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Who Pays for Sustainability? An Analysis of Sustainability-Linked Bonds

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Abstract

We examine the novel phenomenon of sustainability-linked bonds (SLBs). These bonds' coupon is contingent on the issuer achieving a predetermined sustainability performance target. We estimate the yield differential between SLBs and non-sustainable counterfactuals by matching bonds from the same issuer. Our results suggest that issuing an SLB yields an average premium of -9 basis points on the yield at issue compared to a conventional bond, although this premium decreased over time. On average, the savings from this reduction in the cost of debt exceed the maximum potential penalty that issuers need to pay in case of failure of the sustainability performance target. This suggests that SLB issuers can benefit from a 'free lunch', i.e. a financial benefit despite not reaching the target. Investigating the drivers of the premium, we show that there is no clear empirical relationship between the yield at issue and the coupon step-up agreement of SLBs. Instead, an issuer's first SLB seems to command a significantly larger premium, suggesting that especially the first SLB is seen by investors as a credible signal of a company's commitment to sustainability.

Keywords : Sustainable investing, ESG, sustainability-linked bonds, corporate bonds, cost of debt

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1 Introduction

As companies worldwide pledge to achieve net-zero emissions and other sustainability targets, a fundamental question arises: who pays for this shift to sustainability? A recent development in the field of corporate finance is the issuance of sustainability-linked bonds (SLBs).[1] The key characteristic of SLBs is that the coupon rate is contingent on the issuer's achievement of a sustainability performance objective. This sustainability performance target and the associated coupon step-up or step-down is contractually agreed upon in the bond prospectus. For example, in November 2020, the European cement company Holcim Group issued a EUR 850 million SLB with a coupon of 50 basis points (bps) maturing in 2031. This coupon will increase by 75 bps, if the company fails to achieve its sustainability target of 475 kg net CO_2 per ton of cementitious material by 2030 (Holcim, 2020).

SLBs are emerging as a major sustainable capital financing instrument for corporations. While the volume of SLBs is still relatively small, it has been growing strongly. The first SLB was issued in December 2018. Since then, the value of outstanding SLBs has grown to over USD 193.1 billion (as of June 2022). SLBs are distinct from green bonds, which have been studied in the literature. Green bonds have a "use of proceeds" clause stating that the financing will be used for green corporate investments. SLBs do not determine the use of proceeds, the financing can be used for general corporate purposes. Instead, they create a financial incentive for issuers to achieve the specified sustainability target.

In this paper, we try to understand who pays for the sustainability improvement when an SLB is issued. To address this question, we analyze how SLBs are priced at issue in comparison to their non-sustainable counterpart and investigate how the sustainability target agreement affects the issuance price. A priori, one might expect that investors use SLBs to incentivize

[1] SLBs are publicly listed bonds. There also exist sustainability-linked loans (SLLs) which are mostly non-listed loans provided by banks or other financial institutions. While the mechanism is identical for SLLs, the market dynamics and implications may vary.

issuers to improve their sustainability performance. In this case, an SLB that specifies a coupon step-up for failing to reach the sustainability target should have a lower yield at issue compared to a conventional bond. However, it is also possible that companies use SLBs to signal that they are serious about reaching a sustainability target. In this case, an SLB with a coupon step-up could trade in line with conventional bonds.

Our paper addresses this question empirically in a three-step approach. First, we analyze whether SLBs are priced at a premium compared with a non-sustainable counterfactual bond. To this end, we match SLBs to a counterfactual bond from the same issuer and with the same seniority, maturity type, coupon type, and currency. We match to the bond with the closest issue date, bond maturity, and issue size. This matching results in 145 bond pairs, relying on all SLBs issued up until June 2022. Second, we perform a cost-benefit analysis from the perspective of the issuer, comparing the savings at issue to the potential penalty that firms pay in the event of failing to reach the target. Third, we investigate which factors drive the magnitude of the premium at issue.

We obtain three main findings. First, we provide evidence that there is a sustainability premium at issue for the SLBs in our sample. The unconditional yield differential between SLBs and counterfactuals at issue is on average -9 bps and not statistically significant. Yet, when controlling for differences in credit risk and interest rates between the matched bonds, we estimate a statistically significant premium of -21.5 bps. We also find that the premium varies over time: while there was a statistically significant unconditional premium for SLB issues of -31 bps in 2021, there has not been a significant premium in 2022. This may be due to the more volatile market environment in the aftermath of the Ukraine invasion and rising inflation and interest rates.

Second, our cost-benefit analysis suggests that the average SLB issue creates savings of USD 7.1 million for the issuer compared to a conventional bond issue. The average penalty for failing to reach the target amounts to USD 4.1 million. This result suggests that SLB issuers in our sample benefit on average from a ’free lunch’ of USD 3 million, regardless of sustainability target achievement.

Third, we find that the magnitude of the potential penalty is not a driver of an SLB’s premium at issue, as there is no statistically significant relationship between the time-weighted step-up and the SLB premium. This suggests that the value of the option that is embedded in SLBs is not a first-order influence on the pricing of SLBs. Instead, we find that the first SLB issue commands a significantly greater premium compared to subsequent SLBs by the same issuer. Other factors, such as the issuer’s ESG profile and the nature of the target have no significant effect.

Our interpretation is that SLBs serve as a signaling device for issuers, but that indiscriminate investor demand for SLBs drives the pricing. SLBs allow issuers to signal a credible commitment to achieving a certain sustainability target. This signal is costly, since firms need to either bear the cost of realizing the target, or pay a penalty when they do not reach the target. How costly (and thus credible) the signal is exactly is very difficult to determine for outsiders because of information asymmetry on the cost of achieving the sustainability target. Nonetheless, an SLB target is more credible than a mere pledge to pursue a sustainability target, because it is specified in a contract, includes a penalty, and invites scrutiny from outsiders. We believe it is this qualitative signal, rather than the details of the financial structure, that generates demand from ESG investors for SLBs and drives down yields at issue. This would explain why the premium for SLBs is stronger for the first SLB issue and results in a ’free lunch’ when compared to the potential penalty agreed in the SLB.

Our paper is related to the literature on sustainable fixed income securities. Several empirical studies have analyzed green bonds and the existence of a ‘greenium’ (green bond premium) comparing the pricing of green and non-green bonds, with mixed evidence (Ehlers and Packer, 2017; Baker, Bergstresser, Serafeim, and Wurgler, 2018; Hachenberg and Schiereck, 2018; Karpf and Mandel, 2018; Zerbib, 2019; Larcker and Watts, 2020; Flammer, 2021; Tang and Zhang, 2020). Some research highlights that green bonds sell for a moderate premium, meaning that companies benefit from lower cost of capital on green bonds, while more recent papers based on tighter matching procedures find no such greenium, and suggest that firms may issue green bonds even if it is costly to signal their commitment to sustainability (Larcker and Watts, 2020; Flammer, 2021).

Recently, a literature on sustainability-linked bonds emerged. Berrada, Engelhardt, Gibson, and Krüger (2022) offer a theoretical model of incentive compatibility for SLBs.[2] They emphasize the conditions under which an SLB contract is incentive compatible. We take a more empirical approach in our paper, covering a larger sample of existing SLBs. Furthermore, Barbalau and Zeni (2021) model how the choice between issuing an SLB versus a green bond depends on how much firms can manipulate the contracted outcomes. Pohl, Schüler, and Schiereck (2022) analyze the pricing dynamics of sustainability-linked loans. In addition, there are several papers providing commentary on the SLB concept or case studies of individual SLBs (e.g. Liberadzki, Jaworski, and Liberadzki, 2021).

Our findings have important implications for the SLB market. First, due to the existence of a sustainability premium, issuers can benefit from a lower cost of capital by issuing SLBs. It is unclear, however, whether this premium will exist in the future, given the market dynamics observed in 2022. Second, given that the average penalty associated with failing to reach a target is relatively small and in many cases smaller than the savings in the cost of debt, companies could issue SLBs purely for financial reasons without the intention to reach the target. Finally, if demand for the category of SLBs is driving the pricing, rather than an assessment of the contractual details, it may be necessary to specify minimum requirements for a bond to qualify as an SLB to avoid that SLBs are used as a greenwashing tool. This concerns in particular the ambitiousness of the target and the size of the penalty.

[2] There is also a more practitioner-oriented approach to value SLBs using option pricing by Mielnik and Erlandsson (2022)

2 Sustainability-Linked Bonds

As defined by the Sustainability-Linked Bond Principles (ICMA, 2020), an SLB is any type of bond instrument which incentivizes the issuer's achievement of predetermined sustainability performance objectives. The financial and/or structural characteristics of the bond can vary depending on the achievement of these objectives. Predefined sustainability performance targets (SPTs) are set for these objectives, measured using predefined key performance indicators (KPIs) and usually externally verified by an independent third party. These KPIs may include external ratings (ESG ratings) or metrics, a company's GHG emissions, or the number of female board members, for example. SLBs are fundamentally different from green bonds, as there is no 'use of proceeds' clause for the categorization of SLBs, and the funds are used for general corporate purposes in most cases.[3] The purpose of SLBs is therefore not the specific use of proceeds, but rather to improve the issuer's sustainability profile by aligning bond terms to the achievement of predetermined SPTs. The Sustainability-Linked Bond Principles (ICMA, 2020) further encourage issuers to select ambitious SPTs, and KPIs that are measurable and transparently defined. Furthermore, issuers should disclose the relevant information and appoint an external review to confirm the bond's alignment with the Sustainability-Linked Bond Principles (ICMA, 2020). The sustainability KPIs are thus included in the bond structuring documentation, tested on a regular basis, and used for coupon redetermination over the life of the SLB. The coupon adjustment typically works as follows: If the company fails to achieve the predetermined criteria, then the coupon increases by 25 bps. The SLB may in some cases be tied to several SPTs, and thus have several coupon step-ups (e.g. 5 bps per SPT). As described in Section 3, the typical coupon step-up is 25 bps, but can be lower or higher for certain firms. In some cases, the coupon may also decrease by 25 bps in case of KPI attainment. Figure 1 below illustrates the typical mechanism

[3] Note that in some instances a bond may be structured as both a green bond (aligned with the Green Bond Principles) and a sustainability-linked bond (ICMA, 2020).

of an SLB. The coupon step-down in Figure 1 is represented as a light-grey dashed line, since the most common case is to only include a penalty for failing to achieve the SPT (see Section 3).

Thus, SLBs can have impact through two channels. First, SLBs create a clear financial incentive for firms to address their sustainability. If the firm does not meet the SPT, it leaves money on the table. Thus, unless the SPTs would have been reached anyways, SLBs give companies an incentive to change. Second, SLB issuers must commit to explicit sustainability goals, for which they will be held accountable and financially liable in the future. SLBs could therefore constitute a public commitment to sustainability that is costly to walk back beyond the financial penalty for reputational reasons.

Figure 1. Typical mechanism of an SLB.

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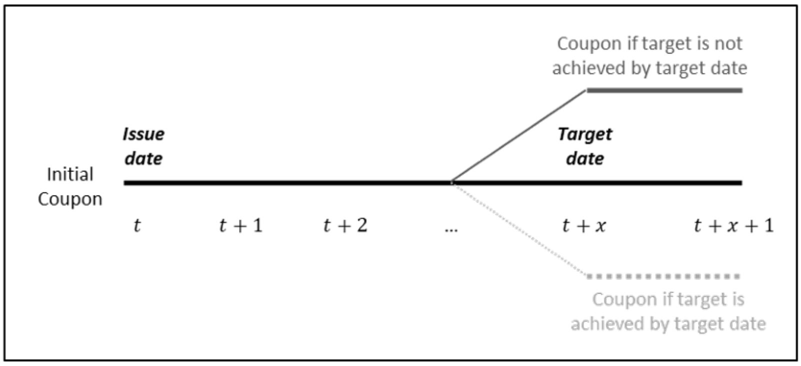


The impact of SLBs is therefore much more explicit than many other mechanisms in sustainable investing. For example, while an increasing volume of funds is managed according to ESG ratings, it is uncertain for firms what metrics they should improve and how substantial the market's reward will be. SLBs effectively put a price on specific improvements, giving firms a clear signal what they need to do, and what the reward will be.

3 Data and market overview

Our sample of (corporate) SLBs is extracted from Bloomberg's fixed income database, covering all bonds labeled as 'sustainability-linked bonds' as of December 31, 2021. Given the extent of the coverage of Bloomberg's fixed income database, we assume that the resulting data is likely to map closely the full universe of SLBs issued until June 30, 2022. The extraction results in a total of 441 SLBs issued by a total of 264 companies. For each bond, Bloomberg provides the standard bond characteristics (issue size, maturity, coupon, seniority, etc.) and a security description with information on the sustainability components. Bloomberg's security description contains details on the SPT, the target date and coupon adjustment for most SLBs. However, in some cases the security description does not provide complete information on the coupon step-up or the SPT. In these cases, we manually complete the data based on company press releases, publicly available investor relations materials or by contacting the investor relations of the respective company.

Table 1
SLBs over time.

Year	# SLBs	Amount (USD billion)	# SLBs in matched sample
2018	1	0.2	0
2019	15	7.0	1
2020	41	14.1	9
2021	271	123.4	91
2022 H1	113	48.4	44
Total	441	193.1	145

In Table 1, we provide a descriptive overview of the current market for SLBs as of June 30, 2022. For the sake of comparison, we convert all amounts into US dollars. While some media commonly attribute the world's first SLB in September 2019 to the Italian utility company Enel (Financial Times, 2021), Bloomberg data indicates that Beijing Infrastructure Investment Corporation Limited, the Chinese state-owned rail transportation company, issued an SLB in December 2018. The market for SLBs is growing strongly. In 2019, the total issuance of

SLBs was USD 7.0 billion, it doubled the year after, and reached USD 123.4 billion in 2021. In the first half of 2022 sustainable bond issuance slowed down due to macroeconomic and geopolitical risk (Bloomberg, 2022), but reached nearly USD 50 billion.

Table 2
SLBs across regions.

Region	# SLBs	Amount (USD billion)
Asia-Pacific	95	19.7
Europe	286	142.0
North America	23	16.9
Rest of World	37	14.5
Total	441	193.1

In Tables 2 and 3 we provide a breakdown of SLBs by region and sector. Sectors are partitioned according to the GICS sector classification. The majority of SLB issuance is made up of European companies (USD 142.0 billion), followed by companies in Asia-Pacific (USD 19.7 billion). With less than 10% of total bond issuance in North America by mid-2022, the phenomenon of SLBs has not yet been established in the US market and among the largest S&P 500 companies. In terms of sector breakdown, the industrials, consumer discretionary and utilities sector issued the largest amount of SLBs. The leading SLB issuers are mainly from capital-intensive sectors which are most concerned by the transition to a more energy-efficient, low-emission economy. Furthermore, Table 3 also shows that many sectors, beyond capital-intensive companies, such as in healthcare or financials, started to issue SLBs.

Table 3
SLBs across sectors.

GICS Sector	# SLBs	Amount (USD billion)
Communication Services	16	8.0
Consumer Discretionary	46	21.3
Consumer Staples	45	21.8
Energy	29	13.9
Financials	30	9.0
Health Care	12	8.5
Industrials	133	44.1
Information Technology	6	3.8
Materials	51	19.4
Real Estate	32	11.2
Utilities	41	32.2
Total	441	193.1

Table 4 provides a breakdown of the SLB market by maturity type.[4] While 54% of the SLBs issued are at maturity (233 bonds), 66% of the SLB market volume consists of callable bonds (USD 127.9 billion). The use of callable corporate bonds has increased since the Great Financial Crisis to a share of over 60% in advanced economies due to the advantages for financing and liquidity optimization allowing issuers to redeem the bond due to changes in the interest rate or credit environment or for restructuring purposes (Çelik, Demirtaş, and Isaksson, 2019).

Table 4
SLBs by maturity type.

	# SLBs	$ Amount (billion)
At maturity	233	62.1
Callable	195	127.9
Callable / Perpetual	4	0.4
Callable / Sinkable	1	0.4
Convertible	2	1.3
Putable	3	0.3
Sinkable	3	0.7
Total	441	193.1

[4]The plain vanilla maturity type for bonds is 'at maturity', meaning that the issuer must repay the bond at maturity. Callable bonds give the issuer the option redeem the bond before maturity y subject to time constraints or other special constraints (Çelik, Demirtaş, and Isaksson, 2019). Putable bonds offer the bondholders the right to demand early repayment of the principal from the issuer. Convertible bonds offer the possibility to convert the bond into a number of common stock or equity shares at a predetermined date. Sinkable bonds are bonds backed by a fund set aside by the issuer.

Despite the Sustainability-Linked Bond Principles and the efforts to create universal guidelines, there is a lot of diversity with respect to the SPTs and the concrete KPIs set by issuers. Table 5 summarizes the SPTs and coupon margin adjustments across the entire sample of 441 SLBs based on the available Bloomberg data, as well as company press releases, investor relations materials, as well as information provided by investor relations contacts. The most common SPTs are linked to a company's GHG emissions or energy efficiency measures followed by a target related to an ESG score or other sustainability rating. Some issuers have their SPT linked to diversity, water or waste management, or some company-specific renewable energy target, which we classified as 'Other'. The coupon step-up, however, is comparable across companies. The most common feature of SLBs is a coupon step-up of 25 bps if the company fails to reach the predetermined SPT at the given date (USD 86.5 billion). 10% of the SLB market volume has a step-down in case of achievement of the SPT or a two-sided coupon adjustment (step-up and step-down).

Table 5
Targets and step-ups.

Summary statistics of sustainability performance targets and coupon adjustments of SLBs.

	# SLBs	$ Amount (billion)
Sustainability performance target (SPT)		
GHG emissions & energy efficiency	223	120.5
ESG score	64	16.3
Other	125	47.7
No information	29	8.6
Coupon margin adjustment		
Step-up: <25 bps	155	49.3
Step-up: 25 bps	133	86.5
Step-up: >25 bps	89	38.7
No step up or other penalty	24	5.3
No information	40	13.3
Step-down	91	19.7

In summary, the SLB market as of June 2022 is still in the early stages. It is mainly a European phenomenon, dominated by the industrials, consumer and utilities sectors. The variety in SPTs and coupon adjustment highlight the varying motivations and ambitions of issuers.

4 Matching Methodology

To address our research question and test for the existence of a sustainability premium, we perform a matching approach at the bond-level. The aim of our matching procedure is to match bond pairs with an SLB and a non-sustainable bond by the same issuer, which is as similar as possible except for the sustainability features linked to it. This procedure allows us in a second step to compare and analyze the yield differential, as SLBs and conventional bonds of the same company are subject to the same financial risk once all their differences have been controlled for. Our matching procedure is similar to studies analyzing the greenium.[5]

Matching procedure. In a first step, we require that issuer, bond seniority, maturity type, coupon type and currency are identical for both, the SLB and the counterfactual bond. In terms of maturity type, we focus on at maturity and callable bond pairs and exclude putable and convertible bond pairs. Furthermore, for callable SLBs with a 'make-whole' call option[6] we require as a necessary condition that the counterfactual bond also includes a make-whole call option, while we accept differences in the make-whole spread.[7] While studies on green bonds use the bond rating as an additional matching criteria, we only take into consideration

[5]Studies analyzing the green bond premium are based on different matching approaches. Gianfrate and Peri (2019) apply three different propensity score matching techniques (nearest neighbours matching, kernel matching and radius matching) to predict the probability of bonds being green, using Logit and Probit functions. Hachenberg and Schiereck (2018) match each green bond with two comparable non-green bonds (one with a shorter and one with a longer maturity) from the same issuer with the closest maturity, same ranking, currency, rate structure (fixed or floating), secured/unsecured, and that are not structured (callable, etc.). Zerbib (2019) uses a matching method known as model-free or direct approach, which consists of matching a pair of instruments with the same properties except for this one green property. He thus matches every green bond with a conventional bond with the same currency, rating, bond structure, seniority, collateral, and coupon type (Zerbib, 2019). Larcker and Watts (2020) base their matching approach on the specific feature of the municipal bond market which consists in the fact that municipal issuers commonly price tranches of securities, including green and non-green bond in their case, on the same day with the similar maturities. Thus, this allows them to match green bonds with quasi-identical non-green bonds. Flammer (2021) applies Larcker and Watts (2020) methodology to the corporate green bond market, matching each green bond to the most comparable brown bond of the same issuer in two steps. Her first step requires the credit ratings to be the same, and the second step then picks the closest neighbor using the Mahalanobis distance based on four characteristics: log(issuance amount), maturity, coupon, and the number of days between the green and brown bond issuance (Flammer, 2021).

[6]Bonds with a 'make-whole' call option have a call price that is above the market price of the bond, making the investors 'whole' and reducing concerns about early redemptions (Çelik, Demirtaş, and Isaksson, 2019).

[7]The difference in make-whole spread of the SLBs and the counterfactuals within our sample is on average 4.1 bps.

the bond seniority. Due to the early stage of the SLB market, many SLBs do not have a rating. Yet, none of the bond pairs differ in the bond rating conditional on ratings being available. The bond seniority is therefore a reasonable matching requirement.

In a second step, we select the counterfactual bond with the closest issue date, maturity and issue size based on the Euclidean distance.

Issue date. We limit the difference between issue dates for the bond pairs to a maximum of five years. As the SLB market is strongly driven by Europe, the monetary and interest rate environment during the observed period is relevant. The European Central Bank started its quantitative easing program in 2015. Thus, matching SLBs issued in 2020 with non-sustainable counterfactuals prior to 2015 would imply macroeconomic variation and lower comparability. An issue date restriction of five years therefore seems reasonable.

Maturity. We limit the difference in maturity between SLBs and conventional bonds to three years. This maturity difference is marginally higher than in studies on green bonds.[8] Additionally, we limit the ratio between the SLB's maturity and the counterfactual's to a factor of 1.5 (i.e. an SLB with maturity of 4 years would not match a counterfactual with maturity of 2 years, although the maturity difference is two years).

Issue size. We limit the issue size ratio between the SLB and its counterfactual to a factor of 4 (i.e. not larger than four times the SLB's issue amount and not smaller than one-quarter). We do not set a constraint for the minimum issue size, as liquidity considerations do not affect our pricing analysis of the yield differential at issue.[9]

[8] Larcker and Watts (2020) limit the maturity differential to be within one year, as they argue that this restriction maximizes the number of securities for which they can obtain matches, while also minimizing the differences in the slope of the credit spread. Zerbib (2019) limits the maturity of the counterfactual bond to two years shorter or longer than the green bond's maturity.

[9] For liquidity reasons, some studies on green bonds have set constraints on the issue size. Hachenberg and Schiereck (2018) focus on bonds with a minimum issue size of USD 150 million, while Gianfrate and Peri (2019) set a minimum of EUR 200 million. Zerbib (2019) imposes the restriction of factor four on the issue size ratio between the green bond and the counterfactual.

While our sample is reduced by some missing values in the data, as Bloomberg does not provide yield for the complete SLBs sample, we rely in some cases on the Refinitiv database to complete the data on yield at issue for some SLBs and counterfactuals.

Finally, our matching process results in 145 bond pairs from 115 issuers. There are 24 issuers with more than one bond pair (19 issuers with 2 bond pairs, 4 issuers with 3 bond pairs and one issuer with 4 bond pairs). Table 6 provides summary statistics for the sample of bond pairs of SLBs and counterfactual bonds.

Table 6
Comparison of means

This table compares the means and standard deviations between SLBs and their matched counterfactual bonds. The matching covariates are maturity, issue size, and issue date. In addition, the table displays the bonds' coupon and yield. The three columns to the right display the average difference, and the t-statistics and p-values for a paired t test.

Variables	SLBs		Counterfactuals		Diff.	t.stat.	p.val.
	Mean	SD	Mean	SD			
Maturity (years)	7.06	3.92	7.07	3.95	-0.01	0.15	0.88
Issue size (USD million)	408.40	388.97	395.14	380.65	13.26	-0.67	0.50
Issue Date	2021-09-05	186.25	2020-03-25	458.76	528.43	-14.60	0.00
Coupon (percent)	2.59	1.63	2.72	1.78	-0.13	1.77	0.08
Yield (percent)	2.62	1.64	2.71	1.76	-0.09	1.30	0.20

Our matching procedure results in a sample of bond pairs with a maturity difference of close to zero, and a similar issue size (average ratio of 1.21). The issue date difference within our bond pairs is on average 1.44 years. Table 6 does not include information on the bond seniority, as this was a necessary matching requirement, and thus identical for all bonds. In terms of bond seniority, most bonds are Senior Unsecured bonds (113 out of 145), while a minority are of higher seniority (4 out of 145) and lower seniority (28 out of 145).[10] Table 6 also provides the average coupon, excluding any potential step-up, and the yield at issue for the bond pairs.

[10] Among the bonds with higher seniority the breakdown is 1 First Lien, 1 Senior preferred and 2 Secured bonds. Among the bonds with lower seniority there are 28 Unsecured bonds.

We observe that the average coupon of SLBs is 14 bps lower than for counterfactual bonds, and the yield at issue 9 bps lower. Thus, at first glance, SLBs within our sample benefit from a sustainability premium.

Overall, our sample reflects the general SLB market in several dimensions (see Table A.1 in the Appendix). First, our sample covers 33% of the total SLB market (145 out of 441 SLBs), 31% of the total SLB market volume (USD 59 billion) and 44% of all issuers in the SLB market (115 out of 264). Second, in terms of maturity type, our sample has similar proportions of at maturity and callable SLBs as the overall market (83 at maturity and 62 callable). Third, the sector breakdown within our sample is comparable to the overall market. However, our sample of bond pairs has a higher share of SLBs from Asia-Pacific and a lower share from Europe, as compared to the overall SLB market.

5 Results

5.1 Is there a sustainability premium?

In a first step, we test whether there is a sustainability premium. We perform an OLS regression to test the statistical significance of the yield differential between the SLBs and the counterfactuals. The dependent variable is the yield at issue of every bond $Yield_i$ and the OLS regression takes the following form:

$$Yield_i = \beta_0 + \beta_1 \cdot SLB_i + \beta_j \cdot Bond\ pair_j + \sum \beta_k \cdot Control\ variables_{ki}$$

The variable $Bond\ Pair_i$ identifies bond pairs with one dummy variable for each of the 145 bond pairs. The variable SLB_i is a dummy variable indicating whether the bond is an SLB.

As control variables we include changes in the market environment (risk-free rate and credit spreads), as well as matching differences (issue date, maturity, issue size and covenants[11]).

The results are shown in Table 7. The unconditional yield differential in Model 1 is -9.1 bps between SLBs and the counterfactua bonds. The negative yield differential implies that the yield for SLBs is on average lower than for non-sustainable counterfactuals, thus resulting in a sustainability premium for SLB issuers. However, as Model (1) shows, the unconditional yield differential is not statistically significant. In Models (2) and (3) we control for changes in the risk-free rate, credit spreads and matching differences, and obtain a statistically significant sustainability premium of -21.6 bps and -18.7 bps, respectively. In Model (4) we additionally include a dummy variable indicating whether there are any differences in the covenants between the SLB and its counterfactual. The coefficients for SLB remains stable.

Figure 2 shows how the cumulative average yield differential has evolved over time. The average sustainability premium decreased since early 2022. This is confirmed by the results in Table 8, where we estimate the SLB dummy separately for each year. It appears there has been a premium for SLBs issued in 2021 of at least -31 bps in any model specification. But SLBs issued in 2022 did not receive a statistically significant premium. Also in 2019 and 2020 there is not a statistically significant premium, but with 1 and 9 matched SLBs this is likely due to an insufficient sample size. It appears that the SLB premium varies over time. Most likely, the increased uncertainty introduced by the invasion of Ukraine in February 2022 has contributed to this change. These results are qualitatively similar with quarter fixed effects.

In sum, we find that issuers benefit from a lower cost of debt when issuing SLBs, while investors receive a lower return on SLBs. However, the magnitude and significance of the premium seems to have decreased over the sampling period.

[11]The covenants we include in our regression are the negative pledge clause, change of control, fundamental change, limit indebtedness, cross default, negative covenant, certain sales assets, restriction on ACTS, debt service coverage ratio, cashflow to debt servicing, restrictive covenant, merger restrictions, limit sale leaseback, limit subsidiary debt, restricted payments, ratings trigger provision, collective action clause, material adverse change and force majeure.

Table 7
SLB yield at issue vs. counterfactual bonds

Regression of the yield at issue for a sample of matched bond pairs. SLBs and counterfactual bonds are from the same issuer, and have identical seniority, maturity type (at the money or callable), coupon type (fixed or floating), and currency. The are matched to their nearest neighbour in terms of maturity, issue size, and issuance date. Model 1 estimates the effect of a dummy variable for SLB on yield at issue, controlling for each bond pair with a dummy. Model 2 adds credit risk and risk free rate at the time of issue for each individual bond. Model 3 adds the matching variables as additional controls. Model 4 includes a dummy indicating whether the SLB has at least one different bond covenant. Standard errors in parentheses.

	Yield at issue			
	Model 1	Model 2	Model 3	Model 4
SLB (TRUE)	−9.07	−21.56***	−18.77**	−21.57**
	(7.00)	(5.75)	(9.33)	(10.10)
Credit spreads		0.96*	1.04*	1.06**
		(0.52)	(0.53)	(0.53)
Risk free rate		76.42***	76.10***	75.88***
		(8.26)	(8.55)	(8.57)
Issue Date			−0.00	−0.00
			(0.00)	(0.00)
Issue Size			0.01	0.01
			(0.02)	(0.02)
Maturity			−1.09	−1.16
			(5.77)	(5.78)
Covenant Diffs (TRUE)				8.39
				(11.53)
Constant	71.69*	87.70**	196.81	232.47
	(42.31)	(33.69)	(266.26)	(271.18)
Bond Pair FE	Y	Y	Y	Y
R^2	0.94	0.96	0.96	0.96
Adj. R^2	0.88	0.92	0.92	0.92
Num. obs.	290	290	290	290

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

5.2 How large is the sustainability premium?

In a second step, we perform a cost-benefit calculation of SLB issuance. We calculate the explicit dollar value of the savings by multiplying the yield differential with the issue size and the bond's lifetime. We rely on the unconditional estimate of the yield differential of -9 bps from Table

Table 8
SLB yield at issue vs. counterfactual bonds over time

Regression of the yield at issue for a sample of matched bond pairs. This table is nearly equivalent to Table 7. The only difference is that the SLB dummy variable is interacted with the year in which the SLB was issued.

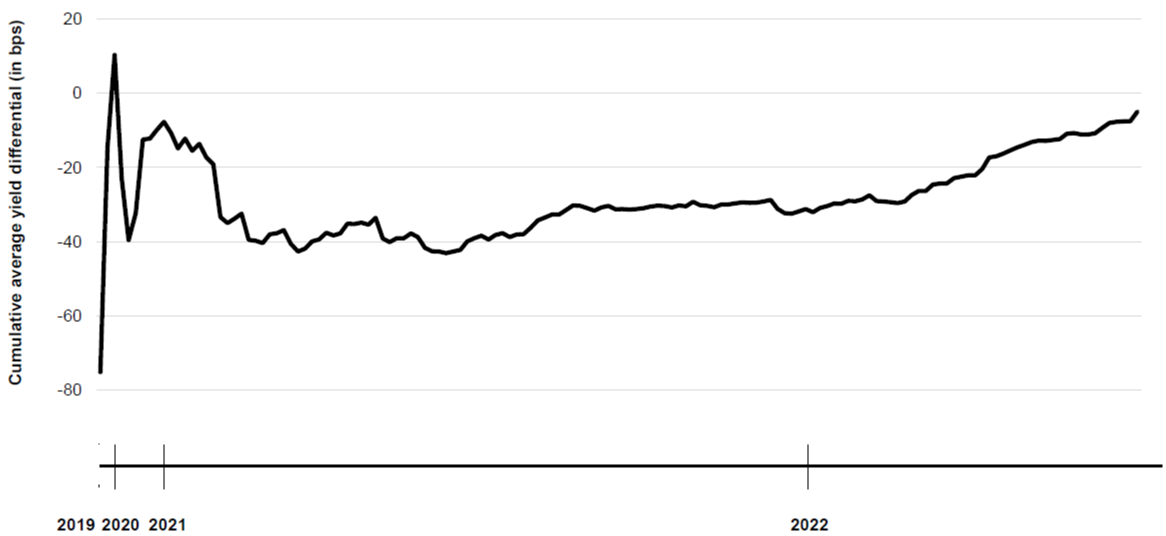
	Model 1	Model 2	Model 3	Model 4
(Intercept)	84.06**	94.88***	325.03	360.74
	(39.03)	(32.19)	(257.89)	(262.28)
SLB:2019	−75.10	−6.16	2.27	3.51
	(77.63)	(64.53)	(65.69)	(65.80)
SLB:2020	−0.19	32.98	37.63	34.78
	(25.88)	(22.09)	(23.48)	(23.79)
SLB:2021	−33.82***	−37.14***	−31.00***	−33.90***
	(8.14)	(6.79)	(9.37)	(10.09)
SLB:2022	41.78***	0.75	10.01	7.02
	(11.70)	(11.07)	(14.42)	(14.94)
Credit spreads		1.05**	1.17**	1.19**
		(0.50)	(0.52)	(0.52)
Risk free rate		72.68***	70.16***	70.03***
		(8.92)	(9.34)	(9.36)
Issue date			−0.00	−0.00
			(0.00)	(0.00)
Issue size			0.01	0.01
			(0.02)	(0.02)
Maturity			0.32	0.27
			(5.52)	(5.53)
Covenant diffs. (TRUE)				8.59
				(11.01)
Bond Pair FE	Y	Y	Y	Y
R^2	0.95	0.97	0.97	0.97
Adj. R^2	0.90	0.93	0.93	0.93
N	290	290	290	290

$^{***}p<0.01$; $^{**}p<0.05$; $^{*}p<0.1$

7, column 1. Although this estimate is not significant, it is the simplest and most conservative estimate available. We compare this figure to the maximum possible penalty over the period when the step-up applies in case of failure to reach the SPT. This is also a conservative estimate,

Figure 2.
The yield differential over time

This graph shows the cumulative average yield differential for matched pairs of SLBs and counterfactual bonds over time. The temporal order is determined by the SLB issue date.



as it represents the case in which the issuer fails to reach the target with a probability of 1. The expected penalty is lower in reality, because issuers likely set realistic targets.

The results are shown in Table 9. The average sustainability premium is 9.1 bps, while the average coupon step-up is 25.7 bps. While this appears as a striking difference, the step-up applies only over a fraction of the bond's lifetime. The average SLB has a maturity of 7.1 years, and the step-up applies only for 3.0 years, if it is triggered.

Accounting for these temporal differences, SLB issuers save on average USD 7.1 million due to the negative yield differential, while facing a potential penalty of USD 4.1 million (average of 1.3% of the issue size) in case of a coupon step-up for the final years of the bond. Thus, SLB issues result in an average benefit of USD 3.0 million for the issuer in our sample. Our calculation of a potential 'free lunch' is conservative, as we assume the maximum potential

Table 9
SLB cost-benefit analysis

Cost-benefit analysis of SLB issuance. The yield differential is estimated based on Table 7, column 1. The table states sample averages of the step-up rate in case of failing to reach the SLB target, the SLB maturity, and the time over which the step-up applies. The SLB savings are derived by multiplying the yield differential with the maturity and the issue size. The potential penalty is derived by multiplying the step-up rate with the issue size and the period during which the step-up applies. The "free lunch" represents the savings minus the penalty.

	Average
N	145
Yield differential (bps)	-9.1
SLB coupon step-up (bps)	25.7
SLB maturity (years)	7.1
No coupon step-up until SPT date (years)	4.3
Coupon step-up after SPT date (years)	3.0
Potential penalty (USD million)	4.1
SLB savings (USD million)	7.1
SLB net benefit (savings - penalty)	3.0
# SLBs with 'free lunch' (savings > penalty)	64

penalty by consistently estimating the maximum potential penalty (i.e. the scenario where the issuer fails on all SPTs) over the lifetime of the SLBs.

5.3 What drives the sustainability premium?

In a third step, we estimate an OLS regression to analyze the drivers of the sustainability premium. Hypothetically, we see two main drivers. The first driver is related to the financial structure and the incentive mechanism, so the option value of reaching the sustainability performance target priced by primary market investors and the implicit probability of a coupon step-up. The second driver is the signaling to ESG investors. By issuing an SLB, issuers can signal to ESG investors that they are committed to reaching a certain sustainability target. ESG investors, in turn, may prefer the securities of companies willing to demonstrate such a commitment.

On the one hand, ESG leaders could use SLBs as a reinforcement signal for their past commitments to sustainability, indicating that they are now also prepared to be held financially accountable in case of missing sustainability targets. ESG laggards, on the other hand, could use SLBs to signal that they aim to increase their commitment to sustainability.

We aim to determine the effect of the coupon step-up, other SLB characteristics, and issuer characteristics on the yield differential. The dependent variable is the yield differential at issue (in bps) between the SLB and its non-sustainable counterfactual Δ *Yield*$_\mathrm{i}$ for every bond pair *i*. The OLS regression takes the following form:

$$\begin{aligned}\Delta\,\mathit{Yield}_\mathrm{i} = \beta_0 + \sum \beta_\mathrm{h} \cdot \mathit{Financial\ characteristics}_\mathrm{hi} + \sum \beta_\mathrm{j} \cdot \mathit{Sustainability\ characteristics}_\mathrm{ji} \\ + \sum \beta_\mathrm{k} \cdot \mathit{Matching\ differences}_\mathrm{ki} + \sum \beta_\mathrm{l} \cdot \mathit{Bond\ pair\ characteristics}_\mathrm{li} \\ + \sum \beta_\mathrm{m} \cdot \mathit{Issuer\ characteristics}_\mathrm{mi} + \sum \beta_\mathrm{n} \cdot \mathit{Credit\ environment}_\mathrm{ni} + u_i\end{aligned}$$

Table A.2 provides a detailed overview and description of all variables. The independent variables are divided into six groups. The first group of variables is linked to the financial characteristics of the SLB: the time-weighted step-up *Time-weighted step-up*$_\mathrm{i}$ as well as the total penalty in case the SPTs are not achieved *Penalty*$_\mathrm{i}$. These variables reflect what the company needs to pay to investors in case the target is not reached. If investors price these additional cash flows, they should have a negative effect on the yield differential (i.e. a larger yield differential).

The second group of variables is linked to the sustainability characteristics of the SLB and the issuer. At SLB level, we include a binary variable whether the SPT is related to the reduction of GHG emissions *GHG target*$_\mathrm{i}$, as well as a binary variable whether it is the first SLB issued *First SLB*$_\mathrm{i}$. At issuer level, we include the company's exposure to negative ESG news at the time of issuance measured by the RepRisk Index (RRI) at the time of the SLB issue and whether the issuer is included in the Dow Jones Sustainability Indices.[12] Furthermore, we include as a binary variable whether the issuer signed up to the science-based target initiative (SBTi).

[12]The DJSI constituents are available on the S&P website.

These variables allow us to distinguish ESG leaders and laggards and indicate the strength of a signal that issuers may be able to send. We expect a negative effect on the yield differential (i.e. a larger yield differential), when the issuer is an ESG laggard, for the first SLB issue.

As controls, we include matching differences, bond pair characteristics, issuer characteristics, and changes in the credit environment. The third group of variables, $\textit{Matching differences}_{\mathrm{ki}}$, is intended to capture the differences between the SLB and the counterfactual bond due to our matching approach. This includes the difference in issue date, maturity, as well as the ratio in issue sizes. $\textit{Bond pair characteristics}_{\mathrm{li}}$ aims to control for the common bond pair characteristics, such as the maturity type (at maturity or callable), the coupon type (fixed or floating), the bond seniority and the maturity. $\textit{Issuer characteristics}_{\mathrm{mi}}$ include firm control variables, such as the issuer's credit category (high yield or investment grade), credit rating changes, as well as region and sector. Finally, we include credit environment variables, such as the change in risk-free rate and credit spreads between the issue dates of the counterfactual bond and the SLB.[13] In addition, we include year fixed effects, given the previous finding that the yield differential seems to vary over time.

Table 10 shows the results for the regression on the drivers of the yield differential. The controls for the credit environment have the expected positive effect and are highly significant. We view them, therefore, as important control variables and emphasize the models 2 to 5 where they are included. The time-weighted step-up has no significant effect on the yield differential $\Delta Yield$ in any of the model specifications. This does not change when using either the unadjusted step-up rate or the penalty in USD as an alternative regressor (see Table A.3).

For the first SLB issue we estimate a stable and significant negative coefficient in models 2 to 5. This indicates that the first SLB has a yield differential that is about 30 bps wider than

[13] To control for the interest rate change between the issuance of the counterfactual and the SLB, we use the change in the 5-year risk-free rate for bond pairs with a maturity below 7.5 years and the 10-year risk-free rate for bond pairs with a maturity above 7.5 years of the respective bond region, except for EUR-denominated bonds where we use the 10-year EURIBOR swap rate.

Table 10
Drivers of the yield differential

Regressions of the yield differential $\Delta Yield$ at issue between SLBs and their paired counterfactual bond. Time-weighted step-up is the SLB's step-up margin, weighted by the fraction of the bond's maturity over which the step-up applies. Further variables include a dummy whether an SLB is the the issuer's first, membership of the issuers in the DJSI, and the issuer's exposure to negative ESG news at the time of issuance measured by the RepRisk Index (RRI), whether the SPT is a greenhouse gas target and whether the issuer is a signatory to the Science-based targets initiative. Controls include changes in local credit risk and risk free rate and the occurrence of credit rating up- or downgrades between the issue date of the SLB and the counterfactual bond, and remaining differences between the matched bond pairs. Fixed effects include industry, region, year of the SLB issue, and bond pair characteristics (seniority, callable, floating or fixed rate, investment grade). Standard errors in parentheses

	Model 1	Model 2	Model 3	Model 4	Model 5
Time-weighted step-up	−1.23	−1.10	−1.03	0.07	−0.07
	(0.87)	(0.69)	(0.70)	(0.80)	(0.82)
First SLB issue (TRUE)	−23.71	-33.21^{**}	-32.59^{**}	-29.63^{*}	-30.10^{*}
	(19.83)	(15.96)	(16.20)	(15.76)	(16.04)
RepRisk Index	0.06	−0.19	−0.14	−0.17	−0.00
	(0.63)	(0.51)	(0.52)	(0.51)	(0.52)
DJSI member (TRUE)	29.46^{*}	15.18	15.33	13.25	20.00
	(16.30)	(13.24)	(13.65)	(13.36)	(13.99)
GHG target (TRUE)	−16.58	−14.30	−13.46	−0.24	2.76
	(17.40)	(14.04)	(14.47)	(14.61)	(14.89)
Science-based target (TRUE)	-57.60^{**}	−8.49	−12.01	−22.96	−22.88
	(28.93)	(23.79)	(24.97)	(25.29)	(25.64)
Credit risk change		2.35^{***}	2.26^{***}	2.57^{**}	2.66^{**}
		(0.74)	(0.76)	(1.07)	(1.09)
Risk free rate change		81.12^{***}	81.27^{***}	74.05^{***}	70.62^{***}
		(9.49)	(9.70)	(11.01)	(11.39)
Credit upgrade (TRUE)		−17.18	−18.46	−3.14	1.35
		(16.58)	(17.05)	(17.17)	(17.62)
Credit downgrade (TRUE)		27.87	28.48	41.57^{*}	49.84^{**}
		(20.43)	(21.40)	(21.01)	(21.40)
Issue date diff.			−2.71	−3.52	−5.08
			(5.57)	(5.34)	(5.52)
Maturity diff.			0.28	−0.58	−0.35
			(6.27)	(6.03)	(6.23)
Issue size ratio			5.56	5.57	1.56
			(9.36)	(8.83)	(9.16)
Constant	−11.19	−11.28	−15.63	−37.34	−36.42
	(54.78)	(43.91)	(47.87)	(102.12)	(103.21)
Sector FE	Y	Y	Y	Y	Y
Region FE				Y	Y
Year FE				Y	Y
Bond pair characteristics					Y
R^2	0.20	0.51	0.52	0.60	0.62
Adj. R^2	0.09	0.43	0.42	0.48	0.49
Num. obs.	135	135	135	135	135

$^{***}p<0.01$; $^{**}p<0.05$; $^{*}p<0.1$

subsequent SLB issues. It is noteworthy that this coefficient estimate survives the inclusion of year fixed effects in Model 5. The other characteristics, RepRisk Index, DJSI membership, GHG target, and Science-based target have no statistically significant coefficients in Models 2 to 5. The positive coefficient for DJSI membership and the negative coefficient for science-based targets are directionally in line with expectations, but may be spurious given that they change substantially when including controls.

6 Discussion

In summary, our results provide evidence that SLBs are priced lower than non-sustainable counterfactuals, meaning that SLB issuers benefit from a sustainability premium and investors pay — at least in part — for the targeted sustainability improvements. The magnitude of the sustainability premium does not seem to be driven by the bonds' financial penalty structure and incentive mechanisms. Instead, an issuer's first SLB comes with a significantly larger sustainability premium. This is consistent with the hypothesis that SLBs serve as signaling devices, where especially the first issue is valued by investors as a credible commitment to sustainability.

6.1 Limitations

Our study has a number of limitations at this point. First, the market for SLB is still young and this constrains our sample size. We have taken care to create the largest possible sample and to our knowledge, this is the most comprehensive study of SLB pricing to date. As such, the findings of this article should be viewed as somewhat preliminary evidence. Nevertheless, given the fast growth of SLBs and their significant potential for impact investors, our study offers important insights that may help navigate in the market for SLBs.

Second, we do not have any data on the probability that firms will reach their target. One could speculate that this is the reason why we do not find a relationship between the potential penalty and the sustainability premium. In theory, one might assume, that the pricing at issue reflects the probability-weighted value of the future cash flows caused by a step-up event. However, there are reasons to believe that including such a variable will not change much. First, it is inherently difficult to obtain an estimate of such a probability. There are second party opinions on the ambitiousness of targets, which could be used as a proxy. But based on our own attempts, it is very difficult to judge whether a target is ambitious, because the baseline, i.e. what the company would have done without setting this target, is unclear. Second, as our 'free lunch' finding shows, many bonds are overpriced from a rational 'option pricing perspective', since the sustainability premium exceeds the maximum penalty, i.e. a penalty with probability 1. Third, we believe that issuers will tend to set targets that they are fairly certain to reach, so that the probability of receiving step-up payments is actually close to zero in most cases. If this is the case, then the step-up feature would explain even less of the observed sustainability premium. To conclude, we cannot rule out that investors value the possibility of a step-up, but we can conclude that an additional factor, unrelated to the step-up feature, is driving the pricing.

Third, we rely on a matching procedure that rests on the identifying assumption that matched bonds differ only with regards to the SLB feature. Given the nascent state of the market, we face a trade-off between sample size and matching tightness. We attempt to closely follow existing literature with our methodology. In contrast to studies on green bonds, we allow for a slightly larger maturity difference, restricting the difference in maturity between SLBs and conventional bonds to three years. Larcker and Watts (2020) limit the maturity differential to be within one year, as they argue that this restriction maximizes the number of securities for which they can obtain matches, while also minimizing the differences in the slope of the credit spread. Zerbib (2019) limits the maturity of the counterfactual bond to two years shorter or longer than the green bond's maturity. The Achilles heel of our method is the temporal lag between the issue dates of the SLB and the counterfactual bond. We attempt to remedy this by controlling for changes in the credit environment as well as for credit rating changes of the issuer itself.

6.2 Contributions

Our results make several important contributions to the literature on green securities and to the understanding of the fast-growing SLB market. First, our paper provides the first overview and analysis of the SLB market. SLBs are a novel phenomenon, and have gained significant traction since 2020. Due to the early stage of the SLB market, there is a diversity in SPTs and coupon step-up arrangements. Our results provide an overview of this diversity that may be helpful as the market matures.

Second, our paper provides evidence that there is a sizable sustainability premium for SLB issuers. At least there has been such a premium in the stable market environment of the year 2021. This situation may return when financial markets enter once again into a more stable regime in the future. The implication is that issuers may have a financial incentive to issue SLBs. At the same time, our cost-benefit analysis suggests that over a third of existing SLBs offer a 'free lunch, i.e. a saving in the cost of capital that is greater than any potential penalty the issuer may have to pay when failing to reach the target. The existence of the 'free lunch' calls into question, whether SLBs indeed provide an incentive to issuers to pursue a target.

Third, we show that it is in particular the first SLB that commands a sustainability premium, compared to subsequent issues. This finding is consistent with a signaling hypothesis, where issuers use SLBs to convince investors that they are serious about pursuing a certain sustainability target. This may seem inconsistent with the existence of the 'free lunch', but issuers do not know ex ante whether they will get a sustainability premium and how large it will be. Therefore, ex ante, committing to a target and a penalty is a costly signal, as long as the target is not already achieved[14]. There are many ESG commitments by corporations these days, for example under the umbrella of the science-based targets initiative, where the question of credibility naturally arises Bolton and Kacperczyk (2021). Issuing an SLB may thus serve as a credible and costly commitment ex ante, and yet result in financial savings ex post. The finding that those financial savings are particularly pronounced for the first SLB suggest that there is demand from ESG investors for a 'firm commitment' in the form of an SLB. But in line with the fact that investors do not price the size of the penalty, a subsequent SLB seems to have little additional effect on investor perception of commitment.

6.3 Further research

Since our paper is among the first studies addressing the new phenomenon of SLBs, it offers a multitude of future research opportunities. First, future research could analyze to what extent the sustainability targets set by companies are ambitious, and how the distance from the target impacts the sustainability premium of SLBs. Second, market dynamics should be considered. The demand for sustainable investments from institutional investors, especially in Europe, is high. Many company press releases describe the bond emissions as being oversubscribed. Further research could therefore analyze the impact of investor demand on the pricing of these SLBs on the primary and secondary bond market. Third, our paper focuses on the yield differential at bond issuance. Future research could analyze the development of SLBs on the secondary market, and especially price movements as the bond approaches its sustainability target date. Fourth, the actual impact of SLBs on companies' sustainability profile could be analyzed. All these future research opportunities could be similarly addressed for (non-publicly listed) sustainability-linked loans. Research in the loan or private markets space could also offer interesting insights allowing to disentangle the signaling and the financial motives, as non-listed companies are less driven by signaling purposes.

[14] Tesco's has been criticized for an SLB whose target was basically achieved when the bond was issued.

A Appendix

Table A.1
Comparison of overall SLB market and our sample of bond pairs.

	SLB Market: # SLBs (% of market)			Matched bond pairs sample: # SLBs (% of sample)		
Total	441			145		
Region	• Asia-Pacific:	95	(22%)	• Asia-Pacific:	64	(44%)
	• Europe	286	(65%)	• Europe	57	(39%)
	• North America	23	(5%)	• North America	14	(10%)
	• Rest of World	37	(8%)	• Rest of World	10	(7%)
GICS Sector	• Communication Services	16	(4%)	• Communication Services	7	(5%)
	• Consumer Discretionary	46	(10%)	• Consumer Discretionary	7	(5%)
	• Consumer Staples	45	(10%)	• Consumer Staples	19	(13%)
	• Energy	29	(7%)	• Energy	25	(17%)
	• Financials	30	(7%)	• Financials	12	(8%)
	• Health Care	12	(3%)	• Health Care	4	(3%)
	• Industrials	133	(30%)	• Industrials	21	(14%)
	• Information Technology	6	(1%)	• Information Technology	5	(3%)
	• Materials:	51	(12%)	• Materials:	25	(17%)
	• Real Estate	32	(7%)	• Real Estate	15	(10%)
	• Utilities:	41	(9%)	• Utilities:	5	(3%)
Maturity type	• At maturity:	233	(53%)	• At maturity:	83	(57%)
	• Callable:	195	(44%)	• Callable:	62	(43%)
	• Callable / Perpetual:	4	(1%)	• Callable / Perpetual:	-	-
	• Callable / Sinkable:	1	(0%)	• Callable / Sinkable:	-	-
	• Convertible:	2	(0%)	• Convertible:	-	-
	• Putable:	3	(1%)	• Putable:	-	-
	• Sinkable:	3	(1%)	• Sinkable:	-	-

Table A.2
Description of variables

Overview and description of dependent and independent variables for the regression on the drivers of the yield differential.

Variable	Description	Unit
Δ *Yield*	Yield at issue of the SLB minus the yield at issue of the the non-sustainable counterfactual.	Basis points
Financial characteristics		
Time-weighted step-up	Coupon step-up determined in the margin ratchet of the SLB multiplied by the fraction of the bond's maturity over which the step-up applies.	Basis points
Sustainability characteristics		
GHG target	Binary variable equal to 1 if the SPT of the bond includes targets related to GHG emission reduction.	Binary (0 or 1)
First SLB issue	Binary variable for first SLB issued by this company.	Binary (0 or 1)
RepRisk score	Issuer's RepRisk score in the month prior to the SLB issue.	Score (0 to 100)
DJSI	Issuer was included in one of the Dow Jones Sustainability Indices at the time the SLB was issued.	Binary (0 or 1)
SBT	Binary variable equal to 1 if the issuer is a signatory to the science-based target initiative (SBTi).	Binary (0 or 1)
Matching differences		
Issue date diff.	Difference between issue dates of the sustainability-linked bond and the counterfactual bond.	Years
Maturity diff.	Difference between maturity of the sustainability-linked bond and the counterfactual bond.	Years
Issue size ratio	Ratio between the sustainability-linked bond and the counterfactual bond.	Ratio (0.25-4)
Bond pair characteristics		
Callable	Bond pair has a callable maturity type.	Binary (0 or 1)
Floating	Binary variable for floating coupon type.	Binary (0 or 1)
Seniority	Binary variables for seniority higher than Senior Unsecured (First Lien, Senior Preferred, Secured) and for seniority lower than Senior Unsecured.	Binary (0 or 1)
Maturity	Binary variable for maturity shorter than 5 years.	Binary (0 or 1)
Issuer characteristics		
HY	Binary variable whether the issuer is categorized as high-yield based on credit ratings.	Binary (0 or 1)
Credit rating change	Change in one of the issuer's credit ratings during the interval of the counterfactual and SLB issuance.	Binary (0 or 1)
Region	Binary variables for issuer region.	Binary (0 or 1)
Sector	Binary variables for issuer sector.	Binary (0 or 1)
Credit environment		
Risk-free rate change	Change in the risk-free rate between the issue dates of the counterfactual and the SLB.	Basis points
Credit spreads	Change in the credits spreads between the issue dates of the counterfactual and the SLB.	Basis points

Table A.3
Alternative drivers of the yield differential

This table is equivalent to Table 10, but uses alternative specifications for the financial features of the SLB. Models 1–3 include the step up margin in bps, unadjusted for the fraction of the bond's lifetime over which it applies. Models 4–6 include the maximum potential penalty issues must expect to pay, that is the time-weighted step-up multiplied by the bond's issue size.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Step up	−0.13	−0.28	−0.01			
	(0.32)	(0.25)	(0.30)			
Penalty				−1.24	−0.30	−0.12
				(0.79)	(0.65)	(0.72)
First SLB issue (TRUE)	−21.91	−31.95**	−29.01*	−20.50	−31.75**	−27.56*
	(19.47)	(15.54)	(15.43)	(19.24)	(15.69)	(15.70)
RepRisk Index	0.07	−0.16	0.03	0.19	−0.18	0.02
	(0.63)	(0.51)	(0.51)	(0.63)	(0.52)	(0.51)
DJSI member (TRUE)	31.18*	14.82	21.17	36.04**	17.61	20.58
	(16.38)	(13.26)	(13.91)	(16.40)	(13.52)	(13.97)
GHG target (TRUE)	−13.16	−11.98	4.62	−15.04	−15.19	3.40
	(17.13)	(13.78)	(14.51)	(16.90)	(13.83)	(14.52)
Science-based target (TRUE)	−55.35*	−5.49	−22.71	−56.26*	−6.98	−23.06
	(28.99)	(23.64)	(25.42)	(28.62)	(23.83)	(25.42)
Credit risk change		2.37***	2.68**		2.40***	2.64**
		(0.74)	(1.06)		(0.74)	(1.05)
Risk free rate change		82.94***	74.01***		80.60***	70.73***
		(9.42)	(10.88)		(9.69)	(11.30)
Credit upgrade (TRUE)		−18.93	−0.31		−16.73	1.87
		(16.45)	(17.55)		(16.98)	(17.55)
Credit downgrade (TRUE)		28.95	49.59**		29.13	50.22**
		(20.35)	(21.13)		(20.49)	(21.12)
Issue date diff.			−5.34			−5.81
			(5.32)			(5.33)
Maturity diff.			−0.43			−0.52
			(6.16)			(6.15)
Issue size ratio			1.72			2.31
			(9.01)			(9.01)
Constant	−24.46	−15.88	−36.08	−29.17	−25.40	−38.29
	(54.98)	(43.74)	(99.83)	(53.33)	(43.34)	(98.88)
Sector FE	Y	Y	Y	Y	Y	Y
Region FE			Y			Y
Year FE			Y			Y
Bond pair characteristics			Y			Y
R^2	0.17	0.51	0.61	0.20	0.50	0.62
Adj. R^2	0.06	0.42	0.48	0.09	0.42	0.49
Num. obs.	138	138	138	137	137	137

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Figure A.1. Distribution of yield differential within our bond pair sample.

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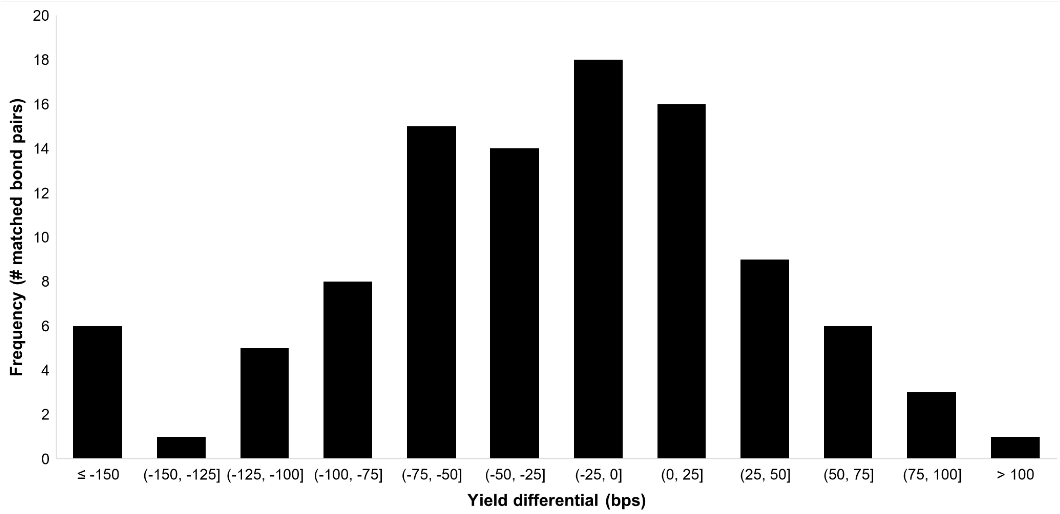

Figure A.2. Distribution of potential penalty for SLBs within our bond pair sample.

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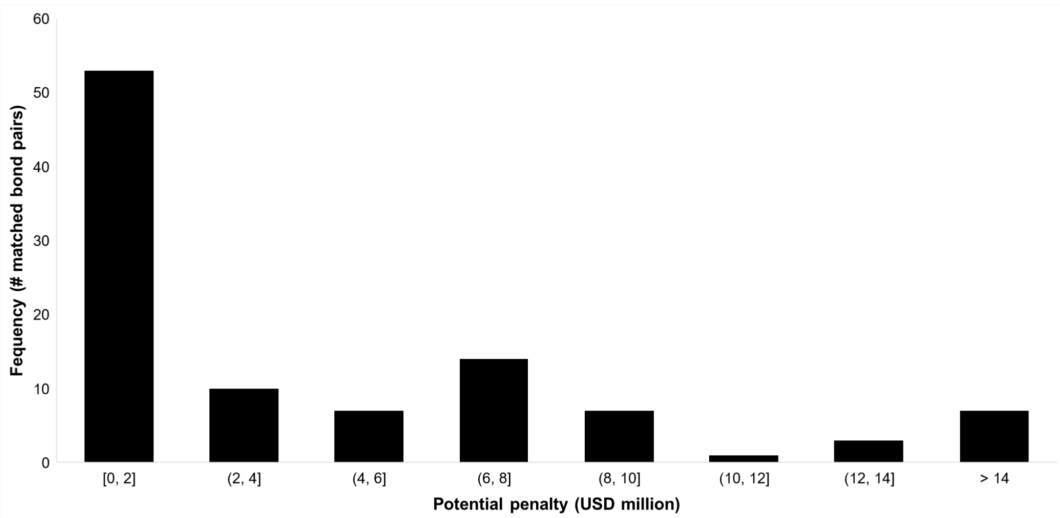

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