91	0.28	1	94
Junior	0	0	0	94
InvGrade	0.83	0.38	1	94
# Green Bonds	94			
# Issuers	44			

[1]Universal rating codes: 1=AAA, 2=AA, 3=A, 4=BBB, 5=BB, 6=B, 7=CCC, 8=CC, 9=C.

Panel C. Summary statistics for issuers of listed Scandinavian bonds

	Mean	Std.dev.	Median	Count
Issuer bonds oustanding (bn)	4.44	6.37	1.60	2,537
Issuer bonds oustanding (#)	9.10	9.16	6	3,168
First coupon (avg.)	1.46	1.70	0.95	2,525
Total assets (bn)	9.54	12.0	4.03	2,623
Revenue (bn)	0.050	0.18	0	2,632
ROA	1.51	2.76	1.08	1,696
Leverage	0.13	0.22	0.022	2,622
% bonds	0.049	0.15	0	2,556
% liabilities to financial institutions	0.12	0.21	0.046	2,556
Finance	0.47	0.50	0	4,169
Municipality	0.13	0.34	0	4,163
Oil	0.096	0.29	0	4,169
Real estate	0.091	0.29	0	4,169
Renewable	0.045	0.21	0	4,169
Shipping	0.029	0.17	0	4,169
Utilities	0.014	0.12	0	4,169
ESG score	0.72	0.25	0.83	125
Environmental score	0.73	0.22	0.80	125
Economic score	0.69	0.27	0.81	125
Corp. gov. score	0.52	0.22	0.54	125
Social score	0.76	0.21	0.83	125
Carbon emissions scope 1 (t)	751.3	2139.1	5.08	192
Carbon emissions scope 2 (t)	67.8	241.9	8.27	192
Carbon emissions scope 3 (t)	837.9	2319.2	132.5	192
Carbon intensity scope 1 /100	3.01	5.88	0.072	192
Carbon intensity scope 2 /100	0.23	0.49	0.072	192
Carbon intensity scope 3 /100	2.54	6.51	1.13	190
Carbon intensity: direct /100	0.0012	0.017	0	192
Carbon intensity: indirect /100	0.78	1.36	0.37	192
GHG direct impact ratio	1.29	3.06	0.027	192
GHG indirect impact ratio	0.56	0.72	0.35	192
# Issuer-Year	4143			
# Issuers	1144			

Table III. Characteristics of Green bonds

The table compares Green and regular bonds. All the Panels display coefficients and heteroskedasticity robust standard errors in brackets from OLS regressions, where the sample is the universe of listed bonds traded in Norway between 2010 and 2020. The unit of observation is one bond. The dependent variable is an indicator of a Green bond. Panel A includes as independent variables bond characteristics, Panel B pre-issuance issuer's characteristics, Panel C pre-issuance Refinitiv ESG scores of the issuer, and Pandel D pre-issuance Trucost carbon emissions of the issuer. Coupon variables in Panel B are average values obtained by the issuer weighted by the initial issuance amount. *** p<0.01, ** p<0.05, * p<0.1

Panel A. Green bond characteristics: Securities

Dependent variable	(1) Green bond	(2) Green bond	(3) Green bond	(4) Green bond	(5) Green bond	(6) Green bond
Fixed rate	0.0055*					0.0091***
	(0.0029)					(0.0032)
First coupon		-0.0012***				-0.0015***
		(0.00027)				(0.00036)
Senior			0.0091***			0.010***
			(0.0019)			(0.0021)
Credit event				-0.0088***		-0.0014
				(0.0026)		(0.0077)
Default					-0.011***	-0.0046
					(0.0011)	(0.0071)
Observations	8768	8335	8768	8768	8768	8335

Panel B. Green bond characteristics: Issuers

Dependent variable	(1) Green bond	(2) Green bond	(3) Green bond	(4) Green bond	(5) Green bond	(6) Green bond	(7) Green bond	(8) Green bond	(9) Green bond	(10) Green bond	(11) Green bond	(12) Green bond
Finance	-0.030***											
	(0.0036)											
Municipality	-0.031***											
	(0.0038)											
Issuer outstanding bonds (bn)		0.0012***										
		(0.00027)										
Issuer outstanding bonds (no)			0.00045***									
			(0.00016)									
First coupon (avg.)				-0.0021***								
				(0.00068)								
Investment grade					0.0049**							
					(0.0022)							
Rating						0.013***						
						(0.0029)						
Revenue (bn)							0.034**					0.017
							(0.014)					(0.015)
Total assets (bn)								0.00030***				0.00042***
								(0.00010)				(0.00011)
Leverage									0.057***			0.062***
									(0.0098)			(0.013)
% bonds										0.031***		-0.013
										(0.011)		(0.015)
% liab. to fin. institutions											0.031***	0.0092
											(0.012)	(0.012)
Observations	8768	5893	6659	5868	8768	8768	5948	5907	5902	5829	5829	5829

Panel C. Green bond characteristics: Issuers' ESG scores

Dependent variable	(1) Green bond	(2) Green bond	(3) Green bond	(4) Green bond	(5) Green bond
ESG score	-0.024				
	(0.040)				
Environmental score		0.027			
		(0.051)			
Economic score			-0.043		
			(0.043)		
Corporate governance score				-0.15***	
				(0.047)	
Social score					-0.059
					(0.058)
Observations	296	296	296	296	296

Panel D. Carbon emissions

Dependent variable	(1) Green bond	(2) Green bond	(3) Green bond	(4) Green bond	(5) Green bond	(6) Green bond	(7) Green bond	(8) Green bond	(9) Green bond
Log emissions scope 1 (t)	-0.0061**								
	(0.0024)								
Log emissions scope 2 (t)		-0.0054							
		(0.0035)							
Log emissions scope 3 (t)			-0.015***						
			(0.0056)						
Carbon intensity scope 1 /100				-0.0031***					
				(0.00100)					
Carbon intensity scope 2 /100					-0.0089				
					(0.0070)				
Carbon intensity scope 3 /100						-0.00068			
						(0.0012)			
Carbon intensity: indirect /100							0.0012		
							(0.0058)		
GHG direct impact ratio								-0.0057***	
								(0.0021)	
GHG indirect impact ratio									0.0038
									(0.014)
Observations	411	411	411	411	411	408	411	411	411

Table IV. Matched sample

The table presents the characteristics of bonds from the matched sample constructed as described in Section 4. Panel A presents basic security characteristics, where the unit of observation is one bond. Panel B presents bond liquidity measures, where the unit of observation is one bond times quarter. *** p<0.01, ** p<0.05, * p<0.1

Panel A. Matched bonds

	Regular bond	Green bond	Regular count	Green count	Diff	t-stat
Outstanding amount (m)	626.53	656.28	50	73	-29.76	-0.32
Maturity	6.74	6.68	50	73	0.06	0.10
Rating	0.64	0.66	50	73	-0.02	-0.20
Fixed rate	0.46	0.36	50	73	0.10	1.15
Investment grade	0.88	0.92	50	73	-0.04	-0.69
First coupon	2.58	2.44	49	66	0.13	0.42
Senior	0.88	0.90	50	73	-0.02	-0.42
Credit event	0.02	0.01	50	73	0.01	0.27
Default	0.00	0.00	50	73	0.00	.
Observations	123					

Panel B. Bond liquidity

	Regular bond	Green bond	Regular count	Green count	Diff	t-stat
% no-trade days	0.96	0.96	536	464	-0.0033	-0.94
Bid-ask spread	0.45	0.33	236	176	0.12***	3.07
Relative bid-ask spread	0.0045	0.0034	236	176	0.0011***	2.74

Table V. Investors

The table presents the characteristics of green and regular investors. The sample includes investors involved with the bonds from the matched sample constructed as described in Section 4. The unit of observation is one investor. Panel A displays the summary statistics of investors' types, trading activity, and portfolios' risk profiles in the overall matched sample. Panel B presents the differences in the basic types and experience of green and regular investors. Panel C displays the industry type for non-individual investors. *** p<0.01, ** p<0.05, * p<0.1

Panel A. Matched investors: Summary Statistics

	Mean	Std.dev.	Median	Count
Value securities (m)	75964.1	312706.8	13387.7	276
Investing years	7.32	3.76	8	276
Entry year	2012.8	3.59	2010	276
Domestic investor	0.76	0.43	1	276
Individual investor	0.065	0.25	0	276
Financial investor	0.37	0.48	0	276
Non-profit investor	0.040	0.20	0	276
Local gov investor	0.043	0.20	0	276
Number of trades per ISIN p.a.	0.90	0.91	0.75	276
Avg. trade size (m)	35.7	179.9	5.90	247
Portfolio volatility	0.0048	0.0039	0.0036	274
Portfolio β: Euro corp.	0.77	0.18	0.77	276
Portfolio β: MSCI green	0.74	0.17	0.75	276
Portfolio β: US corporate	0.75	0.16	0.75	276
Portfolio β: BB global	0.76	0.18	0.76	276
% of portfolio with high β: Euro	0.18	0.16	0.13	276
% of portfolio with high β: MSCI	0.23	0.14	0.23	276
% of portfolio with high β: US corp	0.18	0.15	0.15	276
% of portfolio with high β: Global	0.21	0.18	0.17	276
% of portfolio with low β: Euro	0.040	0.087	0.021	276
% of portfolio with low β: MSCI	0.046	0.047	0.035	276
% of portfolio with low β: US corp	0.039	0.089	0.018	276
% of portfolio with low β: Global	0.036	0.038	0.026	276

Panel B. Matched Investors by Investor Type

	Regular investors	Green investors	Regular count	Green count	Diff	t-stat
Investing years	7.38	7.24	152	124	0.13	0.29
Entry year	2012.7	2012.9	152	124	-0.22	-0.51
Domestic investor	0.76	0.76	152	124	0.0051	0.098
Individual investor	0.066	0.065	152	124	0.0013	0.042
Financial investor	0.39	0.35	152	124	0.048	0.82
Non-profit investor	0.039	0.040	152	124	-0.00085	-0.036
Local gov investor	0.0066	0.089	152	124	-0.082***	-3.38

Panel C. Investor industries: Non-individuals.

	Regular inv		Green inv		Total	
	#.	%	#	%	#	%
Private non-fin. enterprises	26	17.9	23	18.5	49	18.2
Bank	24	16.6	13	10.5	37	13.8
Mutual funds	15	10.3	13	10.5	28	10.4
Other finance	10	6.9	5	4.0	15	5.6
Insurance/Pension funds	11	7.6	12	9.7	23	8.6
government	1	0.7	11	8.9	12	4.5
Non-profit	6	4.1	5	4.0	11	4.1
Foreign	38	26.2	34	27.4	72	26.8
NA	14	9.7	8	6.5	22	8.2
Total	145	100.0	124	100.0	269	100.0

Table VI. Bondholders

The table presents bond ownership characteristics of issuers whose bonds are held by matched green and regular investors. The sample includes investors involved with the bonds from the matched sample constructed as described in Section 4. The unit of observation is issuer times year.

Panel A. All issuers: Bondholders Statistics

	Mean	Std.dev.	Median	Count
% green investors	0.033	0.061	0.013	5,656
% green financial investors	0.020	0.038	0.0028	5,656
% green individual investors	0.00022	0.0018	0	5,656
% green government investors	0.0011	0.024	0	5,656
% green domestic investors	0.029	0.058	0.010	5,656
% green non-profit investors	0.00085	0.0071	0	5,656
% regular investors	0.065	0.10	0.030	5,656
% regular financial investors	0.048	0.092	0.0100	5,656
% regular individual investors	0.00029	0.0014	0	5,656
% regular government investors	0.00035	0.0056	0	5,656
% regular domestic investors	0.056	0.097	0.019	5,656
% regular non-profit investors	0.0036	0.013	0	5,656
# Issuer-Year	5656			
# Issuers	991			

Table VII. Portfolios

The table shows the portfolio structure by investor type. The sample includes investors involved with the bonds from the matched sample constructed as described in Section 4. The unit of observation is investor times year. Panel A displays univariate statistics for securities and Panel B for issuers. Panel C displays the characteristics of issuers excluding the matched sample of bonds. The middle parts of Panels B and C focus on the accounting data, while the bottom parts present the ESG scores and carbon emissions. The values in the panels are weighted with the securities value at the end of a given year. *** p<0.01, ** p<0.05, * p<0.1

Panel A. Security characteristics

	Regular investors	Green investors	Regular count	Green count	Diff	t-stat
Value (m)	132,351.50	35,505.13	1,121	898	96,846.37***	5.36
Green securities value (m)	54.51	531.39	763	614	-476.88***	-9.01
Matched securities value(m)	503.34	370.73	951	764	132.61	0.98
Matched greens value (m)	0.00	453.68	763	614	-453.68***	-9.71
Fraction green	0.00	0.03	1,121	898	-0.03***	-7.44
Fraction matched green	0.00	0.19	1,121	898	-0.19***	-16.23
Unique ISINs	35.32	30.74	1,121	898	4.58***	3.30
Fixed rate	0.21	0.26	1,100	886	-0.05***	-3.27
First Coupon	4.54	5.06	1,094	884	-0.51***	-4.94
Senior	0.85	0.87	1,121	898	-0.02**	-2.41
Junior	0.06	0.06	1,121	898	0.00	0.67
Investment grade	0.63	0.58	1,121	898	0.04**	2.42
Rated	0.50	0.44	1,121	898	0.06***	3.90
Universal rating	3.85	4.16	979	740	-0.31***	-2.83
With credit event	0.09	0.12	1,100	886	-0.03***	-3.20
Defaulted	0.04	0.06	1,100	886	-0.03***	-3.89

[1]Universal rating codes: 1=AAA, 2=AA, 3=A, 4=BBB, 5=BB, 6=B, 7=CCC, 8=CC, 9=C.

Panel B. Issuer characteristics

	Regular investors	Green investors	Regular count	Green count	Diff	t-stat
Number of issuers	26.2	24.3	1,100	886	1.90**	2.07
% renewable industry	0.052	0.037	1,087	878	0.015**	2.48
% real estate industry	0.026	0.037	1,087	878	-0.011**	-2.55
% utilities industry	0.012	0.014	1,087	878	-0.0022	-0.71
% oil industry	0.082	0.11	1,100	886	-0.030***	-3.18
% shipping industry	0.065	0.075	1,100	886	-0.0092	-1.56
% finance industry	0.56	0.51	1,100	886	0.050***	3.33
Total assets (m)	21833.2	19572.3	1,071	868	2260.9***	4.99
ROA	1.30	1.40	544	423	-0.096**	-2.38
Leverage	0.15	0.19	1,071	868	-0.039***	-5.63
% bonds	0.080	0.12	1,071	868	-0.039***	-5.58
% liab. to fin. institutions	0.11	0.12	1,071	868	-0.0041	-0.86
% with ESG score	0.15	0.13	1,100	886	0.020**	2.55
ESG score	0.72	0.72	950	693	-0.0010	-0.092
Economic score	0.67	0.68	950	693	-0.012	-1.01
Environmental score	0.75	0.75	950	693	-0.0059	-0.67
Corp. gov. score	0.50	0.51	950	693	-0.0060	-0.61
Social score	0.79	0.77	950	693	0.016*	1.76
Carbon emissions sc.1 (t)	820.8	893.9	853	677	-73.1	-0.96
Carbon emissions sc.2(t)	78.8	83.0	853	677	-4.18	-0.46
Carbon emissions sc.3(t)	1205.5	1088.9	853	677	116.6	1.04
Carbon intensity sc.1 /100	2.57	2.89	853	677	-0.32	-1.55
Carbon intensity sc.2 /100	0.17	0.18	853	677	-0.018	-1.16
Carbon intensity sc.3 /100	2.73	2.65	851	674	0.083	0.33
Carbon intensity: direct /100	0.0039	0.0039	853	677	0.000038	0.040
Carbon intensity: indirect /100	0.67	0.66	853	677	0.010	0.22
GHG direct impact ratio	1.03	1.25	853	677	-0.22**	-2.19
GHG indirect impact ratio	0.48	0.48	853	677	0.0083	0.35

Panel C. Issuer characteristics: Portfolios excluding matched securities

	Regular investors	Green investors	Regular count	Green count	Diff	t-stat
Number of issuers	26.3	24.4	1,087	878	1.92**	2.07
% renewable industry	0.052	0.037	1,087	878	0.015**	2.48
% real estate industry	0.026	0.037	1,087	878	-0.011**	-2.55
% utilities industry	0.034	0.037	1,087	878	-0.0029	-0.63
% oil industry	0.084	0.11	1,087	878	-0.030***	-3.09
% shipping industry	0.065	0.077	1,087	878	-0.012*	-1.94
% finance industry	0.57	0.52	1,087	878	0.053***	3.54
Total assets (m)	21772.5	19433.0	1,065	861	2339.5***	5.18
ROA	1.30	1.40	544	423	-0.095**	-2.35
Leverage	0.15	0.19	1,065	861	-0.041***	-5.77
% bonds	0.079	0.12	1,065	861	-0.040***	-5.71
% liab. to fin. institutions	0.11	0.12	1,065	861	-0.0042	-0.86
% with ESG score	0.15	0.13	1,087	878	0.024***	3.22
ESG score	0.72	0.72	945	685	0.0012	0.11
Economic score	0.67	0.68	945	685	-0.010	-0.84
Environmental score	0.75	0.75	945	685	-0.0044	-0.51
Corp. gov. score	0.50	0.51	945	685	-0.0054	-0.55
Social score	0.79	0.77	945	685	0.017*	1.90
Carbon emissions sc.1 (t)	829.3	921.9	852	672	-92.5	-1.19
Carbon emissions sc.2(t)	79.3	85.0	852	672	-5.72	-0.62
Carbon emissions sc.3(t)	1216.4	1125.2	852	672	91.2	0.80
Carbon intensity sc.1 /100	2.57	2.92	852	672	-0.36*	-1.72
Carbon intensity sc.2 /100	0.17	0.18	852	672	-0.018	-1.17
Carbon intensity sc.3 /100	2.75	2.74	850	669	0.011	0.041
Carbon intensity: direct /100	0.0039	0.0039	852	672	0.0000067	0.0069
Carbon intensity: indirect /100	0.67	0.67	852	672	0.0060	0.13
GHG direct impact ratio	1.03	1.27	852	672	-0.23**	-2.31
GHG indirect impact ratio	0.49	0.48	852	672	0.0051	0.22

Table VIII. Portfolio risk

The table presents portfolio risk characteristics of green and regular investors. Panels A and presents univariate statistics calculated at the investor-year level. Beta are estimated using various index models. Panel A display the statistics for the overall portfolios, Panel B exclude matched securities. Panels C and D and E present coefficients and heteroskedasticity robust standard errors in brackets from OLS regressions. In Panels C and D, the sample includes all bonds held by matched investors in the years when they hold them. In Panel E, the sample excludes the matched securities. Variable "% defaulted" represents the percentage of bonds that defaulted in years 2010–2020. All portfolio characteristics are value-weighted. *** p<0.01, ** p<0.05, * p<0.1

Panel A. Portfolio risk by investor type: Overall portfolios

	Regular investors	Green investors	Regular count	Green count	Diff	t-stat
Portfolio volatility	0.0038	0.0046	1,097	880	-0.00082***	-3.91
Portfolio β: Euro corporate	0.74	0.74	1,100	885	0.0034	0.25
Portfolio β: MSCI green	0.70	0.71	1,094	882	-0.011	-0.79
Portfolio β: US corporate	0.71	0.72	1,100	886	-0.0094	-0.72
Portfolio β: BB global	0.70	0.72	1,100	885	-0.015	-1.02
% of portfolio with high β Euro	0.16	0.19	1,100	886	-0.027***	-3.04
% of portfolio with high β MSCI	0.24	0.25	1,100	886	-0.0065	-0.63
% of portfolio with high β US corp	0.17	0.19	1,100	886	-0.019**	-2.15
% of portfolio with high β Global	0.20	0.22	1,100	886	-0.019**	-1.96
% of portfolio with low β Euro	0.034	0.043	1,100	886	-0.0089*	-1.92
% of portfolio with low β MSCI	0.058	0.055	1,100	886	0.0027	0.59
% of portfolio with low β US corp	0.031	0.042	1,100	886	-0.012**	-2.43
% of portfolio with low β Global	0.039	0.047	1,100	886	-0.0080**	-1.97

Panel B. Portfolio risk by investor type: Excluding matched securities

	Regular investors	Green investors	Regular count	Green count	Diff	t-stat
Portfolio volatility	0.0037	0.0046	1,086	873	-0.00085***	-4.04
Portfolio β: Euro corporate	0.74	0.74	1,087	878	-0.0055	-0.41
Portfolio β: MSCI green	0.69	0.71	1,081	875	-0.016	-1.16
Portfolio β: US corporate	0.71	0.72	1,087	878	-0.016	-1.23
Portfolio β: BB global	0.70	0.72	1,087	878	-0.020	-1.38
% of portfolio with high β Euro	0.16	0.19	1,087	878	-0.022**	-2.43
% of portfolio with high β MSCI	0.25	0.25	1,087	878	-0.0017	-0.17
% of portfolio with high β US corp	0.18	0.19	1,087	878	-0.015	-1.60
% of portfolio with high β Global	0.20	0.22	1,087	878	-0.021**	-2.18
% of portfolio with low β Euro	0.035	0.039	1,087	878	-0.0042	-0.96
% of portfolio with low β MSCI	0.058	0.056	1,087	878	0.0026	0.56
% of portfolio with low β US corp	0.031	0.038	1,087	878	-0.0068	-1.53
% of portfolio with low β Global	0.040	0.047	1,087	878	-0.0070*	-1.75

Panel C. Volatility: Overall portfolios

Dependent variable	(1) Portfolio volatility	(2) Portfolio volatility	(3) Portfolio volatility	(4) Portfolio volatility	(5) Portfolio volatility
Green investors	0.00065*	-0.00064	0.00029	-0.00078	0.00072*
	(0.00033)	(0.00085)	(0.00021)	(0.00063)	(0.00038)
Financial investors		-0.00058		0.00029	-0.00018
		(0.00047)		(0.00034)	(0.00033)
Green financial investors		-0.0020**		-0.0014***	-0.00077*
		(0.00076)		(0.00053)	(0.00042)
Domestic investors		-0.0025***		-0.0018**	
		(0.00088)		(0.00072)	
Green domestic investors		0.0028**		0.0021***	
		(0.0011)		(0.00081)	
Non-profit investors		-0.00044		0.00034	
		(0.00067)		(0.00055)	
Green non-profit investors		-0.0017		-0.0015	
		(0.0015)		(0.0011)	
Government investors		-0.0017***		-0.0010***	-0.0014***
		(0.00047)		(0.00038)	(0.00041)
Green government investors		-0.0019**		-0.00027	0.00041
		(0.00088)		(0.00063)	(0.00055)
% renewable industry			-0.0014	-0.00089	
			(0.0013)	(0.0014)	
% real estate industry			-0.00087		
			(0.0013)		
% utilities industry			-0.00054	-0.00027	-0.00024
			(0.0015)	(0.0013)	(0.0016)
% shipping industry			0.0027**	0.0028**	0.0031***
			(0.0013)	(0.0012)	(0.0011)
% finance industry			-0.0033***	-0.0028***	-0.0026***
			(0.00071)	(0.00070)	(0.00060)
% oil industry			0.0063***	0.0063***	0.0066***
			(0.0014)	(0.0014)	(0.0013)
Year FE	X	X	X	X	X
Portfolio Value FE	X	X	X	X	X
Investing Years FE	X	X	X	X	X
Observations	1962	1962	1962	1962	1962

Panel D. Default: Overall portfolios

Dependent variable	(1) % defaulted	(2) % defaulted	(3) % defaulted	(4) % defaulted	(5) % defaulted
Green investors	0.028*	-0.024	0.014*	-0.027	0.021
	(0.014)	(0.037)	(0.0079)	(0.023)	(0.016)
Financial investors		-0.011		0.016	0.0041
		(0.018)		(0.013)	(0.0078)
Green financial investors		-0.065*		-0.032	-0.014
		(0.037)		(0.022)	(0.016)
Domestic investors		-0.064		-0.054**	
		(0.040)		(0.026)	
Green domestic investors		0.10**		0.067**	
		(0.052)		(0.031)	
Non-profit investors		-0.026		0.0065	
		(0.019)		(0.012)	
Green non-profit investors		-0.060		-0.023	
		(0.056)		(0.025)	
Local gov investors		-0.032*		0.0095	-0.0054
		(0.018)		(0.014)	(0.013)
Green government investors		-0.088**		-0.032	-0.011
		(0.040)		(0.024)	(0.019)
% renewable industry			0.077	0.071	
			(0.082)	(0.083)	
% real estate industry			0.069		
			(0.056)		
% utilities industry			-0.0068	-0.020	-0.034
			(0.020)	(0.024)	(0.030)
% shipping industry			0.0070	-0.010	-0.032
			(0.039)	(0.040)	(0.051)
% finance industry			-0.0027	-0.010	-0.032
			(0.012)	(0.013)	(0.024)
% oil industry			0.45***	0.43***	0.42***
			(0.063)	(0.063)	(0.068)
Year FE	X	X	X	X	X
Portfolio Value FE	X	X	X	X	X
Investing Years FE	X	X	X	X	X
Observations	1971	1971	1971	1971	1971

Panel E. Volatility and default: Excluding matched securities

Dependent variable	(1) Portfolio volatility	(2) Portfolio volatility	(3) % defaulted	(4) % defaulted
Green investors	0.00065*	0.00074*	0.027*	0.023
	(0.00033)	(0.00039)	(0.014)	(0.016)
Financial investors		-0.00019		0.0052
		(0.00032)		(0.0078)
Green financial investors		-0.00079*		-0.016
		(0.00042)		(0.017)
Government investors		-0.0014***		-0.0039
		(0.00040)		(0.013)
Green government investors		0.00037		-0.014
		(0.00055)		(0.019)
% utilities industry		-0.0015		-0.042
		(0.0017)		(0.036)
% shipping industry		0.0031***		-0.024
		(0.0011)		(0.051)
% finance industry		-0.0027***		-0.033
		(0.00061)		(0.027)
% oil industry		0.0065***		0.41***
		(0.0013)		(0.068)
Year FE	X	X	X	X
Portfolio Value FE	X	X	X	X
Investing Years FE	X	X	X	X
Observations	1943	1943	1949	1949

Table IX. Trading activity

The table presents the trading activity of green and regular investors. Panel A presents univariate statistics, Panel B coefficients and heteroskedasticity robust standard errors in brackets from OLS regressions. The sample includes all bonds held by matched investors in the years when they hold them, except column 4 of Panel B, which only includes matched bonds as described in Section 4. The # *trades* are the average over the total number of trades carried by investors in a given bond in a given year conditional on a given bond being traded. It does not include trading around the issuance and redemption. *Trade size* is the number of exchanged securities multiplied by the bond face value conditional on trade. Variables "*From emission*" and "*Til redemption*" indicate the what fraction of securities traded in a given year by an investor is the trade during issuance or redemption respectively. *Trade around issuance* is defined as any trade that occurs withing 14 days from the issuance data. Similarly, *Trade around redemption* is defined as any trade that occurs within 14 days of the maturity date. The dependent variable in Panel B is one if the investor holds the bond and zero if they sell. The errors are clustered at the investor level. The unit of observation is investor times bond times year. *** p<0.01, ** p<0.05, * p<0.1

Panel A. Univariate: Trading activity

	Regular investors	Green investors	Regular count	Green count	Diff	t-stat
# trades	1.24	1.71	34,819	25,530	-0.47***	-13.2
Trade size (m)	80.1	177.9	25,414	19,387	-97.8***	-6.57
From emission	0.16	0.20	28,856	21,239	-0.038***	-11.0
Till redemption	0.24	0.17	25,062	17,815	0.068***	17.1

Panel B. Holding period

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sample	All	All	Non-individual	Individual investors	Financial investors	Local Gov	All
Green Bond		0.17***	0.16***	0.061	0.19***	-0.093	0.71***
		(0.048)	(0.049)	(0.15)	(0.053)	(0.20)	(0.18)
Matched bond		-0.12***	-0.12***	-0.083	-0.052	0.012	
		(0.029)	(0.030)	(0.092)	(0.037)	(0.077)	
Green investors	-0.060**	-0.062**	-0.063**	0.10*	-0.044	-0.40***	-0.55***
	(0.024)	(0.024)	(0.025)	(0.057)	(0.029)	(0.047)	(0.17)
% no trade days	0.025	0.024	0.016	0.049	-0.035	0.18	-1.12*
	(0.043)	(0.043)	(0.046)	(0.15)	(0.063)	(0.12)	(0.63)
Fixed rate	0.046**	0.046**	0.045*	0.041	0.042	-0.094	0.19**
	(0.022)	(0.022)	(0.023)	(0.088)	(0.030)	(0.068)	(0.084)
Log total assets	0.000012	0.000066	0.00025	0.019**	-0.00013	0.038	-0.15
	(0.0046)	(0.0045)	(0.0048)	(0.0084)	(0.0061)	(0.039)	(0.30)
Leverage	-0.19***	-0.19***	-0.18***	-0.25*	-0.084**	-0.23	-0.36
	(0.036)	(0.036)	(0.037)	(0.14)	(0.040)	(0.14)	(0.76)
Issuer FE	X	X	X	X	X	X	X
Year FE	X	X	X	X	X	X	X
Just Issued FE	X	X	X	X	X	X	X
Close Maturity FE	X	X	X	X	X	X	X
Missing financial FE	X	X	X	X	X	X	X
Rating FE	X	X	X	X	X	X	X
Observations	55180	55180	53252	1895	32059	2253	499
Sample							Matched

Table X. Portfolio ESG scores

The table presents the relationship between the issuer's environmental performance and the percentage of green investors among the firm's bondholders. The coefficients and heteroskedasticity robust standard errors in brackets are from OLS regressions. The sample includes issuers of bonds held by investors involved with the bonds from the matched sample constructed as described in Section 4. The unit of observation is issuer times year. Panel A and B display the results for the current carbon emissions and future carbon emission changes respectively. Panel C and D display the results for the current ESG scores and changes in future ESG scores changes. *** p<0.01, ** p<0.05, * p<0.1

Panel A. Investors and current carbon emissions

Dependent variable	(1) Log emissions scope1	(2) Log emissions scope 1	(3) Log emissions scope 1	(4) Log emissions scope 2	(5) Log emissions scope 3	(6 Carbon intensity scope 1 /100
% green investors	11.9**		-2.10	2.99	0.34	26.7**
	(4.78)		(3.83)	(2.30)	(1.61)	(13.1)
% regular investors	-15.2***		-4.90**	-5.39***	-4.72***	-10.0**
	(2.97)		(2.46)	(1.46)	(1.15)	(4.81)
% green individual investors		708.3*				
		(372.1)				
% regular individual investors		351.5***				
		(77.6)				
% green financial investors		7.07				
		(7.53)				
% regular financial investors		-19.9***				
		(3.10)				
% green government investors		-148.1				
		(109.3)				
% regular government investors		-3147.0***				
		(1041.9)				
Green issuer	-3.62***	-3.65***	-1.22***	-0.28	-0.94***	-5.03***
	(0.52)	(0.44)	(0.36)	(0.30)	(0.21)	(0.62)
Log revenue	0.84***	0.87***	0.80***	0.91***	1.00***	
	(0.093)	(0.093)	(0.098)	(0.073)	(0.069)	
F-stat (green minus regular)	19.102		.713	9.202	5.196	7.055
Year FE	X	X	X	X	X	X
Missing revenue FE	X	X	X	X	X	
Industry FE			X			
Observations	460	460	460	460	460	460

Panel B. Investors and future changes in carbon emissions

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Emissions scope 1 % change	Emissions scope 1 % change	Emissions scope 1 % change	Emissions scope 2 % change	Emissions scope 3 % change	Carbon intensity scope 1 /100 change
% green investors	-49.4		-74.3	-95.3	-641.6	3.13
	(110.9)		(137.2)	(98.9)	(589.5)	(11.2)
% regular investors	-28.0		-101.9	-26.8	-475.7	1.70
	(41.7)		(98.4)	(40.9)	(451.2)	(2.99)
% green individual investors		-6978.9				
		(8468.7)				
% regular individual investors		-3330.3				
		(3262.9)				
% green financial investors		-58.3				
		(181.0)				
% regular financial investors		-17.3				
		(49.2)				
% green government investors		-579.1				
		(1093.4)				
% regular government investors		-40930.7				
		(36190.5)				
Green issuer	-12.9	-11.0	26.8	-13.4	128.8	-0.27
	(16.4)	(14.5)	(23.5)	(16.1)	(109.7)	(0.28)
Log revenue	-22.2	-23.5	-32.6	-22.1	-154.0	
	(20.1)	(21.4)	(28.3)	(20.2)	(132.3)	
F-stat	.081		.132	.675	.116	.017
Year FE	X	X	X	X	X	X
Missing revenue FE	X	X	X	X	X	X
Industry FE			X			
Observations	389	389	389	397	397	397

Panel C. Investors and current ESG scores

Dependent variable	(1) ESG score	(2) ESG score	(3) ESG score	(4) Environment score	(5) Environment score	(6) Environment score
% green investors	-1.28***		-1.28***	-0.91**		-0.93***
	(0.47)		(0.43)	(0.41)		(0.36)
% regular investors	-0.45**		-0.30*	-0.24		-0.12
	(0.18)		(0.18)	(0.16)		(0.15)
% green individual investors		-72.7**			-37.6	
		(31.5)			(28.4)	
% regular individual investors		-67.6***			-75.5***	
		(18.7)			(16.4)	
% green financial investors		-1.77***			-1.44**	
		(0.62)			(0.71)	
% regular financial investors		-0.26			0.039	
		(0.23)			(0.17)	
% green government investors		-16.8			-30.8**	
		(13.3)			(12.6)	
% regular government investors		-146.6			-140.4**	
		(113.1)			(64.4)	
Green issuer	0.092*	0.084*	0.092*	0.082**	0.073**	0.037
	(0.052)	(0.049)	(0.051)	(0.040)	(0.036)	(0.039)
Log total assets	0.039*	0.047**	0.043*	0.022	0.030	0.035*
	(0.023)	(0.022)	(0.024)	(0.019)	(0.018)	(0.020)
Leverage	-0.25	-0.097	0.0052	-0.41***	-0.26*	-0.048
	(0.18)	(0.18)	(0.19)	(0.14)	(0.14)	(0.16)
F-stat (green minus regular)	2.033		2.532	2.214		2.39
Year FE	X	X	X	X	X	X
Missing financial FE	X	X	X	X	X	X
Rating FE	X	X	X	X	X	X
Industry FE			X			X
Observations	279	279	279	279	279	279

Panel D. Investors and future ESG score changes

Dependent variable	(1) Overall score	(2) Overall score	(3) Overall score	(4) Env. score	(5) Env. score	(6) Env. score
% green investors	0.28		0.28	0.24		0.30
	(0.18)		(0.20)	(0.18)		(0.19)
% regular investors	0.17		0.15	0.15		0.13
	(0.11)		(0.097)	(0.10)		(0.100)
% green individual investors		13.5			-18.2	
		(19.0)			(16.6)	
% regular individual investors		-19.6**			-10.5*	
		(8.67)			(6.29)	
% green financial investors		0.40			0.64	
		(0.30)			(0.41)	
% regular financial investors		0.28**			0.18	
		(0.14)			(0.11)	
% green government investors		4.90			-0.30	
		(11.8)			(8.60)	
% regular government investors		181.2**			107.5**	
		(90.3)			(52.5)	
Green issuer	-0.022	-0.030	-0.046*	-0.052**	-0.060***	-0.069***
	(0.026)	(0.025)	(0.027)	(0.023)	(0.022)	(0.025)
Log total assets	-0.011	-0.0097	-0.0029	0.016	0.015	0.021
	(0.014)	(0.014)	(0.015)	(0.012)	(0.012)	(0.013)
Leverage	-0.018	0.042	0.079	0.079	0.12	0.14
	(0.11)	(0.12)	(0.12)	(0.081)	(0.089)	(0.090)
Constant	0.18	0.15	0.040	-0.25	-0.24	-0.34
	(0.24)	(0.24)	(0.26)	(0.20)	(0.20)	(0.22)
F-stat	0		.078	.01		.116
Year FE	X	X	X	X	X	X
Missing financial FE	X	X	X	X	X	X
Rating FE	X	X	X	X	X	X
Industry FE			X			X
Observations	279	279	279	234	234	234

Appendix A. Investor differences

Our sample includes over 24K investors, and only 648 of them hold any non-government green assets. Therefore, we have to ensure comparability of the investors we categorise as green with the control group. In this section, we provide an overview of differences between investors holding green assets and those classified by us as green with the overall population of investors in the sample. It provides a background picture for comparison of the green and regular investors from the main part of the paper. The sample of green and regular traders involved in the same securities is strikingly similar, especially in the view of the differences presented in this part.

First, we compare investor that have any Green bond holdings with those that do not (Table A.11 A). Portfolios with Green bonds are about 100 times larger. They include 32 issuers and 50 different bonds on average, compared to 2 issuers and 3 bonds for the other investors. Investors with Green bonds are much less likely to be individuals (12% vs. 68%) and more likely to be financial institutions (38% vs. 6%). These large differences highlight the importance of comparing investors that hold similar assets. Indeed, the Green investors after the matching procedure are already more comparable to the rest of the sample, also the same patterns persist on a smaller scale when we compare Green Investors with all other investors (A.11 B).

Next, we compare the matched Green investors of our main sample to all other investors with Green bonds (A.11 C). The non-matched investors with Green assets are around ten times larger in their portfolios. This difference also passes onto the number of bonds and different issuers in the portfolios.

Finally, we also compare the matched regular investors from our main sample with any other investors that do not hold any green bonds (A.11 D). Non-matched investors are mostly individuals with much smaller portfolios. Matched regular investors are often financial institutional investors.

Table A.11. Investors

The table shows the characteristics and portfolio structures of investors with and without green bond holdings. The unit of observation is investor times year apart from the bootom parts of the table where it is one investor. *Number of trades* is the average number of trades in a security in a year. Panel A includes all investors and compares those that have any green holdings with those that do not hold any green bonds over they years. Panel B compares the investors we defined as "Green" to the rest of investors from the overall sample. Panel C compares "Green" investors and other investors that hold any green bonds. Panel D compares the chosen control group of "Regular" investors (matched/relevant) to any other "Regular" investors. *** p<0.01, ** p<0.05, * p<0.1

Panel A. All investors - Any green holdings vs the rest

	Non-green investors	Any-green investors	Non-green count	Any-green count	Diff	t-stat
Number of issuers	2.61	32.34	97582	5116	-29.74***	-222.49
Unique ISINs	3.10	50.82	97582	5116	-47.72***	-193.56
Number of trades per ISIN p.a.	0.16	1.25	97582	5116	-1.09***	-88.71
Avg. trade size (m)	19.46	43.03	15193	4124	-23.57***	-4.80
Securities value (m)	3368.19	219924.02	97582	5116	-216555.83***	-75.23
% green	0.00	0.03	97582	5116	-0.03***	-80.63
% matched	0.00	0.02	97582	5116	-0.02***	-52.63
% matched green	0.00	0.12	97582	5116	-0.12***	-130.07
% renewable industry	0.01	0.06	97582	5116	-0.05***	-35.18
% real estate industry	0.06	0.04	97582	5116	0.02***	6.35
% utilities industry	0.01	0.02	97582	5116	-0.01***	-16.33
% finance industry	0.48	0.44	97582	5116	0.04***	5.82
% oil industry	0.10	0.10	97582	5116	0.00	0.81
% shipping industry	0.04	0.10	97582	5116	-0.06***	-26.81
Investing years	4.05	7.90	24,107	648	-3.85***	-31.5
Entry year	2012.0	2012.5	24,107	648	-0.54***	-4.76
Domestic investor	0.94	0.82	24,102	648	0.13***	13.5
Individual investor	0.68	0.12	24,102	648	0.56***	30.2
Financial investor	0.062	0.38	24,107	648	-0.31***	-31.5
Non-profit investor	0.022	0.023	24,107	648	-0.00087	-0.15
Local gov investor	0.0054	0.034	24,107	648	-0.029***	-9.16

Panel B. All investors - Green investors vs the rest

	Non-green investors	Green investors	Non-green count	Green count	Diff	t-stat
Number of issuers	3.91	23.97	101800	898	-20.06***	-53.48
Unique ISINs	5.25	30.74	101800	898	-25.49***	-38.14
Number of trades per ISIN p.a.	0.21	0.90	101800	898	-0.69***	-23.20
Avg. trade size (m)	24.15	33.38	18602	715	-9.22	-0.87
Securities value (m)	13967.81	35505.13	101800	898	-21537.32***	-3.12
% green	0.00	0.03	101800	898	-0.03***	-29.77
% matched	0.00	0.02	101800	898	-0.02***	-33.47
% matched green	0.00	0.19	101800	898	-0.19***	-80.10
% renewable industry	0.02	0.04	101800	898	-0.03***	-8.80
% real estate industry	0.06	0.04	101800	898	0.02***	3.01
% utilities industry	0.01	0.01	101800	898	-0.01***	-3.89
% finance industry	0.48	0.50	101800	898	-0.02	-1.45
% oil industry	0.10	0.11	101800	898	-0.01	-0.94
% shipping industry	0.04	0.07	101800	898	-0.03***	-5.87
Investing years	4.13	7.24	24,631	124	-3.11***	-11.1
Entry year	2012.0	2012.9	24,631	124	-0.96***	-3.69
Domestic investor	0.94	0.76	24,626	124	0.18***	8.75
Individual investor	0.67	0.065	24,626	124	0.60***	14.3
Financial investor	0.069	0.35	24,631	124	-0.28***	-12.1
Non-profit investor	0.022	0.040	24,631	124	-0.018	-1.36
Local gov investor	0.0058	0.089	24,631	124	-0.083***	-11.8

Panel C. Green investors - Matched (relevant) vs any other green

	Any-green investors	Matched green investors	Any-green count	Matched green count	Diff	t-stat
Number of issuers	34.13	23.97	4218	898	10.16***	7.96
Unique ISINs	55.09	30.74	4218	898	24.35***	9.49
Number of trades per ISIN p.a.	1.32	0.90	4218	898	0.43***	5.08
Avg. trade size (m)	45.05	33.38	3409	715	11.68	1.11
Securities value (m)	259186.27	35505.13	4218	898	223681.14***	7.23
% green	0.03	0.03	4218	898	0.00	0.61
% matched	0.01	0.02	4218	898	-0.01***	-3.93
% matched green	0.11	0.19	4218	898	-0.08***	-7.51
% renewable industry	0.07	0.04	4218	898	0.02***	4.11
% real estate industry	0.04	0.04	4218	898	0.00	1.06
% utilities industry	0.02	0.01	4218	898	0.01***	2.84
% finance industry	0.43	0.50	4218	898	-0.07***	-5.93
% oil industry	0.10	0.11	4218	898	-0.01*	-1.85
% shipping industry	0.11	0.07	4218	898	0.03***	5.13
Investing years	8.05	7.24	524	124	0.81**	2.36
Entry year	2012.4	2012.9	524	124	-0.52	-1.60
Domestic investor	0.83	0.76	524	124	0.076**	1.98
Individual investor	0.14	0.065	524	124	0.073**	2.22
Financial investor	0.38	0.35	524	124	0.037	0.76
Non-profit investor	0.019	0.040	524	124	-0.021	-1.41
Local gov investor	0.021	0.089	524	124	-0.068***	-3.78

Panel D. Regular investors - Matched (relevant) vs any other regular

	Any regular investors	Matched regular investors	Any regular count	Matched regular count	Diff	t-stat
Number of issuers	2.38	24.95	96599	983	-22.57***	-148.93
Unique ISINs	2.78	34.24	96599	983	-31.45***	-153.54
Number of trades per ISIN p.a.	0.16	0.80	96599	983	-0.64***	-28.80
Avg. trade size (m)	18.72	32.51	14374	819	-13.79	-1.34
Securities value (m)	1947.70	142959.31	96599	983	-141011.60***	-64.11
% green	0.00	0.00	96599	983	0.00	.
% matched	0.00	0.03	96599	983	-0.03***	-68.70
% matched green	0.00	0.00	96599	983	0.00	.
% renewable industry	0.01	0.06	96599	983	-0.05***	-15.32
% real estate industry	0.06	0.02	96599	983	0.04***	5.13
% utilities industry	0.01	0.02	96599	983	-0.01***	-5.15
% finance industry	0.48	0.59	96599	983	-0.11***	-7.06
% oil industry	0.10	0.07	96599	983	0.03***	3.37
% shipping industry	0.04	0.05	96599	983	-0.01	-1.21
Investing years	4.03	7.28	23,972	135	-3.25***	-12.4
Entry year	2012.0	2012.7	23,972	135	-0.77***	-3.11
Domestic investor	0.95	0.76	23,967	135	0.18***	9.30
Individual investor	0.68	0.059	23,967	135	0.62***	15.6
Financial investor	0.060	0.41	23,972	135	-0.35***	-16.7
Non-profit investor	0.022	0.037	23,972	135	-0.015	-1.17
Local gov investor	0.0054	0.0074	23,972	135	-0.0020	-0.31

Appendix B. Robustness: No oil sector

Table B.12. Portfolio risk

The table presents robustness tests run on the sample excluding issuers from the oil sector. All Panels present coefficients and heteroskedasticity robust standard errors in brackets from OLS regressions. Panel A studies portfolio risk characteristics of green and regular investors. Portfolios exclude the matched securities. Variable "% defaulted" represents the percentage of bonds that defaulted in years 2010–2020. All portfolio characteristics are value-weighted. Panel B present the holding period of bonds held by matched investors. The dependent variable in Panel B is one if the investor holds the bond and zero if they sell. The errors are clustered at the investor level. The unit of observation is investor times bond times year. The # *trades* are the average over the total number of trades carried by investors in a given bond in a given year conditional on a given bond being traded. It does not include trading around the issuance and redemption. *Trade size* is the number of exchanged securities multiplied by the bond face value conditional on trade.*** p<0.01, ** p<0.05, * p<0.1

Panel A. Volatility and default: Excluding matched securities

	(2)	(4)
	Portfolio vol	% defaulted
Green Inv	0.00083***	0.011
	(0.00031)	(0.0085)
Financial Inv	-0.000070	0.0048
	(0.00026)	(0.0056)
Green Inv × Financial Inv	-0.00072**	-0.0072
	(0.00035)	(0.0092)
Local gov inv	-0.0012***	-0.0037
	(0.00029)	(0.010)
Green Inv × Local gov inv	-0.000088	-0.017
	(0.00052)	(0.012)
% utilities ind. sec.	-0.0014	-0.033
	(0.0015)	(0.023)
% shipping ind. sec.	0.0031***	0.030
	(0.00076)	(0.047)
% finance ind. sec.	-0.0030***	-0.039*
	(0.00049)	(0.020)
Year FE	X	X
Portfolio Value FE	X	X
Inv Years FE	X	X
Observations	1888	1899

Panel B. Holding period

	(1)
Sample	All
Green Bond	0.16***
	(0.048)
Matched bond	-0.12***
	(0.029)
Green Inv	-0.057**
	(0.025)
% no trade days	0.021
	(0.051)
Fixed	0.049**
	(0.023)
Ln total assets	-0.0058
	(0.0051)
Leverage	-0.061
	(0.037)
Issuer FE	X
Year FE	X
Just Issued FE	X
Close Maturity FE	X
Missing financial FE	X
Rating FE	X
Observations	51049

Table B.13. Portfolio ESG scores

The table presents the relationship between the issuer's environmental performance and the percentage of green investors among the firm's bondholders. The coefficients and heteroskedasticity robust standard errors in brackets are from OLS regressions. The sample includes issuers of bonds held by investors involved with the bonds from the matched sample constructed as described in Section 4. The unit of observation is issuer times year. Panel A and B display the results for the current carbon emissions and future carbon emission changes respectively. Panel C and D display the results for the current ESG scores and changes in future ESG scores changes. *** p<0.01, ** p<0.05, * p<0.1

Panel A. Investors and current carbon emissions

	(1)	(2)	(3)	(4)
	Log carbon emission sc.1	Carbon emission sc.1 % change	Overall score	Overall score change
% green inv	-3.37	-184.0	-1.43***	0.25
	(3.92)	(178.5)	(0.51)	(0.21)
% regular inv	-6.40***	-122.4	-0.51***	0.18*
	(2.44)	(113.1)	(0.19)	(0.100)
Green issuer	-1.24***	28.1	0.080	-0.047*
	(0.43)	(23.3)	(0.050)	(0.026)
Ln revenue	0.89***	-35.3		
	(0.11)	(30.1)		
Ln total assets			0.055**	-0.0013
			(0.025)	(0.015)
Leverage			0.38*	0.10
			(0.22)	(0.13)
F-stat (green minus regular)	2.98	.005	17.53	.622
Year FE	X	X	X	X
Missing revenue FE	X	X	X	X
Industry FE	X	X	X	X
Observations	422	353	257	257

Appendix C. Bond prices

We use three different data sources in order to obtain the fullest possible coverage of bonds with regularly reported prices: 1) Oslo Stock Exchange information, 2) Euronext VPS transactions register, and 3) Bloomberg. Below we describe the details of each data source and applied pre-processing adjustments.

All prices are expressed as the percentage of the bond face value, which is equivalent to the assumption that all face values of bonds are equal to 100. Using this convention does not change the bond-level return calculations but has implications for the returns calculated for the investors at the portfolio level. Accounting for different bond face values or lack thereof determines whether the investor-level return are value or equally weighted. This is discussed in more detail in the following sections. Additional filters to exclude outliers are applied at the later stages of the analysis.

Oslo Stock Exchange data

Oslo Stock Exchange reports daily prices for all bonds traded both on the main stock exchange in Oslo (OSE) as well as on the unregulated Nordic ABM market. The files include the closing price as well as bid and ask quotes but often only one of them is non-missing for a given ISIN on a given date. Our main measure is the "last price" but we use bid-ask mid-points whenever the "last price" is unavailable.

We manually review ten cases of prices that are unusually high (>150) or low (<15). These are mostly due to misreported commas. After confirming that they differ markedly from the prices reported in the days around, we correct the entries. The dataset we obtain afterward includes prices for 5468 securities and over 215,000 daily price observations from December 2009 until June 2020.

Euronext VPS transactions register

The register of transactions obtained from the Euronext VPS is the most granular data set we have. For each transaction it includes the involved parties, date, security, type of trade, and the number of securities exchanged. For about 75% of transactions we also

have the transaction value from which we infer the price.

The transactions file includes also information on emissions, in-kind coupon payments, calls, puts, and redemptions. These transactions have a pre-agreed price or no price and hence we exclude them from the price recovery process. We infer the bond prices using only transactions categorized as "trades". We do not impose restrictions on the type of investors that participate in trade and look both at buys and sells.

While more filters are imposed later in an attempt to exclude the outliers, at this stage we drop unusually high (>180) or low transaction values (<0.001). Where there is more than one transaction in a bond on a given day, we take their median.

The dataset after these minor corrections includes prices for 7860 securities and over 290,000 daily prices in years 2010–2020. The implied estimates are dirty prices, in contrast to prices we obtain from the other sources. We provide more details about the conversion to clean prices in the following sections.

Bloomberg

Bloomberg reports daily prices, bid-ask quotes, and yields for a selected set of ISINs. The coverage in terms of ISINs is more limited to other data sources, but there are fewer gaps over time, most likely because Bloomberg carries over the prices from the past days whenever there is no trade. We filter out these observations where appropriate. Similar as in case of OSE data, our main measure is the "last price" but we use bid-ask mid-points whenever the "last price" is unavailable. We also use the same filtering as in case of transaction-implied prices to exclude extreme outliers and drop unusually high (>180) or low prices (0.001). The dataset after these minor corrections includes prices for only 2,232 securities, but covers 2,7 m daily prices in years 2010–2020.

Appendix D. Coupons and interest accruals

We obtain exact coupon rates and coupon payment dates from the Stamdata database. It allows us to calculate coupon payments and interest accruals even for the bonds with floating rate coupon payments. This is an improvement relative to, e.g., Chordia et al.

(2017) who exclude floaters from their study. The data set also includes the convention used to calculate coupons and accrued interest.

For the coupon payment dates, we set the accrued interest to be 0, treat the quoted price as clean and add the coupon separately during return calculations. We calculate the coupon according to the convention. The majority of the securities pays coupon according to the convention Act/360, but some bonds rely on the convention Act/Act-ICMA, 30/360, Act/365 or variations. E.g., for a bond paying a coupon semi-annually according to the convention 30/360, the semi-annual coupon would usually be 180/360=0.5 of the quoted annualized coupon rate times the face value.

For the days between the coupon payments, we calculate the interest accrual. For the vast majority of bonds, the convention is Act/365, but some accrued interest are calculates using Act/360 or Act/Act-ICMA conventions. Therefore, for each date we calculate the number of days since the last coupon payment. The accrued interest for the convention Act/365 is:

$$\frac{\text{days since the last coupon payment}}{365} \cdot \text{annualized coupon rate.}$$

The equations is similar for the other conventions. We drop observations when the coupon rate is unavailable or the number of days since the last coupon payment is above 380. These are likely to be reporting errors since the lowest frequency of the coupon for the bonds in our sample is annual. We also replace the accrued interest with the coupon rate when the interest number days are between 365 and 380. Finally, we change the accrued interest to a missing value for values above 20 which corresponds to the 0.01% of the extreme observations.

We match the accrued interest by ISIN-date to the Euronext VPS data in order to calculate clean bond prices. For matching by date, we use the reporting date because coupon-induced price drop coincide with that date, rather than the trading date.

Appendix E. Bond returns

We proceed as follows to combine the three sources of bond data. We first calculate bond returns separately for each price data set. This implies that we obtain a separate coverage of bond returns depending on the underlying price source. For some bonds and some dates, we may have more than one return estimate. Our approach allows us to exploit the strengths and account for the weaknesses of each data set with more flexibility. It also allows us to carry out our robustness tests using one data source at a time. We combine the estimates of returns giving the priority to the data sources as follows: 1) information from the Oslo Stock Exchange, 2) prices implies by transactions from Euronext VPS, 3) Bloomberg. We start with stock Exchange quotes as they exhibit the least number of errors and are the standard in the literature (REFERENCES). We then exploit our unique advantage in our access to Euronext VPS, which covers securities with prices otherwise not recorded. Although Bloomberg data source is widely used in the academic literature outside Norway, its coverage of our sample is the most limited among our sources.

We follow Chordia et al. (2017) in our return calculation. The main difference is that we do not adjust the returns for risk at this stage. This is because we aim to compare the returns of matched investors.

Before calculating the returns we apply additional filters to the prices in order to exclude the outliers. First, we drop 79 securities with a zero redemption price. Because we do not have full information about the amortization and partial repayments of the principal so the returns estimated for these securities are likely to be inaccurate. Then, following Chordia et al. (2017) we drop observations for which the prices bounce back unusually relative to the preceding days. To be more precise, we drop the observations from day t when the price return

$$R_t R_{t-k} < -0.02, \qquad \text{for} \quad k = 1, 2, ...12.$$

R_t is the one-day return calculate on day t. We also set prices to missing if they do not change for a month (22 business days). This is a stricter filter than the three-months applied by Chordia et al. (2017). The reason is that our two main data sources, OSE and Euronext VPS, do not report prices when there is no trade, so a flat price is likely to be simply carried over.

For the month of maturity, we set the price to be equal to the redemption price that we obtain from Stamdata. For the month of issuance, we set the price to be equal to 100 (the equivalent of the issue price consistent with the percentage quotation) if there is no other end-of-month price. We verify this approach with the prices of transactions marked as "Emission" in the month of the issuance in the VPS data. We also do not use issue prices for issuances before Decemeber 2009. This is because we do not record transactions and prices before this period and are not able to tell if the price changes following the issuance and before December 2009.

For observations that are still missing after the above–common given that some bonds are traded very rarely in the the secondary markets (ref. Odegaard)–we impute prices from the previous month. We calculate the time series of returns both using the returns without imputations of previous prices and also including imputed values.

We calculate the bond-level returns at a monthly frequency. This is also the highest frequency at which bonds from our sample pay their coupon. The general formula for the return calculation is as follows:

$$R_{it} = \frac{P_{it} + I_{it} + C_{it}}{P_{it-1} + I_{it-1}} - 1 \tag{E.1}$$

where P_{it} is a price of a bond i at time t (the clean price), I_{it} is the interest accrued by bond i at time t, and C_{it} is the paid coupon on time t. We aim to record the price at the end of the month and hence use the price recorded closest to the end of the month. For simplicity and without greater effect, we calculate the interest accrued as of the end of a month.

Appendix E.1. Final outcome and the coverage

The outcome returns are very consistent across all data sources we use. This can be seen in the Figures E.3 and E.4 for the without and with imputations respectively. The only time series that stands out is the raw returns from Bloomberg in the early period. For that reason, in case of a Bloomberg dataset we rely only on observations from after year 2014.

We are interested in around 8,000 securities traded by the investors from our sample, equivalent to over 330,000 ISIN-month return observations in years 2010-2020. We use the returns from the different data sources according to the following priority: 1) OSI, 2) VPS, 3) BB. We obtain around 44K, 31K, and 29K observations from raw OSI, raw VPS, and raw Bloomberg data respectively. Imputing prices carried over from previous months gives us an additional 180K and 20K observations from OSI and VPS datasets. Bloomberg data with imputed values does not improve coverage. The final coverage is over 90%. We winsorize the returns at 0.005% on both tails.

The difference between raw returns and returns calculated using prices carried over from the previous months are depicted in Figure E.5. The figure does not inlcude the comparison between raw and imputed Bloomberg prices becuase the in the end the we do not use the latter. The trends in all time series are consistent. The returns using imputed prices as expected appear smoother.

Figure E.3. Returns: Raw by data source

This figure shows the average annual bond returns by source of the bond price data. The returns rely on raw prices without the imputations. Returns are winsorized at 0.5% level in both tails.

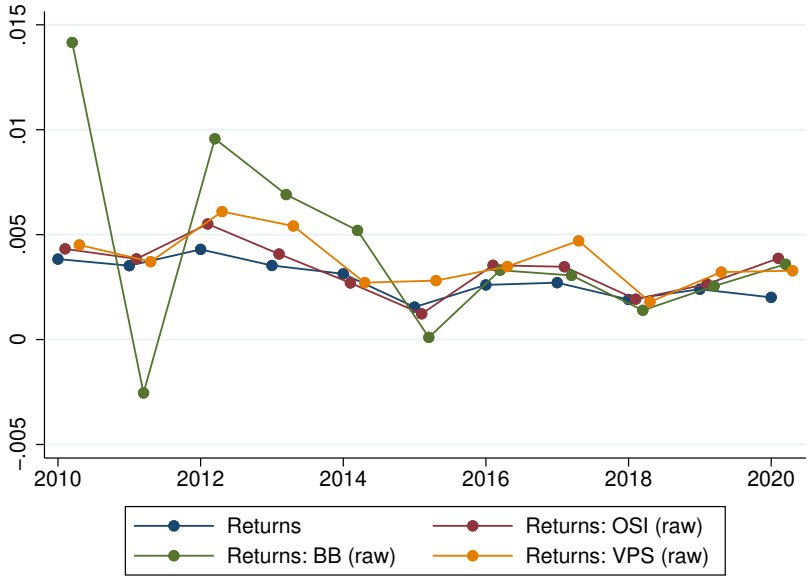


Figure E.4. Returns: With imputations by data source

This figure shows the average annual bond returns by source of the bond price data. Missing prices are imputed with the past values whenever possible. Returns are winsorized at 0.5% level in both tails.

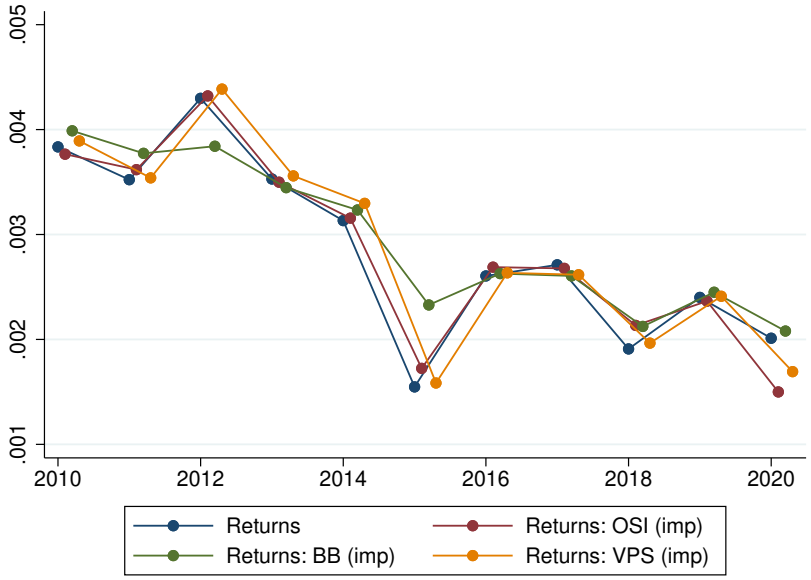


Figure E.5. Returns: Comparison of raw and imputed values

This figure shows the differences in average annual bond returns for time series using the imputed values and not. The differences are presented for two difference data soures: OSI and Euronext VPS. Returns are winsorized at 0.5% leel in both tails.