The Economics of Sustainability Linked Bonds

Finance Working Paper N° 820/2022
September 2022

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Keywords: ESG investing, sustainability linked bonds, security design, managerial incentives, mispricing

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The Economics of Sustainability-Linked Bonds

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Abstract

We develop a framework to understand the incentive structure and pricing of sustainability-linked bonds (SLBs). It provides conditions under which SLBs are incentive compatible for firms. We propose a novel mispricing measure for SLBs. Using the model and mispricing measure, we derive and test several empirical predictions. We show that overpriced SLBs experience negative returns in the secondary market after issuance. When firms issue overpriced SLBs, the stock price reaction at issuance is significantly positive, consistent with a wealth transfer from bond- to shareholders. Finally, we document a significant nonlinear relationship between the mispricing measure and firms' ESG ratings.

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1 Introduction

At the United Nations' COP 26 conference in Glasgow in 2021, global leaders convened and collaborated to reduce global GHG emissions and discuss a more effective implementation of the Paris Agreement. Although countries expressed a strong consensus to take climate action, there remains a large financing gap to meet the world's ambitious climate targets and to finance the energy transition. Similarly, achieving the ambitious social and governance objectives presented in the Sustainable Development Goals (SDGs)[1] will also require substantial financing that cannot be achieved solely via public funds. Thus, the private sector is an important actor in the effort to create a more sustainable global economy, and in this context, firms' debt financing tied to sustainability objectives plays an increasingly important role.

In 2013, corporate borrowers began to issue so-called green, social, and more generally sustainability-related bonds. With the emergence of these sustainability-related debt instruments, sustainable finance and the related security design have become a major trend in debt markets. The most commonly used sustainability-related fixed-income instruments are green bonds (Flammer 2021). These instruments allow firms to raise funds for specific and often predefined green and environmental projects. More recently, sustainability-linked bonds (SLBs) have begun to emerge as an attractive alternative. Indeed, SLBs do not bind the firm to use the collected money for specific investments only. In contrast, funds raised through the issuance of SLBs can be used a variety of 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, and SLBs are designed such that coupon penalty payments are due if a specific key performance indicator (KPI) target is not reached by the issuing firm at a predetermined date. Given the infancy of the SLB market, we know very little about the incentive compatibility of these novel debt instruments (i.e., do these bonds actually incentivize managers to achieve sustainability targets), their pricing in the primary bond market, their performance in

[1] See https://sdgs.un.org/

the secondary market, and finally the conditions under which SLB issues would allow genuinely motivated firms to signal their commitment to sustainability goals.

In this paper, we attempt to fill these gaps. We begin by providing a stylized conceptual framework in which these questions can be addressed. The one-period SLB pricing model that we develop allows us to focus on the following main questions: First, when are SLBs incentive compatible, that is, when can they induce firms to exercise costly effort to achieve their stated KPI targets at a predefined horizon? We show that this can be accomplished whenever the coupon penalty is large enough. Second, 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 mispricing. We call this measure the *mispricing level* and denote it (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 penalty is guaranteed. The lower bound is the theoretical bond price assuming that the KPI target is reached with certainty and, therefore, the penalty is not paid. It is a model-free relative mispricing measure that allows us 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 the measure plays a crucial role in determining SLB market pricing accuracy in the primary market.

In a second step, using both the model and the mispricing measure, we establish the following three empirical findings: First, when our pricing measure ML is strictly greater than one, SLB issues are overpriced. Such overpricing subsequently leads to a post-issuance decrease in their prices on the secondary market. The secondary market underperformance of overpriced SLBs is approximately one percent over a 30-day horizon. Second, when SLBs are overpriced, we also document a significant wealth transfer from the bondholders to the shareholders of the issuing firms. Specifically, in an event study setting conditional on SLBs being overpriced (i.e., $ML > 1$), we find that the larger ML

is, the more positive the stock price reaction on the issuance date of the bond. Third, we document a significant, though complex and nonlinear relationship between ML and the issuing firm's ESG ratings. The latter supports our conjecture that the probability of reaching the KPI and the investors' appetite and derived monetary benefit from the SLB's environmental impact both depend on the firm's ESG score.

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 without accounting for the conditional penalty. We question the standard industry practice that results in systematically documenting yield discounts.

Our paper contributes to the emerging literature on sustainability-related debt securities and more specifically on SLBs by providing the first conceptual framework that allows us to study the conditions under which these bonds create the right incentives for managers to exert effort to meet their sustainability KPIs 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. In the empirical part, we then show that approximately 20 % of these SLBs are overpriced at issuance (i.e., display $ML > 1$, which amounts to the issuance price being superior to the theoretical upper bound), which leads them to subsequently bear negative returns on the secondary market. We then document through an event study that the overpricing ultimately translates into a wealth transfer from the bond- to the shareholders of the firms issuing SLBs. Finally, our empirical analysis supports the model's prediction that the level of (ML) depends nonlinearly on the firm's ESG performance.

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 young SLB market. Section 4 depicts our theoretical model and its main testable predictions. Section 5 describes the data and the computation of our mispricing measure. In Section 6, we test our main implication from the model and discuss the main empirical analysis. Section 7 concludes the paper with a summary of our 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 (2016) 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. Baker, Bergstresser, Serafeim, and Wurgler (2018) use a simple asset pricing framework with nonpecuniary 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. The positive response is more pronounced for first-time issuers and green bonds that are externally certified. Furthermore, after issuance, she 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.

The recent and more comprehensive empirical study by Kölbel and Lambillon (2022) uses a bond matching technique initially developed to study the fair pricing of green bonds and documents for a large sample of 102 SLBs that issuers benefited from a sustainability price premium which is larger for callable bonds and for bonds that bear a higher coupon step-up. Specifically, they identify an average yield discount for their sample of -29.2 bps, which compares favorably with the average coupon step-up of 26.6 bps; thus, companies in their sample collect a net average benefit of 3.5 Mio USD. Given that some SLB issuers have higher yield savings than the potential coupon penalty, the authors argue that there is some degree of greenwashing prevailing in this new sustainable bond market segment.

The conceptual paper by Barbalau and Zeni (2021) 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)[2], 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."

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 SLBs.

Figure 1 about here.

In principle, SLBs can concern environmental, social, and governance targets. In practice, however, most SLBs are related to environmental targets. In Table 1, we tabulate the characteristics of the 434 SLBs that we can identify in Bloomberg as of February 2022.

Table 1 about here.

Panel A of Table 1 shows that the large majority of SLB issues address exclusively environmental issues (65%) or a combination of ESG (17%), EG (3%), or ES (1%) issues. Very few SLBs (less than one 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 (40 %). The second most common KPI used is the issuer's overall ESG

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

Score (14 %). When the KPI is related to the ESG score, a common design is that step-up is triggered by a general decrease in the company's overall ESG score. Note that there are also some SLBs for which Bloomberg does not identify a KPI (16 %). SLBs can have multiple sustainability targets, but the large majority of SLBs are single-target bonds.

As explained above, the payout structure of SLBs can change after issuance, depending on whether the relevant KPI is reached. The change in the payment structure is initiated by a predefined trigger event. Typically, this trigger event corresponds to the company failing to achieve the 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 C of Table 1). However, some SLBs include a coupon step-down option if the KPI is reached, but this structure is less common (only approximately 1.7 % 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.

By combining KPIs and SPTs, the materiality and ambitiousness of the company's sustainability objectives can be externally verified and quantified. Independent and external verifiers can issue a second party opinion before the bond is issued and certify that the SLB issue is aligned with the Sustainability-Linked Bonds Principles (SLBP). As Panel D of Table 1 shows, the majority of SLBs do not have a second party opinion (65 %). Some SLBs are callable. Panel E shows that approximately two-thirds of the SLBs are callable, with half of these bonds featuring a cleanup call [3] and the other half having a call structure different from a cleanup call.

[3] A cleanup call is a contractual call option that permits the issuer to repurchase or extinguish the bond before maturity if a relatively small amount of the original issue remains outstanding. Its often exercised by the issuer to reduce administrative expenses and limited three months before maturity.

3.2 Example: Enel SLB Issue October 2020

An illustrative example of an SLB with a common structure is the SLB 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 25bps 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.

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). 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 SLBP and in line with best practice. The KPI relevance and SPT ambition are assessed to be advanced (the highest category on the scale).

3.3 Market size and evolution

The SLB market has grown strongly since its inception. As Table 1 shows, Bloomberg identifies a total of 434 outstanding bonds flagged as 'Sustainability-Linked" as of February 2022. In contrast, in 2018 (as shown by Figures 2 and 3), there was only a 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 3 about here.

Figure 2 shows that the number of SLBs issued from 2018 to February 21, 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 3 shows that in 2021 SLBs worth $160 bn were issued, compared to only $16bn in 2020. The number of SLBs issued in the first two months of 2022 is already comparable to the total number issued in 2020, whereas the amount raised by these issues (approximately $19.32bn) already exceeds the total amount raised in 2020 by approximately 3 billion. Taken together, these figures demonstrate the rising popularity of these instruments.

SLB issuance is a global phenomenon. As Panel G of Table 1 illustrates, SLB issuers are located in all parts of the world. However, the large majority of issuers (in terms of number of bonds issued) are located in Europe (57%) and North America (28%). Regarding the economic sectors of the issuers, they pertain to industries and sectors that have a potentially material effect on the environment and thus exhibit the potential for sustainability improvements. For instance, firms belonging to the Industrials (22%) and Materials (19%) sectors are the most prominent SLB issuers in terms of number of bonds issued. Note also that there are a few SLBs issued by governments (1.38%).

3.4 Differences with respect to Green Bonds

SLBs are not the first type of sustainability-related fixed-income instrument. A prominent instrument are so-called green bonds (see 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. This gives a company more flexibility in how to use the money raised through SLBs relative to green bonds where proceeds are bound to a specific green project. 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 topics such as those related to governance or social outcomes. However, as we saw above, few SLB issues are actually related to nonenvironmental issues, suggesting that firms currently do not use this possibility.

In terms of market size, there are also important differences. Compared to the approximately 4,600 green bonds issued since 2013, 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.

4 The model

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

4.1 Fair pricing and incentives

We first develop an analysis of the valuation of SLBs. For that purpose, we propose 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 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 also applies by extension to social and governance KPIs.

We consider a one-period model. There is one firm with 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. 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 f to the manager. We can interpret the cost of effort to the manager, f, as actual infrastructure 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" exceeds the cost of exercising the environmental investment.[4] We show in the appendix 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 in the absence of the bond issue. It follows that the environmentally concerned investor is willing to participate in the bond offering).

[4]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.

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

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

and 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 infrastructure, and this is the case when the following condition holds*

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

W is then the amount directly transferred from the bond investors 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

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

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, which 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 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 have the following upper and lower 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 upper bound can be replicated using two different bond portfolios, and the lower bond is simply obtained via the price of a straight pure vanilla bond assuming the penalty is never reached. These quantities can also be computed using predefined yield curves, which can be specific to the issuer or associated with the industry, currency and credit rating.

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

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

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 and $ML = 0$ being a perceived guaranteed success. 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 set of empirical implications.

Empirical implication 1 *For a given SLB, $ML > 1$ indicates overpricing. It follows that bonds with $ML > 1$ at issue should subsequently significantly underperform on the secondary bond market.*

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

Empirical implication 2 *For a given SLB, $ML > 1$ indicates overpricing. It follows that if bonds are issued with $ML > 1$, stock prices should react more positively the higher ML is, reflecting the potential wealth transfer from bond- to shareholders.*

4.1.2 *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 s. This seems plausible, as a better ESG rated firm may be perceived as having greater potential and credibility to reach its KPI. Additionally, many institutional investors pursue investment strategies such as positive screening or ESG integration, which could explain the link between d and the firm's ESG rating. We therefore assume $\overline{p} = p(s)$ and $d = d(s)$. Using the SLB price given in Equation (1), we can write ML as follows:

$$ML = (1 - p(s)) + (p(s) - \underline{p})\frac{d(s)}{G}. \tag{3}$$

The relationship 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 abovementioned 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 analyze this relation in the empirical section, assuming different functional forms for $p(s)$ and $d(s)$.

Empirical implication 3 *Controlling for bond characteristics, we expect ML to be significantly related to the firm's ESG rating. Furthermore, Equation (3) implies that the relation among ML, ESG ratings, and the conditional penalty G is nonlinear.*

4.2 Signaling and the total cost of financing

SLBs can provide managers with a signaling mechanism. They can be used to reveal a firms' environmental concerns and in particular 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 cost of 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.

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 infrastructure) paid at time 0 to increase the probability of reaching the KPI.

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:

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

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 it 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 section Remark 1). This may happen when bondholders are willing to pay a great deal for environmental improvements. Such wealth transfers could be mitigated if f had to be disclosed upfront in the firm's issuance prospectus.

Figure 4 illustrates the situation for various levels of environmental benefit perceived by investors and effort cost to the manager.

Remark 2 *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 4 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 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:

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

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.

4.2.3 Cost of financing assuming KPI is reached

The financial industry's standard approach to quote the yield on an SLB does not account 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, $\hat{\pi}^e_{\text{ind}} < 0$.

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 $G > 0$. 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 infrastructure cost), a more correct measure of the cost of financing is given by $\hat{\pi}^e$, 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 5 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 $\overline{p} = 0.2$ and is hence inferior to 1. Figure 6 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 $\overline{p} < 1$.

Figure 5 about here.

Figure 6 about here.

Thus, to summarize, our conceptual framework allows us to characterize the situations when an SLB is incentive compatible for the firm, it further allows us to rely on a model-free measure ML that identifies the extent of potential mispricing and wealth transfers associated with an SLB at issuance (despite that managerial effort and investors' ESG preferences are unobservable), and finally it allows us to distinguish the proper market yield of such bonds from the standard yield quoted by the industry. This, in turn, allows us to demonstrate that the industry generally overstates the benefits of SLB issuance for firms. In the next section, we turn to the empirical validation of our model's main predictions.

5 Data and Computation of *ML*

In this section, we first describe our data and then detail the procedure followed to construct the mispricing measure ML.

5.1 Data description

We collect data from Bloomberg, Refinitiv, and corporate websites. We begin by extracting all bonds in the Bloomberg database labeled "sustainability-linked". As of February 2022, there were 434 issues on Bloomberg labeled as SLBs. The earliest issue date in our sample is on the 18^{th} of November 2018 and the latest is on the 10^{th} of February 2022.

In addition to the names of the issuing companies and the issuance dates of the SLBs, we collect ISINs, maturity dates, announcement dates, coupon rates, currency of the issue, and issue amount in USD for each bond. We use ISINs to match the bonds extracted from Bloomberg with the Refinitiv database. We also collect the note description[5] from Bloomberg, which provides important information about the coupon step-up option and step-up date of the SLB.

Furthermore, we exclude all bonds that have a callable feature that could affect their pricing[6]. We retain only bonds with a clean-up call option (where the bond can be called within the last three months before maturity) and make-whole callable features (as this call option comes with high cost for the company and is therefore unlikely to be used). Furthermore, we exclude all bonds that have a callable feature that could affect their pricing[7]. We retain only bonds with a clean-up call option (where the bond can be called within the last three months before maturity) and make-whole callable features (as this call option comes with high cost for the company and is therefore unlikely to be used).

We only work with bonds we can identify with their Bloomberg ISIN on Refinitiv and therefore verify the information on Bloomberg[8]. For the remaining bonds, we use the note descriptions on Bloomberg and Refinitiv to infer the coupon step-up (i.e., the penalty) and the step-up date. If the step-up date is not explicitly mentioned, we use the

[5]This is a data item in Bloomberg that provides a brief description of the most important details in the bond contract. Often, the description indicates the coupon step-up and step-up date as well as the KPI to be reached.

[6]Appendix A.2 derives the conditions under which the call feature of an SLB does not affect the effort decision by the manager.

[7]Appendix A.2 derives the conditions under which the call feature of an SLB does not affect the effort decision by the manager.

[8]We only retain bonds if the ISIN is displayed in Bloomberg. This is because only then can we can cross-check the characteristics in Refinitiv

coupon date following the observation date[9]. If there is no information on the coupon step-up and/or step-up date in either Refinitiv or Bloomberg, we collect the data from either the bond prospectus or the announcement on the companies' websites.

To assess the credit quality of the bond, we use the bond rating from Refinitiv. If there is no bond rating available on Refinitiv, we use the issuer rating. Finally, we collect the company's economic and business sector classification from Refinitiv. The overview of the data evolution can be found in the appendix.

In Table 2, we display summary statistics for the matched sample. We provide basic information on the SLBs and issuer information (e.g., ESG scores from Refinitiv).

In total, the final sample has approximately 180 SLBs. The average issuance price is 99.76, and the original yield to maturity as reported by Refinitiv is 2.86%. The average coupon is 2.9. It is paid 1.8 times per year on average, suggesting that a considerable number of bonds have semiannual coupon payments. The median rating of SLBs is BBB.

The average coupon step-up penalty is approximately 28bps, and the median step-up is 25bps. In fact, a large majority of companies uses a step-up of 25 bps given that the first quartile of the variable *Penalty* is also 25bps.

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 4.83 years, which represents on average approximately 59 % of the bond's time to maturity. The average time to maturity of the SLBs is 8.2 years.

A variable of interest in our analysis is the cumulative potential penalty. We calculate it as follows: $\textit{Total cum. penalty} = (T - \tau) \times G$, where G denotes the periodic penalty, T is the time to maturity, and τ is the time until the step-up date. On average, the cumulative potential penalty is 87bps.

Table 2 about here.

[9]The observation date is a date between the issuance date and step-up date and predefined in the bond prospectus. By this date, the company must have reached its target to prevent the coupon step-up. If the company fails to achieve the target on the observation date, the coupon step-up is triggered and realized on the following coupon payment date.

5.2 Computing *ML*

To construct ML, we need the issue price of the SLBs. We also need to price the portfolios of plain vanilla bonds that set the lower and upper bounds. We obtain the SLBs' issue price from Refinitiv.

Payment details

To construct the portfolios that set the upper and the lower pricing bounds, we need to calculate the cash flow profiles of the bond portfolios. We do so by using the issue date, the maturity date, the coupon rate, the coupon frequency, the penalty (e.g., coupon step-up), and the step-up date (i.e., the date on which the potential step-up is triggered). Combining issue and maturity dates, we calculate the maturity T in years. Relating maturity and step-up dates allows inferring τ, which is the time until the coupon is paid without the penalty and after which the step-up option can be activated.

Discount factor

To discount the cash flows of the bond portfolios, we use three different types of credit curves. We obtain the credit curve data from Refinitiv. Specifically, Refinitiv offers issuer-specific credit curves and curves that are based on currency, rating, and sector (economic or business). In this study, we refer to the business sector curve in Refinitiv as the subsector curve and to the economic sector curve in Refinitiv as the sector curve. Refinitiv uses a minimum of five bonds to calculate the curves.

Issuer curves can be retrieved with tenors of 1-10 years, 12 years, 15 years, 20 years, 25 years, and 30 years.

Sector curves cover tenor yields of 3 months, 6 months, 1-10 years, 12 years, 15 years, 20 years, 25 years, and 30 years.

For tenors for which no yield is given, we linearly interpolate between the two closest yields available. Furthermore, we interpolate annual yields to construct semiannual yields to price bonds with semiannual coupon payments. Bonds with quarterly coupon payments are treated as semiannual coupon paying. We use issuer, sector, and subsector credit curves.

UB and LB

The lower bound (LB) is the price of a bond with a fixed coupon equal to the SLB's original coupon, that is, without penalty. The lower bound corresponds to the lowest possible fair price of the SLB, when the probability of reaching the KPI is 1.

The upper bound (UB) is the price of a bond with a fixed coupon equal to the SLB's original coupon until the step-up date and SLB's original coupon plus the penalty from the step-up date until maturity. The upper bound corresponds to the highest possible fair price of the SLB when the probability of reaching the KPI is 0. The upper bound can be constructed as a portfolio of three bonds, as illustrated in Section 4.1.1.

Table 3 about here.

Table 3 reports summary statistics of the pricing-related variables (e.g., the bonds needed to construct the bounds). We also report descriptive statistics for UB, LB, and ML. These are the empirical counterparts to the theoretical objects (see also Section 4.1.2 for more information). To deal with extreme observations of ML, we drop observations that deviate from the median by more than five times the interquartile range. The median value of ML is -1.65, consistent with the notion that the median SLB is underpriced. This is consistent with a median issuance price of 99.91 (see Table 2). The number of observations is higher in this table because we price the bonds using (i) issuer, (ii) sector, and (iii) subsector curves. Hence, if an issuer curve is available, we can price the bond in three different ways and thus potentially have three pricing observations per bond. From Table 2, we see that approximately 21 percent of the bonds are overpriced ($ML > 1$) and 65 percent of the bonds are underpriced ($ML < 0$).

6 Empirical Analysis

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

Values of $ML > 1$ imply that the SLB is overpriced. Empirical implication 1 states that these overpriced bonds should therefore underperform post-issuance. Figure 7 shows secondary market returns for the SLBs during the first 30 days after issuance conditional on ML. We form two portfolios. The first is a portfolio of bonds for which $ML < 0$. The second portfolio contains bonds with $ML > 1$. We restrict the analysis to bonds that are priced using the sector-specific yield curves, as defined in Section 5.2, since this sample has the largest coverage. We calculate bond returns based on daily bid close prices.[10]

The graph plots the average cumulative returns for the two portfolios. Consistent with Empirical Implication 1, we find that overpriced bonds (i.e., bonds with $ML > 1$) exhibit negative cumulative returns of approximately one percent up to thirty days post issuance. In contrast, bonds with $ML < 0$ (i.e., underpriced bonds) do not exhibit post issuance cumulative returns that differ from zero.[11]

Figure 7 about here.

We now perform regression analysis in Table 4 to confirm that the differential post-issuance secondary market returns are driven by mispricing and not due to other observable or unobservable differences of these bonds. We regress the 30-day cumulative post-issuance returns of the bonds used to construct the two portfolios on a dummy variable indicating that ML >1. Standard errors are double clustered by issue date and issuer to reflect that bonds issued on the same day or by the same firm are not independent. Consistent with the graphical evidence in Figure 7, we find in Column (1) of

[10]We obtain similar results when using ask prices.
[11]We obtain almost identical patterns when defining the cutoff points for mispricing as $\{0.2, 1.2\}$ or $\{-0.2, 0.8\}$ instead of $\{0, 1\}$.

Table 4 that the coefficient on the dummy is negative and significant. 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). If anything, controlling for the credit rating strengthens the difference. In Column (3), we control for the original yield as reported by Refinitiv. In Columns (4)-(6), we control for coupon, penalty, and the issue price, respectively. In all these regressions, the dummy remains negative and significant. In Columns (7)-(8), we saturate the model further by simultaneously controlling for the previous control variables and successively adding year, currency, and industry fixed effects: the return difference between over- and underpriced bonds (i.e., the coefficient estimate for the dummy $ML > 1$) remains significant across these specifications. We observe an economically significant negative impact ranging from -1 to -1.4 percentage points depending on the specification. Thus, we can state that our first model implication is supported by these empirical results.

Table 4 about here.

6.2 Testing empirical implication 2: Wealth transfer from bondholders to shareholders

To test whether, consistent with Empirical Implication 2, overpriced SLB issuance results in wealth transfers between different types of investors, we conduct an event study using stock returns. For each firm issuing an SLB and for which stock returns are available, we calculate abnormal returns around the issuance date as the difference between the firm's stock return and the market index in the country in which the firm is headquartered. Following Flammer (2021), we calculate cumulative abnormal returns between five days prior to the issuance date and 10 days after. We split the sample into two groups, i.e., $ML < 0$ and $ML > 1$.

Table 5 about here.

For the two groups, we separately regress in Table 5 the cumulative abnormal returns on a constant and ML: see Column (2) for $ML < 0$ and Column (4) for ML >1. We also report the regressions for the full sample (Column 1) and $0 \leq ML \leq 1$ (Column 3). The analysis shows that abnormal returns are increasing in ML for the group of overpriced bonds (Column 4), consistent with overpriced SLBs resulting in wealth transfers from bondholders to shareholders. However, cumulative abnormal returns around the issuance date are not related to ML in the group of bonds for which $ML < 0$. In terms of economic magnitudes, the regression estimate in Column (4) of Table 5 implies an approximately 1.8-percentage-point higher CAR for an interquartile range increase in ML (conditional on $ML > 1$).

6.3 Empirical implication 3: *ML* and ESG score

6.3.1 Linear regression analysis

Another implication from the theoretical analysis in Section 4.1.2 is a potential relation between ML and a firm's ESG performance, as measured by its ESG rating. In Table 6, we explore this relation in an OLS regression framework. We regress ML on the issuer-level ESG score. We use all available pricing data (i.e., in case we have priced the same bond using issuer, sector and subsector credit curves, we would use three observations for this bond). To account for the resulting clustering at the SLB level, we cluster standard errors at the SLB level. In Panel A, we use the total ESG score. In Panels B-D, we use the E, S, and G component scores. We tend to find a positive relation between ML and a firm's ESG performance. This relation becomes stronger once we control for pricing effects by including fixed effects for the credit curve used to construct ML and other unobservable issuer- and bond-specific characteristics (e.g., the year, currency, or rating of the SLB issue) as well as the industry of the issuer. The relation between ML and the ESG scores is most pronounced when using the environmental component (Panel

B). The last finding seems plausible given that the large majority of the SLBs rely on environmental KPIs.

Table 6 about here.

6.3.2 Structural estimation

In Section 4.1.2, we establish how ML varies when both the probability of reaching the KPI and the monetary value d to the bondholders associated with the case in which $X_1 = g$ depend on the issuing firm's ESG score. In particular, Equation (3) highlights the nonlinear relation between ML, the ESG score, and the conditional penalty G. In this section, we estimate a nonlinear model with the following functional form assumptions. The private value of environmental improvement (d) is given by

$$d(\text{ESG}) = d_0 + \beta_0 \text{ESG} + \beta_1 \text{ESG}^2,$$

and the probability of reaching the KPI is given by

$$\overline{p}(\text{ESG}) = ESG^{\alpha}. \tag{5}$$

It follows that ML can be written as

$$ML = (1 - \text{ESG}^{\alpha}) + (\text{ESG}^{\alpha} - \underline{p}) \frac{d_0 + \beta_0 \text{ESG} + \beta_1 \text{ESG}^2}{G}.$$

The parameters to be estimated are $\Theta \in \left(\alpha, d_0, \beta_0, \beta_1, \underline{p}\right)$, and the observations are triplets (ML, ESG, G).[12] We estimate the model using a nonlinear least squares approach.

Table 7 about here.

[12]One observation with a coupon penalty close to 0 is removed from the sample; we hence focus on 112 observations instead of the 113 observations in the previous analysis.

The results are presented in Table 7. All model parameters are statistically significant, and the adjusted R-squared is 0.443. The dependence between the probability of reaching the KPI, as defined in Equation (5) and the ESG is positive and convex, with an estimated $\hat{\alpha} = 2.2795$. Moreover, the environmental benefit to investors, d, is significantly related to the ESG score, but the relation is indeed nonlinear with a positive coefficient $\hat{\beta}_0$ on the linear term and a negative coefficient $\hat{\beta}_1$ on the quadratic term. These last results support our third testable implication regarding the nonlinear relationship between ML and the firm's ESG rating.

Figure 7 about here.

7 Conclusion

This study develops 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. The conceptual framework allows us to characterize the situations in which the SLB is incentive compatible for the firm, that is, when the conditional coupon penalty is sufficiently large. Second, we propose a measure of mispricing (denoted by ML), which identifies the extent of over/underpricing and allows us to study wealth transfers associated with an SLB issuance (despite that the managerial effort to reach the KPI target and investors' ESG preferences and appetite for SLBs are unobservable). Finally, the conceptual framework enables us to compare the true market yield of SLBs with the standard yield quoted by the industry. The latter analysis allows us to conclude that the industry generally overstates the benefits (in terms of yield discount) for firms that issue SLBs. Our model also delivers several testable predictions, which we then take to the data by computing the ML 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 comparable yield curves. We first confirm that when ML exceeds one at issuance, overpricing occurs, which subsequently leads to falling SLB prices in the secondary bond market. We further show that for these overpriced bonds, which represent approximately one-quarter of our sample, the stock price reaction at issuance is significantly positive when **ML** is greater than one, which is consistent with a wealth transfer from the bond to the shareholders of these issuing firms. Finally, we document a significant relationship between ML and the bond-issuing firms' ESG ratings. As conjectured, the empirical relation between ML and ESG scores is complex and nonlinear and indicates the heterogeneity and complexity of the pricing patterns observed in this new bond market segment.

Our study contains several policy implications. First, one should require greater transparency in the bond prospectus and certification process by requiring 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. 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, sustainable finance literacy is needed to prevent the overpricing of these issues, which ultimately benefits the shareholders of the issuing firms. To achieve that 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 [13] [14] [15] as our ML measure could be a simple conceptually relevant tool to get to the core of the efficient pricing mechanism of these

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

[14] 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.

[15] 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. https://www.ifre.com/story/2908666/enel-speeds-transition-with-jumbo-slb-b6xb6tmvml

bonds while accounting for their expected penalty component.

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Figures

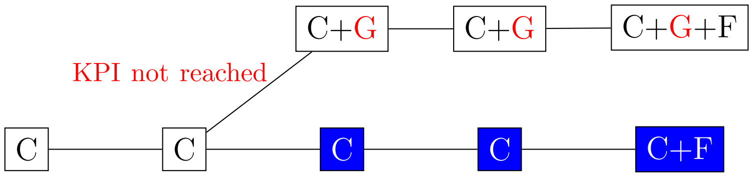

Figure 1: SLB payment structure

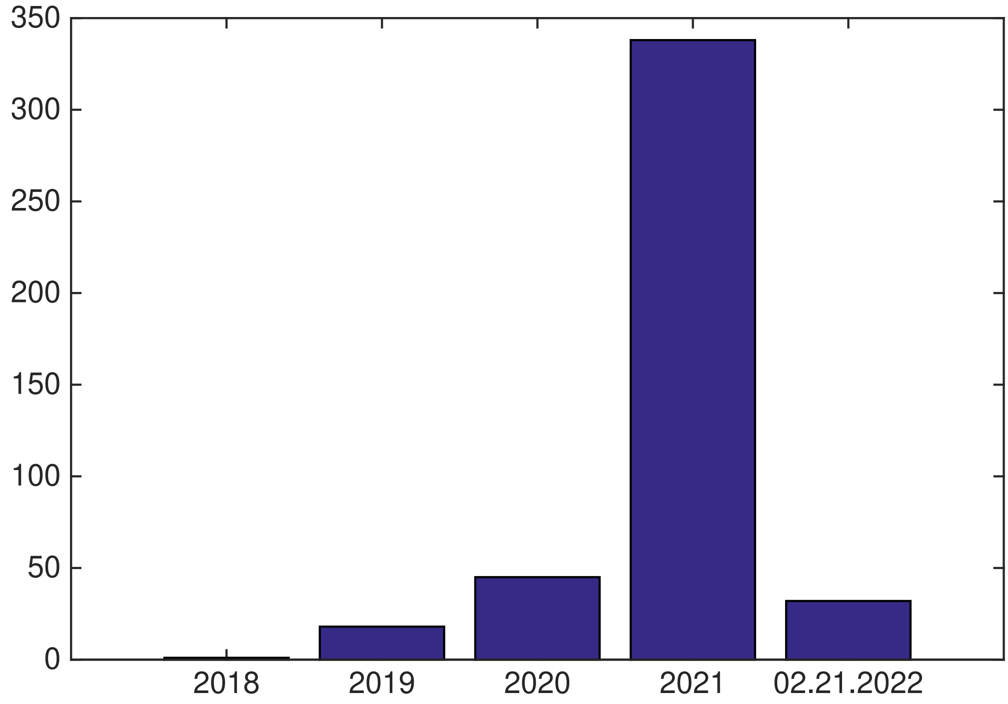

Figure 2: Number of SLB issues

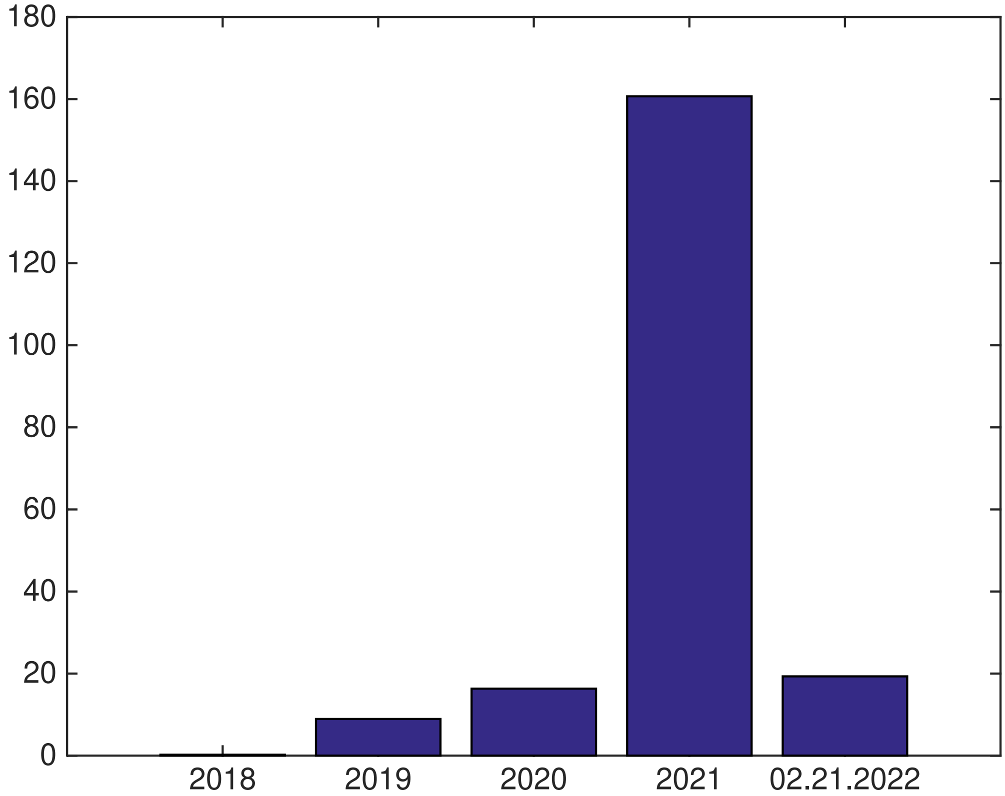

Figure 3: USD amount of SLBs issued (in billions of USD)

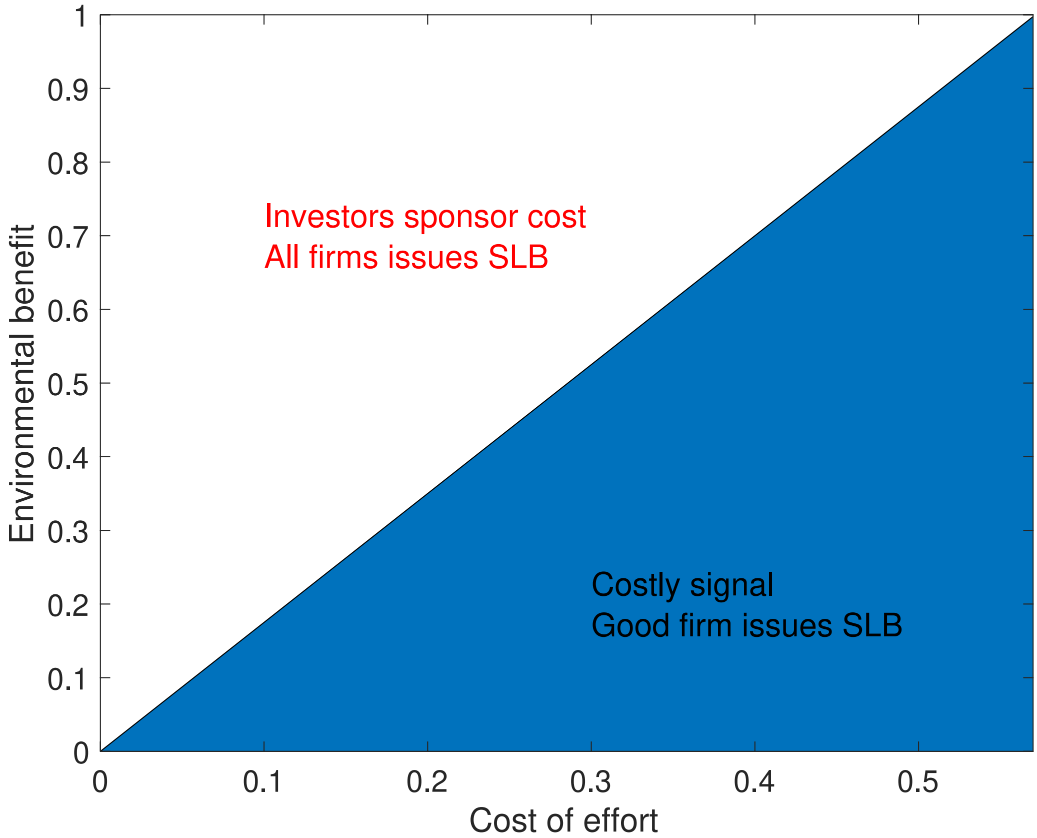

Figure 4: Separating and pooling regions for different levels of environmental benefit perceived by investors and effort cost to the manager. $\overline{p} = 0.8$, $\underline{p} = 0.2$ and $R = 0.05$.

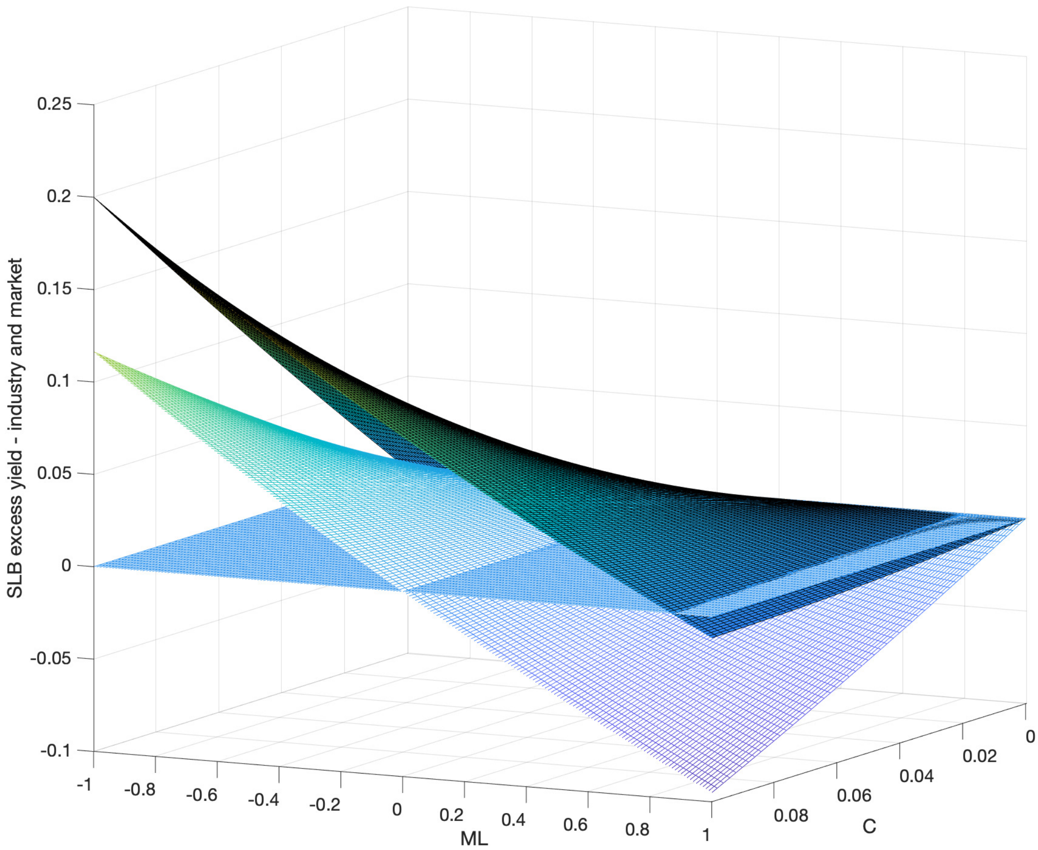

Figure 5: Excess yields from *industry* standard and perceived by the market as a function of ML and penalty C. We assume that $R = 0.05$, $F = 1$ and $\overline{p} = 0.2$.

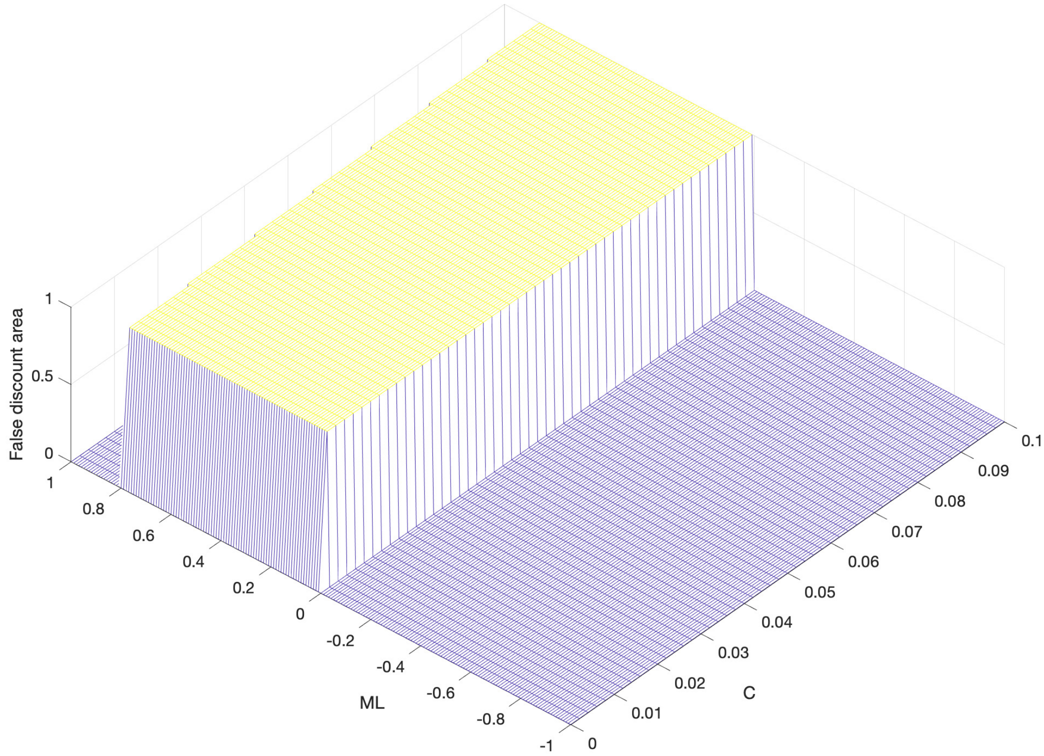

Figure 6: Indicator of a false discount as a function of ML and penalty C. We assume that $R = 0.05$, $F = 1$ and $\overline{p} = 0.2$.

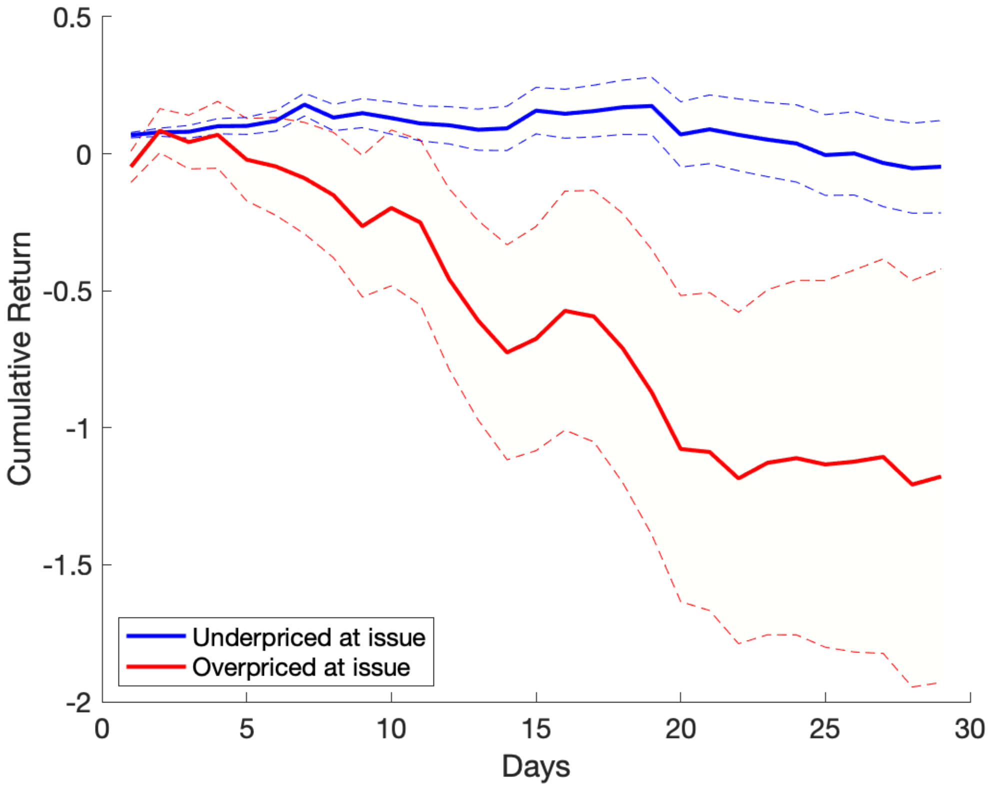

Figure 7: Bond returns 30 days after issuance date for bonds with $ML < 0$ in blue and $ML > 1$ in red. The Shaded areas represent 95 % confidence interval. Units are in percentage.

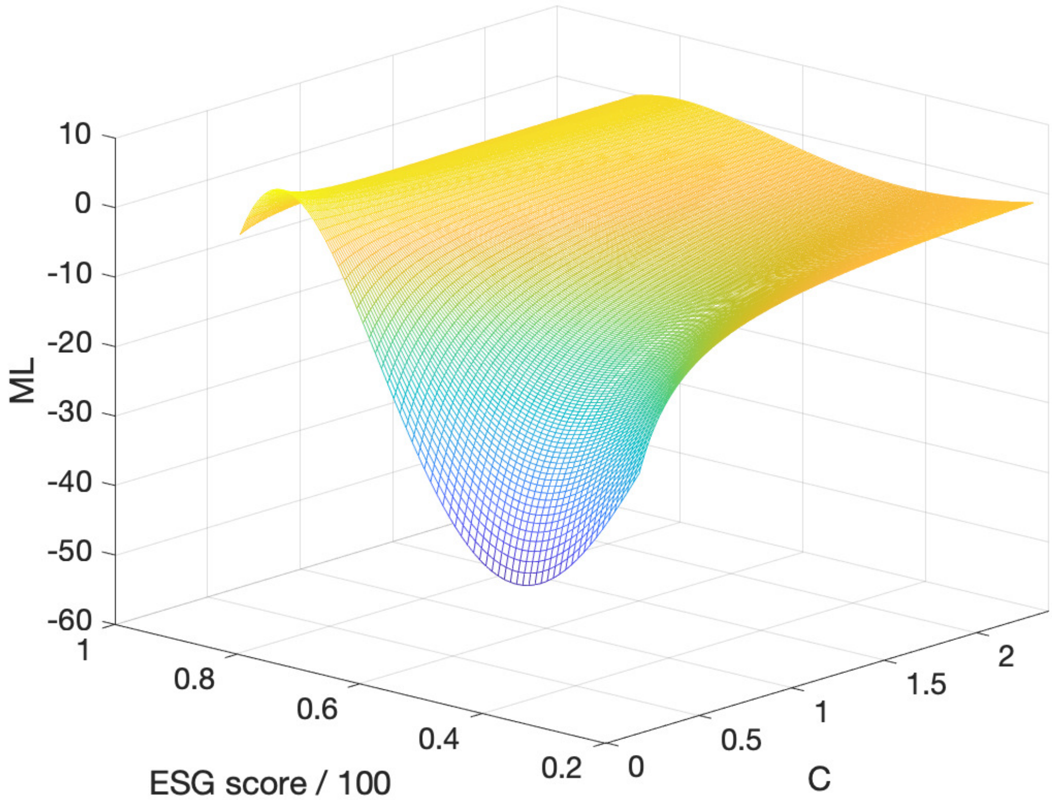

Figure 8: Nonlinear fitted model $ML = (1 - \text{nESG}^{\alpha}) + (\text{nESG}^{\alpha} - \underline{p})\frac{d_0 + \beta_0 \text{nESG} + \beta_1 \text{nESG}^2}{C}$, where $\text{nESG} = \text{ESG}/100$ and $\underline{p} = 0$.

Tables

Table 1: SLB Characteristics

In this table, we tabulate the characteristics of all SLBs that we can identify in Bloomberg as of February 2022. In each panel, we use the maximum number of observations N for the given characteristic.

Panel A: Sustainability Target Theme		
N=434	Percentage	Count
E	64.52%	280
G	0.46%	2
S	0.46%	2
ESG	16.59%	72
ES	1.15%	5
SG	0.00%	0
EG	2.53%	11
No description	14.29%	62
Total	100.00%	434

Panel B: Single KPI items (several per bond)		
N = 551	Percentage	Count
Greenhouse gas emissions	40.11%	221
Other (not specified)	15.97%	88
ESG Score	13.61%	75
Renewable Energy	10.16%	56
Energy efficiency	6.35%	35
Water consumption	4.90%	27
Gender Equality	2.36%	13
Circular economy	2.00%	11
Biodiversity	1.45%	8
Transport	1.09%	6
Labor	0.91%	5
Sustainable farming and food	0.91%	5
Affordable housing	0.18%	1
Total	100.00%	551

Panel C: Penalty structure		
N= 292	Percentage	Count
Step-up	94.86%	277
Step-down	1.71%	5
Carbon offset	1.71%	5
Charity	1.71%	5
Total	100.00%	292

Panel D: Second Party Opinion		
N= 304	Percentage	Count
Yes	34.87%	106
No	65.13%	198
Total	100.00%	304

Panel E: Type of call option		
N= 303	Percentage	Count
Other callable	32.01%	97
Clean up call	37.29%	113
Not callable	30.69%	93
Total	100.00%	303

Panel F: Economic Sectors		
N=434	Percentage	Count
Materials	19.35%	84
Financials	7.83%	34
Communications	3.46%	15
Industrials	21.66%	94
Utilities	14.75%	64
Government	1.38%	6
Consumer Staples	10.14%	44
Energy	4.15%	18
Health Care	2.53%	11
Consumer Discretionary	12.44%	54
Technology	2.30%	10
Total	100.00%	434

Panel G: Issuer location		
N=434	Percentage	Count
Europe	56.91%	247
South America	0.92%	4
North America	27.88%	121
Asia	11.75%	51
Rest of World	2.53%	11
Total	100.00%	434

Table 2: Summary Statistics

Issuance price is the issuance price obtained from Refinitiv. Original yield is the yield to maturity reported by Refinitiv at issuance. *ratingN* is the credit rating transformed into numerical values (e.g., AAA=1, AA=2, A=3). IssueAmounUSD is the issue amount obtained from Bloomberg in millions of USD. Penalty is the coupon-step up penalty. τ is the time between the issuance date and step-up date in years. T is the time to maturity of the bond. ScondOp is a dummy variable if the SLB is verified by a third party. Target Ambition is a variable that captures whether the KPI target is ambitious. KPI Relevance captures whether the KPI is financially material for the issuer. ECB is an indicator variable if the bond is eligible for the ECB bond purchase program. These variables are collected from the bond issuance documentation. ESG scores and their component parts come from Refinitiv.

	count	mean	sd	min	p1	p5	p25	p50	p75	p95	p99	max
Issuance Price	180	99.76	0.87	98.06	98.45	98.72	99.44	99.91	100.00	100.00	105.51	107.75
OriginalYield	162	2.86	1.87	0.06	0.08	0.40	1.08	2.73	4.13	5.63	9.50	9.50
Coupon	184	2.92	1.84	0.00	0.00	0.38	1.31	2.88	4.13	5.63	9.50	9.50
Coupon Frequency	184	1.80	0.75	0.00	1.00	1.00	1.00	2.00	2.00	4.00	4.00	4.00
ratingN	180	4.28	1.27	1.00	1.00	2.00	3.00	4.00	5.00	6.00	8.00	8.00
IssueAmountUSD	184	609.83	338.15	1.67	1.80	31.51	389.84	500.22	787.96	1,249.89	1,530.00	1,852.65
Penalty (G)	179	0.28	0.18	0.03	0.03	0.10	0.25	0.25	0.25	0.75	0.75	1.50
τ	184	4.83	2.47	0.59	0.59	1.65	3.05	4.55	5.65	9.87	11.79	12.39
T	184	8.20	3.14	2.01	3.00	4.67	5.53	7.29	10.01	15.01	20.01	20.01
τ/T	184	0.59	0.21	0.12	0.15	0.25	0.45	0.59	0.72	0.97	1.02	1.02
Total cum. penalty = $(T-\tau)\times G$	179	0.87	0.58	0.00	0.00	0.08	0.42	0.77	1.19	2.00	2.72	2.76
SecondOp	184	0.40	0.49	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Target Ambition	34	3.57	0.49	3.00	3.00	3.00	3.00	4.00	4.00	4.00	4.00	4.00
KPI Relevance	37	3.45	0.81	2.00	2.00	2.00	3.00	4.00	4.00	4.00	4.00	4.00
ECB	184	0.22	0.42	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00
ESG Score	67	69.48	11.50	22.31	22.31	50.04	65.64	71.07	76.49	86.44	88.09	88.09
Social Pillar Score	67	74.04	14.89	12.24	12.24	53.72	63.87	75.08	86.59	91.92	92.83	92.83
Governance Pillar Score	67	63.74	19.22	22.24	22.24	24.10	54.41	65.17	81.07	89.01	99.08	99.08
Environmental Pillar Score	67	68.52	15.82	28.59	28.59	39.15	61.12	69.12	81.21	93.14	95.60	95.60

Table 3: Summary Statistics: Bond Pricing Related Variables

This table shows descriptive statistics of the prices for the bonds used to construct ML. The table pools bond prices obtained from using issuer, sector, and subsector curves.

	count	mean	sd	min	p1	p5	p25	p50	p75	p95	p99	max
B(F,C+G,T)	271	106.18	9.22	90.52	92.73	96.63	100.74	103.04	109.63	124.26	140.28	150.94
B(F,G,τ)	271	95.03	5.67	79.28	81.03	83.18	91.22	96.38	99.62	101.06	101.79	102.64
B(F,0,τ)	271	93.70	6.13	76.44	77.24	80.59	89.90	95.79	98.68	100.45	100.58	101.06
LB = B(F,C,T)	271	104.08	9.15	89.69	90.73	94.82	98.98	100.81	107.01	121.62	138.30	148.97
UB	271	104.85	9.19	89.96	92.38	95.71	99.79	101.80	107.78	122.62	139.28	149.94
ML	271	-7.34	15.53	-53.76	-50.93	-44.33	-10.53	-1.65	0.59	6.58	27.02	38.02
$ML > 1$	271	0.21	0.41	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00
$ML < 0$	271	0.65	0.48	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00

Table 4: 30-day Post-Issuance Performance on Secondary Market (Bond Event Study)
$ML > 1$ is an indicator that identifies overpriced bonds. The variable *ratingN* takes on lower values for better credit ratings. We use bond ratings, and if unavailable, issuer credit ratings. Original yield is the yield as reported in Refinitiv. Coupon, penalty, and issue price are taken Refinitiv, Bloomberg, or the issuer website. Industry fixed effects are defined according to Refinitiv's Business Classifications (TRBC). Standard errors are double clustered at the issuer and issue date level. t–statistics in parentheses. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

	(1) CumRet30	(2) CumRet30	(3) CumRet30	(4) CumRet30	(5) CumRet30	(6) CumRet30	(7) CumRet30	(8) CumRet30	(9) CumRet30
$ML > 1$	-1.115**	-1.369***	-1.476***	-1.383***	-1.137**	-1.096**	-1.318**	-1.029*	-1.442**
	(-2.33)	(-3.06)	(-3.26)	(-3.19)	(-2.41)	(-2.25)	(-2.22)	(-1.84)	(-2.17)
ratingN		-0.386**					-0.042	-0.387	-0.365
		(-2.02)					(-0.14)	(-1.11)	(-1.07)
Original yield			-0.342*				0.222	-0.037	-0.122
			(-1.80)				(0.26)	(-0.03)	(-0.11)
Coupon				-0.317*			-0.604	-0.036	-0.012
				(-1.72)			(-0.67)	(-0.03)	(-0.01)
Penalty					-0.622		-0.683	-0.436	-0.216
					(-0.52)		(-0.50)	(-0.35)	(-0.18)
IssuePrice						0.122	0.140	0.073	0.074
						(0.32)	(0.45)	(0.22)	(0.19)
Observations	140	140	128	140	140	140	128	127	126
R^2	0.040	0.079	0.096	0.088	0.042	0.041	0.238	0.289	0.331
Year FE	N	N	N	N	N	N	Y	Y	Y
Currency FE	N	N	N	N	N	N	N	Y	Y
Industry FE	N	N	N	N	N	N	N	N	Y

Table 5: Equity Event Study Around Issue Date

Abnormal returns are market adjusted and calculated by subtracting the market index return from the SLB issuing firm's stock return. Standard errors are clustered at the issue date level. t–statistics in parentheses. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

	Whole Sample	$ML < 0$	$0 \leq ML \leq 1$	$ML > 1$
	(1) car(5,10)	(2) car(5,10)	(3) car(5,10)	(4) car(5,10)
ML	0.018	0.088	6.145	0.285***
	(0.24)	(1.02)	(1.58)	(4.46)
Constant	1.558*	3.861**	-5.396*	-2.408**
	(1.74)	(2.55)	(-2.30)	(-2.12)
Observations	103	62	13	28
R^2	0.001	0.022	0.266	0.348

Table 6: ML and Issuer ESG Performance

This table shows regressions relating ML to ESG scores. In Panel A, we use the overall ESG score from Refinitiv as the independent variable. Panels B-D use the E,S, and G component scores. Standard errors are clustered at the SLB linked bond level. t–statistics in parentheses. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Panel A: Total ESG Score						
	(1) ML	(2) ML	(3) ML	(4) ML	(5) ML	(6) ML
ESG Score	0.426*	0.421*	0.435*	0.673***	0.458**	0.606***
	(1.92)	(1.95)	(1.85)	(2.88)	(2.52)	(3.95)
Observations	113	113	113	113	113	112
Bonds	62	62	62	62	62	61
R^2	0.158	0.175	0.185	0.336	0.439	0.520
Panel B: Environmental Pillar Score						
	(1) ML	(2) ML	(3) ML	(4) ML	(5) ML	(6) ML
Environmental Pillar Score	0.257**	0.244**	0.250**	0.272**	0.267**	0.410***
	(2.36)	(2.27)	(2.24)	(2.22)	(2.60)	(3.77)
Observations	113	113	113	113	113	112
Bonds	62	62	62	62	62	61
R^2	0.113	0.121	0.133	0.205	0.425	0.522
Panel C: Social Pillar Score						
	(1) ML	(2) ML	(3) ML	(4) ML	(5) ML	(6) ML
Social Pillar Score	0.173	0.174	0.163	0.322**	0.308**	0.362**
	(1.52)	(1.63)	(1.52)	(2.10)	(2.20)	(2.58)
Observations	113	113	113	113	113	112
Bonds	62	62	62	62	62	61
R^2	0.042	0.065	0.073	0.201	0.414	0.468
Panel D: Governance Pillar Score						
	(1) ML	(2) ML	(3) ML	(4) ML	(5) ML	(6) ML
Governance Pillar Score	0.185*	0.189*	0.188*	0.219*	0.089	0.110
	(1.89)	(1.94)	(1.92)	(1.97)	(1.12)	(1.16)
Observations	113	113	113	113	113	112
Bonds	62	62	62	62	62	61
R^2	0.082	0.108	0.120	0.209	0.376	0.425
Curve FE	N	Y	Y	Y	Y	Y
Year FE	N	N	Y	Y	Y	Y
Currency FE	N	N	N	Y	Y	Y
Industry FE	N	N	N	N	Y	Y
Rating FE	N	N	N	N	N	Y

Table 7: Nonlinear Least Squares

This table presents the estimates of the model:

$$ML = (1 - \text{nESG}^{\alpha}) + (\text{nESG}^{\alpha} - \underline{p})\frac{d_0 + \beta_0 \text{nESG} + \beta_1 \text{nESG}^2}{G}.$$

The model is estimated using nonlinear least squares.

Parameter		Estimate	HAC SE	t-statistic	p-value
α		2.2795	0.54718	4.166	6.27E-05
d_0		-373.8	157.14	-2.3787	0.01913
β_0		937.6	405.41	2.3127	0.022633
β_1		-585.11	260.62	-2.2451	0.026799
N	112				
R2	0.458				
AdjR2	0.443				
F-stat	27.5				

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.

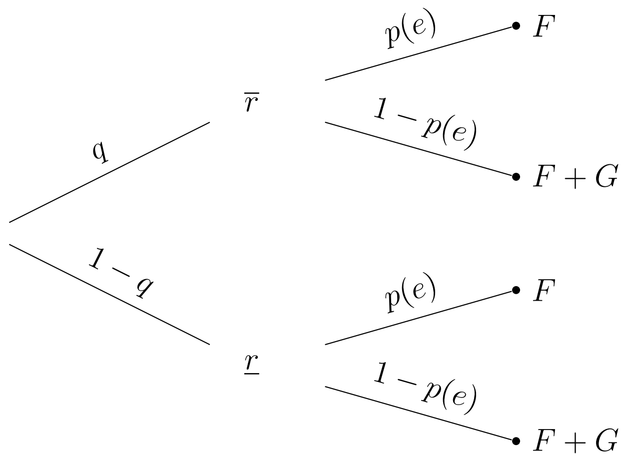

Figure 9: Two-period Model Description.

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

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

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