The Economics of Sustainability-Linked Bonds *

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Abstract

Relying on theory and empirical analysis, we study the real effects and pricing of Sustainability Linked-Bonds (SLBs). Post-issuance, SLB issuers decarbonize about 6 percentage points faster than non-issuers. Our theoretical framework helps understanding SLBs' incentive structure and their pricing. Using a novel mispricing measure, we test several empirical predictions of the model. Overpriced SLBs at issuance experience negative secondary market returns. Stock markets react more positively to overpriced SLB issues that are large, suggesting a wealth transfer from bondholders to shareholders. Finally, SLBs' mispricing increases with firms' ESG ratings. Overall, our analysis shows that SLBs have meaningful implications for firms' decarbonization and financial markets.

Keywords: Decarbonization, real effects, sustainability-linked bonds, security design, ESG investing, managerial incentives, mispricing, wealth transfer

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1 Introduction

Much emphasis in sustainable finance research has been focused on studying sustainability related questions in secondary equity markets. However, the significant incremental financing that is needed to allow firms to reach their sustainability objectives and thereby actively contribute to achieving the ambitious environmental and social targets spelled out in the United Nations (UN) Sustainable Development Goals (SDGs)[1] is unlikely to come from public equity financing alone. A report on the financing of the SDGs published by the UN in April 2024[2] estimates that about USD 4.2 trillion annually will be needed to achieve the SDGs. It is clear that most of this incremental financing for sustainability will have to come from fixed income markets and (bank) lending.

Consistent with the notion that fixed income needs to play a much more fundamental role in financing sustainability, corporate borrowers have accelerated their issuance of green, social, and more generally sustainable fixed income instruments. As sustainable debt instruments become increasingly prominent and more widely used, the design of innovative sustainable debt securities has emerged as a major trend in sustainable finance. The most commonly used sustainable fixed-income instruments are green bonds (Zerbib 2019, Tang and Zhang 2020, Flammer 2021). These instruments allow firms to raise funds for specific and often predefined green and environmental projects. More recently, however, sustainability-linked bonds (SLBs) have emerged as a potentially attractive alternative. SLBs do not require the issuer to allocate the proceeds of the bond exclusively to designated green investment projects. In contrast, funds raised through the issuance of SLBs can be used for all sorts of investments and expenses. Instead of prescribing what the proceeds can be used for, SLBs follow the logic of linking coupon payments to the achievement of specific sustainability targets. To be precise, SLBs are designed such that coupon penalty payments are due if a specific sustainability oriented key performance indicator (KPI) target is not reached by the issuing firm at a predetermined date. In

[1] https://sdgs.un.org/
[2] https://bit.ly/3VOyp6N

other words, the coupon payments of the bond are *contingent* on firms' sustainability performance.

Given the infancy of the SLB market, we know very little about: (i) the incentive compatibility of these novel debt instruments (i.e., do these bonds actually push managers to achieving the spelled out sustainability targets), (ii) their pricing in the primary bond market, (iii) their performance in the secondary market (with the exception of the recent study by Feldhütter, Halskov and Krebbers (forthcoming)), (iv) the conditions under which SLB issues would allow genuinely motivated firms to signal their commitment to sustainability goals, and finally (v) whether they are associated with real sustainability effects. In this paper, we attempt to fill these gaps, using a mix of theory and empirical analysis. We focus mostly on the pricing and potential real effects of sustainability-linked bonds.

We begin our analysis by providing an overview of the nascent SLB market. In this first analysis, we empirically study firm characteristics associated with SLB issuance. We provide evidence that large and more levered firms which operate in environmentally sensitive sectors such as utilities or basic materials are more likely to issue SLBs. While sustainability-linked bonds are issued by firms across the world, most SLBs have been issued by firms located in Europe.

Next, we develop a theoretical framework in which the questions outlined above can be addressed. Specifically, our stylized one-period SLB pricing model allows answering the question of when SLBs are in fact incentive compatible, that is, when can they induce firms to exercise costly effort to achieve the stated sustainability target at the predefined horizon. We show that this can be accomplished whenever the coupon penalty of the SLB is large enough relative to the cost of achieving the environmental target. Following the analysis of incentive-related questions, we proceed to examine pricing aspects. We ask whether it is possible to define a model-free measure of an SLB's fair pricing and develop a novel measure capturing an SLB's relative mispricing at issuance. We call this measure the *mispricing level* and denote it by ML.

ML is defined as the difference between the SLB issue price and a lower pricing bound divided by the distance between an upper and a lower pricing bound. The upper bound is the theoretical bond price assuming the KPI target is never reached and, therefore, the coupon penalty is guaranteed, that is paid with certainty. The lower bound is the theoretical bond price assuming that the KPI target is reached with certainty and, therefore, the coupon penalty is not paid. ML is a model-free relative mispricing measure that allows to circumvent the fact that in practice, we observe neither the probability of a firm achieving the KPI nor the sustainability appetite and thus demand of investors for a specific SLB issue. We show that ML plays a crucial role in determining SLB pricing in the primary market.

Subsequently, using predictions from the model in combination with our unique mispricing measure, we establish the following three novel empirical findings: First, SLB issues with higher values of ML tend to be overpriced at issuance. The overpricing subsequently leads to a post-issuance decrease in the SLBs' prices on the secondary market. The post issuance secondary market under-performance of overpriced SLBs is approximately -0.5 percent over a 20-day horizon after issuance. Second, when SLB issues are overpriced and large, we also document a significant wealth transfer from the bondholders to the shareholders of the issuing firms. Specifically, in an event study setting, we find that when the SLB issue is sizeable relative to the market value of the equity of the firm, the more overpriced (underpriced) the SLB, the more positive (negative) the stock price reaction around the issuance date of SLBs. To be precise, a combined one standard deviation increase in ML and in the relative size of the issue leads to a positive cumulative abnormal stock return of about 0.9 percent during the 5 day post issuance window. The positive relation between cumulative abnormal returns around issuance and ML is consistent with mispricing induced wealth transfers from bond- to shareholders. Third, we document a positive and significant relation between ML and the issuing firm's ESG ratings. The latter supports our conjecture that the probability of reaching the KPI target and the investors' appetite and derived monetary benefit from the SLB's environmental impact depend on the firm's ESG score. The latter and more precisely the environmental rating of the firm play the role of a proxy for the issuer's credibility.

We then extend our theoretical framework and also examine under what conditions sustainability-committed firms can signal their types through the issuance of SLBs. This analysis allows us to compare the correct market yield of SLBs to the standard yield quoted by the industry. The comparison shows that the industry generally overstates the yield discount for firms that issue SLBs, mainly because industry practice consists of calculating the yield to maturity of the SLB without accounting for the conditional coupon penalty. We question the standard industry practice that results in systematically documenting yield discounts.

In a final step, we provide to the best of our knowledge, the first comprehensive empirical analysis on the question of whether SLBs are effective in contributing to the achievement of firms' sustainability targets. To do so we focus on the extensive margin and use a standard difference-in-differences (DID) framework to evaluate whether firms that issue SLBs improve their sustainability performance after issuance. We focus on firms' GHG intensities as the sustainability outcome, mainly because the majority of issued SLBs in our sample have environmentally- and specifically climate-related KPI targets. We do not use our model to inform the empirical analysis of real effects because this would require empirically observing the firm-level cost of achieving the sustainability target (or, in the terminology of the model, the size of the firm's infrastructure cost to improve its environmental performance). We also cannot observe neither the change in the probability of achieving the sustainability target because of a firm's investment in the environment-improving technology, nor the value that investors attach to the environmental performance of firms. Furthermore, the ratio of the coupon penalty to the cost of reducing the environmental externality is a crucial parameter in our model that determines if the incentive constraint is satisfied, but which cannot be easily observed empirically. This is why we focus on reduced form tests of real effects. When focusing on the year-over-year percentage decarbonization of SLB issuers in percentage terms as the outcome variable, we document a significant treatment effect. Specifically, SLB issuing firms decarbonize by about 6-7 percentage points faster after SLB issuance. Relative to the average decarbonization rate, which is about 6 percent, this effect is economically meaningful. Interpreting the reduced form estimates of the treatment effect in the context of our model, the empirical evidence is consistent with the view that for the average SLB issuing firm, the incentive compatibility condition is satisfied. Hence, we believe that our model assumption of a satisfied incentive compatibility condition for SLB issuing firms seems plausible and justified.

Our paper contributes to the emerging literature on sustainability-related debt securities and more specifically on SLBs. We provide the first conceptual framework that allows to study the conditions under which these bonds create the right incentives for managers to exert effort to meet the sustainability KPI targets and the conditions that allow dedicated firms to signal their commitment to their stated sustainability KPIs. Second, we contribute to a better understanding of the pricing of these bonds by providing a "model-free" measure that makes it possible to infer the degree of SLB mispricing and leads to testable implications. Empirically estimating the mispricing measure, we then show that 36 % of issued SLBs are overpriced at issuance, that is display $ML > 1$, which amounts to the issuance price being superior to the theoretical upper bound (i.e., the theoretical bond price assuming the KPI target is never reached). Empirically, overpricing is associated with negative cumulative returns on the secondary market after issuance. We then demonstrate through an event study in equity markets that the overpricing ultimately translates into a wealth transfer from the bond- to the shareholders of the firms issuing SLBs when the SLB issues are large. We also provide empirical support to the model's prediction that the level of ML depends on the firm's ESG performance. Finally, we empirically study the real effects of SLB issuance in a DID setting and provide evidence that firms that issue SLBs decarbonize faster than non-issuing peers, which is consistent with an interpretation that, on average, the incentive compatibility constraint is satisfied for SLB issuing firms.

The structure of the paper is the following: In Section 2, we provide a brief review of related papers. Section 3 presents an example of a typical SLB issue, followed by descriptive statistics of the nascent SLB market, and an empirical analysis of the firm characteristics associated with SLB issuance. Section 4 introduces our theoretical model and its main testable predictions. Section 5 describes how we calculate the mispricing measure ML empirically. In Section 6, we test the main implications of the model. Section 7 contains the real effects analysis and Section 8 concludes the paper with a summary of its main findings, as well as with some policy recommendations.

2 Literature review

Our paper is primarily related to the existing research on green bonds. For instance, Zerbib (2019) compares the yield of green and equivalent plain vanilla bonds to estimate the yield differential between green and otherwise identical conventional bonds and finds lower yields on green than on other conventional bonds, i.e., an average small negative green bond premium. His analysis further shows that issuer sector and rating are important drivers of the green bond premium. Finally, he documents larger premiums for financial bonds and bonds with low ratings. Pástor, Stambaugh and Taylor (2022) document a yield discount for green bonds issued by the German government. Baker, Bergstresser, Serafeim and Wurgler (2022) use a simple asset pricing framework with non-pecuniary utility to investigate the pricing and ownership of U.S. municipal green bonds. They find a premium on green municipal bonds compared to otherwise similar ordinary bonds. Flammer (2021) documents that equity investors react positively when a corporate green bond issuance is announced, a result also found in Tang and Zhang (2020). The positive response is more pronounced for first-time issuers and green bonds that are externally certified. Furthermore, after issuance, Flammer (2021) shows that the environmental rating of the issuing firms increases and that the firm-level CO2 emissions decrease. Based on her evidence, Flammer (2021) argues that firms issue green bonds to send a credible signal of their environmental commitment. Thus, her study does not support the competing greenwashing or access to cheaper cost of capital hypotheses. Finally, she finds no evidence for a greenium. Fatica, Panzica and Rancan (2021) also focus on the pricing of green bonds at issuance. They document a green bond premium for bonds issued by supranational institutions and for corporate green bonds. The premium is larger for bonds with external assurance than for self-labeled bonds. They find supporting evidence of reputation building, as repeat issuers receive an additional premium compared to companies that only issue once. In the case of financial institutions, they cannot find a yield differential at the times of issuance. They argue that this is because investors are unable to connect the green bonds issued by these financial institution to a specific green investment project. (Fatica et al. 2021)

While several recent papers find a premium on green bonds, Larcker and Watts (2020) argue that the "greenium" is essentially equal to zero. They examine investors' willingness to exchange wealth for societal benefits by comparing green bonds to identical non-green bonds issued by the same issuers on the same day. They document that the prices of green and non-green issues are identical. They interpret this as indicating that in a real market environment, investors are not willing to trade off their wealth for environmental projects. Holding the risk and payoffs of green and non-green bonds constant, they show that investors are indifferent between the two types of securities.

Based on the empirical green bonds literature, Daubanes, Mitali and Rochet (2021) create a signaling model where firms have incentives to start green projects because of managerial incentives to avoid carbon penalties. They examine the stock price and stock turnover sensitivity of managerial compensation across variations of carbon pricing. They find supporting evidence for the importance of managerial incentives but also that this importance mainly depends on carbon prices. Finally, they argue that green bonds should not be seen as a substitute for carbon pricing but rather that carbon pricing makes green bonds more effective.

Given that SLBs are rather new instruments, it is not surprising that the literature that focuses on these instruments remains in its infancy. Liberadzki, Jaworski and Liberadzki (2021) examine whether SLBs that were recently issued by Tesco and had greenhouse gas emissions reduction targets were fairly priced. Their main empirical finding is that the yield differential between comparable SLBs and non-ESG bonds issued by Tesco is negative, which is suggestive evidence of a form of a sustainability price premium for these SLBs.

Feldhütter et al. (forthcoming) estimate an SLB pricing model which explicitly accounts for the probability of reaching the KPI and the implicit convenience yield of holding an SLB (sustainium). They use bond-day observations on the secondary market and find a yield that is 1-2bps lower for SLBs. The mispricing we characterize is based on SLB prices on the *primary market*, and therefore can not be directly compared to theirs. We further find in the bond event study that mispricing on the primary market is largely corrected after 20 days on the secondary market, in line with their results. Additional differences may be due to the fact that we work on a sample of 336 bonds up to February 2022, while they focus on a sample of 75 bonds (where their model can be estimated) up to March 2024.

Another study (Kölbel and Lambillon 2023) uses a bond matching technique initially developed to study the fair pricing of green bonds and documents that issuers benefited from a sustainability price premium (yield discount). Specifically, they identify an unconditional but insignificant yield discount for their sample of -9 bps and a significant discount of -21.5 bps when controlling for other bond characteristics. The latter compares favorably with the average penalty; thus, companies in their sample collect a net average benefit of 3 Mio USD. It is worthwhile mentioning that their matching procedure uses bonds with similar characteristics and then compares the SLBs and matched bonds yields (like the industry standard), without accounting for any coupon penalty. They actually compare the yield of the SLB to what we define as the lower bound when computing the mispricing measure ML. For instance, an SLB with a given issue price could thus show a greenium according to their procedure, while still not exceeding the upper bound in our setting and thus being in fact fairly priced. Ignoring the coupon penalty makes it impossible to distinguish the required premium originating from additional expected cash flows from the greenium originating from non-financial aspects such as environmental preferences or excess demand for sustainable debt. This may create the "illusion" of a greenium in some of their documented mispricings.

Another stream of the literature studies pricing and real effects of sustainability-linked loans (Du, Harford and Shin 2023) or more generally ESG related lending, i.e., through green, social and other sustainability oriented loans (Kim, Kumar, Lee and Oh 2022).

There is also a theoretical literature on green fixed income securities. For instance, the conceptual paper by Barbalau and Zeni (2022) focuses on security design and rationalizes the coexistence of green bonds and SLBs. For that purpose, they propose a model of firm financing that embeds verifiable moral hazard, manipulation, and asymmetric information. They show that green bonds correct for moral hazard because they involve costly verification of actions but give rise to an opportunity cost of committing to financing a project before learning about its outcomes. In contrast, SLBs eliminate this commitment cost, but to the extent that the measurement systems on which contingencies are based can be manipulated, they can lead to "a distortion discount." The authors show that if the firm's distortion cost is high, SLBs are the first-best issues. On the other hand, if the cost of distortion is low, then green bonds become optimal.

3 A primer on SLBs

3.1 SLB structure

According to the ICMA (International Capital Market Association)[3], SLBs are "any type of bond instrument for which the financial and/or structural characteristics can vary depending on whether the issuer achieves predefined sustainability/ESG objectives."

[3]The International Capital Market Association or ICMA is a self-regulatory organization and trade association for capital market participants.

The issuer of an SLB commits to a predefined, quantifiable, and verifiable sustainable objective. This objective is documented in the issuance prospectus and includes a time horizon over which the sustainability target must be reached. Objectives must fulfill two main criteria. First, they must be measurable through a KPI. Second, objectives must be assessed against a predefined sustainability performance target (SPT). In Figure 1, we illustrate the step-up mechanism and payout profile of an SLB. In this figure, we can observe that if the firm does not reach the KPI at the target date, the coupon is augmented by the coupon step-up until the maturity date of the issue.

Figure 1 about here.

In principle, SLBs can bear environmental, social, and governance targets. In practice, however, most SLBs rely on an environmental targets. In Table 1, we tabulate the characteristics of the 336 SLBs that we can identify in Refinitiv and Bloomberg from December 2018 to February 2022 and for which we can obtain an ISIN identifier and an issue date.

Table 1 about here.

Panel A of Table 1 shows that the large majority of SLB issues address exclusively environmental matters (84.82%) or a combination of ESG (3.57%) or EG (3.57%) topics. Very few SLBs (less than two percent) address G or S issues. Regarding the specific target KPI, Panel B of Table 1 shows that the majority of SLBs are concerned with greenhouse gas emissions (49.89 %). The second most common KPI used is renewable energy (11.46 %). There are very few ESG, governance, or socially focused KPIs. Note that there are also some SLBs for which we cannot identify a KPI in Bloomberg (5.06 %).

The payout structure of SLBs can change after issuance, depending on whether the relevant KPI target is reached or not. The change in the payment structure is initiated by a predefined trigger event. Typically, this trigger event corresponds to the company failing to achieve a specific KPI by a predefined observation date. If the company fails to reach the KPI in time, the coupon will in most cases *step-up* by a predefined penalty (almost 95% of the bonds; see Panel D of Table 1). However, some SLBs include a coupon step-down option if the KPI is reached, but this structure is less common (only 2.21 % of SLBs). Other SLBs have penalties where the company can choose to purchase predefined CO2 emission offsets or donate a predefined amount to a charitable organization. Again, these structures are less common. In the latter two structures, the coupon payment structure is unaffected.

Panel C shows that SLBs are predominantly issued in Europe with 46.08 %, followed by North America with 35.84 % and only 13.25 % are issued in Asia. Finally, Panel E shows that SLBs are present in most economic sectors, but most notably in Utilities, Basic Materials, Financials and Industrials.

3.2 Example: Enel SLB issue October 2020

An illustrative example of an SLB with a common structure is the SLB that was issued by Enel Finance International NV on October 20th, 2020. Enel Finance is a Netherlands-based company that raises funds for companies belonging to the Enel Group, which is an Italian company active in the energy sector. The SLB (XS2244418609) was issued on October 20th, 2020, and matures on October 20th, 2027. It carried a BBB credit rating and was issued at 97.75 percent of the aggregate nominal amount.

The bond comes with a one percent fixed coupon rate that is subject to a 25 bps coupon step-up option. The additional coupon step-up is conditional on a step-up event concerning Enel's KPI "Renewable Installed Capacity Percentage". The company commits to reach 60% of renewable installed capacity by 2022 compared to its baseline level in 2019 (SPT). Failing to reach the target in time triggers the coupon step-up where the coupon of 1% p.a. increases by 0.25 percentage points. The new coupon rate of 1.25% p.a. must be paid until maturity.

In December 2022, Enel reported a 63% renewable installed capacity and thus met its KPI target at the step-up date, and therefore no coupon penalty was triggered.

The Enel issue comes with a second party opinion evaluation. The evaluation of Enel's sustainability-linked financing framework was performed by Vigeo Eiris (VE), which is now part of Moody's. For the evaluation, VE uses a scale for KPI relevance and the SPT ambition. The range goes from weak, limited, robust, to advanced and maps the firm's objectives to the SDGs. Overall, VE assesses Enel's sustainability-linked framework as aligned with the Sustainability-Linked Bonds Principles and in line with best practice. The KPI relevance and SPT ambition are assessed to be "advanced," which represents the highest category on VE's evaluation scale.

3.3 SLB market size and evolution

The SLB market has grown strongly since its inception (see Figure 2). Bloomberg identifies a total of 454[4] outstanding bonds flagged as 'Sustainability-Linked" as of February 2022. In contrast, in 2018 , there was only one single SLB. The amount raised through the single 2018 SLB issue was $0.22 billion, whereas the total amount raised through all SLBs issued in 2021 was approximately $160 billion.

Figure 2 about here.

Figure 2 shows that the number of SLBs issued from 2018 to February 2022, increased steadily over time. In 2021, the number of SLBs issued was 338, which is 7.5 times more than in 2020. Similarly, Figure 2 shows that in 2021 SLBs worth $160bn were issued, compared to only $16bn in 2020, implying that in value terms the market has grown tenfold between 2020 and 2021. The number of SLBs issued in the first two months of 2022 is already exceeding the total number issued in 2020 and the amount raised by these issues (approximately $27.39bn) exceeds the total amount raised in 2020 by more than

[4] ISIN and issue dates are only available for 336 bonds out of the total universe of 434. The statistics of the previous section and the empirical analysis therefore rely on the smaller identified sample.

$10bn. Taken together, these figures demonstrate the rising popularity and prominence of these instruments.

3.4 Differences with respect to green bonds

SLBs are not the first type of sustainability-related fixed-income instrument. The most prominent sustainability-linked fixed income securities are so-called green bonds (see, for instance, Zerbib (2019) or Flammer (2021)). SLBs differ from green bonds in many respects. First, green bonds do not have any contingencies in terms of the magnitude of the coupon payments. In addition, the proceeds raised from an SLB issue can be used for general-purpose expenses. In contrast, funds raised through green bond issuance are bound to fund exclusively green projects and expenses. Hence, the lack of a constraint regarding the usage of funds gives a company more flexibility in how to use the money raised through SLBs. Due to this flexibility, SLBs might be an attractive way to raise money for companies. However, this flexibility comes with a potential cost: in contrast to green bonds, SLBs come with a coupon step-up option that is contingent on the company's sustainability performance.

Another important difference with respect to green bonds is that the company may address not only environmental topics through SLB issues but also other sustainability issues such as those related to governance or social outcomes. However, as we saw above, much fewer SLB issues are actually related to non-environmental targets, suggesting that firms currently do not exploit this possibility.

Note also that in terms of market size, there are important differences between green bonds and SLBs. Compared to the approximately 4,600 green bonds issued between 2013 and 2022, the number of SLB issues might seem small. However, the average issue amount for SLBs is already larger than that of green bonds. The larger scale of SLB issues might be due to the key differences between SLBs and green bonds mentioned above.

3.5 Characteristics of SLB issuers

We begin our analysis by studying firm characteristics that are associated with SLB issuance. To construct a firm-year panel allowing to examine this question, we first generate a list of all countries where SLB issuing companies are headquartered. To do so, we use the list of all SLBs from Bloomberg and Refinitiv covering all SLBs issued between December 2018 and February 2022 for which we can identify a bond ISIN and an issue date, i.e., the 336 bonds displayed in Panel A of Table 1. Additionally, we augment that country list with countries in which no firms have issued SLBs but which are part of the MSCI ACWI index. We then obtain financial and ESG data from Eikon for firms in these countries.[5] Using the ISINs of the SLBs from Panel A of Table 1, we construct an indicator identifying SLB issuing firms based on the ultimate parent ID and ultimate parent equity ISINs from Refinitiv. Overall, we can identify 100 unique firms that issue SLBs.

In our analysis of what characterizes SLB issuers, we use financial and ESG variables. Table 2 displays conditional summary statistics of firm-level variables for SLB issuers and non-issuers. We partition the sample into SLB-issuers and non-issuers by splitting firm-year observations into those associated with SLB issuance (Panel B) and firm-years that are not associated with SLB issuance (Panel A).

Table 2 about here.

The summary statistics suggest that firms which issue SLBs are larger, more profitable, value, and more levered. In addition, firms that have higher ESG scores and have issued green bonds in the past are also more likely to issue SLBs. Furthermore, it appears that firms with higher levels of both absolute GHG emissions and GHG intensities

[5] We also apply a couple of data filters. First we restrict the universe of equity ISINs to "Primary" and "Major" securities. We require that assets, sales, and debt are observable in Eikon. We drop firms with zero assets or zero sales and also drop firms for which an industry classification is not available. More information on the exact data construction and matching process can be found in Appendix Appendix B:.

are more likely to issue SLBs.[6] The percentage reductions in terms of absolute GHG emissions appear similar across SLB issuers and non-SLB issuers. However, SLB issuing firms appear to have lower GHG emission intensities post issuance, an aspect that we will explore more thoroughly later using difference-in-differences estimation in the real effects analysis (see Section 7)

To study the relation between the issuance of SLBs and firm characteristics more formally, we employ a Probit regression framework. The Probit model estimates the probability of a firm issuing an SLB based on various financial and non-financial characteristics. The model specification is as follows:

$$Post\ SLB_{it} = \Phi(\alpha + \beta' \mathbf{X_{it-1}} + \delta_t + \theta_c) + \epsilon_{it},$$

where $Post\ SLB_{it}$ is a binary variable that equals 1 from the year in which firm i has issued an SLB onwards. Hence, the dummy is equal to one in all years of and after issuance. The vector $\mathbf{X_{it-1}}$ contains covariates that are likely to be associated with SLB issuance. θ_c (δ_t) represent region (time) fixed effects, Φ denotes the cumulative distribution function of the standard normal distribution, and ϵ_{it} is an error term.

We consider six characteristics which we hypothesize to be associated with SLB issuance. We first estimate the relation between SLB issuance and the characteristics using uni-variate models (including fixed effects) and then saturate the model using all characteristics simultaneously as explanatory variables. The results are reported in Table 3.

Table 3 about here.

In column 1 of the table, we explore the role of firm size, which we measure using $log(assets)$. Larger firms have more resources and capabilities to engage in sustainable financing initiatives. We expect them to be more likely to issue SLBs because they can better bear the potential costs associated with SLB issuance and the monitoring and

[6] We calculate GHG emissions as the sum of scope 1 and 2 GHG emissions.

reporting on sustainability performance. Additionally, larger firms are often under greater scrutiny from a wide variety of stakeholders, pushing such firms towards more sustainable financing options like SLBs. Consistent with this view, SLB issuance is strongly positively associated with firm size.

The second characteristic we explore is profitability, which we measure as a firm's *ROA*, defined as EBITDA relative to total assets. Firms with higher *ROA* are generally more efficient in utilizing their assets to generate earnings. Profitable firms may have better financial health and greater flexibility to invest in sustainability initiatives. As a result, they might be more inclined to issue SLBs to align their financing strategies with their sustainability goals and demonstrate their commitment to environmental performance. Column 2 shows that more profitable firms are indeed more likely to issue SLBs.

Tobin's q, that is the ratio of the market value to the replacement cost of a firm's assets, reflects investor perceptions of the firm's growth prospects. Firms with higher *Tobin's q* are perceived to have better growth opportunities. However, value firms are likely to be active in sectors in which the negative environmental impact is stronger, giving then more scope issuing SLBs. We approximate *Tobin's q* as a firm's market to book ratio. Column 3 shows a negative link between the probability of issuing an SLB and *Tobin's q*, but the coefficient estimate is only marginally significant.

The last financial characteristic that we consider is *Leverage*, which we measure as book debt to total assets. Firms with higher leverage have more scope to use SLBs. By issuing SLBs, these firms can seek to signal their commitment to sustainable practices to investors possibly attracting environmentally conscious investors and benefit from more favorable financing terms due to the positive signal associated with sustainability-linked financial instruments. Consistent with this view, *Leverage* appears highly positively correlated with SLB issuance.

In column 5 we jointly estimate a Probit model that uses all four financial characteristics as explanatory variable. The model shows that the characteristics most robustly related with SLB issuance appear to be firm size and leverage.

We now turn to ESG characteristics that are likely to affect SLB issuance. First, we examine whether a firm's past experience in green fixed income instruments is associated with SLB issuance. In case a firm has a history of green bond issuance, the firm is expected to also be more likely to issue SLBs. Firms that have previously issued green bonds are already familiar with the processes and potential benefits associated with sustainable fixed income financing. This experience can lower the barriers to issuing SLBs, as these firms have established mechanisms for tracking and reporting on sustainability metrics. Moreover, past issuers of green bonds may have a stronger reputation and credibility in the market, making it easier for them to attract investors for SLBs. We use a dummy which is equal to one if the firm has issued at least one green bond prior to issuing SLBs. Column 6 shows a positive and highly significant relation between SLB and green bond issuance.

Finally, we hypothesize that a firm's initial GHG intensity, defined as the firm's' absolute GHG divided by its revenues, might be related to its propensity to issue an SLB. The GHG emissions intensity of a firm is a direct measure of its climate impact. Firms with higher GHG intensities may face greater pressure from regulators, investors, and other stakeholders to reduce their carbon footprint. Issuing SLBs provides these firms with a structured framework to commit to and achieve GHG reduction targets. By linking bond characteristics to sustainability performance, firms with high GHG intensity can demonstrate their efforts to mitigate environmental impact and align their financing with their sustainability goals. In column 7, we observe that indeed firms with higher SLB intensities are more likely to issue SLBs.

To summarize, SLB issuance is associated with both financial and non-financial characteristics: Larger and more levered firms as well as firms with higher GHG emissions intensities and a past experience in sustainable fixed income instruments are more likely to issue SLBs.

4 The model

In this section, we develop a theoretical framework to analyze the pricing and incentive mechanisms of SLBs. We then introduce the measure of the potential mispricing ML and describe how it can be used to derive testable predictions about SLB mispricing at issuance as well as resulting wealth transfers between bond- and shareholders. We also examine how ML relates to the firm's ESG score and, finally, analyze the relation between ML and the firm's cost of financing, emphasizing the potential signaling effect of SLB issuance.

4.1 Fair pricing and incentives

We first propose an analysis of the valuation of SLBs. For that purpose, we introduce a highly stylized model that focuses on two elements: (i) The incentive compatibility structure of the coupon penalty, i.e., do SLBs incentivize managers to engage in efforts to improve the environment? (ii) The environmental benefit perceived by investors in order to determine whether managerial incentives are affected by the presence of environmentally concerned investors. We focus on an SLB with an environmental KPI to simplify notation, but the model applies by extension to social and governance KPIs.

We consider a one-period model. There is one firm with an activity aligned with its risk-neutral manager and a unit mass of competitive risk-neutral investors. There is an inelastic risk-free technology paying R per period. At time 0, the firm issues an SLB with face value F at maturity (the maturity date is time 1). The environmental performance is modeled by $X_1 \in \{g, b\}$ where g is the good state. The SLB promises a conditional coupon payment penalty G if $X_1 = b$, i.e., when its environmental performance is poor.[7] The manager can exert effort $e \in \{0, 1\}$ to increase the probability $p(e)$ of $X_1 = g$. We assume that $p(1) = \overline{p} > \underline{p} = p(0)$. A unit of effort has a monetary cost of f to the manager. We can interpret the cost of effort to the manager, f, as an actual infrastructure

[7] Payment of the penalty occurs with certainty in the bad state as we do not consider the possibility of default.

cost paid by the firm to improve its environmental performance.

The fair price of the bond for a risk-neutral investor who derives no benefit/cost from the environmental performance of the firm is

$$B_0 = \frac{F + G(1 - p(e))}{1 + R}.$$

Consider first the case where investors assume that the manager will provide no effort. In this case, investors offer the highest possible value for the SLB, that is $B_0 = \frac{F+G(1-\underline{p})}{1+R}$. The manager's valuation $V(e)$ at time 0 is therefore

$$V(e) = \frac{F + G(1 - \underline{p})}{1 + R} - \frac{F + G(1 - p(e))}{1 + R} - ef.$$

Exerting no effort yields $V(0) = 0$, and exerting effort yields

$$V(1) = \frac{G(\overline{p} - \underline{p})}{1 + R} - f,$$

and it follows that effort is exerted if

$$\frac{G(\overline{p} - \underline{p})}{1 + R} > f.$$

Assuming that the coupon penalty is large enough to verify the above condition and that f is known by investors, then they can offer the lower price for the SLB $B_0 = \frac{F+G(1-\overline{p})}{1+R}$, and $V(e)$ becomes

$$V(e) = \frac{F + G(1 - \overline{p})}{1 + R} - \frac{F + G(1 - p(e))}{1 + R} - ef.$$

In this case, we have in the presence of effort $V(1) = -f$ and in the absence of effort

$$V(0) = \frac{G(\underline{p} - \overline{p})}{1 + R} < 0.$$

It follows that effort is exerted when $V(1) > V(0)$, i.e., when $\frac{G(\underline{p}-\overline{p})}{1+R} < -f$ or alternatively, $\frac{G(\overline{p}-\underline{p})}{1+R} > f$.

Proposition 1 *When the coupon penalty is large enough, i.e., when it satisfies the condition*

$$\frac{G(\overline{p}-\underline{p})}{1+R} > f,$$

effort is exerted by the manager, and investors pay the corresponding lower fair price

$$B_0 = \frac{F + G(1-\overline{p})}{1+R}.$$

The above condition states that effort will only be exerted by the manager if the discounted "expected penalty savings" exceed the cost of carrying out the environmental investment.[8] We show in Appendix A.1 that replacing the penalty structure with a bonus structure, where the investors agree to an interest payment reduction if the KPI is reached, generates the same incentive structure.

Let us now assume that investors internalize the environmental performance, namely, they attribute a positive monetary value d to the case $X_1 = g$. In the absence of a bond issue, the manager exerts no effort $e = 0$, and hence $p(e) = \underline{p}$. When the investors participate in the bond issue, the potential increase in effort yields a monetary improvement of $d\left(p(e) - \underline{p}\right) \geq 0$.

In this case, the fair value of the SLB to the environmentally concerned investor is

$$B_0 = \frac{F + G(1-p(e))}{1+R} + \frac{(p(e)-\underline{p})d}{1+R},$$

and the investor is willing to pay more for the bond. (NB: it is implicitly assumed that the manager does not internalize the environmental performance and would not exert effort

[8] It can be shown that adding the possibility of default to the model yields a condition similar to that in Proposition 1, and this holds even if the probability of default is affected by the effort of the firm. In that case, the lower bound for the coupon penalty changes and also depends on the probability of default.

in the absence of the bond issue. Under these conditions, the environmentally concerned investor is willing to participate in the bond offering).

The manager's valuation for no assumed effort is given by

$$V(e) = \frac{F + G(1 - \underline{p})}{1 + R} + \frac{(\underline{p} - \underline{p})d}{1 + R} - \frac{F + G(1 - p(e))}{1 + R} - ef.$$

Exerting no effort yields $V(0) = 0$, and exerting effort yields

$$V(1) = \frac{G(\overline{p} - \underline{p})}{1 + R} - f,$$

and it follows that effort is exerted if

$$\frac{G(\overline{p} - \underline{p})}{1 + R} > f.$$

This is identical to the situation described in Proposition 1.

If the investors assume effort, the manager's valuation is

$$V(e) = \frac{F + G(1 - \overline{p})}{1 + R} + \frac{(\overline{p} - \underline{p})d}{1 + R} - \frac{F + G(1 - p(e))}{1 + R} - ef.$$

Exerting no effort yields

$$V(0) = \frac{(\overline{p} - \underline{p})d}{1 + R} - \frac{(\overline{p} - \underline{p})G}{1 + R}$$

and exerting effort yields

$$V(1) = \frac{(\overline{p} - \underline{p})d}{1 + R} - f.$$

It follows that effort is exerted if

$$\frac{(\overline{p} - \underline{p})d}{1 + R} - f > \frac{(\overline{p} - \underline{p})d}{1 + R} - \frac{(\overline{p} - \underline{p})G}{1 + R},$$

which is equivalent to

$$\frac{G(\overline{p} - \underline{p})}{1 + R} > f,$$

which again corresponds to the condition identified in Proposition 1 and therefore yields the following proposition

Proposition 2 *When the coupon penalty is large enough, i.e., when it satisfies the condition*

$$\frac{G(\overline{p} - \underline{p})}{1 + R} > f,$$

effort is exerted by the manager, and investors who derive a private benefit d from the environmental performance improvement pay the corresponding fair price

$$B_0 = \frac{F + G(1 - \overline{p})}{1 + R} + \frac{(\overline{p} - \underline{p})d}{1 + R}. \tag{1}$$

This amount is actually the maximum price that investors would pay, but we may think that in a competitive environment, where bonds are often oversubscribed, environmentally concerned investors will bid up to this maximum value to maximize their chances of participating in the bond issue.

Remark 1 *We defined the cost of effort to the manager, f, as the actual infrastructure cost paid by the firm to improve its environmental performance. For some parameter values, the investor pays more than the actual cost of the infrastructure and in this case when the following condition holds*

$$W = \frac{(p(e) - \underline{p})d}{1 + R} - f > 0, .$$

W represents the amount directly transferred from the bondholders to the shareholders of the firm.

It can be shown that if the coupon penalty is paid to a third party (a nonprofit organization, for example), a wealth transfer to shareholders is less likely to happen and occurs only if

$$\frac{(\overline{p} - \underline{p})d}{1 + R} - f - \frac{G(1 - \overline{p})}{1 + R} > 0.$$

We conclude this section with a remark on SLB pricing when the penalty does not satisfy the incentive compatibility condition.

Remark 2 *When the incentive compatibility condition*

$$\frac{G(\overline{p}-\underline{p})}{1+R} > f$$

is not satisfied, effort is not exerted by the manager and the SLB price is

$$B_0 = \frac{F + G(1-\underline{p})}{1+R},$$

both in the presence and absence of environmentally concerned investors.

4.1.1 An empirical measure of SLB mispricing

In practice, it might prove difficult to observe or infer the probabilities $\overline{p}$, $\underline{p}$, and the bond investors' private benefit d. The unobservability, in turn, precludes a direct analysis of the potential wealth transfers described above and other issues related to SLB over- and underpricing. To circumvent this difficulty, we introduce the "mispricing level" variable denoted by ML, which is an empirically observable proxy for either the (risk-adjusted) probability of reaching the KPI ($ML \in [0,1]$) or the extent of SLBs' under- ($ML < 1$) or overpricing ($ML > 1$).

Assume that we observe an SLB at price B_0 with maturity T, face value F, initial coupon C, and conditional penalty G starting at date $\tau \leq T$. We denote by $B(x,y,z)$ the price of a standard bond with face value x, coupon y, and maturity z. For the SLB, we can define the following upper and lower pricing bounds, UB and LB, respectively:

$$\begin{aligned} UB &= B(F, C+G, T) - B(F, C+G, \tau) + B(F, C, \tau) \\ &= B(F, C+G, T) - B(F, G, \tau) + B(F, 0, \tau) \\ LB &= B(F, C, T) \end{aligned}$$

The mispricing level ML relies on simple arbitrage bounds. The upper bound UB delivers a cash flow stream that is superior or equal at all dates to that of the SLB, while the lower bound LB delivers a cash flow stream that is inferior or equal at all dates to that of the SLB. There is an arbitrage opportunity if the SLB lies outside the range defined by the lower and upper bounds. To the extent that we can observe the bonds necessary to form the upper and lower bounds, the mispricing level ML can be obtained without any modeling assumptions. The upper bound which assumes that the penalty is reached with probability one can be replicated using a portfolio of three different straight bonds. In contrast, the lower bond is simply obtained via the price of a straight pure vanilla bond assuming the penalty is never reached. The table below indicates which bonds should be used to construct the respective bounds.

Table: Construction of the upper and lower bounds

	1	...	τ	...	...	T
(1) $B(C+G,T,F)$	C+G	C+G	C+G	C+G	C+G	C+G+F
(2) $B(G,\tau,F)$	G	G	G+F			
(3) $B(0,\tau,F)$			F			
$UB = (1) - (2) + (3)$	C	C	C	C+G	C+G	C+G+F
$LB = B(C,T,F)$	C	C	C	C	C	C+F

For a given SLB, we can now define the mispricing level ML as

$$ML = \frac{B_0 - LB}{UB - LB}. \tag{2}$$

From Proposition 1 (or Proposition 2 with $d = 0$), if the bond is fairly priced, then $ML \in [0, 1]$ and represents the market assessment of the issuing firm's ability to reach the KPI at date τ, with $ML = 1$ being a perceived guaranteed failure (the KPI will not be reached) and $ML = 0$ being a perceived guaranteed success (the KPI will be reached for sure). Note that ML is a probability if agents are risk-neutral or a risk-adjusted probability otherwise. With the above definitions, we can state our first empirical implications.

Empirical implication 1 *For a given SLB, $ML > 1$ ($ML < 0$) indicates overpricing (underpricing) at issue on the primary market. If secondary bond markets are efficient, bond returns should be negatively related to ML.*

Empirical implication 1 is a conditional test of market efficiency on the secondary bond market. It is conditional as it starts from the observed mispricing (inefficiency) on the primary market measured by ML.

Overpriced sustainability-linked bonds at issuance are potentially good news for equity investors, because overpricing implies that firms raise funds at a lower rate and suggests wealth transfers from bondholders to shareholders:

Empirical implication 2 *For a given sustainability-linked bond, the likelihood of overpricing increases with ML. It follows that stock returns of the issuing[9] companies should increase with ML following the issue, reflecting the potential wealth transfer from bond- to shareholders.*

4.1.2 ML and the pricing model

The pricing model developed so far shows the dependence between the bond prices and the SLB issue's characteristics under several assumptions. Relying on the model, we can now replace the elements composing the bounds and the SLB price itself by their theoretical counterparts. We can therefore re-write, under the assumptions of the model, the mispricing level as a function of various bond characteristics.

[9]Note that sometimes the SLBs are issued by an issuing company's finance arm. As in the example described in section 3.2, the entity issuing the SLB was the financing subsidiary Enel Finance International NV. In such cases, the stock market reaction should be observed for the parent company.

To match the setup of the model, we assume $C = 0$ and $\tau = T = 1$. In that case the upper bound is obtained under the assumption that the probability of reaching the KPI is equal to 0

$$UB = B_0(P(e) = 0) = \frac{F + G}{1 + R}$$

and the lower bound under the assumption that the probability of reaching the KPI is equal to 1

$$UB = B_0(P(e) = 1) = \frac{F}{1 + R}.$$

Using the definition of ML together with the two previous expressions and the SLB fair price equation (with investors' environmental concern) provides an analytical model-based expression for ML

$$\begin{aligned} ML = \frac{SLB - LB}{UB - LB} &= \frac{\frac{F+G(1-\overline{p})+d(\overline{p}-\underline{p})}{1+R} - \frac{F}{1+R}}{\frac{F+G}{1+R} - \frac{F}{1+R}} \\ &= (1 - \overline{p}) + (\overline{p} - \underline{p})\frac{d}{G}. \end{aligned} \tag{3}$$

When the environmental concern is absent, i.e. when $d = 0$, ML coincides with the probability of not reaching the KPI. This is intuitive given that investors in our model discount all cash flows at the risk free rate.

4.1.3 ML and ESG performance

In the previous sections, both the upper bound on the probability of reaching the KPI, $\overline{p} = p(1)$, and the positive monetary value d associated with the case in which $X_1 = g$ are assumed to be constant. We now extend the analysis by assuming that both $\overline{p}$ and d are related to the firm's ESG performance, as proxied for example by its ESG rating, which we label by s. This seems plausible, as a better ESG rated firm may be perceived as having greater potential and credibility to reach its KPI especially by responsible investors who care about environmental issues. We therefore assume $\overline{p} = p(s)$ and $d = d(s)$. Using

Equation (3) that relates ML to the SLB characteristics, we can reinterpret it as follows:

$$ML = (1 - p(s)) + (p(s) - \underline{p})\frac{d(s)}{G}.$$

The relation between ML and the firm's ESG performance can be studied more formally:

$$\frac{\partial ML}{\partial s}(s) = p'(s)\left(\frac{d(s)}{G} - 1\right) + d'(s)\left(\frac{p(s) - \underline{p}}{G}\right).$$

For the above-mentioned reasons, it seems reasonable to assume that $p'(s) > 0$ and $d'(s) > 0$. The link between ML and ESG scores, however, is not obvious because the two terms on the RHS of the above expression may act in opposite directions when $\frac{d(s)}{G} < 1$. We will analyze this relation in the empirical section, assuming different functional forms for $p(s)$ and $d(s)$.

Empirical implication 3 *Controlling for the SLB's characteristics, we expect ML to be significantly related to the firm's ESG rating.*

4.2 Signaling and the total cost of financing

SLBs can provide managers with a signaling mechanism. They can be used to reveal firms' environmental credentials and in particular to separate them from other firms that issue conventional bonds. In this section, we provide an analysis of the firm's cost of financing with a particular focus on the cost of environmental effort to the manager, f, and the investors' environmental benefit d. Our goal is to characterize conditions under which costly signaling yields a separating equilibrium.[10]

Note that when the bond is fairly priced, the yield, i.e., the cost of financing, is by assumption equal to R. The cost of financing as perceived by the firm should however incorporate the fixed cost of effort (or environmental infrastructure) paid at time 0 to increase the probability of reaching the KPI.

[10]In this section, we assume that the incentive compatibility constraint is always verified.

4.2.1 Cost of financing perceived by the firm

In the presence of environmentally concerned investors, the firm's additional cost of financing (in terms of yield) π^e can be computed as follows:

$$\frac{F + G(1 - \overline{p})}{1 + R} + \frac{(\overline{p} - \underline{p})d}{1 + R} - f = \frac{F + G(1 - \overline{p})}{1 + R + \pi^e}.$$

We have 3 distinct cases:

$$\begin{aligned}
&(i) \quad \pi^e = 0 \qquad \text{if} \qquad \frac{(\overline{p} - \underline{p})d}{1 + R} = f \\
&(ii) \quad \pi^e > 0 \qquad \text{if} \qquad \frac{(\overline{p} - \underline{p})d}{1 + R} < f \\
&(iii) \quad \pi^e < 0 \qquad \text{if} \qquad \frac{(\overline{p} - \underline{p})d}{1 + R} > f
\end{aligned}$$

Considering a situation where two types of firms are present and only one is willing to pay a positive signaling cost, only case (ii) allows for a separating equilibrium. This corresponds to the case where the firm is willing to pay more for environmental improvements than required by the bondholders due to their derived benefits from the environmental investment, and thus the firm finances itself at a higher cost of debt to signal its "genuine" commitment. When d is large enough compared to f, all firms benefit from a financing cost reduction, and signaling a *good* behavior is rewarded by the market. In that case, firms pool, issue SLBs, and invest in environmental infrastructure. However, this is all done at an increased cost to the bond investors and may actually benefit the shareholders (see Remark 1). This may happen when bondholders attach great importance to environmental improvements and are willing to pay a great deal for such improvements. Wealth transfers could be mitigated if f had to be disclosed upfront in the firm's SLB issuance prospectus.

Figure 3 illustrates the separating and pooling regions for various levels of environmental benefit perceived by investors and environmental effort cost to the manager.

Remark 3 *If firms do not have a preference for signaling a specific behavior, they choose to issue non SLBs in case (ii). SLBs are issued only in cases (i) and (iii) when bond investors' environmental concerns lead them to sponsor the firm to invest in improved infrastructure (effort f).*

Figure 3 about here.

4.2.2 Cost of financing perceived by the market

The additional cost of financing (in terms of yield) $\hat{\pi}^e$ perceived by the market, which we define as the additional yield component needed to equate the expected proceeds of the bond with the discounted expected repayment, can be computed as follows:

$$\frac{F + G(1-\overline{p})}{1+R} + \frac{(\overline{p}-\underline{p})d}{1+R} = \frac{F + G(1-\overline{p})}{1+R+\hat{\pi}^e}.$$

It differs from the firm's additional cost of financing π^e because it does not include the fixed cost paid by the manager/firm. Since $d > 0$ we have only 2 cases:

$$\begin{aligned}
&(i) \quad \hat{\pi}^e = 0 \qquad \text{if} \qquad \frac{(\overline{p}-\underline{p})d}{1+R} = 0 \\
&(ii) \quad \hat{\pi}^e < 0 \qquad \text{if} \qquad \frac{(\overline{p}-\underline{p})d}{1+R} > 0
\end{aligned}$$

When the bond is fairly priced, from the market's perspective, the firm always benefits from a discount ($\hat{\pi}^e \leq 0$) when it issues an SLB.

Note that this apparent discrepancy between the cost of financing perceived by the firm and the market could be resolved if the infrastructure cost f could be verified and publicly disclosed.

4.2.3 Cost of financing assuming KPI is reached

The financial industry's standard approach as well as the matching technique used by Kölbel and Lambillon (2023) both rely on the yield on an SLB without accounting for the potential coupon penalty. Assuming that the KPI is reached with certainty, we can specify the *"industry standard"* firm's additional cost of financing $\hat{\pi}^e_{\text{ind}}$ as follows:

$$\frac{F + G(1-\overline{p})}{1+R} + \frac{(\overline{p}-\underline{p})d}{1+R} = \frac{F}{1+R+\hat{\pi}^e_{\text{ind}}}.$$

We can see that $\hat{\pi}^e_{\text{ind}} < \hat{\pi}^e$. When the bond is fairly priced and following the industry standard, issuing an SLB always implies a yield discount, that is, $\hat{\pi}^e_{\text{ind}} < 0$. However, this yield discount can be "illusory" as we will see below.

4.2.4 Yield and ML

The *"industry standard"* firm's additional cost of financing $\hat{\pi}^e_{\text{ind}}$ can be related to ML by noting that from Equations (1) and (2),

$$ML = (1-\overline{p}) + (\overline{p}-\underline{p})\frac{d}{G}. \tag{4}$$

It follows that

$$\hat{\pi}^e_{\text{ind}} = \left(\frac{F}{F + ML \cdot G} - 1\right)(1+R).$$

We can identify three distinct cases:

1. $ML > 0$ and $G > 0$, then $\hat{\pi}^e_{\text{ind}} < 0$
2. $ML = 0$ or $G = 0$, then $\hat{\pi}^e_{\text{ind}} = 0$
3. $ML < 0$ and $G > 0$, then $\hat{\pi}^e_{\text{ind}} > 0$

This yield does not account for the expected penalty and indicates that a discount is given to the firm, i.e., $\hat{\pi}^e_{\text{ind}} < 0$, whenever $ML > 0$ and $G > 0$, that is whenever an SLB issue is overpriced and bears a penalty which it generally does. This does not indicate that the firm actually benefits from a discount. Even if we do not take into account the cost of effort f (which can also be understood as an environmental infrastructure cost), a more correct measure of the cost of financing is given by $\hat{\pi}^e$, the yield perceived by the market, which, from Equation (4), relates to ML as follows:

$$\hat{\pi}^e = \left(\frac{F}{F + ML \cdot G} + G(1 - \overline{p}) - 1 \right) (1 + R).$$

Note that $\hat{\pi}^e$ and $\hat{\pi}^e_{\text{ind}}$ coincide only when the probability of reaching the KPI is equal to 1, i.e., $\overline{p} = 1$. In general, the so-called *greenium*, is overestimated by the industry by an amount equal to the expected capitalized penalty, $G(1 - \overline{p})\,(1 + R)$.

Figure 4 about here.

Figure 4 displays the additional cost of financing as measured by the industry and as perceived by the market. The latter appears above the former because we assume that $\overline{p} = 0.2 < 1$. The figure shows that in both cases, the greenium increases when ML increases and when the coupon penalty increases. Figure 5 indicates the region where a "false" yield discount is measured, that is, when the industry standard identifies a yield discount whereas the additional cost of financing as correctly perceived by the market is positive. The surface represented in the example is large, as the probability of reaching the KPI is low. Note however that the surface always exists whenever $\overline{p} < 1$. It is important to further remark that the surface increases significantly with the size of the penalty G, all other things being equal.

Figure 5 about here.

Thus, to summarize, this conceptual framework allows one to characterize the situations when an SLB is incentive compatible for the firm, that is when the coupon penalty is high. Using the model-free measure ML that identifies the extent of potential mispricing, the framework also allows one to identify wealth transfers between bondholders and shareholders associated with an SLB at issuance (despite the fact that managerial effort and investors' ESG preferences are unobservable). Finally, it allows us to distinguish the proper market yield of SLBs from the standard yield quoted by the industry. This, in turn, allows us to demonstrate that the industry, by ignoring the threat of the coupon penalty, generally overstates the benefits of SLB issuance to firms. In the next section, we turn to empirically testing the model's main predictions.

5 Computing ML empirically

As explained in Section 3, the starting point for our sample of SLBs consists of all sustainability-linked bonds issued between December 2018 and February 2022 for which we can identify an ISIN and an issue date. Bond characteristics are retrieved from Refinitiv and Bloomberg. Sometimes, additional bond characteristics related to the nature of the KPI are hand-collected from the respective bond prospectuses or company websites. This initial bond universe is made up of 336 SLB issues (See Panel A, Table 1). In Panel A of Table 4 we show some basic descriptive statistics for the bonds. Note that individual bond characteristics can be missing for some issues, which explains why descriptive statistics in that panel are sometimes calculated using a different number of observations.

Table 4 about here.

The average issue price of SLBs is 99.75 with an average coupon of 3.09. It is paid 1.7 times per year on average, suggesting that a considerable number of bonds have semiannual coupon payments. The median rating of SLBs is BBB.[11] The average coupon step-up penalty is approximately 31 bps, and the median step-up is 25 bps. In fact, a

[11] To assess the credit quality of the bond, we use the bond rating from Refinitiv. If there is no bond rating available in Refinitiv, we use the issuer rating.

large majority of companies uses a step-up of 25 bps given that the first quartile of the variable *Penalty* (G) is also 25 bps. As a consequence, the distribution of the coupon step-up (or penalty) is clustered and this could make the empirical analysis delicate. To remedy this problem, we use the cumulative discounted penalty ($CumDisPenalty$) in the analysis. This corresponds to the present value of all future possible penalties. Panel A shows that the cumulative discounted penalty displays significant cross sectional variation with a standard deviation of 0.49, making it a suitable variable for the empirical analysis. The SLBs also differ in terms of step-up dates. The average time until a coupon step-up can be triggered (a variable we denote by τ) is 4.58 years, which represents on average approximately 60.6 percent of the bond's time to maturity. The average time to maturity of the SLBs is 7.56 years.

For our analysis of ML, we now apply several filtering criteria. We drop bonds with a callable feature other than make whole or clean-up call option. This amounts to removing a total of 15 bonds from our sample. We keep only bonds with step-up penalty, i.e., we discard step-down and non-financial penalties like donations or purchases of carbon offsets. We also drop bonds with floating rates, and discard some bonds with data errors (e.g., incompatible cash flow dates, missing penalty information).

To compute ML we require yield curves, which we retrieve from Refinitiv. We follow the description of ML in section 4.1.1 to construct the portfolios of bonds which replicate the lower and upper bound of the SLB. The respective bond prices are computed using the corresponding bond characteristics and matching sector yield curves from Refinitiv.[12] These yield curves are rating, currency, and business sector specific. Refinitiv uses a minimum of five bonds with the same rating, currency, and business sector for calculations. To deal with outliers of ML, we drop observations that deviate from the median by more than five times the interquartile range. Following the above filtering procedure we are able to obtain 146 values for ML. Summary statistics are presented in Panel A of Table 4. The median value of ML is -0.78, supporting the notion that the median SLB is

[12] When required, we linearly interpolate the yield curves to match the cash flow dates.

underpriced. We observe that 53 percent of the issues in the entire sample have an ML strictly smaller than 0 while 36 percent have an ML strictly greater than 1.

Panels B, C, and D provide summary statistics for the sub-samples used to test each of the three empirical implications of the model, which we do in the next section. These sub-samples rely on different data availability restrictions. In each panel, we display information relating to data specifically used to test the corresponding empirical implication and also repeat the summary statistics for ML in the sub-sample.

6 Testing the model's implications

6.1 Empirical implication 1: Post-issuance SLB performance on the secondary market

In this section we test Empirical implication 1 of the model, which states that overpriced bonds should underperform post-issuance if there are some arbitrageurs in the secondary market. Values of $ML > 1$ imply that an SLB is overpriced. Table 4 - Panel B provides summary statistics for an SLB's cumulative return over the 20 trading days following issuance, a variable we denote $TotRet20$. We use the issue price and gross prices[13] at trading day 20 to compute these cumulative returns. The average $TotRet20$ is slightly negative and equal to -0.07, that is -7bps. The distribution of ML in this sub-sample is similar to the one in Panel A for the initial bond universe.

To test if overpriced bonds at issuance subsequently underperform, we now estimate several OLS regression specifications in Table 5. Specifically, we regress the 20 day post-issuance returns of the bonds denoted by *TotRet20* on ML with and without control variables and fixed effects. Standard errors are double clustered by issue date- and issuer, in order to reflect that bonds issued on the same day and/or by the same firm are not

[13] Refinitiv Datastream defines the gross price as the sum of the clean price and the accrued interest. Accrued interest is a system generated value based on the coupon and day count convention provided in the prospectus/terms condition of the issue. Clean prices are derived by Datastream using the following hierarchy logic to determine the best available price: Composite bid price (CMPB), Refinitiv Evaluated bid price (TRPB), Market price (MP) from exchanges, illiquid CMPB price, and illiquid TRPB price.

independent.

Table 5 about here.

Consistent with the first implication of the model, we find in Column (1) of Table 5 that the coefficient on ML is negative and significant, indicating that bonds overpriced at issuance have lower post issuance cumulative returns. The economic magnitude of this effect is quite sizeable as a one standard deviation increase in ML is associated with a -0.56 (8.13 $\times$ -0.069) percent lower 20 day cumulative post-issuance return. This effect reflects a sizeable 25 percent relative to the standard deviation of $TotRet20$.

In Column (2), we control for the credit rating of the bond or, if unavailable, the issuer credit rating. The variable *RatingN* takes lower values for better credit ratings (e.g., AAA=1, BBB=4). Controlling for the credit rating does not affect the magnitude of the coefficient estimate. In Columns (3) and (4), we control for the coupon and the cumulative discounted penalty, respectively. In these regressions, the coefficient associated with ML remains negative and significant. In Columns (5)-(8), we saturate the model further by simultaneously including the previous control variables and successively adding year, currency, and industry fixed effects: the main result becomes slightly more significant relative to the previous specifications. We observe an economically significant decrease of the 20 day cumulative return between -0.68 and -0.76 percent for a one standard deviation increase of ML depending on the selected specification. Thus, we conclude that our first model implication is supported by the data, i.e., overpriced SLB issues subsequently underperform in the secondary market.[14]

[14]The results are robust to total returns computed with different event windows, e.g. 2, 10, or 15 trading days and/or to restricting the sample to clean prices defined as market prices (MP) from exchanges only. These tables are available upon request.

6.2 Empirical implication 2: Wealth transfer from bondholders to shareholders

To test whether, consistent with Empirical implication 2, issuing mispriced SLBs results in wealth transfers between different types of securityholders, we conduct an event study using stock returns. To do so we obtain stock returns from Refinitiv. In total we are able to obtain the issuing firms' stock returns for 99 SLBs . Table 4 - Panel C provides summary statistics for the variables used in the equity event study. *Relative Issue* defined as the nominal amount of the bond issue over the firm's (or parent's) equity market capitalization at the time of the bond issuance expressed in percentage terms. We use this additional variable when testing Empirical implication 2.

For each SLB issue for which stock returns are available for the issuing firm (or its parent, when a finance subsidiary issues the bond), we calculate abnormal returns as the difference between the firm's stock return and the market index in the country in which the firm is headquartered. We calculate cumulative abnormal returns between the SLB issuance date and five trading days later. The average $CAR(0, +5)$ is 67 bps.

We hypothesize that mispricing of SLBs should have an effect on equity prices—and thus result in wealth transfers—primarily when the SLB issue is sufficiently large relative to the equity market capitalization of the issuing firm. In other words, if an SLB issue is mispriced, but the bond issue represents only a small fraction of the equity capital of the firm, we do not expect a meaningful stock market reaction. However, when the issue amount of the mispriced bond is large relative to the market value of the equity capital of the firm, we expect a stronger stock market reaction. To capture this idea, we compute the variable *Relative Issue*, which is the ratio of the SLB issue's nominal amount over the firm's equity market capitalization (the ratio is expressed in percentage terms). The median SLB issue represents about 2.70 percent of the median issuer's equity market capitalization. The distribution of ML in this sub-sample is again similar to the one in Panel A for the full bond universe. (see Panel C - Table 4)

Table 6 about here.

In column (1) of Panel B in Table 6, we regress the cumulative abnormal returns from the issuance date to five days after on the variable *Relative Issue*, ML, and the interaction term *Relative Issue* $\times$ ML. We expect a positive coefficient for the interaction, that is more positive cumulative abnormal returns when the SLB issue is (i) large relative to the equity capital of the issuing firm (i.e., higher values for *Relative Issue*) and (ii) more overpriced (i.e., greater values for ML). Standard errors are double clustered at the issuer and issue date level. The coefficient on the interaction is positive and significant in Column (1). A positive coefficient estimate is consistent with the conjecture that when bond issues are more underpriced (overpriced), the stock market reacts more negatively (positively). In terms of economic magnitude, an SLB with a standard deviation higher mispricing (7.21) and a standard deviation higher value for *Relative Issue* (7.96) is subject to a 0.92 percent higher cumulative abnormal stock return (=0.016×7.96×7.21) during that time interval. Similar to the bond event study, we include year, industry, and country fixed effects in columns columns (2)–(5), which reduces the magnitude of the regression coefficient slightly. We also conduct two placebo tests in Panels A and C of the same table, whereby we perform the same analysis using the CAR(-5,-1) and the CAR(+5,+10) and in both cases the coefficient associated with the interaction term is negligible and always insignificant. Overall, the analysis in Table 6 supports the idea of wealth transfers between bond- and shareholders when SLBs are mispriced (see Empirical implication 2).

6.3 Empirical implication 3: *ML* and ESG ratings

Another implication from the theoretical analysis in Section 4.1.3 is a potential relation between ML and a firm's ESG performance, as measured by its ESG rating. Panel D of Table 4 provides summary statistics for ESG scores. We use ESG scores from MSCI and the environmental greenness score proposed by Pástor et al. (2022) (PST), which is essentially a transformation of MSCI's environmental score. In Panel D, we observe that the average Absolute ESG score[15] is equal to 5.27, lower than the average Weighted ESG score[16], which is equal to 5.97. The support of MSCI's ESG scores is between 0 and 10. The average individual E score is to 5.66. The Pástor et al. (2022) greenness score (*PST Greenness*) is defined as $G_{it} = -(10 - E\_Score_{it}) \times E\_weight_{it}/100$, where E_Score_{it} is MSCI's environmental pillar score and E_weight_{it} is the importance that MSCI attaches to the environmental pillar when evaluating the firm.[17] These weights typically vary at the industry level.

ESG scores are measured in June of the year prior to the issuance of the SLB. The distribution of ML in this sub-sample is again similar to the one in Panel A for the initial bond universe.

Table 7 about here.

In Table 7, we explore the relation between mispricing and ESG ratings in an OLS regression framework. We regress ML on the issuer-level ESG scores from MSCI. We use both the absolute and the industry weighted ESG score. The absolute score captures a firm's absolute ESG performance, whereas the industry adjusted score should be seen as a best-in-class measure of a firm's ESG performance, where the performance is measured relative to industry peers. In Panel A, we use the best-in-class ESG scores. In Panel B, we use the absolute ESG scores. We find a positive relation between ML and a firm's ESG performance in both panels albeit the coefficient is larger for the absolute score, but more precisely estimated for the weighted ESG Score. In both panels, the relation becomes significant only once we include fixed effects to control for, e.g., unobservable issuer- and

[15]The Absolute ESG score is computed as a weighted average of the scores MSCI attaches on ESG key issues relevant to a specific industry.

[16]The Weighted ESG score is computed by normalizing the Weighted Average Score relative to industry peers. This score determines the overall company rating.

[17]The idea behind the *PST Greenness* score is as follows. The quantity $10 - E\_Score_{i,t}$ captures the distance of a company from a perfect environment score of 10. The product between $10 - E\_Score_{i,t}$ and $E\_Weight_{i,t}$ quantifies how brown the firm is. The measure combines how badly the firm performs on environmental issues $(10 - E\_Score_{i,t})$ and how important environmental issues are for the industry's typical firm $(E\_Weighti, t)$. Multiplying the product of the two terms by -1 converts the measure from brownness to greenness.

bond-specific characteristics such as the currency of the SLB issue or the industry of the issuer. In terms of economic magnitudes, a one standard deviation increase in the industry weighted ESG score is associated with an increase in ML of between 1.27 and 3.8 depending on the specification chosen, which represents a sizeable 17 to 50 percent of the standard deviation of ML.

Table 8 about here.

Finally, it is important to mention that in our setting the ESG score of the firm is supposed to capture the commitment of the issuing firm when it comes to meeting its KPI target. We conjecture that, given that the majority of the SLBs have an environmentally related KPI target, this credibility can be directly captured by the environmental score of the firm. To test this conjecture, the two panels of Table 8 examine the relationships between ML and MSCI's E as well as the relation with the Pástor et al. (2022) greenness score. Consistent with our conjecture, the relation is significant for the MSCI's E Score (Panel A) and highly significant when using the PST Greenness score (Panel B).

7 Real effects of SLB issuance

In this last section, we empirically test whether SLBs can deliver on their promise to improve sustainability outcomes at the firm-level. We know relatively little about the real effects of SLBs and aim to fill this gap by investigating whether SLB issuance leads to measurable improvements in ESG related outcomes.

Analyzing the real effects of SLBs issuance on firms' ESG outcomes is important for several reasons. First, given the recent nature of SLBs, empirical evidence on the actual impact of SLBs on firms' sustainability outcomes doesn't exist. Second, SLBs are designed to align financial incentives with environmental performance, making it essential to understand if these instruments effectively drive firms toward reducing their environmental footprint. We aim to produce evidence on the impact of SLB issuance on firms' environmental performance, providing valuable insights for policymakers, investors, and firms considering the adoption of these innovative debt instruments.

We do not use our model to inform the empirical analysis of real effects because this would require empirically observing several crucial model parameters. For instance, we cannot observe the firm's cost of achieving the sustainability target or the value that investors attach to the environmental target. We can also not observe empirically the change in the probability of achieving the sustainability target because of a firm investing in the environmental technology. This is why we focus on reduced form tests of real effects. Nevertheless, the real effects analysis will also likely provide insights for our model assumptions, namely how plausible it is to assume that the incentive compatibility constraint is satisfied.

7.1 Baseline

To analyze the real effects of SLB issuance, we use a standard DID setup. Given that the majority of SLBs are issued with an environmental KPI target, we focus on environmentally related outcomes, specifically on GHG emissions intensities. In further analysis, which we report in the Appendix, we also use ESG scores and absolute GHG emissions as dependent variables.

Our approach compares the changes in GHG emissions intensities of firms that issue SLBs (treatment group) with those that do not (control group) over time. The primary DID equation is specified as follows:

$$y_{it} = \beta_1 SLB\ Issue_{it} + \gamma' \mathbf{X_{it}} + \delta_t + \theta_c + \lambda_s + \epsilon_{it},$$

where y_{it} is the environmental outcome variable at the firm level. We consider primarily the firm's greenhouse gas emissions intensity and the year-on-year change in the intensity as outcome variables. GHG intensities are based on the sum of scope 1 and 2 emissions. $SLB\ Issue_{it}$ is a binary variable that equals 1 if firm i has issued an SLB by time t, and 0 otherwise. $\mathbf{X_{it}}$ is a vector of control variables. δ_t represents year fixed effects to control for time-specific effects. θ_c represents region fixed effects. λ_s represents industry fixed effects. ϵ_{it} is the error term. We also estimate models that include firm fixed effects instead of region and industry fixed effects.

The coefficient of interest is β_1, which captures the DID estimate and measures the effect of SLB issuance on the environmental outcome. It quantifies the effect on treated firms, i.e., firms that issue SLBs, relative to control firms, i.e., firms that did not issue SLBs. We estimate the DID models on the same firm-year panel that we used to analyze the characteristics of SLB issuers (see section 3.5).

Table 9 about here.

We report the results in Table 9. In Panel A we use GHG intensities as the dependent variable. We use several different specifications. In the first two columns, we control only for year fixed effects and financial variables (namely size, ROA, Tobin's q, and Leverage). At first glance, it appears that SLB issuing firms see an *increase* in GHG intensities after issuance relative to control firms. The positive and significant effect suggests that firms issuing SLBs have, on average, higher GHG intensities post-issuance compared to firms that did not issue SLBs. This might initially indicate that SLB issuance is associated with increasing GHG intensities. However, once industry fixed effects are included in the model (see Column 3), the previously significant positive effect becomes insignificant. The latter suggests that the initial positive relationship is likely to be driven by differences across industries rather than the effect of SLB issuance per-se. Different industries have inherently different levels of GHG intensities. For example, the manufacturing and energy industries typically have higher GHG intensities compared to, for instance, services oriented sectors. The initial positive effect likely captures these inherent industry differences. Once these differences are controlled for, there is no significant evidence to suggest that issuing an SLB has an effect on the level of a firm's GHG intensity, which underscores the importance of accounting for industry-specific factors when evaluating the impact of SLB issuance on GHG intensity. In column 4, we additionally include region fixed effects, which doesn't change the estimate much. In column (5) we estimate a firm-fixed effects model. The estimate is now negative but statistically insignificant. We obtain similar conclusions when we code the treatment dummy based only on SLB issues with an environmental KPI target (see columns 6 and 7).

In Panel B, we analyze year-on-year percentage changes in GHG intensities. Studying percentage changes in GHG intensities is perhaps more interesting because it accounts for relative improvement or deterioration in emissions, providing a more dynamic view of a firm's progress in reducing emissions over time. This approach also allows for comparisons across firms of different sizes and initial GHG emissions levels, highlighting the effectiveness of sustainability measures in a more standardized manner. By focusing on percentage changes, we can better assess the rate of decarbonization and the impact of SLB issuance relative to each firm's baseline.

We use the same regression specifications as in Panel A. The results in columns 1-5 consistently show that firms issuing SLBs decarbonize faster, meaning that, after SLB issuance, the year-over-year percentage *reduction* in GHG intensities is higher for issuers than for non-issuers. This suggests that while the levels of GHG intensities may not immediately be lower compared to non-issuers, SLB issuers are on a steeper trajectory towards decarbonization compared to their non-issuing counterparts.

In terms of magnitudes, we estimate an increase in decarbonization of 6 percentage points after issuance. This estimate implies an effect size of 0.06/0.26=23% of a standard deviation of the dependent variable. Relative to the mean of the -6%, SLB issuers double their decarbonization rates post issuance, which is economically meaningful. In columns 6 and 7, we use the refined treatment dummy by treating only on firms that issue environmentally related SLBs. Consistent with the idea that this exercise reduces noise and possible attenuation bias, both the t-statistics as well as the estimates increase slightly. For example, in the firm fixed effects specification of column 7, the effect size increases to

-7 percentage points. An important implication of this finding for our theoretical framework is that the incentive compatibility constraint seems to be satisfied for the average SLB issuing firm. Hence, our assumption in the theoretical part appears plausible.

In the Appendix we also examine cross sectional variation in the treatment effect. We find that SLB issuance matters not only at the extensive, but also the intensive margin. The treatment effect is stronger for firms that issue more than one SLB. We do not find strong evidence that decarbonization effects differ for firms that have also issued green bonds in the past. If anything, the treatment effects are weaker for serial green bond issuers. Exploring geographical differences, we do not observe that decarbonization effects vary across regions, suggesting that decarbonization is not concentrated among issuers from specific regions (e.g., Europe), but a global phenomenon. However, we do find evidence that when more profitable firms issue SLBs, the decarbonization effect of SLB issuance is stronger. Stronger decarbonization from more profitable SLB issuers might arise because more profitable firms have greater financial resources and flexibility to invest in sustainable technologies and practices. Profitable firms can more easily afford the costs associated with implementing energy-efficient processes, renewable energy sources, and other decarbonization initiatives. In our modeling framework, these firms are more prone to invest in the technology that makes it more likely that they achieve the target. Additionally, these firms could also have stronger governance structures and thus be more likely to face pressure from stakeholders, including investors and customers, to enhance their environmental performance. As a result, they are better positioned to achieve significant reductions in GHG emission intensities following SLB issuance.

7.2 Dynamic estimates

Our results provide evidence that SLB issuance improve firms' decarbonization efforts. However, this evidence may, in parts, be confounded by effects prior to issuance. In other words, pre-trends might exist, which would violate the parallel trend assumption key to the difference-in-differences framework. To rule out this possibility, we now evaluate pre-trends in Figure 6. We replace the *Post SLB* dummy with individual indicators, each marking a specific year around issuance of an SLB. Year $t = -1$ (i.e., the year before SLB issuance) is omitted so that the effects are estimated relative to this year, and years that are two or more years before ($t \leq -2$) or after ($t \geq +2$) the issue are grouped together. We use specifications similar to those from Table 9.

Figure 6 about here.

The left hand subfigures are based on pooled cross sectional regressions with control variables as well as year, country, and region fixed effects. The right hand subfigures are based on specifications including control variables, year- as well as firm-fixed effects. The upper subfigures define treatment based on all SLB issues. The lower figures use only SLBs with an environmental target to define treatment. The figures report point estimates with 95 and 90 percent confidence intervals, which are indicated using bars, respectively whiskers.

When we examine the dynamics of the effect of SLB issuance in event-time analysis, we do not observe significant effects prior to the issuance of SLBs. We observe that decarbonization rates improve only after SLB issuance. The effects become significant from year t=+1 onwards and also appear somewhat increasing over time. This evidence is reassuring. First, it is reassuring that we do not observe any pre-trends. Secondly, it is reassuring that decarbonization effects start materializing from period $t \geq +1$ since it would seem implausible that effects of SLB issuance already materialize in the year of issuance itself. When we measure treatment based only on issuance of environmentally related SLBs (lower subfigures), the effects become stronger and appear less noisily estimated. Finally, note also that the confidence bands for $t \geq +2$ are larger. This is likely to have a simple explanation: we have fewer observations to estimate this coefficient, because GHG emissions data becomes available only with a significant lag (Zhang 2024).

7.3 Robustness and further analysis

In the Appendix, we estimate further regressions using other dependent variables. In a first robustness test, we use absolute emissions. We find that in specifications that do not include firm fixed effects, the coefficient on the treatment dummy is significantly positive. Initially, the significant positive effect of SLB issuance on absolute GHG emissions suggests that firms issuing SLBs have higher emissions after issuance when compared to firms not issuing SLBs. However, when firm fixed effects are included, the effect becomes insignificant, indicating that the initially observed relationship is likely to driven by firm-specific characteristics rather than the issuance of SLBs itself. This implies that inherent differences between firms, such as size or baseline emission levels, could be confounding the initial results. The inclusion of firm fixed effects controls for these unobserved, time-invariant characteristics, revealing that SLB issuance does not independently impact absolute GHG emissions. Thus, the initial positive effect was not due to the SLB issuance but rather due to pre-existing differences between firms. When examining changes percentage in absolute emissions, we estimate largely negative treatment effects. However, in terms of statistical significance, the picture is less consistent.

8 Conclusion

In this paper, we make several contributions to the sustainable finance literature on fixed income securities. First, we develop a novel conceptual framework designed to foster a better understanding of the intended and unintended incentive and pricing effects as well as wealth transfers associated with issuing SLBs. Second, we propose a novel mispricing measure for SLBs and use it to test empirical implications of our model. Finally, we study the real effects of SLB issuance.

The conceptual framework allows us to characterize the situations in which the SLB is incentive compatible for the firm, which is given when the cumulative discounted coupon penalty is sufficiently large. Our novel measure of an SLB's mispricing (denoted by

ML) identifies the extent of over/underpricing and enables us to study wealth transfers associated with SLB issuance (despite the fact that the managerial effort to reach the KPI target and investors' ESG preferences and appetite for SLBs are unobservable). The conceptual framework can also be used to compare the true market yield of SLBs with the standard yield quoted by the industry. The latter analysis leads us to conclude that the industry generally overstates the benefits (in terms of yield discount) to SLBs' issuing firms.

Our model delivers several testable predictions, which we take to the data by computing the mispricing measure using the issue prices of SLBs and these bonds' upper and lower pricing bounds, which are obtained from the hypothetical prices of plain vanilla bond portfolios calculated using the appropriate yield curves. We first confirm that when ML is high at issuance, overpricing occurs, which subsequently leads to a reduction in SLB prices on the secondary bond market. Next, we demonstrate that when the SLB issue is large relative to the equity market capitalization of the issuing firm, the more overpriced (underpriced) the SLBs at issuance, the more positive (negative) the stock market reaction upon issuance. Higher cumulative abnormal stock returns for issuing firms with higher values for ML are consistent with wealth transfers from the bond- to shareholders in those firms. Finally, we document a significant positive relation between ML and the bond-issuing firms' ESG ratings which seems to be essentially driven by the environmental rating. The latter observation is consistent with the conjecture that the environmental rating stands as a proxy for the issuing firm's commitment when it comes to meeting its KPI target.

In a last step we examine the real effects of SLB issuance and document that firms issuing SLBs decarbonize about 6-7 percentage points faster after issuance compared to non-issuing firms. The latter finding has important implications for firms and policy makers as it suggests that SLBs are not merely a greenwashing tool, but are a viable financing tool that can be used to accelerate the decarbonization of firms. The real effects analysis also provides valuable insights regarding our conceptual framework in that the empirical evidence appears consistent with the view that the incentive compatibility constraint is satisfied for the average SLB issuing firm.

Our study further carries some policy implications. First, one should require greater transparency in the bond prospectus and certification process by demanding that firms also disclose the parameter f, that is, the cost of implementing the environmental (or social or governance) infrastructure needed to reach the KPI target. Second, for overpriced bonds, the wealth transfer to shareholders can be mitigated if part or all of the coupon penalty is actually externalized (as in the case of a charity donation). Third, greater sustainable finance literacy among investors is needed to prevent the overpricing of these issues, which ultimately benefits the shareholders of the issuing firms. To achieve this goal, investors' and, in particular, institutional investors' flows should be channeled less mechanically into these issues because their excess demand for sustainable assets is in part driving these abnormal price premiums and their unintended wealth transfers. Finally, we would recommend prudence with the practice of relying on the industry standard for quoting excessive yield discounts and publicizing them in the press[18,19,20]. In principle, the ML measure could be used as a simple indicator to assess if the pricing of these bonds is fair by accounting for their expected discounted coupon penalty.

[18] ESG-linked transactions typically raise a book 30%-40% larger than their non-sustainable counterparts (see https://www.spglobal.com/marketintelligence/en/news-insights/blog/esg-sustainability-linked-bonds-offer-pricing-perk-for-right-high-yield-credits)

[19] The company launched a €1bn June 2027 tranche at 38bp over swaps, a €1.25bn June 2030 note at plus 50bp and a €1bn June 2036 bond at 65bp. That implied concessions of 3bp on the six-year note, 5bp–10bp on the nine-year note and 10bp on the 15-year note. Books were €3.1bn-plus, €3.6bn-plus and €3.7bn-plus, respectively. (see https://www.ifre.com/story/2908666/enel-speeds-transition-with-jumbo-slb-b6xb6tmvml)

[20] On Monday, oil company Eni also paid a premium on its inaugural SLB. The issuer priced a €1bn 0.375% June 2028 at swaps plus 50bp, for a concession of 3bp–5bp. (see https://www.ifre.com/story/2908666/enel-speeds-transition-with-jumbo-slb-b6xb6tmvml)

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Figures

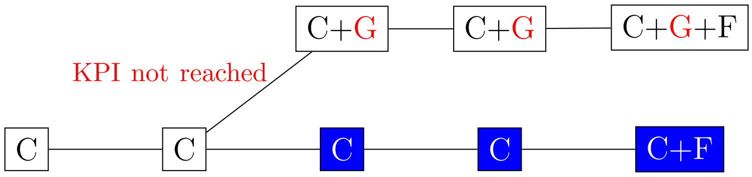

Figure 1: SLB payment structure

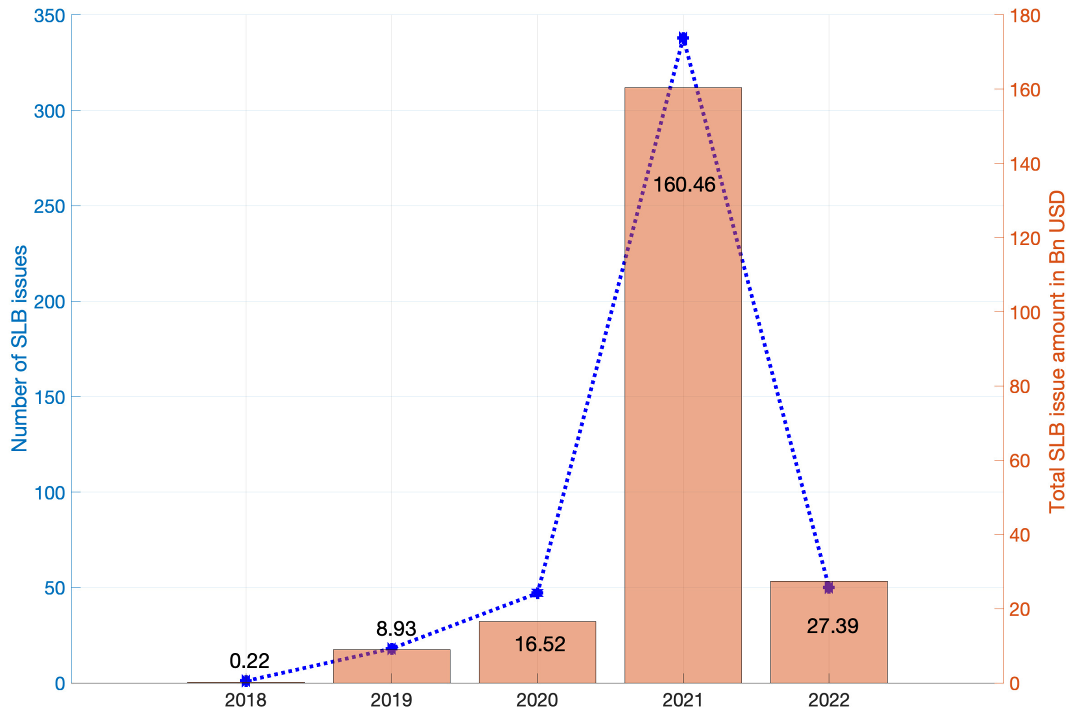

Figure 2: Number and total amount of SLB issued.

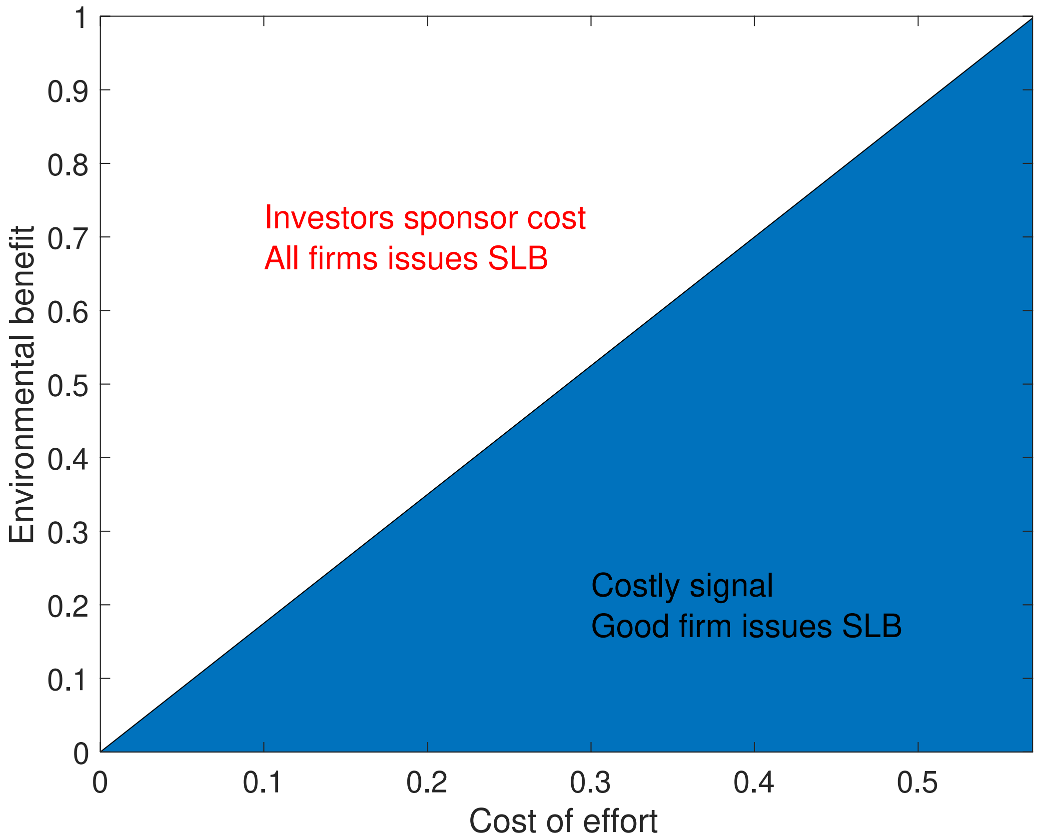

Figure 3: Separating and pooling regions for different levels of environmental benefit perceived by investors and effort cost to the manager. $\overline{p} = 0.8$, $\underline{p} = 0.2$ and $R = 0.05$.

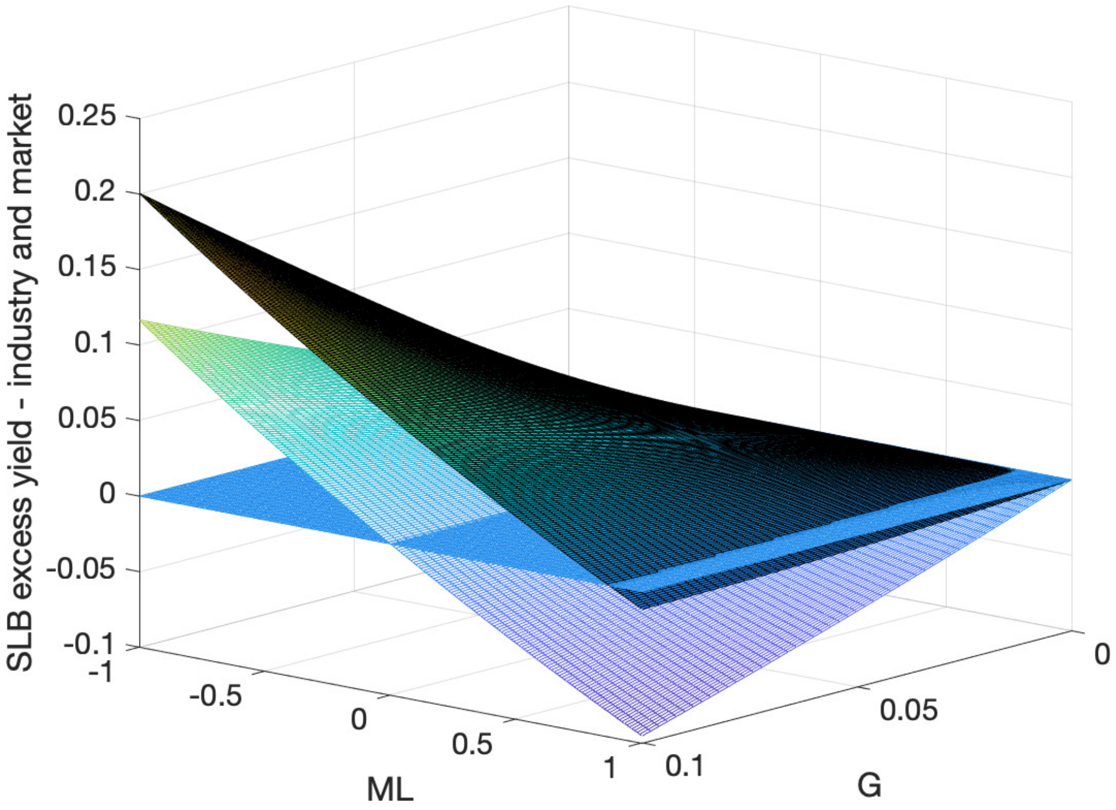

Figure 4: Excess yields from *industry* standard (light shaded) and perceived by the market (dark shaded) as a function of ML and penalty G. We assume that $R = 0.05$, $F = 1$ and $\overline{p} = 0.2$.

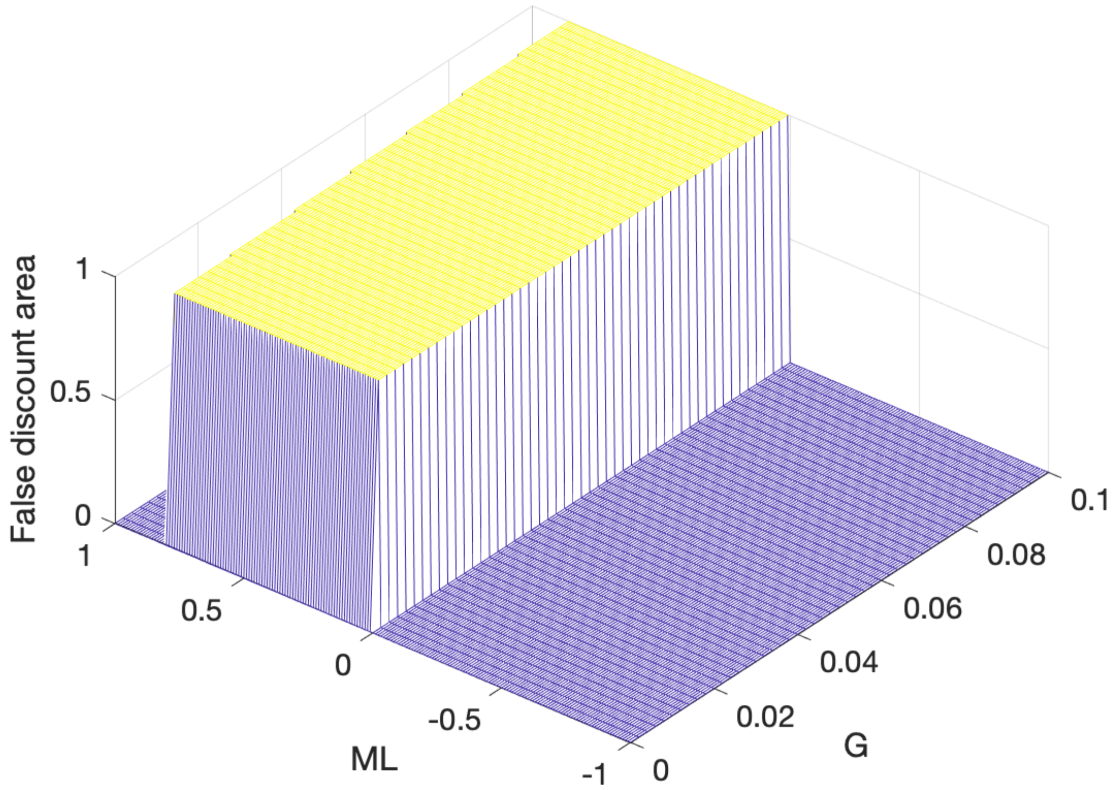

Figure 5: Indicator of a false discount as a function of ML and penalty G. We assume that $R = 0.05$, $F = 1$ and $\overline{p} = 0.2$.

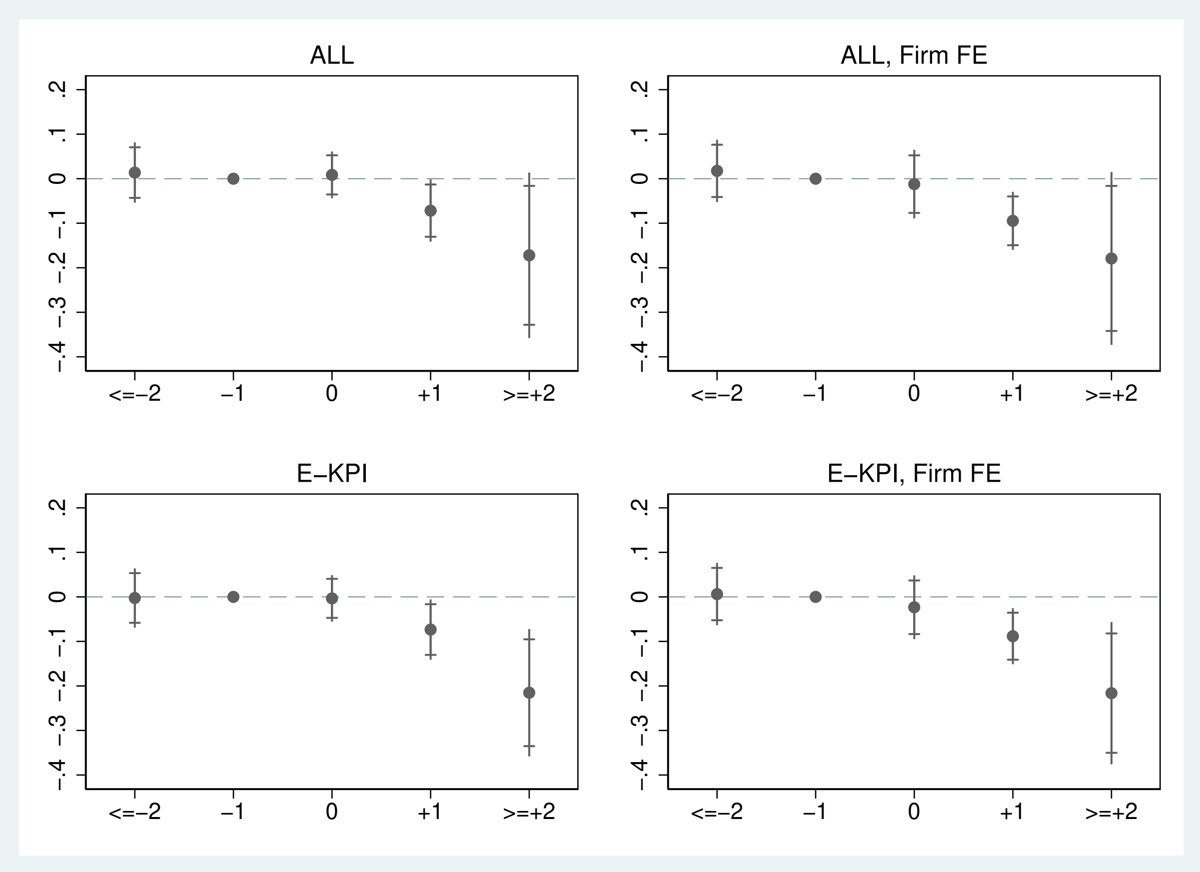

Figure 6: Dynamic DID estimates:
In this figure we present dynamic estimates from an event-time analysis using *% change GHG Intensity* as the dependent variable. We replace the *Post SLB* dummy with individual indicators, each marking a specific year around issuance of an SLB. Year $t = -1$ (i.e., the year before SLB issuance) is omitted so that the effects are estimated relative to this year, and years that are two or more years before ($t \leq -2$) or after ($t \geq +2$) the issue are grouped together. We use specifications similar to those from Table 9. The left hand figures are pooled cross sectional regressions with control variables as well as year, country, and region fixed effects. The right hand figures are specifications including controls, year-, and firm fixed effects. The upper figures calculate treatment based on all SLB issues. The lower figures use only SLBs with an environmental KPI target to define treatment. The figures report point estimates with 95 percent (bars) and 90 percent (whiskers) confidence Intervals.

Tables

Table 1: SLB Characteristics

This tables displays the SLBs' characteristics for the largest sample (N=336) of bonds gathered from Refinitiv and Bloomberg from December 2018 to February 2022. Panel A describes the Sustainability Target Themes on bond basis based on the KPI description from Bloomberg. Panel B shows the single KPI items listed in Bloomberg. Note that a single bond can have several KPI items. Panel C shows the Issuer location. Panel D shows the Penalty structure based on the notes description from Bloomberg. Panel E shows the Economic Sector based on the Refinitiv classification. Panel F shows the callable features based on Refinitiv.

Panel A: Sustainability Target Theme		
N=335	Percentage	Count
E	84.82%	285
No description	5.06%	17
ESG	3.57%	12
EG	3.57%	12
G	1.79%	6
S	0.60%	2
ES	0.60%	2
SG	0.00%	0
Total	**100.00%**	**336**

Panel C: Issuer location		
N=332	Percentage	Count
Asia	13.25%	44
Europe	46.08%	153
North America	35.84%	119
Rest of World	3.31%	11
South America	1.51%	5
Total	**100.00%**	**332**

Panel D: Penalty structure		
N=317	Percentage	Count
Carbon offset	1.58%	5
Donation	1.58%	5
Step-down	2.21%	7
Step-up	94.64%	300
Total	**100.00%**	**317**

Panel F: Callable feature		
N=332	Percentage	Count
Make whole and/or clean-up	66.87%	222
Not callable	28.61%	95
Normal callable	4.52%	15
Total	**100.00%**	**332**

Panel B: Single KPI items (several per bond)		
N=456	Percentage	Count
Affordable housing	0.64%	3
Biodiversity	0.42%	2
Circular economy	4.03%	19
ESG Score	2.55%	12
Education	0.64%	3
Energy efficiency	6.16%	29
Gender Equality	2.76%	13
Greenhouse gas emissions	49.89%	235
Labor	1.91%	9
Other	11.04%	52
Renewable energy	11.46%	54
Sustainable farming and food	1.06%	5
Sustainable sourcing	0.64%	3
Transport	1.27%	6
Water consumption	5.52%	26
Total	**100.00%**	**471**

Panel E: Economic Sector		
N=331	Percentage	Count
Academic & Educ. Services	0.30%	1
Basic Materials	16.92%	56
Consumer Cyclicals	6.04%	20
Consumer Non-Cyclicals	10.27%	34
Energy	4.83%	16
Financials	15.41%	51
Government Activity	0.30%	1
Healthcare	3.02%	10
Industrials	13.90%	46
Real Estate	7.25%	24
Technology	2.72%	9
Utilities	19.03%	63
Total	**100.00%**	**331**

Table 2: Summary Statistics - Firm-Year Panel

This table displays descriptive statistics for firms that issue SLBs and those who do not. In Panel A we calculate descriptive statistics for firm-years that are not associated with SLB issuance. In Panel B we use firm-year observations in the year of issuance and thereafter. Q is the market to book ratio. $Leverage$ is book debt over assets. $Green\ Bond\ Issuer$ is a variable that identifies firms that have issued green bonds in the past. $GHG\ Intensity$ is the ratio of absolute greenhouse gas emissions to sales. GHG emissions are based on the sum of scope 1 and 2 GHG emissions. $\%\ ch.\ GHG\ Intensity$ ($Emissions$) is the year-on-year change in the GHG intensities (respectively total GHG emissions). $Env\ Pillar\ Score$ is the MSCI ESG Score and $Absolute\ ESG\ Score$ is the weighted ESG score from MSCI. ESG scores are measured in June of the calendar year. The sample period runs from 2018–2023.

	count	mean	sd	p1	p5	p50	p75	p99	min	max
Panel A: Non-SLB Issuers ($Post\ SLB = 0$)										
$log(Assets)_t$	215428	12.23	2.47	6.45	8.27	12.17	13.76	18.37	0.00	22.60
$MarketCap_t$	191760	2.34	21.33	0.00	0.00	0.15	0.77	38.49	0.00	2530.98
$Assets_t$	215428	6.75	85.03	0.00	0.00	0.19	0.95	94.63	0.00	6548.06
ROA_t	194928	0.07	0.13	-0.37	-0.17	0.08	0.13	0.39	-0.48	0.63
Q_t	183578	1.29	1.08	0.10	0.25	0.93	1.58	5.47	0.00	6.41
$Debt_t$	214018	1.69	30.02	0.00	0.00	0.02	0.20	22.81	0.00	4222.72
$Leverage_t$	212194	0.23	0.23	0.00	0.00	0.18	0.35	0.96	0.00	1.77
$Green\ Bond\ Issuer$	216205	0.01	0.11	0.00	0.00	0.00	0.00	1.00	0.00	1.00
GHG Intensity	22459	105.13	177.86	0.11	0.80	27.19	109.18	840.55	0.00	967.20
log(Abs. GHG Emissions)	24577	11.22	2.90	4.09	6.19	11.28	13.16	17.59	-2.21	30.13
% ch. GHG Intensity	19513	-0.05	0.27	-0.79	-0.47	-0.07	0.05	0.87	-1.00	1.15
% ch. GHG Emissions	19348	-0.02	0.22	-0.68	-0.37	-0.02	0.07	0.70	-0.94	0.91
Env. Pillar Score	39858	4.83	2.24	0.30	1.40	4.60	6.40	10.00	0.00	10.00
Absolute ESG Score	39858	4.66	1.05	2.00	2.90	4.70	5.30	7.20	0.50	9.00
Panel B: SLB Issuers ($Post\ SLB = 1$)										
$log(Assets)_t$	277	16.43	1.25	13.70	14.36	16.46	17.36	19.03	13.47	19.27
$MarketCap_t$	281	16.98	29.07	0.16	0.34	6.56	18.71	196.26	0.04	205.91
$Assets_t$	277	27.56	36.60	0.89	1.73	14.10	34.60	183.84	0.70	233.45
ROA_t	272	0.10	0.08	-0.13	-0.01	0.10	0.14	0.32	-0.34	0.50
Q_t	277	1.06	0.70	0.27	0.45	0.89	1.24	3.60	0.22	6.30
$Debt_t$	277	10.01	13.71	0.23	0.47	5.38	12.61	69.66	0.12	98.12
$Leverage_t$	277	0.38	0.16	0.07	0.14	0.37	0.47	0.82	0.06	0.96
$Green\ Bond\ Issuer$	281	0.28	0.45	0.00	0.00	0.00	1.00	1.00	0.00	1.00
GHG Intensity	156	161.23	227.79	0.06	2.58	51.56	236.46	925.88	0.03	931.97
log(Abs. GHG Emissions)	178	13.30	2.82	2.39	8.34	13.62	14.89	18.58	2.38	18.65
% ch. GHG Intensity	170	-0.13	0.21	-0.68	-0.44	-0.12	-0.03	0.76	-0.89	0.98
% ch. GHG Emissions	169	-0.03	0.19	-0.60	-0.35	-0.02	0.06	0.56	-0.89	0.62
Env. Pillar Score	247	6.11	2.25	2.40	2.80	5.90	7.70	10.00	2.00	10.00
Absolute ESG Score	247	5.37	1.10	3.00	3.50	5.50	6.00	8.10	2.20	8.50

Table 3: Characteristics of SLB Issuers

This table presents the results from Probit regressions in which the dummy variable *Post SLB* is related to firm characteristics. The dependent variable *Post SLB* is equal to one in the year of issuance and the years after, and zero otherwise. All other variables are defined in Table 2. The regressions include year, region, and industry fixed effects. Standard errors are clustered at the firm-level. t-statistics are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post SLB							
$log(Assets)_{t-1}$	0.302***				0.301***	0.271***	0.244***
	(14.62)				(13.94)	(12.43)	(7.91)
ROA_{t-1}		0.572***			0.463	0.425	0.053
		(3.65)			(1.25)	(1.15)	(0.11)
Q_{t-1}			-0.068*		-0.004	-0.002	-0.030
			(-1.87)		(-0.07)	(-0.04)	(-0.45)
$Leverage_{t-1}$				0.751***	1.017***	0.980***	1.029***
				(9.80)	(5.48)	(5.42)	(4.37)
Green Bond Issuer						0.532***	
						(4.32)	
$GHG\ Intensity_{t-1}$							0.001**
							(2.07)
Observations	171,715	188,797	173,711	204,678	161,093	161,093	21,607
R^2	0.337	0.185	0.181	0.201	0.356	0.369	0.230

Table 4: Summary statistics - Pricing Samples

This table displays summary statistics at the bond-level for all SLBs issued from December 2018 to February 2022 for which we can obtain an ISIN and an issue date in Refinitiv and Bloomberg. For each variable, we use the maximum available number of observations. Panel A displays summary for the whole bond universe (N=336). *Issue Price* is the bond's issuance price, When calculating summary statistics for *Coupon* and *Coupon Frequency*, we exclude bonds with floating rates. *RatingN* is the credit rating of the bond at issuance transformed into numerical values (e.g., AAA=1, AA=2, A=3). *Penalty* is the coupon step-up penalty. *CumDisPenalty* is the cumulative discounted penalty. τ is the time between the issuance date from Refinitiv and step-up date from Bloomberg in years. T is the time to maturity of the bond reported by Refinitiv. *ML* is the computed mispricing level. To deal with outliers in ML, we drop observations that deviate from the median by more than five times the interquartile range. Panel B displays summary statistics of the variables used in the bond event study in Table 5. *TotRet20* is the total bond return between the issuance date and twenty days after, expressed in percentage. Panel C displays summary statistics of the variables used in the stock event study of Table 6. The variable *Relative Issue* corresponds to the bond's issue amount divided by the issuer's (or parent's) equity market capitalization at the time of the bond issuance date, and is expressed in percentage terms and excludes values larger then the 99th percentile. *CAR* denotes the cumulative abnormal stock market returns for several event windows around the bond issuance. Abnormal returns are in percentage and market adjusted by subtracting the market index return from the SLB issuing firm's parent stock return. Panel D displays summary statistics for the variables used in the regressions ot Tables 7 and 8, which relate ML and ESG scores. The ESG scores and their component parts come from MSCI as reported in September 2019. *Absolute ESG Score* is the weighted average of scores received on all industry-relevant Key Issues contributing to the ESG Rating of a company whereas the *Weighted ESG Score* is calculated by normalizing the Weighted Average Key Issue Score to the industry peer set. *PST Greenness* is the unadjusted greenness proposed by Pástor et al. (2022).

	count	mean	sd	min	p1	p5	p25	p50	p75	p95	p99	max
Panel A: Bond Universe												
Issue Price	319	99.75	0.65	98.05	98.12	98.70	99.59	100.00	100.00	100.00	100.37	107.75
Coupon (C)	297	3.09	2.04	0.00	0.00	0.26	1.50	3.00	4.25	6.75	9.71	10.75
Coupon Frequency	301	1.70	0.62	1.00	1.00	1.00	1.00	2.00	2.00	2.00	4.00	4.00
RatingN	275	4.17	1.38	1.00	1.00	1.00	4.00	4.00	5.00	6.00	7.00	7.00
Penalty (G)	299	0.31	0.22	0.00	0.03	0.10	0.25	0.25	0.37	0.75	1.20	1.50
CumDisPenalty	156	0.88	0.49	0.06	0.08	0.27	0.49	0.78	1.13	1.77	2.34	2.61
τ	307	4.58	2.46	0.00	0.57	1.14	2.94	4.20	5.47	9.70	11.21	14.96
T	330	7.56	3.15	1.50	2.01	3.01	5.00	7.01	10.01	12.42	20.01	20.01
ML	146	-0.78	7.97	-27.17	-17.31	-12.61	-4.46	-0.22	2.59	7.89	35.80	35.80
$ML > 1$	146	0.36	0.48	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
$ML < 0$	146	0.53	0.50	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00

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	count	mean	sd	min	p1	p5	p25	p50	p75	p95	p99	max
Panel B: Bond Event Study												
ML	139	-0.84	8.13	-27.17	-17.31	-12.61	-4.56	-0.22	2.59	8.26	35.80	35.80
$ML > 1$	139	0.36	0.48	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
$ML < 0$	139	0.53	0.50	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00
TotRet20	139	-0.07	2.41	-6.93	-6.43	-4.90	-1.21	0.44	1.43	3.17	4.64	5.62
CumDisPenalty	139	0.91	0.47	0.12	0.24	0.29	0.55	0.88	1.15	1.77	2.34	2.61
Panel C: Stock Event Study												
ML	99	1.59	7.21	-14.73	-14.73	-6.46	-0.93	0.54	3.63	9.66	35.80	35.80
$ML > 1$	99	0.46	0.50	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
$ML < 0$	99	0.39	0.49	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Relative Issue	99	5.70	7.96	0.05	0.05	0.35	1.14	2.70	8.04	21.17	47.70	47.70
CAR(-5;-1)	99	0.17	2.96	-5.45	-5.45	-4.16	-1.75	0.03	1.85	5.16	8.31	8.31
CAR(0;+5)	99	0.67	4.11	-11.49	-11.49	-5.61	-1.11	0.70	2.35	7.91	13.68	13.68
CAR(+5;+10)	99	0.82	5.11	-7.17	-7.17	-5.82	-1.80	0.22	1.57	6.88	37.56	37.56
Panel D: ML and ESG Performance												
ML	97	1.24	7.57	-17.31	-17.31	-10.85	-0.93	0.33	3.14	8.50	35.80	35.80
$ML > 1$	97	0.44	0.50	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
$ML < 0$	97	0.41	0.49	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Absolute ESG Score	97	5.27	1.55	1.90	1.90	2.60	4.10	5.20	6.40	7.50	7.50	7.50
Weighted ESG Score	97	5.96	3.14	0.00	0.00	0.00	4.20	6.00	8.30	10.00	10.00	10.00
Environmental Pillar Score	97	5.66	2.35	1.80	1.80	2.00	3.80	5.30	7.90	9.70	10.00	10.00
PST Greenness	97	-1.87	1.20	-4.61	-4.61	-4.19	-2.58	-1.54	-1.10	-0.01	0.00	0.00

Table 5: 20-day Post Issuance Performance on Secondary Market (Bond Event Study)

This table shows regressions relating *ML* to the SLB total bond returns over a 20 day horizon starting at the issuance date of the bonds. *RatingN* is the rating of the bond at issuance transformed into numerical values, *Coupon (C)* is the annual coupon rate, *CumDisPenalty* is the cumulative discounted penalty and *TotRet20* describes the total bond returns computed with the *IssuePrice* and the gross price 20 trading days after issuance, from Refintitiv. If there are no prices within the period up to the 60th calendar day, no returns are constructed. If there is no price on the first calendar day the first trading price is taken. Errors are clustered on ultimate parent and issue date level. t–statistics in parentheses. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

	(1) TotRet20	(2) TotRet20	(3) TotRet20	(4) TotRet20	(5) TotRet20	(6) TotRet20	(7) TotRet20	(8) TotRet20
ML	-0.069**	-0.072***	-0.069**	-0.069**	-0.087***	-0.086**	-0.094***	-0.084***
	(-2.37)	(-2.65)	(-2.12)	(-2.37)	(-3.02)	(-2.26)	(-4.03)	(-3.17)
RatingN		-0.378			-0.328	-0.369	-0.252	-0.416
		(-1.10)			(-0.97)	(-0.91)	(-0.66)	(-0.77)
Coupon (C)			-0.003		0.174	0.192	0.251	0.364
			(-0.02)		(1.18)	(0.76)	(1.57)	(1.35)
CumDisPenalty				0.023	0.022	-0.027	-0.093	-0.213
				(0.05)	(0.06)	(-0.07)	(-0.24)	(-0.47)
Observations	139	139	139	139	139	138	138	137
R^2	0.054	0.067	0.054	0.054	0.386	0.393	0.481	0.505
Year FE	N	N	N	N	Y	Y	Y	Y
Currency FE	N	N	N	N	N	Y	N	Y
Industry FE	N	N	N	N	N	N	Y	Y

Table 6: Equity Event Study

This table shows regressions relating cumulative abnormal returns (CAR) around the SLB issuance to *ML*. Panel A uses *CAR(-5;-1)* that is the cumulative abnormal stock return computed between five days prior up to one day prior to issuance. Panel B uses *CAR(0;+5)*, which is computed from the issuance day up to five days after issuance, and Panel C uses *CAR(+5;+10)* computed from five days after up to ten days after issuance. The cumulative abnormal stock returns in all panels are computed based on a market model and calculated by subtracting the market index return from the SLB issuing firm's (or its parent's) stock return. *Relative Issue* corresponds to the bond's amount issued divided by the parent's equity market capitalization at the time of the bond issuance, and is expressed in percentage terms. Standard errors are clustered at the Ultimate Parent and Issue Date level. t–statistics in parentheses. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Panel A: Pre Issue CAR (-5;-1)					
	(1) CAR	(2) CAR	(3) CAR	(4) CAR	(5) CAR
Relative Issue	-0.056	-0.085	-0.081*	-0.098	-0.083
	(-0.92)	(-1.62)	(-1.76)	(-1.57)	(-1.39)
ML	0.015	-0.018	-0.031	-0.010	-0.032
	(0.19)	(-0.26)	(-0.41)	(-0.15)	(-0.34)
Relative Issue × ML	-0.003	-0.001	-0.002	-0.002	-0.002
	(-0.60)	(-0.26)	(-0.42)	(-0.56)	(-0.37)
Constant	0.530	0.712*	0.697*	0.806**	0.725*
	(1.03)	(2.00)	(1.96)	(2.08)	(1.74)
Panel B: Around Issue CAR (0;+5)					
	(1) CAR	(2) CAR	(3) CAR	(4) CAR	(5) CAR
Relative Issue	0.122	0.127	0.130	0.155***	0.108
	(1.38)	(1.36)	(1.19)	(2.86)	(1.63)
ML	-0.172	-0.147	-0.155	0.058	0.009
	(-1.24)	(-1.06)	(-1.00)	(0.64)	(0.08)
Relative Issue × ML	0.016**	0.016**	0.016**	0.009*	0.011**
	(2.48)	(2.42)	(2.20)	(2.00)	(2.15)
Constant	-0.114	-0.181	-0.203	-0.505	-0.192
	(-0.16)	(-0.25)	(-0.24)	(-1.24)	(-0.38)
Panel C: After Issue CAR (+5;+10)					
	(1) CAR	(2) CAR	(3) CAR	(4) CAR	(5) CAR
Relative Issue	-0.020	-0.011	-0.064	0.059	0.013
	(-0.29)	(-0.15)	(-0.84)	(0.75)	(0.13)
ML	-0.023	-0.026	-0.130	-0.007	-0.064
	(-0.25)	(-0.25)	(-0.89)	(-0.06)	(-0.47)
Relative Issue × ML	0.006	0.005	0.009	0.004	0.006
	(1.45)	(1.18)	(1.64)	(0.76)	(1.13)
Constant	0.833	0.802	1.184	0.432	0.721
	(1.30)	(1.08)	(1.29)	(0.61)	(0.80)
Observations	99	99	97	98	96
Year FE	N	Y	Y	Y	Y
Currency FE	N	N	Y	N	Y
Industry FE	N	N	N	Y	Y

Table 7: *ML* and Issuer ESG Performance

This table shows regressions relating *ML* to ESG scores from MSCI. In Panel A, we use the industry weighted ESG scores and Panel B uses the absolute ESG scores. *Absolute ESG Score* is a weighted average of scores that a firm receives for specific industry-relevant key ESG issues that contribute to the ESG rating of a company. The *Weighted ESG Score* is calculated by normalizing the weighted average key issue score relative to industry peers and thus reflects a best-in-class assessment. Standard errors are clustered on ultimate parent and issue date-level. t–statistics in parentheses. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Panel A: Industry Weighted ESG Score					
	(1) ML	(2) ML	(3) ML	(4) ML	(5) ML
Weighted ESG Score	0.406	0.501	1.005*	0.744	1.211**
	(1.29)	(1.49)	(1.98)	(1.60)	(2.17)
Constant	-1.179	-1.746	-4.748	-3.267	-6.039*
	(-0.56)	(-0.81)	(-1.55)	(-1.33)	(-1.92)
Observations	97	97	97	94	94
R^2	0.028	0.100	0.348	0.180	0.413
Panel B: Absolute ESG Score					
	(1) ML	(2) ML	(3) ML	(4) ML	(5) ML
Absolute ESG Score	0.254	0.485	1.704*	0.740	1.933*
	(0.71)	(1.17)	(1.86)	(1.49)	(1.72)
Constant	-0.098	-1.319	-7.742	-2.741	-9.011
	(-0.04)	(-0.50)	(-1.63)	(-1.06)	(-1.60)
Observations	97	97	97	94	94
R^2	0.003	0.068	0.295	0.124	0.343
Year FE	N	Y	Y	Y	Y
Currency FE	N	N	N	Y	Y
Industry FE	N	N	Y	N	Y

Table 8: ML and Issuer Environmental Performance

This table shows regressions relating ML to the MSCI Environmental Pillar Score (Panel A) and the PST Greenness computed based on Pástor et al. (2022) (Panel B). Standard errors are clustered on ultimate parent and issue date level. t–statistics in parentheses. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Panel A: Environmental Pillar Score					
	(1) ML	(2) ML	(3) ML	(4) ML	(5) ML
Environmental Pillar Score	-0.030 (-0.08)	0.134 (0.34)	0.756 (1.49)	0.249 (0.69)	0.849* (1.77)
Constant	1.409 (0.45)	0.479 (0.15)	-3.039 (-0.92)	-0.250 (-0.09)	-3.622 (-1.18)
Observations	97	97	97	94	94
R^2	0.000	0.060	0.273	0.111	0.316
Panel B: PST Greenness					
	(1) ML	(2) ML	(3) ML	(4) ML	(5) ML
PST Greenness	-0.457 (-0.53)	-0.332 (-0.40)	2.474** (2.32)	-0.180 (-0.23)	3.147** (2.30)
Constant	0.386 (0.29)	0.619 (0.53)	5.857** (2.63)	0.810 (0.57)	7.080** (2.36)
Observations	97	97	97	94	94
R^2	0.005	0.061	0.308	0.107	0.363
Year FE	N	Y	Y	Y	Y
Currency FE	N	N	N	Y	Y
Industry FE	N	N	Y	N	Y

Table 9: Real Effects of SLB Issuance

This table presents results from estimating the effects of issuing SLBs on GHG intensities. To do so we regress GHG intensities (Panel A) and year-on-year % changes in GHG intensities (Panel B) on an indicator variable *Post SLB* that equals one in the years of and after SLB issuance and zero otherwise. *GHG Intensity* is calculated as total emissions scaled by sales. In columns 1-5 we use all SLB issues to code the dummy *Post SLB*. The control group in these regressions are firms that did not, or did not yet issue SLBs. In columns 6 and 7 we calculate the treatment dummy *Post Envir SLB* using SLB issues with environmental KPIs only. Consequently, in columns 6 and 7 the control group also includes firms that issue SLBs with non-environmental KPIs. The regressions control for $log(Assets)$, ROA, $Tobin's\ q$, and *Leverage*. *Post SLB* is a dummy based on all SLBs. *Post Envir SLB* defines the treatment dummy based on the issuance of SLBs with an Environmental KPI target. Standard errors are clustered at the firm-level. t-statistics are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Panel A: GHG Intensities							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post SLB	61.83**	56.31**	20.81	34.35	-4.16		
	(2.35)	(2.13)	(0.95)	(1.55)	(-0.44)		
Post Envir SLB						34.36	-3.99
						(1.49)	(-0.41)
Observations	22,615	20,960	20,960	20,960	20,028	20,960	20,028
R^2	0.002	0.036	0.264	0.283	0.930	0.283	0.930
Panel B: Y-o-Y % Change GHG Intensities							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post SLB	-0.06***	-0.06***	-0.06***	-0.06***	-0.06***		
	(-3.68)	(-3.64)	(-3.68)	(-3.37)	(-2.59)		
Post Envir SLB						-0.06***	-0.07***
						(-3.51)	(-2.77)
Observations	19,683	18,714	18,714	18,714	17,476	18,714	17,476
R^2	0.006	0.010	0.012	0.019	0.256	0.019	0.256
Controls	N	Y	Y	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y
Industry Fixed Effects	N	N	Y	Y	N	Y	N
Region Fixed Effects	N	N	N	Y	N	Y	N
Firm Fixed Effects	N	N	N	N	Y	N	Y

Appendix A: Model extensions

In this appendix, we extend the base model to allow first for a bonus payment instead of a penalty and second for callable features.

A.1 Bonds with a coupon bonus

Most SLBs are associated with a coupon penalty when the KPI is not reached. There is however an alternative structure that grants the firm a bonus, or a coupon payment reduction, when the KPI is reached. In this section, we analyze the effect of a bonus structure and the pricing of the SLB and the associated incentives for the manager.

We revert to the model analyzed in Section 4.1 and modify the payoff at maturity to account for the coupon payment reduction. In this case, the payoff to investors at maturity is given by

$$F - G\mathbf{1}_{X_1=g},$$

the investor accepts a reduction in payment of G if the environmental performance is increased. The fair price of the bond in this case is

$$B_0 = \frac{F - Gp(e)}{1+R}.$$

We can see that the terms depending on the probability of improvement, $-Gp(e)$, are unchanged compared to the SLB with a penalty, and it follows that incentives are unchanged. The price of the bond differs from the penalty SLB and reflects the lower payment at maturity. Again, if G is large enough, i.e., when

$$\frac{G(\overline{p} - \underline{p})}{1+R} > f,$$

effort is exerted by the manager, and investors pay the low price

$$B_0 = \frac{F - C\overline{p}}{1+R}.$$

Here again the structure implies that the cost of environmental performance improvement is paid by the manager. When the investor attributes a positive monetary value d to the case of

$X_1 = g$, the incentive is not modified, and the results under the penalty structure carry over to the bonus structure.

A.2 Callable bonds

A large share of SLBs have a callable feature. In this section, we extend the base model to allow for callable bond features and analyze when this setting can modify the incentives of the manager. We maintain the simplicity of the initial model but introduce a stochastic evolution of the interest rate, as otherwise the callable feature would be useless.

There are 3 dates $t \in \{0, 1, 2\}$. The interest rate r_t varies over time. At time 1 $r_1 \in \{\overline{r}, \underline{r}, \}$ with probability q and $(1-q)$, and at time 2, the KPI is measured, and the bond penalty is 0 or G. The probability of reaching the KPI at time 2 follows the description of the previous section and depends on the manager's effort $e \in \{0, 1\}$. At time 1, the bond can be called back at price K.

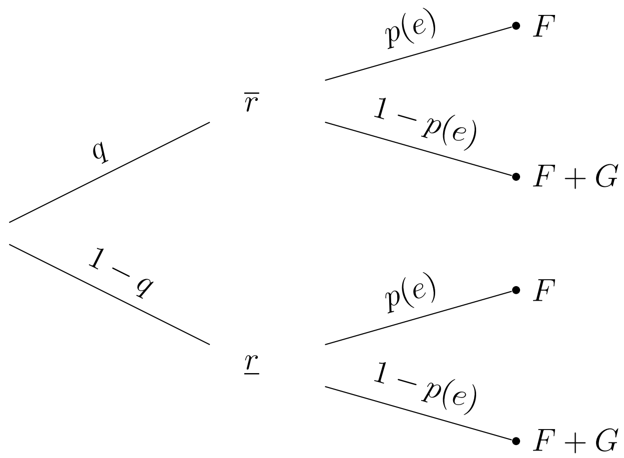

Figure A.1: Two-period Model Description.

The fair price at time 0 becomes

$$\frac{1}{1+r_0}\left(q \ \min\left[K, \frac{F+G(1-p(e))}{1+\overline{r}}\right] + (1-q) \ \min\left[K, \frac{F+G(1-p(e))}{1+\underline{r},}\right]\right)$$

Assume, without loss of generality, that without the KPI-linked penalty, the bond is only called when $r_1 = \underline{r}$, i.e.,

$$K < \frac{F}{1+\underline{r}}$$

in that case, effort is by construction not affected by the call feature since if $K < \frac{F}{1+\underline{r}}$, we necessarily have that

$$K < \frac{F + G(1 - p(0))}{1+\underline{r}}.$$

The potentially problematic case occurs when

$$K > \frac{F}{1+\underline{r}},$$

as we could then observe

$$\frac{F}{1+\underline{r}} < K < \frac{F + G(1-\overline{p})}{1+\underline{r}} < \frac{F + G(1-\underline{p})}{1+\underline{r}},$$

or even

$$\frac{F + G(1-\overline{p})}{1+\underline{r}} < K < \frac{F + G(1-\underline{p})}{1+\underline{r}},$$

which would condition the effort decision.

This can be resolved by assuming that the call exercise price is adjusted by an amount $A > 0$, if the bond is called prior to the KPI measurement (as is done in practice). In that case, we have the following result.

Proposition 3 *If $A > \frac{G(1-\underline{p})}{1+\underline{r}}$, then there is no situation where (i) effort is affected by the call feature and (ii) the bond is called because of the sustainability-linked penalty and not because of interest rate movement.*

As $\underline{p}$ may not be observable in practice, a natural alternative is to set

$$A > \frac{G}{1+\underline{r}}.$$

Appendix B: Data construction

The starting point for constructing the different datasets used in our empirical analysis is the list of SLB ISINs from Bloomberg and Refinitiv, covering all SLBs issued up to and including February 2022, without any filters. The total number of SLBs in this dataset amounts to 336 bonds (see Panel A of Table 1 in the paper). We explain in Section 5 of the paper how we construct the pricing samples. Here, we focus on the construction of the firm-year sample used in sections 3.5 (Characteristics of SLB issuers) and 7 (Real effects of SLB issuance). Figure B.1 illustrates the construction of the samples used to test the different hypotheses and carry out the empirical analysis.

B.1 Firm-year sample

Using the 336 SLB ISINs, we retrieve the ultimate parent permit ID from Datastream. From the ultimate parent permit ID, we generate a list of countries where the companies that issued SLBs during this period are headquartered. Additionally, we add countries which are part of the MSCI ACWI index[21] but in which no firm has issued an SLB to our list of headquarter countries.

For each headquarter country, we retrieve from Datastream the country-specific "all market equity list," which includes all listed equities within that market across all exchanges, regardless of instrument type. We use pre-constructed Datastream equity lists for this purpose. For all countries, we retrieve both active and inactive equity lists.

We then retrieve both time-invariant and time-varying data from 2016 to 2024 from Datastream.

The time-invariant data includes the companies' industry and country characteristics as well as security-specific information. For each ISIN, we record the instrument type, quote type (primary or secondary), major security indicator, and equity list type (active or inactive list).

The time-varying data encompasses the companies' financial and non-financial information. Financial information includes net sales or revenues, market value, earnings before interest, taxes, depreciation, and amortization (EBITDA), total assets, and total debt.

[21] Feb 2024; https://www.msci.com/documents/10199/8d97d244-4685-4200-a24c-3e2942e3adeb

Non-financial information includes the companies' total GHG emissions and emissions intensity, measured as total CO2 equivalent emissions relative to revenues in USD millions. GHG emissions capture Scope 1 and 2 emissions.

Based on the financial information, we construct four key financial indicators: the logarithm of total assets as a measure of company size; leverage, defined as the debt-to-asset ratio; Tobin's q, calculated as market values of the companies shares [22] plus total debt over total assets; and profitability, measured as return on assets, i.e., EBITDA over total assets.

For the time series data, we delete all data for companies delisted before 2016, i.e., before the start of our observation period. Furthermore, we delete all data following a company's delisting.

In the firm year sample, we are able to identify 100 unique ultimate parent equity ISINs from the list of SLBs ISINs. We do so using the ultimate parent permit ID and the ultimate parent stock ISIN. We then calculate a dummy variable that identifies firm years at and after SLB issuance (i.e., *Post SLB*). We also calculate another post issuance dummy variable that is based only on SLBs issued with an environmental KPI target, i.e., *Post Envir SLB*.

B.1.1 MSCI ESG scores

Based on the ultimate parent stock ISIN, we match also the MSCI ESG scores from 2016 to 2023 for any corresponding issuer ISINs. To do so, we gather monthly industry weighted scores and absolute average weighted scores as well as the environmental pillar score from MSCI. For each year, we use the scores from MSCI that are valid in June of that specific year.

B.1.2 Green Bond variables

To construct variables capturing green bond issuance, we collect data on all green bond issuance from 2016 to 2024 from Eikon, including their issuance dates and the ultimate parent stock ISINs. We then calculate two green bond variables, one that captures if the firm has issued green bonds in the past (*Green Bond Issuer*) and one that captures the cumulative number of green bonds issued *Number GBs issued*.

[22]The market value is calculated by multiplying the total number of shares outstanding and the security price.

Appendix figures

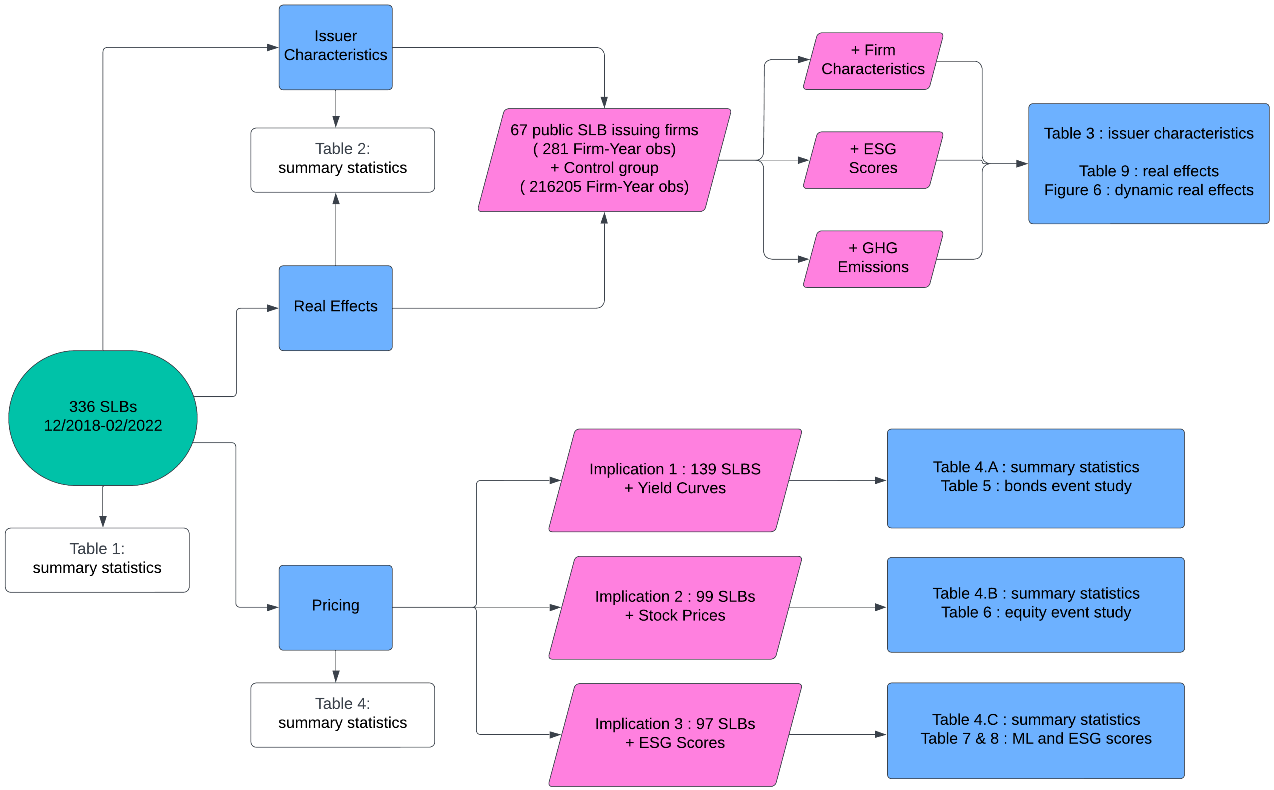

Figure B.1: Data construction chart:
In this figure we present the various steps in the data construction process, referring to the different outputs in the paper.

Appendix C: Real Effects - Further analysis

In this section we conduct further analysis on the real effects of SLB issuance. Section C.1 focuses on analysis in which we use alternative dependent variables, namely absolute GHG emissions and ESG scores. In C.2 we explore cross sectional variation in the treatment effects.

C.1 Alternative dependent variables

In tables C.1 and C.2 we estimate DID specifications similar to those in Table 9 using alternative dependent variable. Table C.1 uses *log(absolute GHG emissions)* and year-on-year percentage change in absolute GHG emissions as the dependent variables. Similar to our analysis of GHG intensity, we observe some evidence that absolute emissions increase after SLB issuance. Yet the positive effects are not robust to including firm fixed effects. The latter indicates that the initial observed effect may be driven by unobserved heterogeneity across firms. In Panel B of the table we study percentage changes in total absolute GHG emissions. The estimates are generally negative, suggesting that issung firms are on a steeper decarbonization path. However, the estimates are mostly non-significant (apart from one specification).

In Table C.2 we evaluate the effect of SLB issuance on the level and year on year percentage change in MSCI's environmental and absolute ESG scores. We generally find that there is no effect in terms of percentage changes. Yet, given that ESG scores are scale-invariant across firms, analyzing percentage changes in ESG is less important than for scale-variant GHG measures. When we focus on levels of the environmental scores, however, we find in Panel A that environmental scores improve consistently after issuance, independent of the specification used. In terms of economic magnitudes we estimate a sizeable improvement of between 4% (0.19/4.84) and 25% (1.21/4.83) relative to the mean environmental score, where the magnitude depends on the chosen specification. Panel C of shows some evidence that the absolute ESG score of issuing firms also improves, yet the result is not robust to firm fixed effects.

C.2 Cross-sectional variation in treatment effects

In this section we estimate several triple-difference equations to explore plausible cross-sectional variation in the effects of SLB issuance on the percentage year-on-year change in GHG intensities.

C.2.1 Intensive margin

In Table C.3 we explore the extensive margin. To do so, we interact the treatment dummy *Post Envir SLB* with the number of SLBs issued by the firm and a dummy that identifies firms that issued more than one SLB. Even though the estimates appear to be nosily estimated, perhaps due to the fact that relatively few firms have issued more than one SLB to date, the table shows negative and significant triple-difference coefficients, suggesting that firms that issue more than one SLB are subject to stronger decarbonization after issuance.

C.2.2 Other green securities (intensive and extensive margin)

Next we explore if the issuance of other green fixed income securities plays a role. In Table C.4, we interact the treatment dummy with variables capturing the extent to which firms have been active issuers of green bonds. There is not much evidence of stronger effects for green bond issuers. If anything, the estimate in column 4 suggests that the effect goes in the opposite direction, i.e., weaker effects for serial green bond issuers.

C.2.3 Regional variation

In Table C.5 we explore issues related to geography and interact the treatment dummy with dummies identifying the headquarter location. There is no evidence that decarbonization effects due to SLB issuance vary geographically.

C.2.4 Financials

In a final set of tests, we interact the treatment dummy with financial variables. Panel A of Table C.6 shows pooled cross sectional and Panel firm-fixed effects regressions. Our analysis suggest that post issuance decarbonization is stronger among more profitable firms, as measured by ROA. This appears plausible as such firms are more likely to pay the infrastructure cost required to reduce the negative environmental externality.

Appendix Tables

Table C.1: Real Effects of SLB Issuance (Absolute GHG Emissions)

This table presents results from estimating the effects of issuing SLBs on absolute GHG. To do so we regress log(GHG emissions) (Panel A) and year-on-year % changes in GHG emissions (Panel B) on an indicator variable *Post SLB* that equals one in the years of and after SLB issuance and zero otherwise. In columns 1-5 we use all SLB issues to code the dummy *Post SLB*. The control group in these regressions are firms that did not, or did not yet issue SLBs. In columns 6 and 7 we calculate the treatment dummy *Post Envir SLB* using SLB issues with environmental KPIs only. Consequently, in columns 6 and 7 the control group also includes firms that issue SLBs with non-environmental KPIs. The regressions control for $log(Assets)$, ROA, $Tobin's\ q$, and $Leverage$. *Post SLB* is a dummy based on all SLBs. *Post Envir SLB* defines the treatment dummy based on the issuance of SLBs with an Environmental KPI target. Standard errors are clustered at the firm-level. t-statistics are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Panel A: log(Absolute GHG Emissions)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post SLB	2.37***	1.20***	0.23	0.54***	0.03		
	(7.50)	(4.40)	(1.35)	(3.25)	(0.42)		
Post Envir SLB						0.55***	0.02
						(3.20)	(0.36)
Observations	24,755	23,014	23,014	23,014	22,093	23,014	22,093
R^2	0.025	0.253	0.613	0.641	0.978	0.641	0.978
Panel B: Y-o-Y % Absolute GHG Emissions							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post SLB	-0.02	-0.02	-0.03**	-0.02	-0.01		
	(-1.43)	(-1.51)	(-2.01)	(-1.17)	(-0.62)		
Post Envir SLB						-0.02	-0.01
						(-1.04)	(-0.57)
Observations	19,517	18,548	18,548	18,548	17,308	18,548	17,308
R^2	0.018	0.022	0.028	0.036	0.320	0.036	0.320
Controls	N	Y	Y	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y
Industry Fixed Effects	N	N	Y	Y	N	Y	N
Region Fixed Effects	N	N	N	Y	N	Y	N
Firm Fixed Effects	N	N	N	N	Y	N	Y

Table C.2: Real Effects of SLB Issuance (ESG Scores)

This table presents results from estimating the effects of issuing SLBs on ESG scores. We regress either the level or the % change in ESG scores on an indicator variable *Post SLB* that equals one in the years of and after SLB issuance and zero otherwise. Panel A (B) uses the level of (percentage change in) MSCI's environmental score. Panels C and D use MSCI's Absolute ESG score. In columns 1-5 we use all SLB issues to code the dummy *Post SLB*. The control group in these regressions are firms that did not, or did not yet issue SLBs. In columns 6 and 7 we calculate the treatment dummy *Post Envir SLB* using SLB issues with environmental KPIs only. Consequently, in columns 6 and 7 the control group also includes firms that issue SLBs with non-environmental KPIs. The regressions control for $log(Assets)$, ROA, $Tobin's\ q$, and $Leverage$. *Post SLB* is a dummy based on all SLBs. *Post Envir SLB* defines the treatment dummy based on the issuance of SLBs with an Environmental KPI target. Standard errors are clustered at the firm-level. t-statistics are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Env. Pillar Score							
Post SLB	1.21***	0.83***	0.84***	0.47**	0.19**		
	(4.87)	(3.47)	(3.77)	(2.18)	(1.97)		
Post Envir SLB						0.49**	0.21**
						(2.25)	(2.10)
Observations	40,105	37,051	37,051	37,051	35,317	37,051	35,317
R^2	0.004	0.056	0.146	0.181	0.904	0.181	0.904
Panel B: Y-o-Y Change in Env. Pillar Score	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post SLB	0.01	-0.02	-0.00	-0.03	-0.03		
	(0.37)	(-0.41)	(-0.08)	(-0.77)	(-0.44)		
Post Envir SLB						-0.03	-0.02
						(-0.62)	(-0.20)
Observations	29,878	28,099	28,099	28,099	26,958	28,099	26,958
R^2	0.004	0.008	0.012	0.014	0.213	0.014	0.213
Panel C: Absolute ESG Score	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post SLB	0.67***	0.54***	0.53***	0.23**	0.07		
	(5.71)	(4.58)	(4.69)	(2.19)	(1.06)		
Post Envir SLB						0.27**	0.07
						(2.52)	(1.00)
Observations	40,105	37,051	37,051	37,051	35,317	37,051	35,317
R^2	0.021	0.043	0.089	0.232	0.875	0.232	0.875
Panel B: Y-o-Y Change in Absolute ESG Score	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post SLB	0.03	0.02	0.02	0.01	0.01		
	(1.25)	(0.90)	(0.62)	(0.23)	(0.23)		
Post Envir SLB						0.01	0.02
						(0.25)	(0.45)
Observations	29,878	28,099	28,099	28,099	26,958	28,099	26,958
R^2	0.039	0.042	0.047	0.049	0.221	0.049	0.221
Controls	Y	Y	Y	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y
Industry Fixed Effects	N	N	Y	Y	N	Y	N
Region Fixed Effects	N	N	N	Y	N	Y	N
Firm Fixed Effects	N	N	N	N	Y	N	Y

Table C.3: Real Effects of SLB Issuance - Intensive Margin

In this table we estimate triple difference equations in which the treatment dummy *Post Envir SLB* is interacted with variables capturing whether the firm has issued multiple SLBS. *(Number of SLBs issued)* is the cumualtive number of SLBs issued and *(SLBs issued ¿ 1)* is a dummy idnetifying fdirms that have issued more than one SLB. The dependent variable is % change GHG Intensity and we use the same control variables as in Table 9 of the paper. t-statistics are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

	(1)	(2)	(3)	(4)
Post Envir SLB	-0.05**	-0.05*	-0.03	-0.03
	(-2.34)	(-1.74)	(-1.32)	(-1.02)
Number SLBs issued	0.00	0.00		
	(0.29)	(.)		
Post Envir SLB × Number SLBs issued	-0.01*	-0.01*		
	(-1.77)	(-1.84)		
SLBs issued > 1			0.01	0.00
			(0.63)	(.)
Post Envir SLB × SLBs issued > 1			-0.07*	-0.07
			(-1.85)	(-1.48)
Observations	18,714	17,476	18,714	17,476
R^2	0.019	0.256	0.019	0.256
Control variables	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Industry Fixed Effects	Y	N	Y	N
Region Fixed Effects	Y	N	Y	N
Firm Fixed Effects	N	Y	N	Y

Table C.4: Real Effects of SLB Issuance - The Role of Green Bond Issuance

In this table we estimate triple difference equations in which the treatment dummy *Post Envir SLB* is interacted with a variable capturing whether the firm has issued green bonds in the past *(Green Bond Issuer)* or the cumulative number of green bonds issued in the past *(Number GBs issued)*. The dependent variable is % change GHG Intensity and we use the same control variables as in Table 9 of the paper. *t*-statistics are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

	(1)	(2)	(3)	(4)
Post Envir SLB	-0.04*	-0.05*	-0.06***	-0.08***
	(-1.95)	(-1.69)	(-3.53)	(-3.05)
Green Bond Issuer	-0.00	0.00		
	(-0.73)	(.)		
Post Envir SLB × Green Bond Issuer	-0.06*	-0.05		
	(-1.73)	(-0.95)		
Number GBs issued			-0.00	0.00
			(-0.21)	(.)
Post Envir SLB × Number GBs issued			0.01	0.01**
			(0.56)	(2.03)
Observations	18,714	17,476	18,714	17,476
R^2	0.019	0.256	0.019	0.256
Control variables	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Industry Fixed Effects	Y	N	Y	N
Region Fixed Effects	Y	N	Y	N
Firm Fixed Effects	N	Y	N	Y

Table C.5: Real Effects of SLB Issuance - The Role of Geography

In this table we estimate triple difference equations in which the treatment dummy *Post Envir SLB* is interacted with dummy variables that identify the region in which the firms are headquartered. The dependent variable is % change GHG Intensity and we use the same control variables as in Table 9 of the paper. t-statistics are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

	(1)	(2)	(3)	(4)
Post Envir SLB	-0.07***	-0.06***	-0.07***	-0.06***
	(-2.61)	(-2.95)	(-3.59)	(-3.00)
Post Envir SLB × europe	0.02			
	(0.46)			
Post Envir SLB × asiaoceania		-0.03		
		(-0.61)		
Post Envir SLB × northamerica			0.03	
			(0.48)	
Post Envir SLB × southamerica				-0.06
				(-1.61)
Observations	20,895	20,895	20,895	20,895
R^2	0.021	0.021	0.021	0.021
Control variables	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Industry Fixed Effects	Y	Y	Y	Y
Region Fixed Effects	Y	Y	Y	Y
Firm Fixed Effects	N	N	N	N

Table C.6: Real effects - The role of Financial Variables

In this table we estimate triple difference equations in which the treatment dummy *Post Envir SLB* is interacted with several financial variables. Panel A contains pooled panel regressions with fixed effects. Panel B estimates firm-fixed effects models. The dependent variable is % change GHG Intensity and we use the same control variables as in Table 9 of the paper. t-statistics are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Panel A: No firm fixed effects

	(1)	(2)	(3)	(4)
Post Envir SLB	0.57***	-0.01	-0.09**	-0.12***
	(2.77)	(-0.47)	(-1.97)	(-2.92)
Post Envir SLB × $log(Assets)_{t-1}$	-0.04***			
	(-3.06)			
Post Envir SLB × ROA_{t-1}		-0.51**		
		(-2.08)		
Post Envir SLB × $Leverage_{t-1}$			0.08	
			(0.78)	
Post Envir SLB × Q_{t-1}				0.06
				(1.52)
Observations	18,714	18,714	18,714	18,714
R^2	0.019	0.019	0.019	0.019
Control variables	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Industry Fixed Effects	Y	Y	Y	Y
Region Fixed Effects	Y	Y	Y	Y
Firm Fixed Effects	N	N	N	N

Panel B: With firm fixed effects

	(1)	(2)	(3)	(4)
Post Envir SLB	0.29	0.02	-0.13*	-0.10**
	(0.81)	(0.54)	(-1.91)	(-2.23)
Post Envir SLB × $log(Assets)_{t-1}$	-0.02			
	(-0.99)			
Post Envir SLB × ROA_{t-1}		-0.89***		
		(-4.09)		
Post Envir SLB × $Leverage_{t-1}$			0.15	
			(0.95)	
Post Envir SLB × Q_{t-1}				0.03
				(0.90)
Observations	17,476	17,476	17,476	17,476
R^2	0.256	0.257	0.256	0.256
Control variables	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Industry Fixed Effects	N	N	N	N
Region Fixed Effects	N	N	N	N
Firm Fixed Effects	Y	Y	Y	Y