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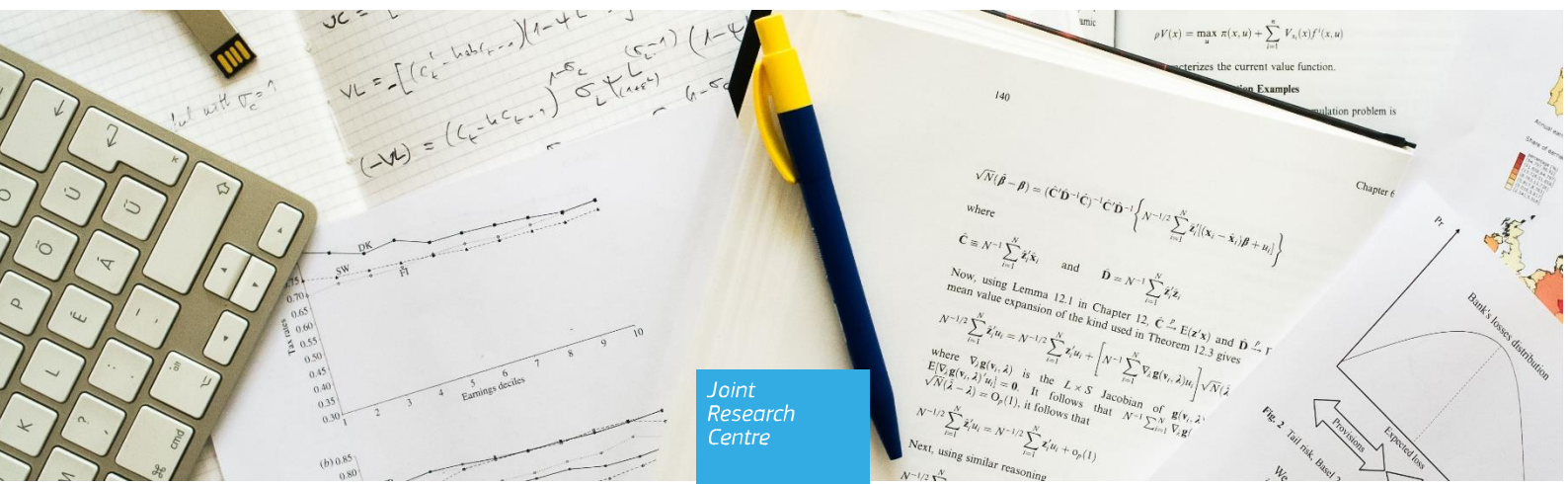

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# Sustainable investing in times of crisis: evidence from bond holdings and the COVID-19 pandemic

Serena Fatica [*] Roberto Panzica [§]

**Abstract**

Using data on institutional investors' bond holdings, we investigate the resilience of green bonds to the COVID-19 shock in a difference-in-differences framework. We find that during the COVID outbreak green bonds experience lower sales, on average, while in normal times no significant differences emerge compared with conventional bonds. The result is robust across different investor classes and is not driven by those that have a longer-term investment horizon. Furthermore, we find that sustainability-oriented funds sell less of green bonds than their peers without sustainability concerns. We also document that the ownership of green fixed income securities is more concentrated than that of comparable conventional bonds, and that concentration has increased in the first quarter of 2020.

**JEL Classification**: G12, G20, Q52, Q53, Q54

**Keywords**: Sustainable finance, climate change, green bonds, institutional investors

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# 1. Introduction

Capital markets plays an increasingly important role in scaling up the financing of investments that provide environmental and social benefits. The sustainable bond market is rapidly expanding and diversifying, with innovative instruments developed to meet growing investor demand and ramping up corporate commitments towards tackling environmental and social challenges. While these novel asset classes provide attractive investment opportunities, the associated financial risks are largely unexplored. In this respect, amidst the concerns for financial fragility generated by their expansion in the decade following the financial crisis of 2008, it is still unclear to what extent investment funds contribute to the development of sustainable investment in the bond market.

Using data on bond holdings by institutional investors and a difference-in-differences setup, in this paper we explore the resilience of sustainable debt instruments during the period of market turmoil due to the COVID-19 pandemic. We focus on a specific class of sustainable financial instruments – green bonds. Having already emerged as the 'star of climate finance' in the recent years, green bonds are becoming increasingly popular as companies need to fund operations that are more environmentally friendly and policymakers seek a sustainable recovery from the coronavirus crisis. Further momentum for this asset class is expected from the political agenda, particularly at European level. In September 2020, the European Commission revealed its intention to raise 30% of Next Generation EU – its recovery instrument worth €750 billion – through the issuance of green bonds, and to use the proceeds to finance green policies. Furthermore, as a part of its broader agenda on sustainable finance, in July 2021 the EU put forward a proposal for a common framework of rules for bonds that pursue environmentally sustainable objectives. Building on existing market best practices, the so-called European green bond (EuGB) standard puts in place strict requirements in order to enhance the transparency, comparability and credibility of the green debt market for both borrowers and investors. Against this background, evidence on the performance of this asset class in periods of financial markets stress is still lacking. In this respect, as a truly exogenous shock, the COVID-19 pandemic represents a unique opportunity to shed light on this issue.

In the context of rapidly deteriorating conditions on bond markets, including those for investment grade securities, green indices outperformed conventional bond indices in the period of highest market volatility during the COVID outbreak. Consistent with that, Ma et al. (2020) find a sharp drop of the greenium (that is, the negative yield premium for green bonds) in March 2020, almost at the very same moment the VIX spiked. Demand side factors, notably the behaviour of market makers, seem to play a crucial role. Arguably, green bonds are held

proportionally more in portfolios of investors focusing on environmental, and more broadly non-pecuniary, aspects. By the same token, green bonds may be part of more buy-and-hold long-term strategies and therefore less affected by market volatility. In this paper, we investigate these issues by exploring the role of institutional investors for the performance of green bonds in a time of crisis. To the best of our knowledge, ours is the first attempt to make such an assessment. This is partly due also to the very young age of the green bond market, which had barely started when the global financial crisis hit, and grew rapidly in popularity only in the aftermath. In our analysis of fixed income holdings in institutional investors' portfolios, we do not find evidence of significant differences in sales of green bonds with respect to conventional bonds in normal times, i.e. until the end of 2019. However, during the COVID outbreak in the first quarter of 2020, green securities experience consistently lower sales than conventional bonds, also in the case of mutual funds, which would need to liquidate assets in order to grant withdrawal rights to their clients. Further, we find evidence of reduced selling pressure for green bonds by sustainability-oriented investors during market turmoil, suggesting indeed that non-financial concerns are at play here. Recent survey evidence on the investment decisions of European asset managers substantiates this point. As reported in Sangiorgi and Schopohl (2021), strong green credentials are the most relevant factor for institutional investors' decision to invest in green bonds, while unclear and poor reporting on the actual allocation of proceeds to green projects prevents investors from buying or leads them to sell a green bond already included in the portfolio. The relevance of non-pecuniary factors is also consistent with market evidence that points to only small differences in the liquidity of green and conventional bonds using proxy indicators. While the former appears somewhat tighter, the differential with conventional bonds remained small and broadly constant during the COVID-19 turmoil (Mazzacurati et al., 2021). Finally, we find that green bond ownership is more concentrated than that of conventional bonds in normal times, and that concentration appears to have increased during the COVID outbreak.

Within the burgeoning literature that investigates the impact of the COVID-19 outbreak on financial markets (see, e.g., Ding, Levine, Lin, Xie, 2021; Ramelli and Wagner, 2020; Capelle-Blancard and Desroziers, 2020), our analysis is among the few contributions that investigate bonds (Becker and Benmelech, 2021; Zaghini, 2020).[1] In this context, by focusing on the

[1] Becker and Benmelech (2021) find U.S. bond market to be an important and resilient source of funding for corporations during crises, as it proved remarkably resilient against a sharp contraction caused by the pandemic outbreak. Still focusing on the primary market, and considering cost conditions at issuance, Zaghini (2020) documents significantly different effects of the pandemic for investment-grade and high-yield bonds, and an increased pricing premium as additional source of risk. Interestingly, he finds no premium on the issuance of green bonds, which would mark a sharp divergence with evidence on issues in 'normal times', at least for some types of borrowers (Fatica et al., 2021).

behaviour of institutional investors, our work relates to Falato et al. (2021), and more closely to Manconi et al. (2012), who document how mutual funds and insurers contributed to the transmissions of shocks in the bond market during the GFC. Compared to them, and to papers based on more aggregate data (e.g., Carvalho and Schmitz, 2020), we adopt a more granular approach that directly follows from our primary interest in investigating the resilience and performance of a specific type of debt securities. Similarly, we contribute to the emerging literature on sustainability in the investment fund industry and ESG investors, which importantly indicates that attention to sustainability has not faltered during such major crisis (Pastor and Vorsatz, 2020).

The rest of the paper is organized as follows. Section 2 describes the data we use. Section 3 introduces the empirical setup for the analysis of bond sales. Section 4 presents the main results together with robustness checks and extensions. Section 5 illustrates the empirical analysis of bond holdings concentration. Finally, Section 6 offers some conclusions.

## 2. Data

Our sample combines a variety of data source. Our main source is the Refinitiv eMAXX database, which reports fixed income positions of thousands of North American, European and other international institutional investors, such as insurance companies, mutual funds and leading US public pension funds.[2] Information on bond ownership is reported at quarterly frequency. Our sample covers the period from 2018-Q3 to 2020-Q2. Bond holdings are recorded in units of USD 1,000 in par amounts, that is nominal values, not in market values. This is a definite advantage, as in this way we can accurately measure quarterly quantity changes (as opposed to market value changes) in holdings of individual bond tranches.

We match the data on bond holdings with additional information at the security level using the unique bond ISIN identifier. Our source for bond issue information is Dealogic DCM, a leading provider of data on global debt capital markets. DCM provides details on bond issue characteristics at the tranche level, such as the amount issued, currency of denomination, yield, maturity, as well as the presence of embedded options or collateral linked to the tranche. DCM provides also minimal information about the immediate issuer of the bond and its parent company, notably the country of business operations and the sector of activity.[3]

[22] Reporting is based on regulatory requirements, e.g., for the US, insurance company holdings are based on NAIC disclosures and mutual fund holdings are based on SEC disclosures, or on voluntary disclosure.

[3] In assigning bonds to the issuing entity, we account for the fact that several corporate bonds are technically issued by financial vehicles. In particular, if the issuer is classified as a financial company (based on its sectoral code), we then treat it as a vehicle and consider the parent company as the ultimate issuer of the bond. In all other cases, the immediate issuer is considered to be also the ultimate issuer of the bonds.

Further, we draw additional data from a variety of sources. To measure investors' environmental and broader sustainability engagement, we rely on the already established categorization of Environmental, Social and Governance (ESG) aspects. Specifically, we use the Bloomberg classification of ESG funds. Funds are ESG-labelled if they invest in companies compliant with specific ESG criteria. As an alternative measure for sustainability, we obtain ESG scores from MSCI's ESG research database. MSCI provides ESG ratings and scores of publicly traded companies designed to measure their exposure and resilience to long-term, industry material environmental, social and governance risks. For our purposes, we focus on the environmental (E) component of ESG scores. To merge the information from the different providers, we run a string matching algorithm on the investors' names. Additional data on sectoral stock market returns and secondary bond markets are drawn from Refinitiv Eikon and Bloomberg, respectively. All variable definitions and data sources that we use in the analysis are reported in Table A.1 in the Appendix.

## 2.1. Matching

For our analysis, we select those green and conventional bonds that are reported in eMAXX, and have an adequate coverage therein. Most small bonds do not appear in eMAXX because they are owned entirely by retail investors or small institutions. For reported bonds, holdings in eMAXX do not always sum up to the entire outstanding amount, mostly due to gaps in reporting. As a first data culling step, we sample only bonds for which we observe at least 25% of the par amount outstanding in eMAXX. In this way, we ensure that are drawing inference on a sufficiently large fraction of the bond value, while keeping the sample coverage in the cross-section of securities at adequate levels.[4]

Our interest lies in the identification of the resilience of green labelled securities compared to conventional bonds during market turmoil as it appears from actual changes in the holdings by institutional investors. The fact that a security is held (and sold) is not random, of course. Therefore, we need to ensure that potential differences in holdings and trading between conventional and green securities are not driven by inherent dissimilarities of the bonds, such as the financial features that make up their risk-return profile. While we hold relevant financial features constant by introducing ad hoc bond-level controls in the regression models, we also define our initial sample using a two-step matching procedure to make sure that the conventional bonds in the control group are as similar as possible to the green securities. Specifically, for each green bond, we first consider only conventional bonds issued in the same

[4] Since matured bonds would automatically disappear from holdings reports, we further consider only securities with maturity date after the year 2020.

industry and country. Then, we apply the propensity score matching algorithm to select as the control group conventional bonds similar to the green securities based on observable pre-determined characteristics of the bond issuance, namely its yield, year of issuance and years to maturity, financial rating (transformed into a categorical variable) and potential embedded options (i.e., whether the bond is puttable or callable). The matching procedure is a nearest neighbour matching of propensity scores, as first proposed by Rosenbaum and Rubin (1983). For each green bond, the three most similar conventional bonds or nearest neighbours are selected using the predicted probabilities of a probit model. The matching is done with replacement, as this this should improve the accuracy of the matching procedure (Smith and Todd, 2005). Table A.2 in the Appendix shows the outcome of the matching. In particular, we report summary statistics for the groups of green and conventional securities, both before and after the matching procedure. The t-test on the averages illustrate less significant differences between all the variables used in the propensity score for green bonds and the control group of conventional bonds after the matching. Thus, by removing meaningful differences along observable dimensions, we effectively control for the primary confounding factors that could lead to spurious inferences.

## 3. Analysis of net bond sales

We investigate net sales of bonds during the COVID period in a difference-in-differences framework. In particular, we run variants of the following baseline regression model:

$$Log\ NetSales_{bhjt} = a_0 + a_1 green\ bond_b + a_2 COVID_t + a_3 green\ bond_b \times COVID_t + \boldsymbol{\beta}\text{Controls}_{bhjt} + \mu_j + \mu_h + \varepsilon_{ihjt}. \quad (1)$$

The dependent variable is the logarithm of the par amount of bond $b$ (issued by issuer h), that is sold by investor $j$ at quarter $t$.[5] The variable $green\ bond_b$ is a dummy that assumes value one if the bond is green, and zero otherwise. $COVID_t$ is an event dummy that equals one during the COVID period, and zero before that, i.e. up to 2019-Q4. As the developments of the COVID pandemic and subsequent policy reactions had markedly different impacts on financial markets, in order to have a cleaner identification of the effect of the shock we run two alternative specifications of model ( 1). In the first specification, we retain only observations from 2020-Q1 as those from the pandemic period. In this way, we focus on the effects of the COVID outbreak. In an alternative specification we consider the so-called

[5] Sales are obtained as the negative value of net changes in the holdings of the bond. We retain the zero net changes in reported holdings by defining $Ln\ NetSales_{ijt} = \ln(-Net\ change_{ijt} + 1)$.

rebound period, and hence retain only observations from 2020-Q2 as those from the COVID period.[6] The interaction term $green\ bond_b \times COVID_t$ allows us to identify any abnormal sales of green bonds with respect to conventional bonds in the two COVID sub-periods that we have defined.

The baseline specification of model (1) includes a number of additional time-varying controls defined at the bond, investor and bond-investor levels. First, at the bond level, we include the outstanding amount (in logs) of the issue in each quarter. From the findings in Alexander et al. (2000) that larger issues do have higher trading volume, we expect sales to correlate positively with the par value of the bond in each quarter. In this respect, bond size may also proxy for liquidity. In the same spirit, we also control for the par amount of the bond held in the investor's portfolio in each quarter. Next, we include the age of the issue, expressed as (log) quarters. There is evidence that bonds trade more actively around their issuance date and much less in later periods, as they settle into the portfolio of investors who intend to hold them to maturity (Warga, 1992). Over time, inactive portfolios absorb more and more of the original float, leaving smaller amounts of the seasoned securities available for trade. As transaction cost increase with age (Edwards et al., 2007), we expect age to correlate negatively with sales (Alexander et al., 2000). To account for changes in the bond's credit quality, we define a dummy variable that equals one if the bond has been downgraded at least once during the relevant quarter, and zero otherwise. The literature documents higher turnover and larger trade sizes for high credit risk bonds (Alexander et al., 2000; Jostova et al., 2013) and lower transaction costs for highly rated securities (Edwards et al., 2007). Based on these results, we would expect worsening credit risk to be positively associated to bond sales. As for investor-specific controls, we control for the total par value (in logs) of the portfolio of bonds held by the institutional investor.

The baseline regression model includes a set of dummy variables that capture other relevant bond issue characteristics. Specifically, we use a dummy equal to one if a bond is callable, zero otherwise; a dummy equal to one if a bond is puttable, zero otherwise; and a dummy that equals one if a bond has some underlined collateral, zero otherwise. We also create dichotomous variables for the currency of issuance. Furthermore, we define a categorical variable that distinguishes among short-term (less than five years), medium-term (between five and ten years) and long-term (more than ten years) bonds. We also consider the bond financial rating at issuance, as provided by S&P, Moody's or Fitch, and define eleven categories

[6] Naturally, when we focus on the COVID outbreak (rebound) period we drop observations from the other COVID quarter.

with 1 assigned to the top rating (AAA) and 11 to the worst rating (or not rated).[7] In all model specifications, we introduce investor fixed effects $(\mu_h)$ to capture time-invariant issuer-specific characteristics, including unobservable issuer quality, that might have a bearing on holding of their securities and selling behaviour by institutional investors. Similarly, we include investor fixed effects to account for unobservable factors at the investor level that might affect the decision to hold the bond, and eventually sell it.

Our matched sample incudes bonds issued by the corporate sector and by governmental bodies.[8] While we run our benchmark regressions on the full matched sample, we also check the robustness of the results to the use of an alternative sample that comprises only bonds issued by the corporate sector. In this case, we augment our regressions with variables capturing stock market movements, which, by inducing investors to rebalance their portfolios, may influence bond trading. Specifically, we account for equity market conditions introducing two variables that measure average returns and volatility. Both are defined at the sector-country levels, and are time varying. In additional specifications, we account for aggregate shocks by including interaction time fixed effects. Specifically, we use issuer country × sector × time fixed effects to control for time-varying unobservables that are specific to the industry and the country of the issuer. This reflects the consideration that trading activity may be different across industries due to differences in transparency, regulation or market outlook. Moreover, we include investor country × time fixed effects to control for shocks in the country of the investor that may have a bearing on its trading activity. Finally, we check the robustness of the baseline results by using bond × investor fixed effects to control for unobservable factors at the security and investor level that may be correlated with sales. In this more restrictive specification, for identification we rely on multiple bond sales by the same investor. Robust standard errors are clustered at the level of the investor to account for potential correlation of disturbances among bonds held in the same portfolio following investor-specific investment strategies. Table 1 reports descriptive statistics for the variables used in the regressions.

[Table 1 around here]

## 4. Results

This section discusses the results of the analysis of net bond sales. After illustrating the baseline findings, we explore whether heterogeneity across institutional investors matters. First, we consider separately mutual funds and insurance companies. Secondly, we investigate

[7] Our sample comprises only investment grade bonds.
[8] Supranational institutions and US municipalities are frequent green bond issuers.

whether sustainability concerned investors behave differently than other institutional investors when it comes to sales of green securities.

## 4.1. Baseline results

The results from the baseline difference-in-differences model for bond net sales are in Table 2. We consider two different periods to investigate the impact of the pandemic. Columns 1-4 report the coefficient estimates for the outbreak period, where the COVID event indicator refers to the first quarter of 2020. Columns 5-8 present the estimates for the rebound period, where the COVID event dummy refers to the second quarter of 2020. All the regressions include the time-varying and time-invariant controls at the bond and investor levels, and full sets of issuer and investor fixed effects. In this way, we hold constant any issuer-specific characteristics, including unobservable firm quality. This addresses the endogeneity concern that the inclusion of a bond in the investors' portfolios depends on some unobserved characteristics about the issuing firm. Investor fixed effects allow us to control for any time-invariant investor-specific characteristics that may affect their trading behaviour. Column 1 reports the results for our benchmark specification on the full sample of matched bonds. Our main variable of interest, the interaction term $green\ bond_b \times COVID$, is negative and statistically significant at 1% level, suggesting that during the COVID outbreak green bonds experience lower sales than conventional bonds, ceteris paribus. By contrast, the dummy for green bonds, while also negative, is not identified with precision. This suggests that, in normal times, sales of green securities do not seem to experience a different pattern than that of conventional bonds. The coefficient estimate for the COVID event dummy is positive and highly statistically significant, pointing to higher bond sales by institutional investors during the COVID outbreak period than during compared to the pre-pandemic quarters.

As for the controls, a bond outstanding amount correlates positively with its net sales. This is consistent with Alexander, Edwards, and Ferri (2000), who find that larger bond issues do have higher trading volume. Similarly, sales are larger for those bonds for which the investor has larger holdings. By contrast, the size of the investor's whole portfolio correlates negatively with the bond sale volume, indicating that larger investors are selling less. Moreover, in line with expectations, bonds tend to sell less as they become more seasoned. However, the effect of bond age is not identified with precision. Finally, the positive and highly statistically significant coefficient on the indicator for downgrades suggests that credit rating deterioration is associated with higher bond sales.

Next, we focus on corporate bonds only. First, we augment the benchmark regression with variables capturing average returns and volatility on the stock market, at the country-sector level (column 2). In general, the results are qualitative and quantitative similar to those for the full sample which includes also governmental bond issuers. The coefficient for the COVID period indicator doubles in size compared to the full sample. As expected, the corporate sector is particularly affected by the COVID shock, with changes in corporate bond holdings mirroring the developments on global stock markets.

Column 3 controls for aggregate shocks affecting the issuer's sector and country, and the investor's country by including time interactive fixed effects. In this case, while the green bond dummy is still insignificant, we identify again a highly significant and negative effect of its interaction with the COVID event dummy. The same holds for column 4, where we further saturate the model including bond x investor fixed effects. Overall, these findings suggest that institutional investors do not liquidate their holding of green securities as much as they do with conventional bonds during the market turmoil in the first quarter of 2020. Sales of green bonds are on average 7% lower during the COVID outbreak quarter.[9] Coefficients on the other covariates are also rather stable across the richer model specifications.

Columns 5-8 of Table 2 report the coefficient estimates from model (1) when the COVID event indicator identifies the second quarter of 2020. The results in the first two columns do not point to an abnormal sale behaviour during the rebound period. However, the interaction term of interest, still negative, turns again highly significant in the specifications with the more restrictive set of fixed effects in columns 7 and 8. Overall, these findings seem to suggest that bond sales by institutional investors had, only to some extent, already normalized in the second quarter of 2020.

[Table 2 around here]

## 4.2. Heterogeneity across investor types

In this section, we present the results from estimating equation (1) on two sub-samples that comprise homogenous types of investors. This allows us to investigate potential differences in selling behaviour that may be hidden in the baseline analysis on the full sample of institutional investors. In particular, we consider two broad categories of investors, notably mutual funds and insurance companies. In this way, we address issues that concern inherent

[9] To obtain the percentage effect of the interaction term on the dependent variable we apply the correction proposed by Kennedy (1981) for dummy variables in log-linear specifications, as follows: $\hat{p} = 100 * [\exp(\hat{c} - 0.5 * V(\hat{c})) - 1]$, where $\hat{p}$ is the percentage change in the dependent variable given a change in the dummy variable from zero to one, $\hat{c}$ is the coefficient estimate for the dummy variable, and $V(\hat{c})$ is the estimated variance for this coefficient. We discuss this transformed coefficient throughout the text.

dissimilarities in liabilities structure, which may ultimately translate into different portfolio dynamics and rebalancing, particularly in periods of market turmoil.

### 4.2.1. Mutual funds

Table 3 reports the results from estimating equation (1) on the sub-sample of institutional investors that includes mutual funds, for the COVID outbreak (columns 1-4) and rebound periods (columns 5-8), respectively. The results are in line with the findings from the whole sample. In particular, the lack of statistical significance for the green bond dummy across all specifications confirms that green bonds in mutual fund portfolios do not sell differently than ordinary bonds in normal times. The coefficient for the COVID dummy in columns 1-2 is positive and highly statistically significant. In the COVID outbreak period mutual fund sell on average 30% more of bonds in their portfolios compared to the previous quarters, 50% more if only corporate bonds are considered. This is a clear indication of the market pressure that they face for redemptions. Our variable of interest, the interaction term $green\ bond_b \times COVID$ is again negative and highly statistically significant in the outbreak period. During market turmoil in the first quarter of 2020, mutual funds have reduced the sales of green bonds by around 8% compared with was to be expected in normal times. Notwithstanding pressure to liquidate their assets to meet redemption demand by clients, mutual funds have not liquidated green bonds as much as they have sold comparable conventional bonds. Columns 5-8 in Table 3 report the results for the rebound period. The regression coefficients for the COVID event dummy and its interaction are not identified with precision across all specifications. This suggests that bond selling behaviour by mutual funds has already normalized in the second quarter of 2020.

[Table 3 around here]

### 4.2.2. Insurance companies

Table 4 presents the regression results from the sub-sample of insurance companies. The coefficient estimates for the interaction variable of interest from the COVID outbreak period (columns 1-4) confirm that green bonds in insurers' portfolios sell less than conventional bonds during the period of market turmoil. The negative and highly significant point estimates indicate that, on average, green bond sales are 13% lower in this quarter. In contrast, we again document that green bonds experience selling behaviour that is similar to that for conventional bonds in normal times. The COVID event dummy, negative and marginally statistically significant throughout the model specifications, suggests that insurers sell less of bonds in their portfolios during market turmoil compared to normal times. Interestingly, we

do not find significant differences in insurers' selling behaviour across the two quarters of the COVID period that we analyse. As documented for the COVID outbreak, in the rebound quarter insurance companies sell less of bonds, and even less of green-labelled ones than they have done in the quarters before the end of 2019.

In contrast to mutual funds, this class of institutional investors face longer-term end investors and are equipped with long lock-ups, penalties for early withdrawals, and predictable payout schedules. Hence, they do not face so high pressure to sell as mutual funds, especially in the event of temporary deviations of prices from fundamentals. At the same time, the high uncertainty in the initial COVID period might have put strain on insurer profitability, due to lower than expected premium inflows and the contemporaneous increase in claim outflows resulting from the confinement measures and economic downturn at the onset of the pandemic (Liedtke, 2021). Insurers' propensity to sell might have been also negatively influenced by the fact that, in an economic environment of extremely low interest rates, significant amounts of earned coupons and redemptions from matured securities should be reinvested at already lower yields, with further bearing on medium and long-term income developments. This might further discourage portfolio rebalancing, compounding the already limited activity of insurers on the secondary bond market. As noted by Becker and Ivashina (2015), the buy-and-hold strategy that characterizes the insurance business model results in most of the investment activity in fixed income occurring at issuance.

[Table 4 around here]

## 4.3. The role of sustainability oriented funds

The results in the previous sections document that heterogeneity across investor types does seem to affect the liquidation of conventional bonds during the period of market turmoil. By contrast, different types of investors equally refrain from selling green bonds during the COVID outbreak period. While the different behaviour of mutual funds and insurance companies is inherent to their different business models, additional relevant sources of heterogeneity materialize also within homogeneous groups of investors. In particular, if the decision to hold green bond in their fixed income portfolios is part of a broader socially and environmentally responsible activity, we would expect this to be reflected also in the selling strategy during the period of high market stress.

In this section, we test whether our main results are driven by sustainability-oriented funds. We capture sustainability concerns as reflected in the already standard classification based

on the environmental, social and governance (ESG) dimensions. In particular, we consider mutual funds with an ESG mandate, as defined by Bloomberg. Funds are ESG-labelled if they invest in companies compliant with specific ESG criteria.[10] For our purposes, we define an indicator variable that equals one for ESG funds, and zero otherwise. Then, we augment the baseline model in equation (1) with the dummy for ESG mandate, and its interactions with the relevant indicators for green bonds and the COVID event dummies. The results are reported in Table 5. We are most interested in the coefficient of the triple interaction term in the augmented regression model. Columns 1-4 in Table 5 show that sales of green bonds by mutual funds with ESG mandate are indeed lower than those of their non-ESG peers during the pandemic outbreak period in the first quarter of 2020. The effect is sizable: the point estimates indicate, on average, 30% lower sales of green securities. In line with the results in Table 2, no differences emerge in the rebound period. Moreover, the fact that the dummy for sustainability-oriented funds is negative and highly statistically significant throughout the specifications corroborates the view that these investors adopt an investment strategy that is more oriented towards the long term than that of their non-ESG peers.

These findings suggest that non-financial factors are indeed behind the different performance of green and conventional bonds in times of market stress. This is consistent with recent survey evidence on the investment decisions of European asset managers (Sangiorgi and Schopohl, 2021). Strong green credentials are reportedly the most relevant factor for institutional investors' decision to invest in green bonds, while unclear and poor reporting on the actual allocation of proceeds to green projects prevents investors from buying or leads them to sell a green bond if already included in the portfolio.

[Table 5 around here]

## 4.4. Robustness and extensions

In this section, we check the robustness of our results along several dimensions, including the potential impact of policies.

### 4.4.1. An alternative measure of sustainability

In the previous section, we have provided evidence that funds with sustainability concerns engage in lower sales of green bonds during the COVID outbreak compared to their peers without an ESG mandate. Here, we make use of an alternative ESG-based metric to test the

[10] Sample descriptive evidence indicates that green bonds are held proportionally more by ESG funds. Green securities account for roughly 80% of the holdings of ESG funds in the sample. By contrast, green bond holdings by non-ESG funds amount to only 23.5% of their bond portfolio.

role of sustainability in shaping selling strategies. Specifically, we employ the ESG ratings produced by MSCI, focusing on the environmental (E) component. For investment companies, the latter measures the resiliency of portfolios to long-term, material risks and opportunities of environmental nature. The ratings are based on scores that are normalized at the industry level, and range from 1 (for a company lagging its industry based on its high exposure and failure to manage significant environmental risks) to 10 (for industry leaders). We rank the funds environmental scores in deciles by considering the investors' sample distribution. Hence, we define a dummy equal to one if the fund is in the top decile, and zero otherwise. We label investors in the top decile as E top-rated investors. Again, while we augment the baseline model with this additional variable and all its relevant interactions, we are most interested in the triple interaction term. Table 6 reports the results for the sub-sample of mutual funds. Focusing on columns 1-4, we find some evidence that during the COVID outbreak quarter investors with the highest environmental scores behave differently when it comes to liquidating fixed income securities in their portfolio than funds with lower scores. In particular, the coefficient on the triple interaction term is always negative and statistically significant across all specifications and sub-samples. We do not find strong evidence of statistically significant differences in the behaviour of top-rated behaviour mutual funds in the COVID rebound quarter (columns 5-8).

[Table 6 around here]

### 4.4.2. EU policy action to foster sustainable finance

A number of policy initiatives to bolster sustainable finance have followed the commitment under the Paris agreement to 'making finance flows consistent with a pathway towards low Greenhouse Gas emissions and climate-resilient development'. In March 2018, the European Union adopted a Sustainable Finance Action Plan, setting out a comprehensive strategy to promote sustainable investment, manage climate and environmental risks and foster transparency and long-termism in financial and economic activities. As key actions, the plan envisaged the development of a classification system (so-called Taxonomy) for sustainable activities, alongside the establishment of a Green Bond Standard and an Ecolabel for retail financial products. By putting forward the ambitious goal of climate neutrality for the continent by 2050, the European Green Deal of 11 December 2019 reinforced the commitment of EU policymakers to the need to re-direct financial and capital flows to green investments. The related investment plan announced the establishment in 2020 of an EU Green Bond Standard, which, inspired by best market practices, aims at enhancing the transparency, comparability and credibility of the green bond market for both borrowers and investors.

Policy action can very well affect expectations and behaviour on financial markets. According to the survey evidence in Krueger et al. (2020), most institutional investor reckon that climate risks related to regulation have already started to materialize. Such regulations may favour green companies or products and tax, or even ban, brown ones. Similarly, the policy stance and public pressure can strengthen investors' preference for green holdings, potentially increasing divestment from brown assets. Against this background, our previous results might very well be driven by the anticipation of policy action to favour green investments, both on the demand and on the supply side of (green) securities. To verify this, we check the robustness of our baseline results to two different sample definitions. Specifically, we first exclude EU investment funds, which would be the ones directly affected by the regulatory and legislative initiatives described above. Second, in a similar way, we define another sub-sample that further excludes also EU bond issuers. In this way, we implicitly exploit the fact that, during our sample period, the environmental policy stance was markedly different in the US, which has the highest representativeness in our bond sample. The results are shown in Table 7. Panel A reports the estimates on the sub-sample that excludes bond holdings by European investment funds. Panel B shows the estimates for the sub-sample that excludes bonds held by EU funds and issued by EU borrowers. Across all model specifications, the results for both the COVID outbreak and rebound periods are quantitatively and qualitatively similar to those obtained in the baseline specification. This suggests that the shift in environmental preferences of financial markets participants started well before the COVID crisis, as noted by Pastor and Vorsatz (2020), and, importantly, that has not been reversed by a less environmentally concerned policy stance.

[Table 7 around here]

### 4.4.3. Central banks' bond purchase programs

In response to the sudden and severe deterioration of financing conditions due to the COVID outbreak, central banks implemented aggressive emergency action to reduce stress on bond markets. On March 23, 2020, the Federal Reserve announced interventions to support credit to employers on both primary and secondary markets. In particular, the Secondary Market Corporate Credit Facility (SMCCF) aimed at supporting market liquidity by purchasing in the secondary market corporate bonds issued by investment grade US companies. Together with the primary market facility, the program envisaged bond purchases for up to USD 750bn until December 2020. The European Central Bank responded to the pandemic outbreak by strengthening its outstanding programs of corporate bond purchases. On 18 March 2020, a

temporary Pandemic Emergency Purchase Program (PEPP) was announced for private and public sector securities. The initial €750 billion envelope was increased by €600 billion on 4 June 2020, and by €500 billion on 10 December, for a new total of €1,850 billion.

The programs had significant impact on bond markets. As noted by Falato et al. (2021), the mere announcement of the Corporate Credit Facilities, marking the very first intervention on corporate debt markets in the history of the Fed, helped to stop panic and reverse corporate bond spreads. An important channel through for market stabilization was that of investment funds, with fund outflows significantly reversed in the months after the announcement, particularly from most fragile ones, i.e. those exposed to illiquid securities and fire sales. Importantly, the stabilization of secondary markets had positive spillovers on to primary markets. For instance, Zaghini (2021) documents that bonds eligible under the PEPP benefited from a more muted increase in issuance costs compared to non-eligible securities.

To formally test whether central banks' bond purchase programs affect bond sales in our sample, we first discriminate between eligible and non-eligible securities.[11] Then, we define two indicator variables that are equal to one if the bond is eligible under the relevant bond purchase program, and zero otherwise. Finally, we augment the regression model for the COVID rebound period with the eligibility dummy, in turn for the US and the Euro area, and the relevant interaction terms. The results are reported in Table 8. We do not find evidence that, in our sample, the sales of corporate conventional and green bonds by investment funds are significantly affected by bond purchasing programs in the second quarter of 2020. Since our sample period ends at June 2020, we are not be able to capture the potential medium term impacts of the policies. Another possibility is that purchasing programs have exerted their effect on the institutional investors' channel mainly by reducing vulnerability stemming from overall exposure to illiquid bonds (Falato et al., 2021), rather than through the holding of specific securities.

[Table 8 around here]

## 5. Bond ownership concentration

In this section, we investigate bond ownership concentration in institutional investors' portfolios. Further, we test whether it has been significantly affected by the selling behaviour

[11] Eligible bonds under the SMCCP must be issued by an issuer that (i) is created or organized in the United States; (ii) was rated at least BBB-/Baa3 as of March 22, 2020; (iii) is not an insured depository institution, depository institution holding company, or subsidiary of a depository institution holding company; and in each case, the bonds must have a remaining maturity of five years or less. Eligibility under the PEPP requires the bond to: i) be issued by a corporate issuer in the Euro area (excluding credit institutions); ii) be denominated in euros; iii) have a minimum rating of BBB-; iv) have minimum residual maturity of 6 months and less than 31 years.

during the COVID period that we have documented in the previous sections. We measure ownership concentration of each bond using the familiar Herfindahl-Hirschman Index (HHI), as follows:

$$HHI_{bt} = \sum_{j=1}^{J} s_{btj}^2$$

where $s_{btj}^2$are the squared shares of bond *b* holdings in the cross-section of institutional investors (indexed with j) over the bond outstanding amount in each quarter *t*.

As a first pass through the data, we inspect the distribution of the HHI indices. In our sample, the average index of concentration is 0.28 for green bonds, and 0.15 for conventional bonds. Figure 1 shows that ownership concentration is higher for green bonds along the entire distributions of the HHI indices for the two groups of debt instruments. The median HHI for green securities is 0.20, while that for conventional bonds is 0.06. Comparably sizable differences are apparent also in the values of other relevant quantiles. The fact that ownership of green bonds is more concentrated than that of conventional bonds is consistent with the insights provided by Baker et al. (2018). In a simple modelling framework, they show that the presence of investors with environmental objectives next to investors without green preferences can generate more concentrated ownership for securities with positive environmental scores, particularly if they have low market value and risk. In the case of debt instruments, the small supply of green securities with respect to conventional bonds would indeed lead to the former being held in more concentration than the latter.

[Figure 1 around here]

Next, we investigate whether bond ownership concentration has changed during the COVID period. Specifically, we run the following difference-in-differences model:

$$HHI_{bht} = a_0 + a_1 Green\ bond_b + a_2 COVID_t + a_3 Green\ bond_b \times COVID_t + \boldsymbol{\beta}\text{Controls}_{bt} + \mu_h + \varepsilon_{bht}. \quad (2)$$

where $HHI_{bt}$ is the Herfindahl-Hirschman Index of concentration for bond *b* (issued by issuer *h*) at quarter $t$. The variable $Green\ bond_b$ is a dummy that assumes value one if the bond is green, and zero otherwise. $COVID$ is an event dummy that equals one during the COVID period, and zero before that, i.e. up to 2019-Q4. As before, we consider two different definitions of the COVID period where we let the corresponding event dummy indicate alternatively the outbreak period, as the first quarter of 2020, and the rebound period, that is the second quarter of 2020. Equation (2) also includes bond-level controls, notably the

outstanding amount and the bond age in quarters, both taken as logarithms, as well as bond issue characteristics. The results are reported in Table 9. As before, columns 1-4 show the coefficient estimates for the COVID outbreak quarter. The interaction term points to no significant changes in ownership concentration for the full set of bonds (column 1). However, focusing on securities issued by corporate borrowers (columns 2-4) reveals a statistically significant increase in the concentration index during the first quarter of 2020. The coefficient estimate of 0.03 translates into a 10% average change at the green bond sample mean of the HHI. By contrast, and in line with the findings that bond sales have already normalized during the COVID rebound period, we do not find strong evidence that the ownership concentration of green securities has increased in the second quarter of 2020 (columns 5-8). Only the specification that includes bond X investor fixed effects (column 8) indicates an increase in the ownership concentration of corporate green bonds, while in those with a less stringent set of fixed effects this effect is not identified with precision. Across all specifications in Table 9, the coefficient for the green bond dummy is positive and statistically significant at 1% level. Controlling for relevant bond characteristics and other potential confounding factors at the issuer and aggregate levels, the Herfindahl-Hirschman index is on average around 0.14 points higher for green bonds than for conventional securities (or 0.11 points if only corporate issuances are considered), which is in line with the evidence based on the sample unconditional means.

[Table 9 around here]

## 6. Conclusions

While the range of sustainable debt instruments is rapidly expanding and diversifying, there is practically no evidence on the performance of these new asset classes in periods of market stress, and on the role played by institutional investors as market makers. Using data on bond holdings by institutional investors, in this paper we shed light on these issues focusing on the period of market turmoil due to the COVID-19 pandemic. We consider a specific class of sustainable financial instruments – green bonds – that have emerged as the 'star of climate finance' in recent years. Our sample period spans from the third quarter of 2018 to the second quarter of 2020, and covers the period of severe and sudden stress experienced by financial markets as pandemic-related events unfolded. We do not find evidence of significant differences in sales of green bonds with respect to conventional bonds in normal times, i.e. until the end of 2019. However, during the COVID outbreak, i.e. the first quarter of 2020, green securities experience consistently lower sales than conventional bonds, even by mutual

funds, which, by granting withdrawal rights to clients, face the risk of asset liquidation. Next, we test whether sustainability orientation in investment strategies significantly alters the selling behaviour of institutional investors during the period of market turmoil. We find evidence of reduced selling pressure for green bonds by sustainability-oriented investors during the peak of financial market stress. The findings are robust to alternative definitions of sustainable funds. This corroborates the view that is indeed concerns for non-pecuniary aspects, rather than other financial considerations, are indeed driving the results. Finally, we find that green bond ownership is more concentrated than that of conventional bonds in normal times, and that concentration appears to have increased during the COVID outbreak.

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# Appendix

**Table A.1 Variable definitions and sources.**

| Variable | Definition | Source |
|---|---|---|
| *Net sales* | Natural logarithm of net sales of the bond by the investor in the quarter. Net sales are defined as $(-Net\ change_{ijt} + 1)$, i.e. the negative value of the net change of the bond par amount held by investor since the date of last report, plus one. | Refinitiv eMAXX |
| *HHI* | Herfindahl-Hirschman Index of concentration for bond holdings. For each bond, it is calculated as the sum of the squared percentage holdings across investors. | Refinitiv eMAXX |
| *COVID* | Event dummy that equals one during the *COVID period,* and zero before that, i.e. up to 2019-Q4. We use two mutually exclusive definitions of the variable, to indicate, respectively, the outbreak (2020-Q1) and the rebound (2020-Q1) quarter. | |
| Bond level variables | | |
| *Green Bond* | Indicator variable that equals one if the bond is green, and zero otherwise. | Dealogic DCM |
| *Bond holding by investor* | Natural logarithm of the bond par amount held by the investor in the quarter. | Refinitiv eMAXX |
| *Bond outstanding amount* | Natural logarithm of the bond outstanding amount. | Refinitiv eMAXX |
| *Bond age* | Natural logarithm of the bond age, expressed in quarters. It is obtained as the difference between the relevant quarter and the date of issuance. | Dealogic DCM |
| *Downgraded* | Indicator variable that equals one if the bond has been downgraded in the quarter, and zero otherwise. We define the dummy starting from the raw information on the monthly changes in credit risk rating. | Bloomberg |
| Bond issue characteristics (coefficients not reported in regression tables) | | |
| *Callable* | Indicator variable that equals one if the bond can be redeemed by the issuer prior to its maturity, and zero otherwise | Dealogic DCM |
| *Puttable* | Indicator variable that equals one if the bond gives the bondholders the right to demand early repayment of the principal from the issuer or a third party acting as an agent for the issuer, and zero otherwise. | Dealogic DCM |

| | | |
|---|---|---|
| *Collateralized* | Indicator variable that equals one if a bond has been backed by a collateral, and zero otherwise. | Dealogic DCM |
| *Credit rating* | Bond rating at issuance, as provided by Moody's (or S&P and Fitch if not available). We define eleven categories with 1 assigned to the top rating and 11 to the worst rating (or not rated). | Dealogic DCM |
| Investor-level variables | | |
| *Portfolio size* | Natural logarithm of the total value of the bonds held by the investor in the quarter. It is obtained summing up the bond par amounts in each investor's portfolios. | Refinitiv eMAXX |
| *ESG mandate* | Indicator variable that equals one if a fund invests in companies compliant with ESG criteria according to the Bloomberg classification of funds' general attributes, and zero otherwise. | Bloomberg |
| *E top rated* | Indicator variable that equals one if the investor's E-score according to MSCI ESG rating system lies in the first decile, and zero otherwise. A fund's environmental score measures holdings' management of and exposure to key environmental risks and opportunities | MSCI |
| Market-level variables | | |
| *Stock market index* | Index of daily stock returns at the industry-country level, redefined on a quarterly basis. | Refinitiv Eikon |
| *Volatility* | Volatility of daily stock returns at the industry-country level, redefined on quarterly basis. | Refinitiv Eikon |

**Table A.2 Propensity score summary table.** The table reports the mean, standard deviation (in parentheses) for the following variables: yield at issuance (%); maturity (in years); rating (categorized over a 1-11 scale, from AAA to lower ratings); callable (0/1 indicator); puttable (0/1 indicator); bond age as of 2020 (number of years computed as the difference between the year 2020 and the year of the bond issuance). These variables are used as covariates in the propensity score in order to reduce the difference between the treated (green bonds) and control (conventional bonds) groups. Differences in mean are reported in the last but one column. The last column reports the t-statistics for testing the null hypothesis that the mean difference is statistically different from zero. Panel A shows the results for the data before the matching procedure. Panel B exhibits the statistics after the matching procedure.

| Panel A: Unmatched data | Conventional Bond | Green Bond | Difference | t-stat |
|---|---|---|---|---|
| Yield at issuance | 4.210 | 2.763 | 1.447 | 8.729 |
| | (2.466) | (1.901) | (0.166) | |
| Maturity | 12.657 | 10.634 | 2.023 | 2.933 |
| | (10.245) | (9.689) | (0.690) | |
| Rating | 7.353 | 6.999 | 0.355 | 1.628 |
| | (3.229) | (3.730) | (0.218) | |
| Callable | 0.679 | 0.430 | 0.249 | 7.922 |
| | (0.466) | (0.496) | (0.031) | |
| Puttable | 0.247 | 0.082 | 0.165 | 5.704 |
| | (0.430) | (0.274) | (0.029) | |
| Bond age (as of 2020) | 4.528 | 2.607 | 1.921 | 10.017 |
| | (2.859) | (1.409) | (0.192) | |

| Panel B: Matched data | Conventional Bond | Green Bond | Difference | t-stat |
|---|---|---|---|---|
| Yield at issuance | 2.843 | 2.614 | 0.230 | 1.385 |
| | (1.788) | (1.787) | (0.166) | |
| Maturity | 11.879 | 10.484 | 1.395 | 1.422 |
| | (11.197) | (8.965) | (0.981) | |
| Rating | 6.632 | 6.747 | -0.115 | -0.340 |
| | (3.548) | (3.818) | (0.337) | |
| Callable | 0.501 | 0.414 | 0.087 | 1.835 |
| | (0.501) | (0.494) | (0.048) | |
| Puttable | 0.034 | 0.047 | -0.013 | -0.740 |
| | (0.179) | (0.209) | (0.018) | |
| Bond age (as of 2020) | 2.745 | 2.684 | 0.062 | 0.430 |
| | (1.594) | (1.423) | (0.143) | |

# Tables and figures

**Table 1 Descriptive statistics.**

| VARIABLES | N | Mean | St. Dev. | p50 | min | max |
|---|---|---|---|---|---|---|
| Net sales (logs) | 177,745 | 0.584 | 1.772 | 0 | 0 | 8.248 |
| Bond holding by investor (logs) | 205,571 | 6.319 | 2.138 | 6.477 | 0 | 10.53 |
| Bond outstanding amount (logs) | 179,876 | 13.28 | 0.833 | 13.22 | 4.382 | 14.91 |
| Portfolio size (logs) | 213,307 | 13.27 | 2.316 | 13.20 | 0 | 18.89 |
| Bond age (quarters) | 213,687 | 1.626 | 1.102 | 1.792 | -2.303 | 3.555 |
| Downgraded | 191,248 | 0.144 | 0.995 | 0 | 0 | 1 |
| Sectoral stock market volatility | 212,873 | 0.261 | 0.197 | 0.156 | 0.0603 | 0.689 |
| Sectoral stock market return | 212,873 | 0.00828 | 0.134 | 0.0346 | -0.504 | 0.349 |

**Table 2 Net bond sales by institutional investors.** The table reports regression results for net sales at the bond-investor level based on model (1). The dependent variable is the logarithm of net sales of bond b by investor j in quarter t. Green bond is a dummy variable equal to one if the bond is green, and zero otherwise. COVID is a variable that equals one during the COVID period, and zero before, i.e. until 2019-Q4. In columns 1-4 we consider as COVID period only the outbreak quarter, i.e. 2020-Q1. In columns 5-8 we consider as COVID period only the rebound quarter, i.e. 2020-Q2. Green bond × COVID is the interaction between the two variables. All other control variables are defined in Table A.1 in the Appendix. Bond issue characteristics include dummies that indicate whether a bond is puttable, callable, collateralized, and dummies for currency categories, maturity categories and rating categories. Sets of fixed effects included as specified. All models include an intercept (coefficient not reported). Robust standard errors, clustered at the investor level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

| | *Outbreak period* | | | | *Rebound period* | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | All bonds | | Corporate bonds | | All bonds | | Corporate bonds | |
| Green bond × *COVID* | -0.0705*** | -0.0675*** | -0.0807*** | -0.0686*** | -0.0107 | -0.0219 | -0.0654*** | -0.0729*** |
| | (0.022) | (0.022) | (0.023) | (0.023) | (0.024) | (0.022) | (0.023) | (0.024) |
| Green bond | -0.0260 | -0.0237 | -0.0256 | | -0.0249 | -0.0163 | -0.0138 | |
| | (0.018) | (0.018) | (0.018) | | (0.017) | (0.017) | (0.017) | |
| *COVID* | 0.1070*** | 0.1939*** | | | -0.0046 | 0.0213 | | |
| | (0.019) | (0.049) | | | (0.014) | (0.051) | | |
| Bond outstanding amount | 0.0555*** | 0.0640*** | 0.0591*** | 0.8287*** | -0.0047 | 0.0031 | -0.0033 | 0.2419*** |
| | (0.019) | (0.022) | (0.022) | (0.105) | (0.017) | (0.020) | (0.020) | (0.093) |
| Bond age | -0.0130 | -0.0125 | -0.0091 | -0.0262* | -0.0137 | -0.0144 | -0.0158* | -0.0185 |
| | (0.009) | (0.009) | (0.009) | (0.016) | (0.009) | (0.009) | (0.009) | (0.015) |
| Downgraded | 0.0327*** | 0.0382*** | 0.0395*** | 0.0270*** | 0.0145 | 0.0185* | 0.0146 | 0.0125 |
| | (0.011) | (0.011) | (0.011) | (0.010) | (0.010) | (0.010) | (0.010) | (0.010) |
| Bond holding by investor | 0.0234*** | 0.0193** | 0.0191** | -0.5933*** | 0.0116 | 0.0094 | 0.0081 | -0.4755*** |
| | (0.008) | (0.009) | (0.009) | (0.051) | (0.009) | (0.009) | (0.009) | (0.048) |
| Portfolio size | -0.0976*** | -0.0967*** | -0.0953*** | -0.0461** | -0.1456*** | -0.1339*** | -0.1272*** | -0.0772*** |
| | (0.027) | (0.027) | (0.027) | (0.020) | (0.043) | (0.036) | (0.035) | (0.027) |
| Sectoral stock market volatility | | -0.1285 | | | | -0.0783 | | |
| | | (0.110) | | | | (0.100) | | |
| Sectoral stock market return | | 0.1384** | | | | 0.0923 | | |
| | | (0.058) | | | | (0.061) | | |
| Bond issue characteristics included | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Fixed effects: | | | | | | | | |
| Issuer | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Investor | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Issuer sector X country X time | No | No | Yes | Yes | No | No | Yes | Yes |
| Investor country X time | No | No | Yes | Yes | No | No | Yes | Yes |
| Bond X Investor | No | No | No | Yes | No | No | No | Yes |
| Number of investors | 6196 | 6042 | 6042 | 5965 | 6241 | 6088 | 6088 | 5945 |
| Observations | 119,510 | 114,450 | 114,450 | 111,417 | 118,998 | 113,975 | 113,975 | 109,732 |
| R-squared | 0.3714 | 0.3681 | 0.3743 | 0.5835 | 0.3765 | 0.3755 | 0.3808 | 0.5863 |
| Adjusted R-squared | 0.336 | 0.332 | 0.336 | 0.453 | 0.341 | 0.339 | 0.343 | 0.455 |

**Table 3 Net bond sales by mutual funds.** The table reports regression results for net sales at the bond-investor level based on equation (1), estimated on the sub-sample of mutual funds. The dependent variable is the logarithm of net sales of bond b by investor j in quarter t. Green bond is a dummy variable equal to one if the bond is green, and zero otherwise. COVID is a variable that equals one during the COVID period, and zero before, i.e. until 2019-Q4. In columns 1-4 we consider as COVID period only the outbreak quarter, i.e. 2020-Q1. In columns 5-8 we consider as COVID period only the rebound quarter, i.e. 2020-Q2. Green bond × COVID is the interaction between the two variables. All other control variables are defined in Table A.1 in the Appendix. Bond issue characteristics include dummies that indicate whether a bond is puttable, callable, collateralized, and dummies for currency categories, maturity categories and rating categories. Investor-level dummies include dummies for the investor country of domicile and for investor types. Sets of fixed effects included as specified. All models include an intercept (coefficient not reported). Robust standard errors, clustered at the investor level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

| | *Outbreak period* | | | | *Rebound period* | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | All bonds | | Corporate bonds | | All bonds | | Corporate bonds | |
| Green bond × *COVID* | -0.0942*** | -0.0859** | -0.0763** | -0.0680** | 0.0158 | 0.0002 | -0.0355 | -0.0493 |
| | (0.033) | (0.034) | (0.033) | (0.034) | (0.035) | (0.032) | (0.032) | (0.034) |
| Green bond | -0.0042 | 0.0015 | 0.0003 | | -0.0154 | 0.0018 | 0.0091 | |
| | (0.025) | (0.027) | (0.027) | | (0.025) | (0.026) | (0.026) | |
| *COVID* | 0.2638*** | 0.4081*** | | | 0.0824*** | 0.0999 | | |
| | (0.032) | (0.073) | | | (0.022) | (0.076) | | |
| Bond outstanding amount | 0.1252*** | 0.1528*** | 0.1483*** | 0.8406*** | 0.0526** | 0.0664*** | 0.0666*** | -0.0549 |
| | (0.024) | (0.027) | (0.027) | (0.156) | (0.021) | (0.024) | (0.024) | (0.122) |
| Bond age | -0.0361*** | -0.0371*** | -0.0344** | -0.0174 | -0.0324** | -0.0336*** | -0.0379*** | -0.0060 |
| | (0.013) | (0.013) | (0.014) | (0.020) | (0.013) | (0.013) | (0.014) | (0.019) |
| Downgraded | 0.0294* | 0.0355** | 0.0345** | 0.0195 | 0.0033 | 0.0093 | 0.0065 | 0.0002 |
| | (0.016) | (0.016) | (0.017) | (0.016) | (0.014) | (0.014) | (0.016) | (0.016) |
| Bond holding by investor | 0.0400*** | 0.0366** | 0.0373*** | -0.5696*** | 0.0237* | 0.0216 | 0.0216 | -0.4498*** |
| | (0.013) | (0.014) | (0.014) | (0.057) | (0.014) | (0.015) | (0.015) | (0.052) |
| Portfolio size | -0.2694*** | -0.2801*** | -0.3015*** | -0.1114 | -0.3914*** | -0.3766*** | -0.3867*** | -0.2343*** |
| | (0.067) | (0.072) | (0.076) | (0.074) | (0.106) | (0.092) | (0.094) | (0.090) |
| Sectoral stock market volatility | | -0.2117 | | | | -0.0672 | | |
| | | (0.160) | | | | (0.148) | | |
| Sectoral stock market return | | 0.2052** | | | | 0.1884** | | |
| | | (0.086) | | | | (0.095) | | |
| Bond issue characteristics included | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Fixed effects: | | | | | | | | |
| Issuer | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Investor | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Issuer sector X country X time | No | No | Yes | Yes | No | No | Yes | Yes |
| Investor country X time | No | No | Yes | Yes | No | No | Yes | Yes |
| Bond X Investor | No | No | No | Yes | No | No | No | Yes |
| Number of investors | 3523 | 3409 | 3409 | 3352 | 3550 | 3438 | 3438 | 3332 |
| Observations | 66,653 | 62,476 | 62,476 | 60,415 | 66,081 | 61,926 | 61,926 | 59,015 |
| R-squared | 0.3690 | 0.3651 | 0.3725 | 0.5814 | 0.3792 | 0.3777 | 0.3826 | 0.5890 |
| Adjusted R-squared | 0.331 | 0.326 | 0.331 | 0.439 | 0.342 | 0.339 | 0.341 | 0.446 |

**Table 4 Net bond sales by insurers.** The table reports regression results for net sales at the bond-investor level based on equation (1), estimated on the sub-sample of insurers. The dependent variable is the logarithm of net sales of bond b by investor j in quarter t. Green bond is a dummy variable equal to one if the bond is green, and zero otherwise. COVID is a variable that equals one during the COVID period, and zero before, i.e. until 2019-Q4. In columns 1-4 we consider as COVID period only the outbreak quarter, i.e. 2020-Q1. In columns 5-8 we consider as COVID period only the rebound quarter, i.e. 2020-Q2. Green bond × COVID is the interaction between the two variables. All other control variables are defined in Table A.1 in the Appendix. Bond issue characteristics include dummies that indicate whether a bond is puttable, callable, collateralized, and dummies for currency categories, maturity categories and rating categories. Sets of fixed effects included as specified. All models include an intercept (coefficient not reported). Robust standard errors, clustered at the investor level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

| | *Outbreak period* | | | | *Rebound period* | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | All bonds | | Corporate bonds | | All bonds | | Corporate bonds | |
| Green bond × *COVID* | -0.1334*** | -0.1328*** | -0.1448*** | -0.1408*** | -0.1251*** | -0.1209*** | -0.1443*** | -0.1412*** |
| | (0.033) | (0.033) | (0.035) | (0.035) | (0.032) | (0.032) | (0.034) | (0.035) |
| Green bond | 0.0263 | 0.0290 | 0.0251 | | 0.0318 | 0.0298 | 0.0298 | |
| | (0.027) | (0.027) | (0.027) | | (0.025) | (0.025) | (0.025) | |
| *COVID* | -0.0998*** | -0.1300** | | | -0.1382*** | -0.1580*** | | |
| | (0.014) | (0.063) | | | (0.014) | (0.058) | | |
| Bond outstanding amount | -0.1085*** | -0.1152*** | -0.1259*** | 0.9676*** | -0.1483*** | -0.1402*** | -0.1452*** | 0.7939*** |
| | (0.042) | (0.042) | (0.043) | (0.173) | (0.040) | (0.041) | (0.042) | (0.153) |
| Bond age | 0.0076 | 0.0145 | 0.0151 | -0.0439* | 0.0052 | 0.0058 | 0.0113 | -0.0304 |
| | (0.013) | (0.013) | (0.011) | (0.025) | (0.012) | (0.012) | (0.011) | (0.022) |
| Downgraded | 0.0314** | 0.0381*** | 0.0212 | 0.0135 | 0.0204 | 0.0207 | 0.0144 | 0.0130 |
| | (0.014) | (0.014) | (0.015) | (0.014) | (0.014) | (0.014) | (0.015) | (0.013) |
| Bond holding by investor | -0.0133 | -0.0143 | -0.0135 | -0.8836*** | -0.0111 | -0.0101 | -0.0099 | -0.5759*** |
| | (0.009) | (0.009) | (0.009) | (0.184) | (0.009) | (0.009) | (0.009) | (0.138) |
| Portfolio size | -0.0179 | -0.0171 | -0.0208 | -0.0145 | -0.0140 | -0.0143 | -0.0179 | -0.0185 |
| | (0.013) | (0.013) | (0.013) | (0.012) | (0.012) | (0.012) | (0.012) | (0.012) |
| Sectoral stock market volatility | | 0.2729* | | | | 0.0331 | | |
| | | (0.148) | | | | (0.119) | | |
| Sectoral stock market return | | 0.2935*** | | | | -0.0125 | | |
| | | (0.084) | | | | (0.078) | | |
| Bond issue characteristics included | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Fixed effects: | | | | | | | | |
| Issuer | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Investor | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Issuer sector X country X time | No | No | Yes | Yes | No | No | Yes | Yes |
| Investor country X time | No | No | Yes | Yes | No | No | Yes | Yes |
| Bond X Investor | No | No | No | Yes | No | No | No | Yes |
| Number of investors | 1842 | 1839 | 1839 | 1832 | 1852 | 1848 | 1848 | 1832 |
| Observations | 42,108 | 41,851 | 41,851 | 41,238 | 42,255 | 41,996 | 41,996 | 41,115 |
| R-squared | 0.3210 | 0.3218 | 0.3308 | 0.5579 | 0.3196 | 0.3215 | 0.3308 | 0.5521 |
| Adjusted R-squared | 0.287 | 0.288 | 0.296 | 0.435 | 0.286 | 0.288 | 0.296 | 0.427 |

**Table 5 Net bond sales by funds with ESG mandate.** The table reports regression results for net sales at the bond-investor level based on equation (1), estimate on the sub-sample of mutual funds. The dependent variable is the logarithm of net sales of bond b by investor j in quarter t. Green bond is a dummy variable equal to one if the bond is green, and zero otherwise. COVID is a variable that equals one during the COVID period, and zero before, i.e. until 2019-Q4. In columns 1-4 we consider as COVID period only the outbreak quarter, i.e. 2020-Q1. In columns 5-8 we consider as COVID period only the rebound quarter, i.e. 2020-Q2. ESG mandate identifies ESG funds according to the Bloomberg classification. All other control variables are defined in Table A.1 in the Appendix. Bond issue characteristics include dummies that indicate whether a bond is puttable, callable, collateralized, and dummies for currency categories, maturity categories and rating categories. Sets of fixed effects included as specified. All models include an intercept (coefficient not reported). Robust standard errors, clustered at the investor level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

| | *Outbreak period* | | | | *Rebound period* | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | All bonds | Corporate bonds | | | All bonds | Corporate bonds | | |
| Green bond × COVID ×ESG mandate | -0.3407** | -0.3354** | -0.3974** | -0.4952*** | -0.3110* | -0.3016 | -0.3116* | -0.2520 |
| | (0.153) | (0.153) | (0.164) | (0.183) | (0.182) | (0.184) | (0.166) | (0.170) |
| Green bond × ESG mandate | 0.1224 | 0.1413 | 0.1547* | | 0.1067 | 0.1145 | 0.1187 | |
| | (0.084) | (0.087) | (0.090) | | (0.077) | (0.076) | (0.075) | |
| COVID × ESG mandate | 0.2649 | 0.2726 | 0.2703 | 0.3444* | 0.3449** | 0.3466* | 0.3571** | 0.3476** |
| | (0.179) | (0.181) | (0.183) | (0.184) | (0.173) | (0.178) | (0.160) | (0.160) |
| Green bond × *COVID* | -0.0866*** | -0.0786** | -0.0659** | -0.0558 | 0.0184 | 0.0025 | -0.0323 | -0.0496 |
| | (0.033) | (0.035) | (0.033) | (0.035) | (0.036) | (0.033) | (0.033) | (0.035) |
| Green bond | -0.0065 | -0.0009 | -0.0028 | | -0.0169 | 0.0003 | 0.0073 | |
| | (0.026) | (0.027) | (0.027) | | (0.025) | (0.026) | (0.026) | |
| *COVID* | 0.2598*** | 0.4039*** | | | 0.0783*** | 0.0958 | | |
| | (0.032) | (0.073) | | | (0.022) | (0.076) | | |
| Bond outstanding amount | 0.1256*** | 0.1533*** | 0.1489*** | 0.8395*** | 0.0531** | 0.0670*** | 0.0672*** | -0.0554 |
| | (0.024) | (0.027) | (0.027) | (0.156) | (0.021) | (0.024) | (0.024) | (0.122) |
| Bond age | -0.0360*** | -0.0370*** | -0.0344** | -0.0171 | -0.0321** | -0.0334*** | -0.0377*** | -0.0057 |
| | (0.013) | (0.013) | (0.014) | (0.020) | (0.013) | (0.013) | (0.014) | (0.019) |
| Downgraded | 0.0400*** | 0.0365** | 0.0372*** | -0.5702*** | 0.0237* | 0.0216 | 0.0216 | -0.4506*** |
| | (0.013) | (0.014) | (0.014) | (0.057) | (0.014) | (0.015) | (0.015) | (0.052) |
| Bond holding by investor | 0.0296* | 0.0357** | 0.0347** | 0.0198 | 0.0031 | 0.0091 | 0.0065 | 0.0003 |
| | (0.015) | (0.016) | (0.017) | (0.016) | (0.014) | (0.014) | (0.016) | (0.016) |
| Portfolio size | -0.2719*** | -0.2823*** | -0.3046*** | -0.1139 | -0.3955*** | -0.3806*** | -0.3920*** | -0.2359*** |
| | (0.066) | (0.072) | (0.076) | (0.074) | (0.106) | (0.092) | (0.094) | (0.090) |
| Sectoral stock market volatility | | -0.2111 | | | | -0.0674 | | |
| | | (0.160) | | | | (0.148) | | |
| Sectoral stock market return | | 0.2064** | | | | 0.1858** | | |
| | | (0.086) | | | | (0.094) | | |
| Bond issue characteristics included | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Fixed effects: | | | | | | | | |
| Issuer | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Investor | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Issuer sector X country X time | No | No | Yes | Yes | No | No | Yes | Yes |
| Investor country X time | No | No | Yes | Yes | No | No | Yes | Yes |
| Bond X Investor | No | No | No | Yes | No | No | No | Yes |
| Number of investors | 3523 | 3410 | 3410 | 3352 | 3550 | 3439 | 3439 | 3332 |
| Observations | 66,653 | 62,476 | 62,476 | 60,415 | 66,081 | 61,926 | 61,926 | 59,015 |
| R-squared | 0.3691 | 0.3653 | 0.3726 | 0.5815 | 0.3792 | 0.3779 | 0.3827 | 0.5890 |
| Adjusted R-squared | 0.331 | 0.326 | 0.331 | 0.439 | 0.342 | 0.339 | 0.341 | 0.446 |

**Table 6 Bond net sales by environmentally top-rated investors.** The table reports regression results for net sales at the bond-investor level based on equation (1), estimated on the sub-sample of mutual funds. The dependent variable is the logarithm of net sales of bond b by investor j in quarter t. Green bond is a dummy variable equal to one if the bond is green, and zero otherwise. COVID is a variable that equals one during the COVID period, and zero before, i.e. until 2019-Q4. In columns 1-4 we consider as COVID period only the outbreak quarter, i.e. 2020-Q1. In columns 5-8 we consider as COVID period only the rebound quarter, i.e. 2020-Q2. E top-rated identifies investors in the top decile of the sample distribution of MSCI environmental (E) scores. All other control variables are defined in Table A.1 in the Appendix. Bond issue characteristics include dummies that indicate whether a bond is puttable, callable, collateralized, and dummies for currency categories, maturity categories and rating categories. Sets of fixed effects included as specified. All models include an intercept (coefficient not reported). Robust standard errors, clustered at the investor level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

| | *Outbreak period* | | | | *Rebound period* | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | All bonds | Corporate bonds | | | All bonds | Corporate bonds | | |
| Green bond × COVID ×E top-rated | -0.3851** | -0.3852* | -0.4111** | -0.4156** | -0.1229 | -0.1374 | -0.2269* | -0.0867 |
| | (0.187) | (0.198) | (0.196) | (0.191) | (0.116) | (0.118) | (0.119) | (0.128) |
| COVID × E top-rated | 0.2936 | 0.3049 | 0.3777* | 0.3246* | -0.0004 | 0.0020 | 0.0047 | -0.0225 |
| | (0.205) | (0.215) | (0.212) | (0.180) | (0.106) | (0.113) | (0.117) | (0.115) |
| Green bond × COVID | -0.0779** | -0.0692** | -0.0595* | -0.0505 | 0.0300 | 0.0136 | -0.0187 | -0.0401 |
| | (0.034) | (0.035) | (0.034) | (0.036) | (0.038) | (0.034) | (0.034) | (0.036) |
| Green bond × E top-rated | 0.1951* | 0.2108* | 0.2140* | | 0.1802* | 0.1942* | 0.2139* | |
| | (0.116) | (0.124) | (0.124) | | (0.107) | (0.114) | (0.114) | |
| Green bond | -0.0120 | -0.0067 | -0.0078 | | -0.0247 | -0.0076 | -0.0010 | |
| | (0.026) | (0.028) | (0.028) | | (0.026) | (0.027) | (0.027) | |
| COVID | 0.2574*** | 0.3984*** | | | 0.0828*** | 0.0993 | | |
| | (0.033) | (0.076) | | | (0.022) | (0.078) | | |
| Bond outstanding amount | 0.1318*** | 0.1598*** | 0.1552*** | 0.8479*** | 0.0586*** | 0.0733*** | 0.0727*** | -0.0527 |
| | (0.024) | (0.028) | (0.028) | (0.158) | (0.021) | (0.024) | (0.024) | (0.123) |
| Bond age | -0.0372*** | -0.0381*** | -0.0354** | -0.0185 | -0.0327** | -0.0343*** | -0.0386*** | -0.0065 |
| | (0.013) | (0.013) | (0.014) | (0.020) | (0.013) | (0.013) | (0.014) | (0.019) |
| Downgraded | 0.0304* | 0.0365** | 0.0352** | 0.0193 | 0.0032 | 0.0096 | 0.0064 | -0.0008 |
| | (0.016) | (0.016) | (0.017) | (0.016) | (0.015) | (0.015) | (0.016) | (0.016) |
| Bond holding by investor | 0.0407*** | 0.0373*** | 0.0380*** | -0.5819*** | 0.0247* | 0.0228 | 0.0228 | -0.4556*** |
| | (0.013) | (0.014) | (0.014) | (0.059) | (0.014) | (0.015) | (0.015) | (0.053) |
| Portfolio size | -0.2790*** | -0.2884*** | -0.3126*** | -0.1190 | -0.4091*** | -0.3923*** | -0.4012*** | -0.2468*** |
| | (0.070) | (0.075) | (0.079) | (0.076) | (0.110) | (0.096) | (0.098) | (0.093) |
| Sectoral stock market volatility | | -0.2019 | | | | -0.0667 | | |
| | | (0.164) | | | | (0.150) | | |
| Sectoral stock market return | | 0.2091** | | | | 0.1935** | | |
| | | (0.087) | | | | (0.096) | | |
| Bond issue characteristics included | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Fixed effects: | | | | | | | | |
| Issuer | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Investor | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Issuer sector X country X time | No | No | Yes | Yes | No | No | Yes | Yes |
| Investor country X time | No | No | Yes | Yes | No | No | Yes | Yes |
| Bond X Investor | No | No | No | Yes | No | No | No | Yes |
| Number of investors | 3523 | 3410 | 3409 | 3352 | 3550 | 3439 | 3438 | 3332 |
| Observations | 66,653 | 62,495 | 62,476 | 60,415 | 66,081 | 61,945 | 61,926 | 59,015 |
| R-squared | 0.3675 | 0.3644 | 0.3716 | 0.5805 | 0.3780 | 0.3776 | 0.3824 | 0.5883 |
| Adjusted R-squared | 0.330 | 0.325 | 0.330 | 0.437 | 0.340 | 0.339 | 0.341 | 0.445 |

**Table 7 Net bond sales and green policies.** The table reports in panel A regression results for net sales at the bond-investor level based on equation (1), estimated on the sub-sample of bonds that are not held by the European funds. Panel B reports regression results for net sales at the bond-investor level based on equation (1), estimated on the sub-sample of bonds not held by European funds and not issued by European issuers. The dependent variable is the logarithm of net sales of bond b by investor j in quarter t. Green bond is a dummy variable equal to one if the bond is green, and zero otherwise. COVID is a variable that equals one during the COVID period, and zero before, i.e. until 2019-Q4. In columns 1-4 we consider as COVID period only the outbreak quarter, i.e. 2020-Q1. In columns 5-8 we consider as COVID period only the rebound quarter, i.e. 2020-Q2. Green bond × COVID is the interaction between the two variables. All other control variables are defined in Table A.1 in the Appendix. Bond issue characteristics include dummies that indicate whether a bond is puttable, callable, collateralized, and dummies for currency categories, maturity categories and rating categories. Sets of fixed effects included as specified. All models include an intercept (coefficient not reported). Robust standard errors, clustered at the investor level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

**Panel A: excluding European funds**

| | *Outbreak period* | | | | *Rebound period* | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | All bonds | Corporate bonds | | | All bonds | Corporate bonds | | |
| Green bond × *COVID* | -0.1320*** | -0.1298*** | -0.1055** | -0.0996** | -0.0614* | -0.0551 | -0.0875** | -0.1055** |
| | (0.046) | (0.047) | (0.047) | (0.047) | (0.036) | (0.036) | (0.038) | (0.044) |
| Green bond | 0.0207 | 0.0235 | 0.0193 | | 0.0127 | 0.0194 | 0.0247 | |
| | (0.038) | (0.038) | (0.038) | | (0.037) | (0.037) | (0.037) | |
| *COVID* | 0.3236*** | 0.6794*** | | | 0.0770*** | 0.0354 | | |
| | (0.048) | (0.134) | | | (0.026) | (0.119) | | |
| Bond outstanding amount | 0.2202*** | 0.2673*** | 0.2661*** | 0.8411*** | 0.0818** | 0.1305*** | 0.1312*** | -0.0701 |
| | (0.040) | (0.041) | (0.041) | (0.202) | (0.033) | (0.037) | (0.038) | (0.149) |
| Bond age | -0.0575*** | -0.0622*** | -0.0544*** | 0.0005 | -0.0576*** | -0.0582*** | -0.0700*** | -0.0073 |
| | (0.018) | (0.018) | (0.020) | (0.028) | (0.018) | (0.018) | (0.020) | (0.026) |
| Downgraded | 0.0304 | 0.0312 | 0.0235 | -0.0153 | -0.0111 | -0.0155 | -0.0268 | -0.0488** |
| | (0.024) | (0.024) | (0.025) | (0.023) | (0.023) | (0.023) | (0.025) | (0.024) |
| Bond holding by investor | 0.0501** | 0.0464** | 0.0488** | -0.6336*** | 0.0403** | 0.0381* | 0.0384* | -0.4657*** |
| | (0.020) | (0.021) | (0.021) | (0.085) | (0.020) | (0.021) | (0.021) | (0.060) |
| Portfolio size | -0.1721* | -0.1770* | -0.1741* | 0.0071 | -0.2051*** | -0.2223*** | -0.2176** | -0.0716 |
| | (0.090) | (0.099) | (0.102) | (0.102) | (0.079) | (0.085) | (0.086) | (0.083) |
| Sectoral stock market volatility | | -0.8165*** | | | | 0.0662 | | |
| | | (0.282) | | | | (0.226) | | |
| Sectoral stock market return | | 0.1211 | | | | 0.0205 | | |
| | | (0.134) | | | | (0.149) | | |
| Bond issue characteristics included | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Fixed effects: | | | | | | | | |
| Issuer | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Investor | Yes | Yes | No | No | Yes | Yes | No | No |
| Issuer sector X country X time | No | No | Yes | Yes | No | No | Yes | Yes |
| Investor country X time | No | No | Yes | Yes | No | No | Yes | Yes |
| Bond X Investor | No | No | No | Yes | No | No | No | Yes |
| Number of investors | 1789 | 1755 | 1755 | 1729 | 1799 | 1766 | 1766 | 1725 |
| Observations | 36,793 | 35,629 | 35,629 | 34,364 | 36,493 | 35,353 | 35,353 | 33,664 |
| R-squared | 0.3918 | 0.3831 | 0.3921 | 0.6036 | 0.4143 | 0.4089 | 0.4139 | 0.6201 |
| Adjusted R-squared | 0.357 | 0.348 | 0.354 | 0.465 | 0.381 | 0.374 | 0.376 | 0.485 |

**Panel B: excluding European funds and European issuers**

| | Outbreak period | | | | Rebound period | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | All bonds | Corporate bonds | | | All bonds | Corporate bonds | | |
| Green bond × *COVID* | -0.1228*** | -0.1164** | -0.1030** | -0.1050** | -0.0484 | -0.0405 | -0.0814** | -0.1058** |
| | (0.047) | (0.047) | (0.048) | (0.048) | (0.038) | (0.038) | (0.040) | (0.046) |
| Green bond | 0.0240 | 0.0219 | 0.0233 | | 0.0301 | 0.0271 | 0.0362 | |
| | (0.037) | (0.038) | (0.038) | | (0.036) | (0.036) | (0.036) | |
| *COVID* | 0.3297*** | 0.7726*** | | | 0.0796*** | 0.0627 | | |
| | (0.050) | (0.143) | | | (0.027) | (0.118) | | |
| Bond outstanding amount | 0.2991*** | 0.3197*** | 0.3149*** | 0.8514*** | 0.1458*** | 0.1821*** | 0.1835*** | -0.0753 |
| | (0.039) | (0.040) | (0.040) | (0.203) | (0.038) | (0.036) | (0.037) | (0.152) |
| Bond age | -0.0570*** | -0.0643*** | -0.0537*** | -0.0003 | -0.0568*** | -0.0557*** | -0.0666*** | -0.0076 |
| | (0.018) | (0.019) | (0.020) | (0.028) | (0.018) | (0.018) | (0.020) | (0.026) |
| Downgraded | 0.0306 | 0.0315 | 0.0245 | -0.0160 | -0.0143 | -0.0152 | -0.0264 | -0.0498** |
| | (0.024) | (0.025) | (0.026) | (0.024) | (0.024) | (0.024) | (0.026) | (0.025) |
| Bond holding by investor | 0.0480** | 0.0436** | 0.0461** | -0.6454*** | 0.0377* | 0.0355* | 0.0365* | -0.4578*** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (0.020) | (0.021) | (0.021) | (0.087) | (0.020) | (0.021) | (0.021) | (0.061) |
| Portfolio size | -0.1448 | -0.1635 | -0.1664 | 0.0085 | -0.2082** | -0.2196** | -0.2195** | -0.0823 |
| | (0.095) | (0.102) | (0.105) | (0.107) | (0.083) | (0.086) | (0.087) | (0.085) |
| Sectoral stock market volatility | | -1.0491*** | | | | 0.0045 | | |
| | | (0.302) | | | | (0.225) | | |
| Sectoral stock market return | | 0.0803 | | | | 0.0509 | | |
| | | (0.142) | | | | (0.150) | | |
| Bond issue characteristics included | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Fixed effects: | | | | | | | | |
| Issuer | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Investor | Yes | Yes | No | No | Yes | Yes | No | No |
| Issuer sector X country X time | No | No | Yes | Yes | No | No | Yes | Yes |
| Investor country X time | No | No | Yes | Yes | No | No | Yes | Yes |
| Bond X Investor | No | No | No | Yes | No | No | No | Yes |
| Number of investors | 1724 | 1709 | 1709 | 1683 | 1733 | 1719 | 1719 | 1679 |
| Observations | 34,704 | 34,007 | 34,007 | 32,801 | 34,456 | 33,769 | 33,769 | 32,153 |
| R-squared | 0.3757 | 0.3749 | 0.3837 | 0.5954 | 0.4033 | 0.4051 | 0.4103 | 0.6152 |
| Adjusted R-squared | 0.340 | 0.339 | 0.345 | 0.454 | 0.369 | 0.370 | 0.373 | 0.479 |

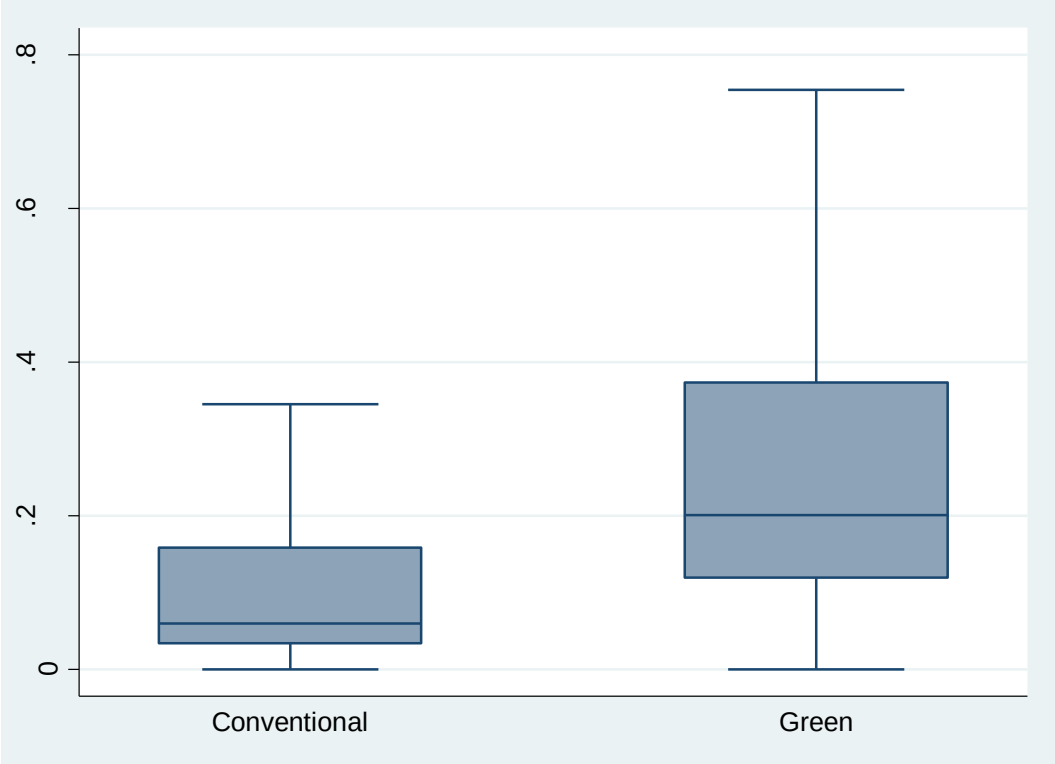
**Table 8 Net sales of corporate bonds eligible for central banks' corporate bonds purchase programs.** The table reports regression results for net sales at the bond-investor level based on equation (1), estimated on the sub-sample of corporate issuers. The dependent variable is the logarithm of net sales of bond b by investor j in quarter t. Green bond is a dummy variable equal to one if the bond is green, and zero otherwise. COVID is a variable that equals one during only the rebound period, and zero before, i.e. until 2019-Q4. Eligible is a dummy variable equal to one if the corporate bond is eligible for the central banks' corporate bonds purchase program, and zero otherwise. In columns 1-3 we consider as eligible only corporate bonds eligible for Secondary Market Corporate Credit Facility (SMCPP) program launched by FED in March 2020. In columns 5-8 we consider as eligible only corporate bonds eligible for the pandemic emergency purchase program (PEPP) launched by the ECB in March 2020. Green bond × COVID is the interaction between the two variables. All other control variables are defined in Table A.1 in the Appendix. Bond issue characteristics include dummies that indicate whether a bond is puttable, callable, collateralized, and dummies for currency categories, maturity categories and rating categories. Sets of fixed effects included as specified. All models include an intercept (coefficient not reported). Robust standard errors, clustered at the investor level, are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

| | FED SMCCP | | | ECB PEPP | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Green bond × COVID ×eligible | -0.0999 | -0.0613 | -0.0698 | 0.0564 | -0.0122 | -0.0043 |
| | (0.079) | (0.081) | (0.082) | (0.089) | (0.106) | (0.108) |
| COVID × eligible | -0.0079 | 0.0231 | 0.0157 | -0.0942 | -0.0760 | -0.1379 |
| | (0.045) | (0.048) | (0.053) | (0.079) | (0.125) | (0.126) |
| Green bond × COVID | 0.0211 | -0.0212 | -0.0345 | 0.0109 | -0.0300 | -0.0522 |
| | (0.036) | (0.036) | (0.037) | (0.036) | (0.036) | (0.037) |
| Green bond × Eligible | 0.1098** | 0.1068** | 0.0368 | -0.1732* | -0.1459 | |
| | (0.053) | (0.052) | (0.087) | (0.091) | (0.091) | |
| Eligible | -0.0498 | -0.0517 | -0.0060 | | | |
| | (0.047) | (0.050) | (0.078) | | | |
| Green bond | -0.0246 | -0.0161 | | -0.0010 | 0.0098 | |
| | (0.028) | (0.028) | | (0.029) | (0.029) | |
| COVID | 0.0864 | | | 0.0728 | | |
| | (0.078) | | | (0.082) | | |
| Bond outstanding amount | 0.0690*** | 0.0693*** | -0.0549 | 0.0797*** | 0.0791*** | -0.1382 |
| | (0.024) | (0.024) | (0.123) | (0.026) | (0.026) | (0.157) |
| Bond age | -0.0360*** | -0.0412*** | -0.0077 | -0.0418*** | -0.0420*** | -0.0065 |
| | (0.013) | (0.014) | (0.019) | (0.013) | (0.014) | (0.021) |
| Downgraded | 0.0087 | 0.0061 | -0.0015 | 0.0274 | 0.0174 | -0.0043 |
| | (0.014) | (0.016) | (0.016) | (0.019) | (0.022) | (0.022) |
| Bond holding by investor | 0.0226 | 0.0226 | -0.4563*** | 0.0216 | 0.0217 | -0.4861*** |
| | (0.015) | (0.015) | (0.053) | (0.016) | (0.016) | (0.060) |
| Portfolio size | -0.3924*** | -0.4032*** | -0.2481*** | -0.3629*** | -0.3621*** | -0.1829* |
| | (0.097) | (0.099) | (0.093) | (0.105) | (0.105) | (0.099) |
| Sectoral stock market volatility | -0.0371 | | | 0.0281 | | |
| | (0.152) | | | (0.163) | | |
| Sectoral stock market return | 0.2042** | | | 0.2180* | | |
| | (0.096) | | | (0.113) | | |
| Bond issue characteristics included | Yes | Yes | No | Yes | Yes | No |
| Fixed effects: | | | | | | |
| Issuer | Yes | Yes | Yes | Yes | Yes | Yes |
| Investor | Yes | No | No | Yes | No | No |
| Issuer sector X country X time | No | Yes | Yes | No | Yes | Yes |
| Investor country X time | No | Yes | Yes | No | Yes | Yes |
| Bond X Investor | No | No | Yes | No | No | Yes |
| Number of investors | 3438 | 3438 | 3332 | 3296 | 3296 | 3108 |
| Observations | 61,926 | 61,926 | 59,015 | 48,849 | 48,849 | 44,907 |
| R-squared | 0.3775 | 0.3823 | 0.5883 | 0.3812 | 0.3866 | 0.6076 |
| Adjusted R-squared | 0.339 | 0.340 | 0.445 | 0.333 | 0.336 | 0.435 |

**Table 9 Bond ownership concentration**. The table reports regression results for concentration of bond holdings by institutional investors, based on equation (2). The dependent variable is the Herfindahl-Hirschman Index (HHI) of bond **b** (issued by issuer h) in quarter t. Green bond is a dummy variable equal to one if the bond is green, and zero otherwise. COVID is a variable that equals one during the COVID period, and zero before, i.e. until 2019-Q4. In columns 1-3 we consider as COVID period only the outbreak quarter, i.e. 2020-Q1. In columns 4-6 we consider as COVID period only the rebound quarter, i.e. 2020-Q2. Green bond × COVID is the interaction between the two variables. All other control variables are defined in Table A.1 in the Appendix. Bond issue characteristics included include dummies that indicate whether a bond is puttable, callable, collateralized, and dummies for currency categories, maturity categories and rating categories. Sets of fixed effects included as specified. All models include an intercept (coefficient not reported). Robust standard errors clustered at the bond level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

| | *Outbreak period* | | | | *Rebound period* | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | All bonds | Corporate bonds | | | All bonds | Corporate bonds | | |
| Green bond X COVID | 0.0212 | 0.0305** | 0.0300** | 0.0383*** | 0.0105 | 0.0162 | 0.0144 | 0.0259** |
| | (0.014) | (0.015) | (0.013) | (0.013) | (0.015) | (0.015) | (0.014) | (0.013) |
| Green bond | 0.1416*** | 0.1053*** | 0.1073*** | | 0.1438*** | 0.1070*** | 0.1092*** | |
| | (0.021) | (0.020) | (0.021) | | (0.021) | (0.020) | (0.021) | |
| COVID | -0.0033 | 0.0168 | | | -0.0050 | 0.0379 | | |
| | (0.006) | (0.028) | | | (0.008) | (0.033) | | |
| Bond outstanding amount | -0.0822*** | -0.1002*** | -0.1000*** | 0.0777* | -0.0843*** | -0.0990*** | -0.0989*** | 0.1048* |
| | (0.011) | (0.014) | (0.015) | (0.045) | (0.011) | (0.014) | (0.014) | (0.058) |
| Bond age | -0.0070 | -0.0105* | -0.0134* | 0.0006 | -0.0064 | -0.0092* | -0.0122* | 0.0040 |
| | (0.005) | (0.005) | (0.007) | (0.006) | (0.005) | (0.005) | (0.007) | (0.006) |
| Downgraded | -0.0172* | -0.0042 | -0.0059 | -0.0058 | -0.0067 | 0.0012 | 0.0009 | -0.0004 |
| | (0.009) | (0.006) | (0.007) | (0.004) | (0.007) | (0.005) | (0.006) | (0.004) |
| Sectoral stock market volatility | | -0.0512 | | | | -0.0894 | | |
| | | (0.067) | | | | (0.070) | | |
| Sectoral stock market return | | -0.0149 | | | | 0.0276 | | |
| | | (0.021) | | | | (0.039) | | |
| Bond issue characteristics included | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Fixed effects: | | | | | | | | |
| Issuer | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Issuer sector X country X Time | No | No | Yes | Yes | No | No | Yes | Yes |
| Bond | No | No | No | Yes | No | No | No | Yes |
| Observations | 1,931 | 1,693 | 1,678 | 1,674 | 1,941 | 1,701 | 1,686 | 1,680 |
| R-squared | 0.7974 | 0.7931 | 0.8030 | 0.9398 | 0.7903 | 0.7818 | 0.7931 | 0.9291 |
| Adjusted R-squared | 0.771 | 0.764 | 0.757 | 0.903 | 0.763 | 0.751 | 0.745 | 0.886 |

**Figure 1 Distribution of the Herfindahl-Hirschman Index of ownership concentration by bond type.**



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