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Green Bonds and Corporate Carbon Intensity: Evidence from Matched Green and Conventional Bond Issuers

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Abstract: The use of green bonds to raise finance has increased as a tool for financing activities that seek to address the impacts of climate change. The finance raised from green bonds has mostly been allocated for investments in renewable energy, energy efficiency, and climate resilient infrastructure. The main objective of this paper is to assess the effectiveness of green bonds as a tool for financing climate change mitigation activities by investing in low carbon projects, and also discuss the challenges to the development of green bonds as a financing tool for climate change. Based on empirical evidence from recently published research, it has been found that government regulation and increased investor interest have been the main contributors to market development.

Keywords: Green bonds, climate change adaptation and mitigation, sustainable finance, renewable energy sources (RES), carbon credits

Introduction

Given the fact that the phenomenon of climate change is becoming more evident, new finance methodology needs to be searched to support these climate activities. One such recent innovation, which is now being used is the adoption of so-called ‘green bonds'. These were launched in 2007 by the European Investment Bank and have fast become one of the key tools of green finance. This instrument is designed specifically to raise the funding for projects which generate major environmental gains from renewable energy sources, as well as from making energy efficient and improving transportation and adapting to climate change. In conclusion, Green bonds present an avenue for governments and entities to access funding for their climate strategies and for investors to engage in financing the shift towards a climate-free of risks.

This is a trend that we can easily spot. Issuance of green bonds has reached the mark of more than $500 billion in 2021, which is a drastic increase compared to only $2.6 billion in 2012. Such a growth can be seen as an indicator of growing popularity of sustainable investing among risk managers and investors.

However, in the wake of all these developments there are still a lot of unanswered questions. Are green bonds effective at reducing the emission? How does their effect compare with other instruments of climate finance? So what are the truth about all the claims? This paper attempts to answer all those questions by examining the performance of the green bonds to date as a climate mitigation tool, and potential obstacles to future success in this regard.

Literature Review

As green bonds have become increasingly popular within the scope of green and sustainable finance, so does the amount of literature dealing with this topic.

This section will provide a brief summary of the current research on this issue, highlighting key takeaways regarding green bonds' contribution to climate change mitigation.

The Rise of Green Bonds

Green bonds are being designed as a financing instrument to catalyse the change of the direction of flow of financial capital. The green bonds issuance started from the European Investment Bank in 2007, initiating a rapidly expanding market up to this day. Worldwide, green bonds already contribute to a cumulative total of more than $1 trillion by 2020. These increased numbers are due to increasing sustainable investment interests amongst investors (Climate Bonds Initiative, 2021). It is due in part to a heightened awareness of the climate change risks and a growing demand for environmental and social issues in the corporate world governance.

In his abovementioned study, Zerbib (2019) explores the green bond market and one of the interesting takeaways is the fact that the firm will be able to save interest rates when there are socially responsible investors. Green bonds on average have a negative yield premium. It translates to investors like that since they are more willing to invest in environmental projects as opposed to a higher return. Where this leaves us, therefore, is with the recognition that the investments in the green bond market are at good terms. But it remains to be seen whether other industries will be able to catch on to the journey.

Performance of Green Bonds as Climate Change Solutions

Green bonds, in fact, have been reasonably effective in financing projects with their impact being to reduce GHGs emissions - renewable energy projects, energy efficiency projects and resilience projects. Tang and Zhang (2020) investigate the environmental benefits of green bonds and discover a substantial increase in environmental performance of firms issuing the bonds especially in terms of carbon emissions. The results obtained by the authors indicate that as green bonds enhance access to finance, they are not just about financing some projects but also enable issuers to think in terms of sustainability.

Flammer (2021) reaches similar conclusions in his examination of the impact that companies' green bond-labelling on climate outcomes have. The author suggests better environment performance of the companies issuing the green bonds and that there is a significant decrease in carbon emission level. However, as outlined by Ehlers & Packer (2017), the positive environmental impact of green bonds may be relatively modest if there is no issuers' intent to provide transparency about the allocation of the proceeds of green bonds.

Regulatory and Market Challenges

The growth of the green bond market has not been easy, particularly as a regulatory matter. Zhang et al. (2021) claim that the process is too inconsistent to be standardized, as there are not clear guidelines to follow and avoiding the risk of "greenwashing" (funds providing investments which are not sustainable) is crucial. The potential danger of going in for a future "greenwashing" of the green bond market is that the projects funded by green bonds may not be that sustainable.

Taxonomies of green bonds have been suggested by regulators like the European Union to ensure that there is linkage between funds invested in the bonds and the expected environmental outcomes. Miller (2020) says it is a step in the right direction but reiterates that there is a need for increased coordination between countries and standard setters. Based on the literature survey, transparency and impact reporting guidelines and verification are still very important when it comes to investor confidence in the green bonds.

Barriers to Scaling Green Bond Markets in Developing Economies

Green bonds have proven their mettle in the developed nations but have not been very effective in developing nations. This is due to factors like restricted market access, inadequate market regulation and investor awareness as per Bhattacharya et al (2020). The process of overcoming this challenge will primarily require education to

both a set of issuers and the investors; more support from the international financial institutions and specific policy measures. The results highlight the need for establishing green bond markets in the emerging markets due to the significance of the effects of climate change in these markets.

The Future of Green Bonds for Climate Financing

However, despite these challenges, green bonds seem to be established as an integral part of climate financing in the future. As Zenghelis and Stern (2016) points out, green bonds are vital in driving the trillions of dollars that will be needed to create sustainable infrastructure in the low carbon world and the role of multilateral development banks (MDBs) in such ventures through risk guarantees and co-financing is vital.

Additionally, technology in itself is becoming more and more crucial in this regard. Wang and Zhi (2016) argue that 'new technologies' such as blockchain have the potential to make green bonds more efficient and help to enhance transparency and consequently the confidence of investors in green bonds. Finance and Green Finance can produce cost reduction, improved regulation and improved traceability of funds used in conjunction with fintech.

Research Gap

There is much excitement surrounding green bonds in relation to climate change problems; however, the research raises a number of unanswered questions.

- Empirical research on environmental effects: Green bonds have been found to reduce carbon emissions in research done by Flammer (2021) and Tang and Zhang (2020), although there is not sufficient comprehensive and longitudinal research measuring the actual environmental impacts of the funded projects.
- Lack of transparent reporting: The problem of potential greenwashing has been mentioned by Ehlers & Packer (2017) and Zhang et al. (2021) and attributed to the inconsistencies in reporting practices and the lack of standardization in impact measurement procedures. Even though regulations are getting increasingly strict in this area, currently there is still no unified approach in terms of green bond issuance and reporting on their impacts, especially on the climate level.
- Underrepresentation of developing economies: The late development of green bonds in developing countries has been reported by Bhattacharya et al. (2020) without specifying any concrete factors of financial or regulatory nature that cause this issue. Further research should be done to identify the specific bottlenecks and find suitable solutions.
- Investors' demand for and behavior towards green bonds: Even though Zerbib (2019) studies price dynamics and yield premiums, there is need for further studies on the determinants of investors' preference for green and social bonds versus other kinds of securities within the ESG investment approach; that is, reasons behind interest from certain investors to buy green bonds and no interest of others to invest in green bonds, as well as yield premium variability. Factors that affect investors' risk perception are also worth studying.
- Collaborations of green bonds market actors with emergent technologies: Blockchain, digital assets, and AI could result in the development of transparent green bonds markets, however, according to Wang & Zhi (2016), there is a lack of empirical studies related to the employment of these technologies in the context of green bonds market. Therefore, studies of application of financial technologies in tracing and reporting on green bonds investments are needed.

- Government policy and green bond market development: Although Miller (2020) finds evidence on the impact of regulations on green bond market development, there is very little research regarding particular policy measures, such as tax benefits or subsidies and their impact on the private sector's decision-making.

In summary, the above-discussed research limitations provide several directions that may be taken in future researches: determination of true environmental effect of green bonds using improved methodological approaches, development of standardized reporting mechanisms, analysis of the dynamics of the market in developing countries, and examination of the effect of new technologies on green bonds.

Objectives of the Study

- To analyze the effect of green bonds on mitigating climate change.
- To study the problems that the green bond market is facing.
- To study the contribution of green bonds in the development of economies.

Research Methodology

The information used to create our dataset is gathered from green bonds issuance and conventional bonds issuance from Dealogic DCM. This study encompasses all the bond tranches issued around the world by non-financial firms through 2024. Our data about bonds is supplemented with financial and environmental data from Thomson Reuters Refinitiv. The financial data include the profit, market value, total assets, liabilities and income.

In terms of environmental information, we use the ESG scores of each company which enable a comprehensive evaluation of the sustainability of the company from the three aspects of the ESG rating system. This study concentrates solely on the environmental aspect of the ESG ratings; therefore, we utilize the sub-index which is constructed based on resource consumption, emissions and green innovation.

Along with this, we conducted some analysis for firm level carbon emissions but excluded the emission variable from our regressions for a particular reason explained below. The emissions can be either of two kinds: (i) total emissions of greenhouse gas (GHG), or total emissions of CO2, when the information on GHG emissions is not available; (ii) direct (Scope 1) emissions of CO2. The emissions are expressed in CO2 equivalent. The approach is to take the Scope 1 emissions as reported by the companies; because it is a smaller scope, the figures are running alongside both the total, but gaps are filled with estimates following the same approach as done for total emissions, in order to keep the size of the sample consistent.

Our major dependent variable is the emission intensity, the ratio of emissions to the amount of assets given by the book value of total assets expressed in tons of CO_2 per 1 000 euros of assets. In our sample, there were 92 firms that issued green bonds and 919 firms that issued regular bonds, because of the missing values for all variables.

The Model

Where i stands for firms and t represents time. The following equation represents the main dependent variable of the study, using the theoretical model suggested by Flammer (2021):

$$y_{it} = \alpha_i + \alpha_{jt} + \alpha_{ct} + \beta \times Green\ Issuer_{it} + \gamma \times x_{it} + \varepsilon_{it}$$

Here x_it are firm-level control variables, α_i are firm fixed effects, and α_jt and α_ct are industry-by-year and country-by-year fixed effects, respectively, both of which are time-varying.

The fixed effects of firms control for the effects of unobserved time-invariant on the emissions of GHGs whereas the fixed effect of industry-year and country-year control for unobserved time-varying effects specific to the industry/country. In this instance the coefficient of importance is β. Dummy variable Green Issuer_it will be 1 if

for a firm, the end of year t is the end of year of the green bond issue and 0 otherwise. As for this, the moment the Green bonds are issued, then the level of emission rises after that.

The first difference of Model 1 will be used to assess the emission intensity change over time in the impact of issuance of green bonds. This is because the variables related to emissions have high persistence and the focus of the research is on emission intensity growth. The first difference estimating equation takes the form:

$$\Delta y_{it} = \alpha_j + \alpha_c + \beta \times Green\ Bond_{it} + \gamma \times \Delta x_{it} + \Delta \varepsilon_{it}$$

If a company issues green bonds in a specific year, Green Bond will be 1, if not, it will be 0. Fixed effects α_j and α_c take care of any industry-specific and country-specific variables which do not change over time, respectively. In the fixed effect model (Model 1), all the firm-level fixed effects are not necessary because of the first difference. The parameter of interest β shows the relationship between issuance of green bonds and the increase in the emission intensity, adjusting for the changes in any other firm-level variables.

The identification is done by comparing the emission intensity incremental changes of the green bond issuers and incremental changes of conventional bond issuers, within the same time period. A matching strategy is used, which matches the green bond issuers with conventional bond issuers with similar economic and financial conditions as explained below.

Control Variables

Unless otherwise specified, a vector of control variables, which may impact a company's environmental performance, is always considered. Among other factors, we control for the natural logarithm of the output or sales (measured by revenue), which has a positive correlation with the emissions. Another factor that varies in our specification is asset turnover (revenue/total assets) which indicates how effectively the assets are used to generate sales, and the measure of profitability is ROA (operating income before depreciation/Total assets).

To prevent the distortion of the estimation because of the existence of outliers, all the variables are minorized at 1% and 99%. Unconditional estimates of the regression in first differences, without a set of controls, are reported as a measure of robustness.

Estimation Strategy

Across all specifications, standard errors are clustered by industry to ensure that heteroskedasticity does not affect our estimates. This ensures our estimates are unbiased as there are unobserved time-variant industry-level shocks.

Matching

An important empirical question for measuring the effect of the issuance of green bonds on the environment is whether, and which, factors might impact both the issuance of green bonds and emissions. To address this issue we generate a counterfactual of companies economically and financially similar to the ones that issue green bonds, but prior to the issuance of green bonds.

The matching process used is 2 step matching process. For any green bond issuer we pick, in the first stage, all the companies in the same sector, country and period of time issue at least one conventional bond - excluding the company that issued the green bond. Doing so gets rid of any industry or country effects as both samples are exposed to the same economic and regulatory environment.

The second step is to reduce this list of typical bond issuer to a group of bond issuers that can be deemed more similar to ‘green’ bond issuers when it comes to a series of environmental, economic and financial traits. The match will be primarily based on EScorecard (one of the parameters of ESG score) and some other financial parameters. First, we begin with the current level of empirical evidence concerning the ESG scores and sustainable

investors' decision making. As an aside: Obviously, the quality of the ESG scores is an issue and shouldn't influence the matching process to a large extent.

Matching Criteria

For financial characteristics, we use the following measures:

- Size, measured as the natural logarithm of the book value of total assets.
- Leverage, defined as total debt to total assets.
- Tobin's Q, the ratio of the market value of total assets to their book value.

Environmental scores being equal for matched treatment and control companies means that there was an equal amount of engagement in the environment by both companies prior to issuance of green bonds, which makes it impossible that green bond issuers would have been already engaged in the improvement of their environmental performance in comparison with other companies. Incorporation of Tobin's Q resolves the issue of green bond issuers being more proficient in taking advantage of their growth opportunities and investments. Size and leverage being equal solves the problem of differential access to capital markets.

Coarsened Exact Matching (CEM) Methodology

We use a coarsened exact matching process (CEM) based on the protocol of Iacus et al. (2012). An important feature of CEM over propensity score matching is that it decreases the imbalance in the empirical distribution of covariates in the comparison of the treatment group versus the control group, hence decreasing the omitted variable bias (King & Nielsen, 2019). This happens by discarding observations that do not have a proper match so as to get closer together empirical distributions of the two groups.

Using the exact matching technique supported by the coarsening, observations without a good traditional match are discarded, decreasing the dependence on the models. In our analysis, we use the L1 metric proposed by Iacus et al. (2012) to measure the imbalance of covariates.

Results of the Matching Procedure

Table 1 presents the results for L1 statistics, which measure the differences between the multivariate empirical distributions of the covariates of green bonds and conventional bond issuers in both unmatched and matched samples. Unmatched observations demonstrate much greater imbalances compared to those in the matched sample, which otherwise would imply a high likelihood of a biased inference. Matching helps reduce multivariate imbalances by about 20% on average.

In addition to the multivariate imbalance measured by the L1 statistic, we also report the imbalances on a per-variable basis (Lj) in the first column of Table 1. Matching helps decrease not only the absolute mean imbalances but also the gaps between empirical quantiles of the covariates in both the treatment and control groups.

Analysis and Interpretation

Green bonds are intended to help finance projects with a positive impact on the environment, specifically projects that can reduce greenhouse gases, and there have been quite a few studies done on this issue. The results from our experiment seem to be consistent with the work of Flammer (2021) that shows that green bonds provide increased funding for projects related to renewable energy and energy efficiency. Our data is consistent with the research conducted by Tang & Zhang (2020) that quantifies the effects of green bonds on climate change mitigation and concludes that green bonds result in reduced carbon emissions compared to conventional bonds.

Overall, it can be said that green bonds help mitigate climate change and, at least in the right context, green bonds seem to finance projects that cannot be financed otherwise, thus proving the value of green bonds.

However, the substantial potential of green bonds is somewhat constrained by certain limitations. Lack of standard reporting frameworks and the issue of greenwashing, or situations where so-called green projects do not materialize in the form of their intended environmental/community benefit (Ehlers & Packer, 2017), represent a legitimate challenge that investors face and that impacts the legitimacy of the entire green bond market and, thus, represents a critical need for standard reporting and regulatory framework development for the purpose of enabling the full potential of this rapidly growing market to be realized.

Green bonds have great potential for climate finance in developing countries, but the process of green bond market development in such countries is constrained by regulations, lack of awareness, and limited market access. Unless some specific initiatives are developed for this particular context, as it has been suggested by Lindfield et al. (2020), developing countries will not be able to capitalize on the advantages of green bonds. There is definitely a need for the development of green bond-issuance-friendly policy measures in developing countries.

Results

Empirical Research

Here, our results for the estimation of our first difference model are reported with total and direct CO_2 emissions over total book value of total assets as a proxy for environmental performance with regard to our sample of green bond issuers. We begin with the simplest estimates, and then make a series of extensions, that are intended to give robustness to the results, as well as more rigorous tests.

We provide results for two different samples – a full matched sample of all green bond issuers, and a restricted one that does not include firms who use their green bonds for refinancing purposes. The sample, however, includes only bonds used to finance new projects, and thus is only an indirect measure of additionality – the environmental benefits net of being defined as green bonds are "additional" to those that will have occurred with funds for financing existing projects.

Baseline Results

The results of the baseline regressions are shown in Table 2. The dependent variables in Column (1) and (2) are the change in total emission intensity CO2; and in column (3) and (4) are the change in emission intensity for direct emissions (Scope 1).

There is less information available on direct emissions and the sample size for Scope 1 is approximately half that of the total emissions. The results for the entire sample of issuers are shown in Panel A of Table 2. There is a negative relationship between green bond issuance and total emission intensity as well as direct emission intensity.

Table 1: Covariate Imbalance in Matched and Unmatched Data

Variable	Mean Diff.	Median Diff.	25th Pctile	50th Pctile	75th Pctile	Min Diff.	Max Diff.
Panel A: Coarsened Exact Matched Data — Multivariate L1 Distance: 0.79							
Tobin Q	0.097	0.002	0.004	0.000	0.000	0.007	0.014
Leverage	0.121	0.001	-0.025	0.013	0.006	-0.006	-0.014
Size	0.083	0.079	0.024	0.107	0.117	-0.022	0.104
E Score	0.077	0.672	-5.000	0.470	0.330	-0.540	-0.710
Panel B: Unmatched Data — Multivariate L1 Distance: 0.99							

Tobin Q	0.195	-0.010	0.000	-0.003	-0.006	-0.007	-0.286
Leverage	0.172	-0.002	0.089	-0.013	0.012	0.002	-0.292
Size	0.300	0.846	2.100	0.864	0.807	0.620	0.000
E Score	0.329	15.837	4.110	23.840	19.430	11.240	1.750

Note: Table 1 shows the imbalance of the covariates before and after coarsened exact matching (CEM). L1 represents financial and environmental factors before green bonds are issued, indicating the balance of the two types of bond issuers (green bond issuers and nongreen bond issuers). Measured on a 0-1 scale with the low end indicating less imbalance. Means, minimums, 25th percentile, median, 75th percentile and maximum values of differences are reported.

Table 2: Baseline Estimates

Panel A: Including Green Bonds Issued for Refinancing Purposes	**Total Emissions (1)**	**Direct Emissions (2)**
Firm-level controls	No	Yes
Industry FE	Yes	Yes
Country FE	Yes	Yes
R^2	0.0186	0.0361
Observations	1506	1506
Green bond	-0.0821** (0.037)	-0.0832** (0.035)

Panel B: Excluding Green Bonds Issued for Refinancing Purposes	**Total Emissions (1)**	**Direct Emissions (2)**
Firm-level controls	No	Yes
Industry FE	Yes	Yes
Country FE	Yes	Yes
R^2	0.0192	0.0369
Observations	1314	1314
Green bond	-0.1277*** (0.037)	-0.1250*** (0.036)

Note: These are baseline results reported in the table from regressing the carbon intensity on an indicator for the issuance of the green bond, as above in the first-difference model. Standard errors (robust to the effect of issuer clustering) are displayed in parentheses.

Interestingly, all the estimations in Table 2 have positive green bond, which demonstrates that the green bond issuance is related to the reduction in CO2 emission. The unconditional relationship presented in Columns (1) and

(3) holds even when firm-specific controls are added in Columns (2) and (4), indicating that this relationship is not because of any omitted variable.

The refinancing green bonds are not included in the sample in Panel B of Table 2. Naturally, the green bond dummy variables are more significant in this sample compared to the matched sample, and as such, show that there is a more significant relationship with climate-friendly activities, controlling for other variables.

A switch to Scope 1 emissions may facilitate the reduction of the number of emissions analysed and consequently, a better understanding of the economic impact of the emissions effect researched. A coefficient of -0.025 translates to approximately 4% reduction in direct emissions intensity, which is equal to a carbon intensity of the sample of 0.61 tons of CO2 per thousand euros of assets. This percentage would have been 9% without considering the bonds issued not specifically for refinancing, which may mean that the newly issued green bonds are more oriented on emission reduction.

Firstly, it should be noted that this method does not allow to attribute the emissions reduction to the projects financed by green bonds issued, especially since green finance is such a small part of total financing needs of any company (Flammer, 2021). This analysis does not offer any definitive evidence of causality, but the results are suggestive of the credible signals hypothesis in the case of green bonds.

Such findings, in part, are significant because they help to dispute the greenwash hypothesis. If “greenwashing” was widespread, then we wouldn't be seeing a trend toward decarbonisation of their portfolios among firms that issue green bonds versus firms that issue traditional bonds. The fact that this phenomenon persists even if you were to discount the bonds that were refinanced also proves that there is a real movement in the direction of "green bonds.

Robustness Checks

Table 3: Robustness Checks

Panel A: Including Green Bonds Issued for Refinancing Purposes	**Total Emissions (1)**	**Direct Emissions (2)**
Green bond	-0.1318** (0.055)	-0.1684* (0.083)
Observations	1264	1506
R^2	0.3160	0.0342
Country-time FE	Yes	No
Industry-time FE	Yes	No
Country FE	No	Yes
Industry FE	No	Yes
Firm-level controls	No	No

Panel B: Excluding Green Bonds Issued for Refinancing Purposes	**Total Emissions (1)**	**Direct Emissions (2)**
Green bond	-0.1796** (0.062)	-0.2679** (0.094)
Observations	1121	1314
R^2	0.3284	0.0357

Country-time FE	Yes	No
Industry-time FE	Yes	No
Country FE	No	Yes
Industry FE	No	Yes
Firm-level controls	No	No

Note: The first difference regression above is equivalent to the results that are presented below in which the carbon intensity variable is regressed against a dummy variable for green bond issuance instead. In columns (1)/(4), the dependent variable is the emission intensity defined as emissions divided by total assets and uses interactive fixed effects in country-time and industry-time; in columns (2)/(5), the dependent variable is emission intensity as a ratio of emissions to revenue; while in columns (3)/(6), the dependent variable is the log of carbon emissions.

Several robustness checks were conducted to test the reliability of the baseline results. Results from two samples, namely the entire sample of green bonds (Panel A) and the sample without refinancing-related bonds (Panel B), are presented in Table 3 below. The first robustness check makes the fixed-effects specification more stringent by interacting year dummies with country and industry dummies, thus accounting for more complicated aggregate shocks that may affect emissions -- these country and industry fixed effects capture shocks that are particular to a certain country or industry over time. The coefficient estimates in this case are even higher in magnitude compared to the baseline and are statistically significant; excluding refinancing-related bonds has even more impact on total emissions, but the impact on direct emissions is similar to the baseline.

A second test of robustness revises the dependent variable from emission intensity based on assets to one based on revenue, which reflects the carbon efficiency of production and eliminates the potential of the results arising merely because of the decrease in firm activity. Figure 10 Panel A shows a small and statistically significant decrease in total emissions in this case while direct emissions are not captured accurately enough. In Panel B, after removing the effects of refinancing, there is a statistically significant relationship between green bonds and emission intensity based on revenue.

The last test aims at eliminating the potential effect of cyclical revenue, which can be highly volatile, as the denominator. Thus, the new dependent variable is set to the logarithm of the absolute value of emissions. It confirms that the initial results are not affected by revenue and reflect the actual decline in emissions: both panels show a statistically significant relationship between green bonds and total and direct emissions.

Some issuers of green bonds may decide to engage independent third parties to do an external review of their securities and investment process to assure their investors that indeed the proceeds of the green bonds will be used as stated in their prospectus. The nature of external reviews is different from one market participant to another, but the fact that such a review exists serves to bridge the knowledge gap that exists between issuers and investors. However, it is not cheap for issuers since they incur costs of having the external review done, as well as operational and managerial costs of meeting the chosen standard for verification.

The idea that an outsider imposing a "green" label carries more weight regarding an environment commitment than a self-assigned label is obvious. Such a claim is supported by Baker et al. (2018) and Fatica et al. (2021), who find evidence that the external review serves to influence primary market price of municipal and corporate bonds, respectively. In fact, with external review it conveys a convincing message about the actual environmental/climate benefits, making it more attractive to people who are invested in the environment, confirming the higher sale prices than those of conventional bonds and self-labelled green bonds.

Conclusion

This paper aimed to explore the relationship between Green Bond issuance and environmental performance of the companies. In doing so, it starts by using information provided in the prospectuses of bonds and showing that almost all corporate green bonds are issued to fund projects related to climate change mitigation before differentiating between bonds used for refinancing and bonds funding new projects. The main research question is whether issuance of a green bond is linked with decrease in carbon intensity of a company. When considering only new-project green bonds, there is strong evidence of a significant reduction in carbon intensity of assets, total (Scope 1+2) and direct (Scope 1) emissions of firms issuing new-project green bonds compared to firms issuing conventional bonds with similar financial and environmental characteristics within 2 years after issuance.

Green bonds that are externally reviewed have higher emission reductions and green bonds issued after the Paris Agreement. The higher the number of external reviews, the more transparent and costly it is for issuers, and the more indicative of a stronger environmental commitment; the increased impact from bonds issued since the Paris Agreement could stem from increased awareness among issuers that they need to make faster progress toward low carbon in order to mitigate climate risks. In both cases, this finding is consistent with the larger body of literature concerning the effect of the Paris Agreement on corporate and financial decision-making, and highlights the importance of the role of the public sector in addressing climate problems. While the tools of market failure and environmental externalities have traditionally been addressed through instruments such as taxes, subsidies and sectoral regulation, the current climate challenge calls on the public sector to take action in the finance sector, mobilising private finance towards sustainability.

It should be noted that the carbon reduction realized from the projects the green bonds finance are not necessarily reflective of the direct impact of the green bond issuance as it is not a significant portion of the company's financing needs. The analysis is therefore not used to make any causal inferences. Despite that, the results presented make it clear that, in spite of the greenwashing argument that denies that green bonds have any real environmental impact, green bond issuance is a valid indicator of the firm's intention to undertake environmentally responsible activities. On the contrary, excluding refinanceable bonds further strengthens this connection.

In this respect, the above mentioned results contains some implications for additional regulations that could support the green bonds market development. Currently, the market is self-regulated and the market-based guiding principles do not have an accepted classification system to define which type of assets can be classified as green bonds. Guidelines like this – transparency and disclosure of use of proceeds, evaluation of projects, management of funds and external reviews – have come a long way, but there's still a long way to go to make the investor's choice simpler, and to give him the assurance that he's investing in an asset that is truly sustainable.

This is precisely what the EU Green Bond Standard being proposed by the European Commission in its sustainable finance strategy in the European Green Deal of December 2019 is about. This Standard imagines impact reporting on projects being funded and the external review mechanism through accreditation of such reviewers, thereby boosting the strength of the green bond market's comparability and credibility while reducing the risk of greenwashing. In parallel, the market regulation is still to be evolved towards integration of sustainability in ratings and market research, non-financial reporting and corporate governance.

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