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Review

Sustainability-Linked Bonds Research: A Bibliometric and Content Analysis Review

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Abstract: One of the most significant recent developments in the debt financing sector pertains to new products and standards applicable to sustainability-related issues. Therefore, research on this has increased substantially. One of the most recent such developments is that of sustainability-linked bonds (SLBs). In 2023, global sustainable bond issuance experienced an increase of three percent, nearly reaching USD 1 trillion with significant shifts observed in categories, including green-, social-, sustainability-, and sustainability-linked bonds (GSSSBs). This paper presents one of the most extensive literature reviews on SLBs research, examining trends, research evolution, thematic landscape, and underexplored topics by employing bibliometric and content analysis approaches. It identifies future research avenues and trends, including supporting issuers in transitioning towards net-zero emissions or broader objectives, such as implementing sustainability targets to fight climate change, the premium associated with bond pricing, the potential for greenwashing, and the blockchain technology for issuance and target's monitoring transparency. In addition, this paper discusses the new trend of thematic bonds, such as those addressing gender characteristics, as innovative strategies to promote societal equity. The systematic literature review also explores the significance of SLBs as public instruments, like sovereign bonds or private instruments, while identifying research areas, including linking SLBs with the evolution of management theory.

Keywords: sustainability-linked bonds; GSSSB; performance-based; debt financing; sustainable finance; thematic bonds; bibliometric analysis; financial innovation; greenwashing risks; blockchain

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1. Introduction

Financial innovation is increasing with the demand for new financial instruments in the financial market to pursue the objective of financing sustainable development goals (SDGs), particularly those about climate change. The existing financial instruments need adaptation, new product development, or the blending of products to face the challenges of finance sustainability. Since the Paris Agreement 2015 and the 2030 Agenda with its 17 SDGs, companies have been pressed to significantly reduce negative externalities and promote sustainability practices. The Paris Agreement and the SDGs are responsible for and encourage these market needs (Agliardi & Agliardi, 2021). Financing climate change adaptation and mitigation need more than developing financial instruments; additional government support will also be necessary (Bolton et al., 2023), as climate change investments have a positive cost–benefit analysis, considering how climate change affects generations (Bolton et al., 2023).

When the world faces sustainability-related challenges, the financial markets estimate the capital needed to address them. This is particularly evident in the case of climate change issues. According to Monasterolo et al. (2024), mitigation and adaptation in the climate change scenario would cost substantially and require adequate policies. To illustrate this need, Buchner et al. (2021) put forward the amount of USD 5 trillion annually as required for the climate change fight globally. Klaaßen and Steffen (2023) identified a need for USD 90 billion between 2021 and 2025, prioritising some sectors such as power plants, electric grids, and rail infrastructure.

Sustainable finance is responsible for integrating financial mechanisms, instruments, and policies into sustainability themes and how to mitigate environmental and social impacts (Singhania et al., 2024). In this context, there was an expressive movement to adopt sustainability practices and promote sustainable investments, including in the financial markets, by creating new sustainable finance instruments and adapting existing ones. Described as "forward-looking performance-based instruments" by the ICMA Group (2023, p. 2), sustainability-linked bonds (SLBs) tie financial performance to sustainability targets, incentivise future sustainability improvements, and provide the flexibility to adapt to a corporation's strategy. They are the most recent instruments in this area and are the focus of this study. Unlike green bonds, the issuer's sustainability performance is responsible for the SLB's return, not a specific green project. Consequently, the issuance allows the issuer to commit to transition to net-zero emissions (Vulturius et al., 2024), improving the issuer's sustainability profile (Kölbel et al., 2022).

The growing demand for sustainable financial instruments brings innovation to the financial markets to address climate change and other sustainability challenges. SLBs are among the most recent results of such innovation. Dissimilar to green bonds, SLBs provide issuers flexibility while ensuring accountability through predefined sustainability performance targets. Studies on SLBs are very recent and very diverse in terms of the focus of the analysis and methods used. Their findings are also diverse. Therefore, there is a need for a comprehensive review of such literature to promote its further development and offer guidance on how such development can occur.

This study applies a bibliometric review to the literature on SLBs, examining trends, research evolution, thematic landscape, and underexplored topics and clarifying misunderstandings about the bond structure. Subsequently, it performs a content analysis to identify literature gaps and future research themes. While doing this, this study identified three research questions. The first is "What are the current trends in the SLB domain regarding publications, citations, journals, and authors?", the second is "What is the intellectual structure of SLB research, how has it evolved, and what are the current developments in this area of study?", and the last concerns the identification of the main gaps and research questions that require future research in the SLB domain. By addressing these aspects, this research contributes to understanding the growing importance of SLBs in financing the transition toward a more sustainable economy. In sum, this study offers a synthesis of the knowledge on the topic while revealing the dominant research themes and clusters, thus offering a valuable resource for those interested in contributing to this literature.

The remainder of the paper is structured as follows. The research context and relevant definitions are described in the following section. Section 3, the research design, presents the data collected and the method utilised. Still, in Section 3, a bibliometric review describes the support software used (Bibliometrix 4.0). Section 4 delineates the selected sample, followed by a bibliometric review, and presents the content analysis findings. To sum up, this section spotted some themes that need to be deepened. Section 5 discusses the results, while potential future research is presented. Section 6 concludes.

2. Literature Review

In 2023, global sustainable bond issuance increased by 3%, nearly reaching USD 1 trillion, but with notable shifts to specific categories like green-, social-, sustainability-, and sustainability-linked bonds (GSSSBs) (Gardiner, 2023). Green bonds raise capital for environmentally beneficial projects, ensuring the direct allocation of proceeds to green investments for greater transparency. Their sales surged to USD 575 billion, led by corporate and government issuances, including a significant EUR 10 billion issuance by the Italian government. On the other hand, social bonds focus on financing projects with positive social outcomes, such as affordable housing and education. Social bond sales remained stable at USD 135 billion, while sustainability bond sales declined slightly to USD 161 billion, even though they combined green and social bond projects. Notably, SLBs saw a 22% decrease in issuance volumes, totalling USD 68 billion. Looking ahead to 2024, signs of market rebound are evident, such as Enel's issuance of a USD 1.75 billion sustainability-linked security and potential growth in transition bonds, especially with Japan planning increased issuance over the next decade (Gardiner, 2023). Despite fluctuations, the overall trend reflects sustained momentum in sustainable finance, highlighting ongoing efforts to address environmental and social challenges through innovative financing mechanisms.

Considering the GSSSB market analysis, it is essential to analyse the growth of the issuance of these financial products since their inception, which surpassed USD 4 trillion in 2023, at around 16% of total debt issuance (Gardiner, 2023). Even though this is a recent financial instrument (the first SLB issuance in Europe was in September 2019) (Enel, 2024), the market has grown exponentially. When analysing the issuance per region, the prevalence of issuance was in Europe, led by IBRD (International Bank for Reconstruction and Development-World Bank) and EIB (European Investment Bank). The US saw a rapid rise in bond issuance, considering that their housing finance institutions issued mortgage-backed securities, representing the most relevant issuers' sector by the number of bonds. In the second place, financial institutions are responsible for many bonds, followed by governments and real estate companies. However, the numbers changed completely when the subject was the issuance amount. The most relevant issuer sector is utilities/energy, followed by national governments (Environmental Finance, 2024). The percentage of issuance by bond type is as follows: green bonds, 59%; social bonds, 18%; sustainability bonds, 17%; and SLBs, 6% (Gardiner, 2023). Sovereign bonds, nonfinancial services, financial services, US Public Finance, and International public finance separate the type of issuance institution (Kraemer et al., 2023). Another relevant perspective is about the standards adopted by every issuer that characterise the minimum rules covered by the issuance, including the use of a second party opinion (SPO). Most bonds issued until the end of 2023 used the ICMA (ICMA Group, 2023) guidelines specific to each type of bond (Environmental Finance, 2024).

As the world needs more public or private investment, there is an increase in the research on different sources of finance. Research on SLBs has increased in the last five years as the debt financing sector evolved to consider sustainability-related objectives (Berrada et al., 2022), and the market shows some preferences for sustainable finance products. An SLB is a performance-based instrument that does not have a specific purpose. According to the ICMA Group (2023), SLBs are performance-based bonds with varying financial and structural characteristics, contingent on the issuer's achievement of predetermined sustainability targets. These bonds are linked to sustainability performance objectives set at issuance, attesting the issuer's commitment to enhancing sustainability practices within a specified timeframe. Rather than pursuing sustainability efforts within the company for such characteristics, the issuer defines key performance indicators (KPIs) measured through sustainability performance targets (SPTs), additionally linked to step ups/step

downs, called ratchet mechanism paying interest rates on coupons (Bracking et al., 2023). The coupon ratchet mechanism (Michaelsen & Ramel, 2020) shows that if the company fails to achieve SPTs, the coupon generally increases by 25 basis points (bps), defined as a step up. On the contrary, if the KPI is attained, the coupon can decrease (step down) (Kölbel et al., 2022). An independent third party in a Second Party Opinion (SPO) assures these performance objectives to guarantee the objectives' achievement, offer a reliable opinion about the issuance, and confirm the targets' achievement (Kölbel et al., 2022).

Vulturius et al. (2024) proposed the need for more definitions for KPIs' materiality and SPT's ambitiousness, mainly when the subject is climate change. SLB market participants must agree on which activities align with the Paris Agreement and the EU Taxonomy (EU 2020/852 Regulation, n.d.). The same cautiousness is recommended by The International Capital Market Association (ICMA Group, 2023) with the Sustainability-Linked Bond Principles (SLBPs) (ICMA Group, 2023) regarding the calibration of SPTs. They should be ambitious in representing a material improvement in the KPIs, compared to a benchmark, consistent with the issuer's strategy in sustainability, and must have a previous issuance timeline. The benchmark approach has a unique dedicated space for science-based scenarios. Regarding this latter requirement, Vulturius et al. (2024) reveal their concern regarding adopting the Science-Based Targets initiative (SBTi, 2021), because an internal method is controversial.

Some SLBs' characteristics differ from other debt instruments concerning structure and transparency (Flugge et al., 2021). One difference between SLBs and Sustainability-linked loans is that they are listed in the financial markets if the company is also a listed company. The main difference between the other GSSSB instruments and SLBs is that the latter relies on the absence of the use of proceeds. One criticism of using proceeds is that it promotes only a tiny part of the issuer's activities (Vejarano & Swinkels, 2023). Another view of the coupon ratchet mechanism (step up/step down) is that it can be financially attractive for the bondholder but not favourable for the bond itself, raising concerns about its credibility and failing to attract new investors and promote a fall in the price of the bond, so at the end, it could not be favourable for a bondholder (Liberadzki et al., 2021). As investors pay for sustainability improvements when issuing an SLB, most companies, almost 65%, according to Kölbel et al. (2022), have a financial incentive benefitting from a sustainability premium.

Companies benefit by obtaining a lower cost of capital, even when they fail to achieve their specific targets. We can expect that the three motivations presented by Liberadzki et al. (2021) for issuing green bonds also apply to SLBs premium, signalling the market company's engagement with sustainability practices as an achievement of lower cost of capital and as greenwashing. This latter application illustrated that the issuers could use debt financing for any purpose within the company. Although, the primary motivation relies on the lower cost of capital (Kölbel et al., 2022). Another relevant question concerning the bond's interest rates is that SLB reduces the issuer's capital cost because implementing a green project, for example, costs more than achieving general purpose targets. In recent years, SLBs have become a substitute for green bonds due to their flexibility advantages as they require easier data management when controlling is restricted to KPIs, SPTs, and reporting instead of tracking all the expenses, like in the case of green bonds (Bracking et al., 2023).

Another important topic is that the issuer does not need to be sustainable to issue an SLB, or it does not need to have a green project. When the company issues an SLB, it only needs to define KPIs and targets related to sustainability aspects, such as environmental, social, and governance, independently of its ESG ratings. Haq and Doumbia (2022) describe two loopholes in the design of SLBs. First, late target dates and second, the option to call the bond early. However, Erlandsson et al. (2022) disagreed with these flaws, explaining

that the design is not the problem because these characteristics are familiar and tested successfully and consistently in the sustainability-linked loans (SLLs) market. However, some challenges the corporate SLB faces must be highlighted (Flugge et al., 2021). For instance, the lack of use of proceeds can elevate the risk of greenwashing without identifying the use of the money raised and not tracking the purpose of the expenses, the lack of comparability of metrics used to compare KPIs or targets amongst the benchmarking, the importance to choose a metric relevant for the business issuer, the unambitious targets, that may be too easy to achieve, the reliability of performance measured by a third party to avoid self-reporting and unaudited targets, and, finally, the percentage of financial penalty in an amount to incentivise the issuer to pursue its goals (Flugge et al., 2021).

3. Research Design

This paper consists of a systematic literature review. It addresses several issues, including establishing context, seeking theoretical support, rationalising problems, exploring new lines of inquiry, distinguishing completed research from areas needing further exploration, identifying primary outcomes and methodologies used in prior studies, and avoiding redundant research (Linnenluecke et al., 2020).

In this article, we applied a bibliometric analysis, a method to analyse extensive data (Jain & Tripathi, 2023) based on citation data, mapping frequency of authors, journals, and words, allowing a replicable process (Zupic & Cater, 2015). A bibliometric analysis comprises two stages (Donthu et al., 2021): the first is a performance analysis, offering statistics illustrating the research; the second is science mapping, which presents the relationship between the research topics and each cluster formed. These data will clarify who is researching each topic.

A content analysis follows the bibliometric analysis, presenting areas of research or themes to be exploited in this article and, in future research, cataloguing the documents in groups of trend topics to facilitate understanding (Bryman & Bell, 2011).

In the field of sustainability-related bonds, several literature reviews on instruments such as green bonds (e.g., Gyamerah & Asare, 2024; Kedia & Joshipura, 2023) and social impact bonds (e.g., Broccardo et al., 2020; Dahbi et al., 2024) have been published. As far as we are aware, this is the first Systematic Literature Review on SLB.

The first step in this research was to select keywords to search in the Scopus, Web of Science (WoS), and Google Scholar (GS) databases. The keywords selected were "sustainability-linked bond*", "sustainability-linked", "sustainability bond*", "ESG-linked", or "sustainable bond*". We found several types of names attributed to bonds with a performance-based structure, such as sustainability-linked bonds, which is the object of this paper. Each author names the same bond differently, which can be challenging to identify the literature about this bond. In this search phase, we found several terms related to sustainability-linked bonds, as shown in Table 1. This table shows the principal term related to "sustainability-linked" in the column Principal Term (1), that has sometimes preceding names (Term-0) and following terms (Term-2). Then, we searched the databases selected, read articles to identify relevant contributions and future topics, and finally, the definition of the sample selected for the study (Alvino et al., 2021).

We identified some criteria, such as category and date of publication, to start the search with a keyword search and selected the business, management, accounting, and economics (finance) categories from those databases. The search was limited to the period of 2013–April 2024 because the topic of interest is recent. Given the scarcity of articles in these databases (only four papers), we decided also to use Google Scholar (GS), employing a manual search process (Alvino et al., 2021). It makes sense to use such a strategy when the topic under examination is a very recent one or has suffered a renewed interest in a

certain period, given that the number of working/discussion papers not yet published in academic journals that are likely to have great relevance and be at the forefront of research is substantial (Hutchinson & Lucey, 2024). In addition, concerning the topic examined in this paper, like that of biodiversity finance (Hutchinson & Lucey, 2024), there is great interest in the subject of SLBs by regulatory and policy researchers, which may not translate into publications in academic journals. Because of such scarcity and considering the topic's novelty, we also consider high-quality working/discussion papers, conference papers, and policy reports, encompassing empirical or conceptual papers, besides peer-reviewed articles. Regarding exclusion criteria, we do not consider papers that mention SLBs superficially without substantial analysis, are focused on other types of bonds or lack rigorous analysis and are opinion pieces or market comments. This search allowed us to obtain 30 additional papers. We ended up with 32 documents for a bibliometric analysis (Figure 1).

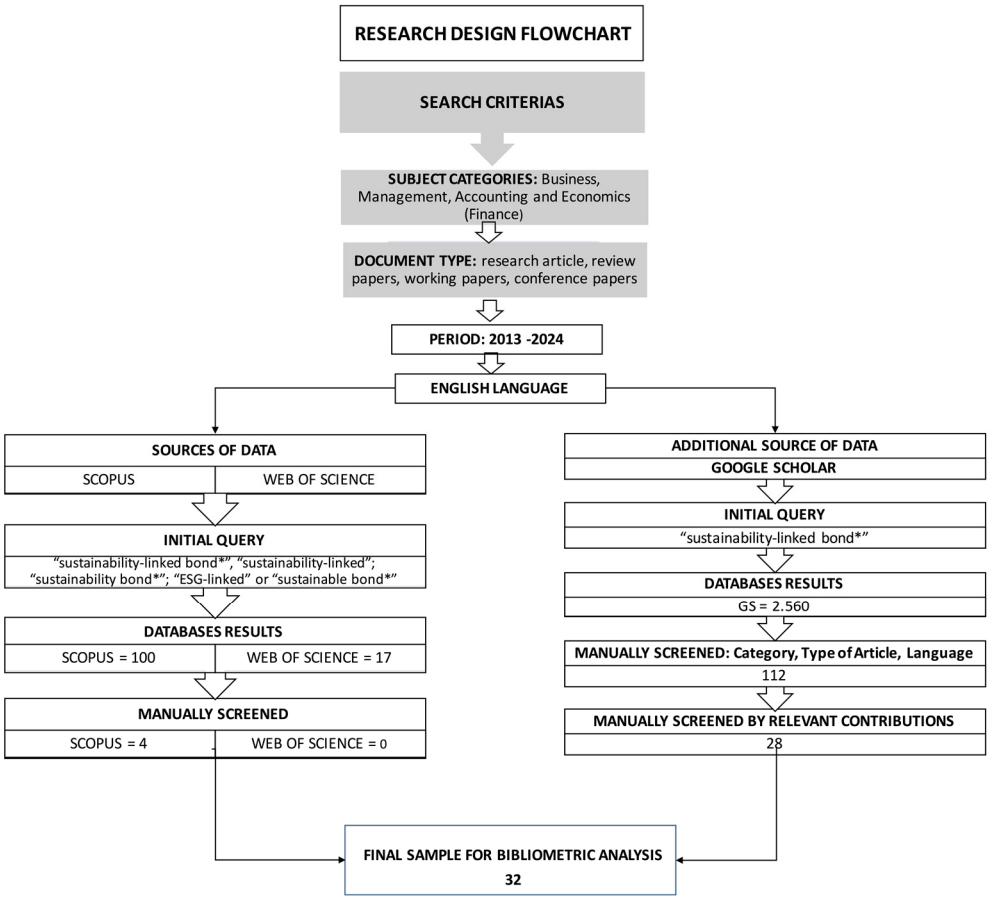

Figure 1. The research design flowchart (authors' design).

Table 1. Database keyword search.

Term 0	Principal Term 1	Term 2	Acronym
-	Sustainability-linked	Bond	SLB
		Derivative	SLD
		Debenture	SLD
		Loan	SLL
		Note	SLN
		Debt, Finance, Fund, Green Bond, Instrument, Monetary Policy, Project, Supply Chain	-

Table 1. *Cont.*

Term 0	Principal Term 1	Term 2	Acronym
Blue	Sustainability-linked	Bond	-
Sovereign	Sustainability-linked	Bond	-
	Sustainability-related	Bond, Loan, Fixed-Income Instrument	-
	Sustainable development goal-linked	Bond	SDG Bond
	Sustainable responsible investment-linked	Sukuk	SRI Sukuk

4. Results

4.1. Sample Analysis

Of the total 32 articles (Appendix A), 22 (69%) are articles, 7 (22%) are working papers, 2 (6%) are research articles, and 1 (3%) is a conference paper.

The bibliometric analysis used Bibliometrix, an R-package (Aria & Cuccurullo, 2017) developed to analyse the article's scientific production, evolution timeline, most influential papers, relevant keywords, and trends to incentivise future themes. Bibliometrix has a tool called Biblioshiny that illustrates and facilitates the analysis of a large sample of data (Moral-Muñoz et al., 2020), not precluding the usage of any sample size.

The literature on the SLB has grown substantially since the publication of the first articles (Liberadzki et al., 2021; Mocanu et al., 2021) and working papers (Bouzidi & Papaioannou, 2021; Flugge et al., 2021) in 2021. In the years before, the focus was green bonds and other types of bonds, such as social and sustainability bonds.

The first analysis extracted from Biblioshiny is an overview of the sample eliciting the primary information of the sample, as shown in Figure 2.

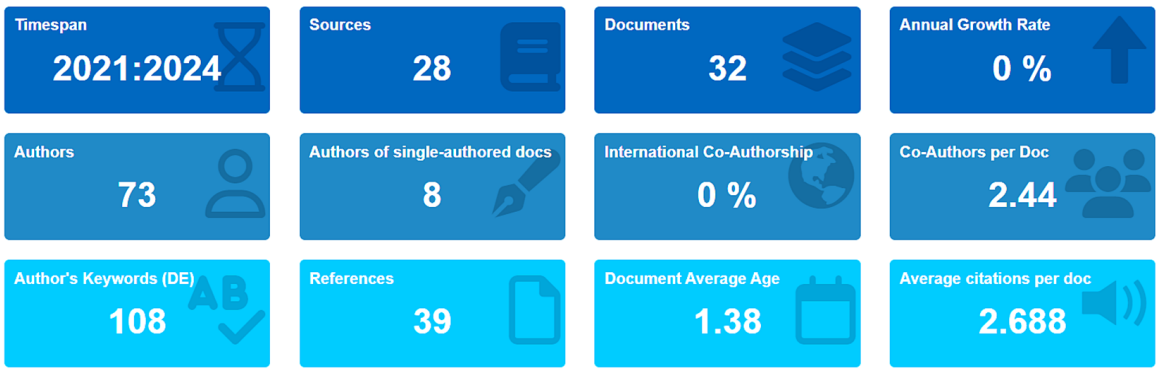

Figure 2. The overview of the papers (Bibliometrix).

The timespan of the sample reflects the scarcity of articles from 2021 to 2024. The growth in publications on SLBs was substantial in the first 3 years of the period analysed (Table 2). It tripled from 2021 to 2022 and almost doubled from 2022 to 2023.

Table 2. Annual scientific production from 2021 to 2024.

Year	Number of Articles
2021	3
2022	9
2023	17
2024	3

Only 8 of the 32 papers did not result from co-authorships, showing the importance of collaborative research on the topic. Curiously, there are no international co-authorships, which we attribute to the recency of research on the topic. The researchers focusing on SLBs have not yet had the time to know each other and form a research community.

4.2. Bibliometric Review and Content Analysis Findings

4.2.1. Sources

Regarding the sources, we distinguish two different types of papers: those published in academic journals (Table 3) and those published as research/working papers. Regarding papers published in journals, they amount to only 13 (40,6%). Regarding the journals, although no journal distinguishes itself as a primary outlet for SLBs research, we deem the following worthy of note: Finance Research Letters, Journal of Cleaner Production, and Journal of Sustainable Finance and Investment. These are highly regarded journals among academics, and they are among the most relevant sources for research on sustainable finance (Singhania et al., 2024) and green bonds (Kedia & Joshipura, 2023). Regarding the other papers, they have been published as working papers (or similar) by several organizations. Of these, the most relevant is undoubtedly the Anthropocene Fixed Income Institute (AFII), a non-profit research organization launched in 2020 and headquartered in London, UK (also with an office in Stockholm, Sweden), led by Ulf Erlandsson. This institute has been investigating SLBs amongst other fixed-income instruments and has contributed significantly to findings about SLB structure and pricing. The World Bank and the Swiss Finance Institute also deserve mention.

Table 3. Most relevant sources.

Panel A-Sources	**Number of Articles**
BIS Quarterly Review	1
Business Lawyer	1
Capital Markets Law Journal	1
Economy and Society	1
Energies	1
Eurasian Economic Review	1
Finance Research Letters	1
Financial Management	1
Journal of Cleaner Production	1
Journal of Impact and ESG Investing	1
Journal of International Economic Law	1
Journal of Sustainable Finance and Investment	1
Oxford Open Economics	1
Total	13
Panel B-Sources	Number of Articles
Anthropocene Fixed Income Institute (AFII)	3
Bids23	1
Bruegel	1
Chair Energy Prosperity	1
ECB	1
Oxford Institute for Energy Studies	1
SSRN	6
World Bank	3
Swiss Finance Institute	2
Total	19

4.2.2. Authors, Countries, and Affiliations

Only four authors have published more than one article: Beat Affolter, Ulf Erlandsson, Julia Meyer, and Stéphanie Mielnik. In Table 4 (author's production over time), there is a list of these authors' papers. Ulf Erlandsson is worthy of note because not only has this researcher authored three papers, but one of these papers (having Stephanie Mielnik as one of the coauthors) is among the most cited. This finding is also a testimony to the importance of collaboration in scientific research. Affolter and Meyer work together and are affiliated with the Institute for Financial Management from the Zurich University of Applied Sciences (ZHAW) School of Management and Law, Switzerland, with Meyer also affiliated with the University of Zurich (from the same country). It is worth noting that one of these researchers' papers has been published in Finance Research Letters, a well-regarded journal by the finance research community. Erlandsson and Mielnik also work with each other. They are both from the AFII.

Table 4. The most relevant sources and corresponding authors.

Author	Pub. Year	Title	Source
Affolter et al.	2024	Signaling sustainability: Differential reaction of the stock market following the announcement of sustainability-linked bonds	Finance Research Letters
Erlandsson et al.	2022	Notes on risk-neutral pricing of SLBs and step-down structures	AFII
Korangi and Erlandsson	2023	SLBs: No cal (l) amity	AFII
Meyer and Affolter	2023	Do Sustainable Companies Receive More Debt? The Role of Sustainability Profiles and Sustainability-related Debt Instruments	SSRN
Mielnik and Erlandsson	2022	An Option Pricing Approach to Sustainability-linked Bonds	AFII

The analysis of countries' production shows no preponderance considering this reduced sample of 32 articles. Table 5 shows that some countries have production over time above two articles, such as the United Kingdom, USA, Sweden, Switzerland, Germany, and Romania. Remember that this sample is filtered by articles written in English.

Table 5. Authors' countries' scientific production.

Country	Number of Articles
UK	7
USA	6
Sweden	5
Switzerland	5
Germany	5
Belgium	2
France	2
Netherlands	2
Denmark	1
Poland	1

The UK, the USA, Switzerland, and Sweden stand out as important countries where SLBs research is conducted. The importance of the UK is undoubtedly related to the AFII

being headquartered there, whilst that of the USA has much to do with the World Bank being headquartered in Washington, D.C. In the case of Switzerland, besides Affolter and Meyer, Kölbel et al. (2022) are also worthy of mention. These researchers are from the University of Zurich, as Meyer, and the paper they wrote is one of the most cited (Table 6). Berrada and his three colleagues (Berrada et al., 2022) are all from the University of Geneva (three of them are also from the Swiss Finance Institute), and their paper is also among the most cited (Table 6). Regarding Sweden, the authors of Vulturius et al. (2024), the most cited paper, are all from Sweden, with two of them being affiliated with the Stockholm Environment Institute.

Table 6. The most cited documents.

Author	Year	Title	Source	Citations
Vulturius et al.	2024	Sustainability-linked bonds–their potential to promote issuers' transition to net-zero emissions and future research directions	Journal of Sustainable Finance and Investment	16
Kölbel and Lambillon	2022	Who Pays for Sustainability? An Analysis of Sustainability-Linked Bonds	Swiss Finance Institute	14
Giráldez, and Fontana	2022	Sustainability-linked bonds: the next frontier in sovereign financing	Capital Markets Law Journal	8
Berrada et al.	2022	The Economics of Sustainability-Linked Bonds	Swiss Finance Institute	8
Haq and Doumbia	2022	Structural Loopholes in Sustainability-Linked Bonds	World Bank	7
Liberadzki et al.	2021	Spread Analysis of the Sustainability-Linked Bonds Tied to an Issuer's Greenhouse Gases Emissions Reduction Target	Energies	6
Mielnik and Erlandsson	2022	An Option Pricing Approach to Sustainability-linked Bonds	AFII	5

4.2.3. Documents, References, and Words

The third part of the bibliometric analysis investigates the relevant articles, considering the number of citations related to their sources. We followed Bilal et al. (2024), listing these documents in a table (Table 6) for better visualisation.

The most cited document is an article by Vulturius et al. (2024) about the probable use of SLBs to contribute to net zero, followed by Kölbel et al. (2022), who analysed the bond structure and its premium.

Also, we analysed the references they cited to show that this theme is relatively recent. Their foundations are primarily based on finance articles, concentrating their references and investigation on recent studies from the year 2008 (Figure 3).

The keywords analysis in the bibliometric and content review shows the most cited words used by the authors in their investigations, giving us guidance on the research theme. The most frequent keywords found in this sample are "sustainability-linked bonds" at the top of the list and ESG aspects commonly cited as a requirement for SLB performance (Berrada et al., 2022; Bouzidi & Papaioannou, 2021; Feldhütter et al., 2023; Liberadzki et al., 2021; Lupo-Pasini, 2022; Povilonis, 2022). The third word is "sustainability", a common sense for the papers as it is the main purpose. The fourth place is for the word "green bonds", cited in some studies as a case study context that similarly applies to the SLBs and

for their pioneering in issuing bonds in the sustainable finance field (Boermans, 2023; Bolton et al., 2023; Bracking et al., 2023; Maino, 2022; Mutarindwa et al., 2024). The Biblioshiny tool "WordCloud" (Figure 4) gives a picture of the most frequent words. The tool selected the 50 most common words in the paper's abstracts, illustrating the SLB's landscape.

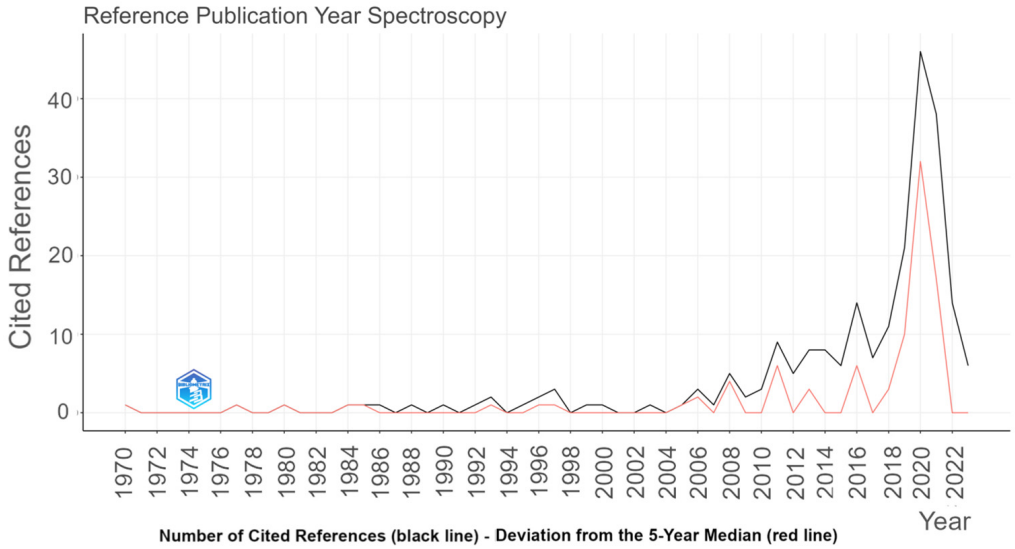

Figure 3. Cited references (Bibliometrix).

Figure 4. Wordcloud—abstracts' most common words (Bibliometrix).

This figure anticipates the thematic evolution of SLB research while categorising abstract topics into clusters based on bibliometric analysis. This analysis allows us to identify the predominant research areas, such as the following: finding similarities in previous green bonds studies and applying to SLB; the importance of the ESG aspects for defining targets, KPIs, and reputational risk; and clarifying greenwashing concerns and its possibilities that raise questions about SLBs' design, including bond premiums and pricing.

We conducted an interconnected approach analysis that identifies co-occurrence networks between the author's keywords (Figure 5), linking SLB research to broader themes like sovereign debt, cost of capital, greenium, spread, climate change, greenwashing, and ESG aspects; all of them are addressed in the content analysis later in this paper.

Figure 5. Network co-occurrence map (Bibliometrix).

We also conducted a thematic map of keywords plus that divides the research in affinity themes separated into clusters within the affinity theme, also studied by Bilal et al. (2024), such as basic (climate change, sustainable development, and impact), niche (cost of capital, coupon step-up, and step-down), emerging or declining (security design, sustainable finance); and motor (sustainability-linked bonds, ESG, sustainability) (Bilal et al., 2024).

4.3. Trend Areas

The co-occurrence network and thematic map analysis reveal that research on SLBs falls into three significant areas: Financial Incentives and Premiums, Challenges and Risks, and Market Trends and Growth. This section presents a detailed discussion of each area based on the content analysis of the reviewed papers.

4.3.1. Financial Incentives and Premiums (Premiums, Bond Characteristics, Coupon Step-Ups, and Callability)

Several studies have examined the financial incentives for issuers of SLBs, mainly through premiums and bond characteristics such as coupon step-ups/step-downs and callability.

The existence of premiums, often referred to as "greenium" or "sustainium" (Kumar, 2022), has been a central topic in SLB research. As investors pay for the issuers' improvements in sustainability, issuers benefit from a premium. Thus, Kölbel et al. (2022) found that SLBs with higher coupon step-ups and callable bonds tend to have more significant premiums. However, Liberadzki et al. (2021) found no significant premium in their study, adding that the financial incentives for issuers may exceed potential penalties and raise concerns about greenwashing. Vejarano and Swinkels (2023) identified minimal yield differences (premiums) between SLBs and regular bonds at around five basis points, which evidences that issuing SLBs lies in the company's alignment with sustainability goals rather than financial returns. Contrary to that, Feldhütter et al. (2023) found no evidence of greenwashing risk because the sum of the penalties is smaller than the premium. There is no evidence of SLB mispricing because investors accept a lower yield investing in SLBs, confirming their interest in responsible investing.

The stock market reaction to SLB issuances has also been a research focus. Mocanu et al. (2021) found that some factors affect the financial markets' reaction translated into stock returns, for instance, issuance size, callability, issuer return on assets, and single or multiple issuer announcements on the same day. They found that the announcement of SLBs can lead to positive stock returns, particularly when issuers signal their commitment to sustainability. Mathew and Sivaprasad (2024) expanded on this, noting that the market reaction to SLBs is more potent than traditional bonds, especially when multiple issuers announce bonds on the same day, suggesting that SLBs can serve as a powerful tool for companies to signal their sustainability commitments to the market.

Investigating pricing models for SLBs has also been a significant area of research for several authors with different views. Berrada et al. (2022) developed a mispricing measure to compare prices at issuance with prices on the secondary markets to conclude that overpriced SLBs experience negative returns in secondary markets. Their study highlighted the importance of aligning SLB pricing with market expectations to avoid mispricing, illustrating that the market perceived SLBs as having a higher yield than they do because the market usually calculates the yield to maturity for SLBs without accounting for the coupon penalty. At this point, the authors questioned whether this practice might mislead investors' attractiveness. Erlandsson et al. (2022) and Mielnik and Erlandsson (2022) introduced risk-neutral pricing models, concluding that SLBs with step-up penalties should have lower coupons, while those with step-down penalties should have higher coupons. These models provide valuable insights into how SLB pricing can be optimised to balance the interests of issuers and investors. Like Erlandsson et al. (2022), Chen et al. (2023) used a risk-neutral pricing approach to analyse the SLB design and find the influences on the issuer's sustainability targets, focusing on penalty and step-up/step-down dates.

The discussion added the cost of capital reduction as a financial incentive for the companies to the detriment of the investors since they accept a lower return for SLBs (Povilonis, 2022). Although sustainability performance can promote the reduction of the cost of capital, when there is an issuance to refinance debts, the company suffers two hits in their cash because the cash refinanced with SLBs will use the money to meet their sustainability targets. The second can occur when the company does not meet their targets and has a penalty (Hoepner & Schneider, 2022). Meyer and Affolter (2023) improved the discussion about the cost of capital by adding the leverage characteristic to compare three types of companies. They found that companies in transition and companies who avoid sustainability risks have an increase in their leverage, not explicitly related to sustainability-linked debt instruments but the entire company's leverage, which does not happen with companies promoting SDGs.

The structure of SLBs, including coupon mechanisms, targets, dates, and callability, is responsible for their effectiveness. The step-up/step-down mechanism is a key feature of SLBs. If issuers fail to meet sustainability targets, the coupon typically increases by 25 basis points (step-up) (Liberadzki et al., 2021). Conversely, if companies achieve their targets, the coupon may decrease (step-down). However, Haq and Doumbia (2022) argued that the penalties are often too low to incentivise issuers to achieve their targets. They found that the average penalty was 31.2 basis points, which may not be sufficient to drive meaningful sustainability improvements.

Key Performance Indicators (KPIs) and Sustainability Performance Targets (SPTs) selection is another critical aspect of the SLB structure. Vulturius et al. (2024) emphasised the importance of ambitious, science-based targets to avoid greenwashing. The issuance objective to tackle climate-change issues emitting SLBs tied to sustainability goals was disproportionally underrepresenting the broader sustainability issues when 82% of SLBs issued until 2022 had mainly environmental targets based on diminishing greenhouse emissions (Vulturius et al., 2024). Wang et al. (2023) questioned the target definition for SLBs, debating that the issuer should avoid choosing KPIs specifically chained to results. In other words, these indicators should consider the issuer's performance related to a specific target or could discourage the issuer. However, Feldhütter et al. (2023) found that 73% of SLBs achieve their targets, raising questions about the ambition of these goals. The International Capital Market Association (ICMA Group, 2023) does not define in detail the terms to comply with the vague requirements for material and ambitious SPTs.

Callability is another structural feature of SLBs that has garnered attention, including the data chosen to exercise it. Callable bonds allow issuers to redeem the bond before

maturity to avoid penalties or for asset allocation purposes. Korangi and Erlandsson (2023) found that 93% of SLBs have embedded call options, but this feature is also common in regular bonds, suggesting it is not unique to SLBs. Haq and Doumbia (2022) criticised the use of early redemption to avoid step-up penalties, arguing that it undermines the credibility of SLBs. However, Korangi and Erlandsson (2023) noted using call options for liquidity or renegotiation purposes rather than to evade sustainability commitments.

The issuance's characteristics focus on the bond itself (size, targets, KPIs, target date, callability, penalty, penalty date) and the issuers' characteristics (sector, sustainability compliance, credit risk, country risk, level of pollution). From the point of view of the issuer's characteristics, Meyer and Affolter (2023) classified the companies into three sustainability profiles: one that has the objective of avoiding risks (financial and sustainability), another that contributes to promoting SDGs, and the last one that defined commitments towards transition. When analysing the issuer side, it is important to add a credit perspective, including rating analysis, because some authors identified that the majority of SLBs have a lower credit risk (Vejarano & Swinkels, 2023), not only having a bond analysis that inducts the reader to think that the problem is with the financial instrument and exempting that the issuer has some peculiar characteristics or comes from some hard-to-abate sector. The problems are with the issuer, not with the instrument. The important message is that the instrument is changeable as needed and presents points of attention to the issuer's behaviour. In addition, the consequences of measures to mislead or take financial advantages from the issuance can harm their reputational risk.

4.3.2. Challenges and Risks

One of the main criticisms of SLBs is the potential for greenwashing, sometimes considering that issuers could prioritise financial performance due to a low cost of debt instead of sustainability improvements when choosing easy targets, consequently increasing the reputational risk. Liberadzki et al. (2021) highlighted the moral dilemma where investors benefit from step-up penalties when issuers fail to meet targets, while issuers benefit from lower capital costs when they achieve the targets. These features often give issuers advantages that sometimes exceed penalties for failing to meet sustainability targets (Kölbel et al., 2022). When conflicting actions appeared, the authors reported a misalignment of interests between issuers and investors, which could harm credibility and limit the investor's attractiveness. Liberadzki et al. (2021) corroborated this idea and suggested more rigorous frameworks to mitigate these risks and ensure that SLBs contribute significantly to sustainable objectives. To reinforce this idea, Barbalau and Zeni (2022) introduced the security design concept for SLBs and green bonds, which involves structuring contracts to mitigate greenwashing risks.

Structural flaws in SLB design have been a topic of concern for Haq and Doumbia (2022), who characterised loopholes such as late target dates and early call options, which could reduce the effectiveness of the bonds. They concluded that these flexible features allow issuers to set easy targets and avoid penalties, undermining the SLBs as financial instruments to promote sustainability and forgetting to analyse the bond structure. However, Erlandsson et al. (2022) counterargued that these features are not flaws but characteristics that need proper calibration. They emphasised that the flexibility of SLBs allows issuers to tailor the bonds with careful design to their specific sustainability goals.

Credit risk is another significant challenge for SLBs included in their studies concerning the payment capacity of the issuers to determine their credit rating, which will influence the investor's decision. Vejarano and Swinkels (2023) noted that issuers with lower credit ratings are likelier to issue SLBs as they may not qualify for green bonds, raising concerns about the creditworthiness of SLB issuers and the potential risks for investors. Flugge

et al. (2021) also highlighted the importance of independent advice in selecting KPIs and targets for sovereign SLBs, emphasising that the credibility of SLBs depends on rigorous verification and monitoring.

Regulatory and verification challenges further complicate the SLB market because the lack of standardised KPIs and targets makes it difficult to compare SLBs across issuers. Giráldez and Fontana (2022) emphasised the need for standard and detailed frameworks to ensure that SLBs contribute to sustainability goals. They also highlighted the importance of independent verification of targets and performance in defining credible indicators to maintain credibility. Bolton et al. (2023) added that advancing policies to improve reliability is necessary, suggesting a legal framework for SLBs.

4.3.3. Market Trends and Growth

Companies with higher ESG scores are more prone to issue SLBs and achieve sustainability targets, and are consequently more attractive to investors, as Berrada et al. (2022) found. Meyer and Affolter (2023) noted that companies with better sustainability profiles have higher leverage, partly due to their use of sustainability-linked debt instruments, suggesting that ESG performance is a key driver of investor demand for SLBs.

Investors drive the demand for SLBs seeking to align their portfolios with sustainability goals. Kumar (2022) identified a "sustainium" that is a premium for sustainable bonds, suggesting that investors are willing to accept lower returns for bonds that contribute to sustainability. In this sense, this action characterises a shift in investor preferences toward responsible investing, balancing financial returns with environmental and social benefits.

Blockchain technology adds transparency to data and transactions in performance-based instruments, delivering more precise benchmarking that helps improve an investment's risk–return measurement. Our sample analysis presents some examples, such as stormwater (Open Storm) (Chung et al., 2023) and a satellite on Amazon Forest called Earth Observation (Borlaf-Mena et al., 2023), to support indicators such as deforestation and land use. The technology on the service of sustainability performance-based instruments ensures accuracy when allowing a verifiable and auditable framework mitigating the gap in technology infrastructure to support financial innovation (Chung et al., 2023). This technology can potentially revolutionise the SLB market by providing a reliable framework for tracking and verifying sustainability performance.

Sovereign and thematic SLBs are gaining visibility for countries and companies to align their financing with sustainability goals (Giráldez & Fontana, 2022). Flugge et al. (2021) proposed a framework for sovereign SLBs, emphasising the importance of selecting relevant KPIs and ambitious targets. These KPIs for sovereign SLBs can determine environmental performance objectives by considering the materiality of each country, allowing country comparison (Bouzidi & Papaioannou, 2021). Another relevant aspect cited in this study is that sovereign SLB pricing depends on the country's credit rating, even though the issuance has KPIs monitored closely. Some authors mentioned that SLBs could act as a hedge for risks, including Giráldez and Fontana (2022), noting that sovereign SLBs protect against ESG risks, providing investors with a way to align their portfolios with national sustainability commitments. Bouzidi and Papaioannou (2021) also reinforced the importance of selecting the KPIs and targets for sovereign SLBs, highlighting that these instruments can act as a hedge for investors against policy goals.

Thematic SLBs, such as gender-linked or blue bonds (Benzaken et al., 2024; Bosmans & Mariz, 2023), are emerging as innovative strategies to address specific sustainability challenges. Vulturius et al. (2024) highlighted the potential of thematic bonds to promote investments in areas like climate change adaptation and gender equity. Chung et al. (2023) propose an Amazon sustainability-linked bond to incentivise policy efforts based

on a matrix of sustainability targets established compared to benchmarking. The authors discussed the contract form of SLBs, considering that it is impossible to specify how the issuer must achieve the targets, ensuring that issuers adapt to reach their targets. First, they suggested using performance benchmarks as other financial instruments to evaluate performance, including a matrix to measure the additionalities and impacts and identify feasible targets to suppress deforestation. These bonds represent a growing trend in the SLB market as issuers seek to address a broader range of sustainability issues.

Companies in carbon-intensive industries are using transition bonds to finance their shift toward sustainability. Another challenging perspective in the SLB issuance is the possibility of companies in transition, most with fossil fuel backgrounds, refinancing their bonds and loans using a performance-linked instrument (Hoepner & Schneider, 2022). Vulturius et al. (2024) raised concerns about the ambition of targets in transition bonds, emphasising that some issuers may set easy targets to benefit from lower capital costs without making significant sustainability improvements. Mielnik and Erlandsson (2022) also recognised the need for ambitious targets to ensure that transition bonds drive feasible change. They highlighted the relevance of the issuer's sustainability commitments and the target ambition to succeed with transition bonds.

5. Discussion and Future Research

Future research on SLBs should focus on several key areas. First, most of the studies analysed in this paper draw attention to the structure design of SLBs, including aspects pertaining to calibrating targets, selecting KPIs, defining dates and callabilities, and coupon mechanisms. Thus, there is a consensus concerning the need to research how to mitigate flaws by improving targets, KPIs, regulations, and external opinion. It is all a matter of calibration of the bond's characteristics, not precisely flaws.

Second, other topics that need empirical studies to improve the research are the pricing drivers and the impact of premiums on bond performance. As the underexplored coupon structure becomes more familiar and studied from both sides, the parties can explore its complexity with multiple step-up/step-down conditions (Mielnik & Erlandsson, 2022).

Third, researchers have identified a significant challenge with the lack of standardised KPIs and targets. Research and policymakers should focus on developing frameworks for SLB issuance, similar to the EU Green Bond Standards, to ensure transparency and credibility. A broader analysis of different regulatory initiatives from other regions, including Asia, provides valuable insights into how standardisation impacts market development and investor confidence.

Fourth, more research is necessary to address the risks of greenwashing and reputational damage to companies that issued SLBs, which includes developing robust verification mechanisms and third-party opinions, framework and issuance assurance, and exploring the role of blockchain and other technologies in enhancing transparency. Examining how these verification mechanisms affect investor trust and market pricing remains an open question.

While most studies focus on European markets, a fifth area for future research should examine SLBs in other regions, particularly emerging markets, to understand their potential for growth and impact. One suggestion is a comparative analysis between developed and developing economies, revealing the behaviour of different financial, regulatory, and market conditions shaping the adoption of SLBs and their effectiveness in driving sustainability goals.

Thematic and transition bonds represent innovative areas for future research and our sixth research topic. Studies should explore using these bonds to address specific sustainability challenges, such as climate change adaptation and gender equity. Several SLBs are

emerging because of their design, such as sovereign, thematic bonds (gender, blue, green, Amazon) and transition bonds to mitigate impacts and adapt regions to climate change. In this matter, we can foresee a combination of products or a blended product to promote investments to secure the existence of ecosystems, such as financing Nature-Based Solutions through performance-based bonds emitted privately, compensating the returns with carbon credits from the regions. Some authors investigated the carbon emissions' compensation in bond issuances with this type of penalty; where the issuer fails to meet their targets, the obligation is to deliver carbon offsets in a percentage of the principal amount as a contractual agreement (Haq & Doumbia, 2022). Another study found a positive relation between those SLBs and carbon penalties as a form of premium (Feldhütter et al., 2023).

Finally, applying management theories, such as signalling and stakeholder theories, to SLBs is an underexplored topic. Future research should examine how these theories can inform the design and implementation of SLBs. Signalling theory could provide insights into how issuers use SLBs to pursue their sustainability commitments, while stakeholder theory assesses how investor expectations and regulatory pressures influence SLB adoption. In addition, the agency and institutional theories explore governance structures and market incentives shaping SLB issuance and performance.

6. Conclusions

Although the bond characteristics of SLBs are different from those of other sustainable, social, and green bonds, they have been accepted and operated by the market, changing how the players interact in the financial markets and introducing the performance-based bond tied to sustainable targets, representing a significant evolution in the field of sustainable finance, making them a flexible and innovative tool for addressing environmental, social, and governance (ESG) challenges. This paper aims to provide a comprehensive literature review on SLBs—the research design employed bibliometric and content analysis to map the evolution and trends of the research.

This study verified the growing interest in SLBs to support the transition to net-zero emissions and broader sustainability goals accommodating companies and governments. The SLB market grew rapidly, considering the significant issuance volumes since its inception, but it is still in its beginning, evidencing the need for further exploration to address the challenges and risks, such as greenwashing, target ambition, and transparency.

The review firstly highlights several important themes in the SLB literature, starting with the financial incentives and premiums associated with SLBs that have been a significant research focus. Studies have explored the pricing of SLBs, the role of coupon step-up/step-down mechanisms, and the market reaction to SLB issuances. However, most authors raised concerns that the penalties are insufficient to stimulate meaningful change, raising questions about the credibility and the potential for greenwashing.

Second, the review identifies several challenges and risks, naming the lack of standardised KPIs and targets, the potential for greenwashing, and the credit risk of issuers. Even though authors considered the flexibility of SLBs a strength, this characteristic also presents challenges in calibrating ambitious targets, dates, and penalties. Independent verification and the rigorous frameworks mentioned by some studies revised in this paper will enhance the credibility of SLBs and ensure that they contribute meaningfully to companies' and countries' sustainability objectives.

Third, the review highlights emerging trends, including the growth of sovereign and thematic bonds, the use of technology for transparency, and the development of transition bonds for carbon-intensive industries. These trends reflect the diversity and flexibility of the performance-based instrument and the potential to address sustainability.

The review also identified several gaps in the literature, such as more empirical studies on pricing and premiums, the development of standardised frameworks for issuance, and the exploration of SLBs in different geographical regions in emerging markets. Additionally, one underexplored topic is the application of management theories, such as signalling and stakeholder theories, to SLBs.

Finally, SLBs have relevant characteristics to confirm their position as a prominent financial instrument for driving sustainability and aligning financial markets with sustainability goals depending on the credibility of the targets set, the verification process's rigour, and the incentives' alignment between issuers and investors. Policymakers, regulators, and market participants must work together to deal with the challenges and risks and ensure they contribute meaningfully to the transition to a more sustainable economy.

The main contribution of this study to the literature pertains to filling the gap in existing research focusing mainly on green bonds. In addition, the methodology used combines bibliometric and content analysis to map the evolution and trends of the research.

Among the possible implications of this study, we want to emphasise the relevance of its findings for scholars and policymakers. They are likely helpful for the former, given that they give them a detailed picture of research on SLBs. Their usefulness for the latter resides in the assistance they are likely to offer them in making informed decisions regarding policies and legislation about sustainable finance.

This paper has limitations concerning data scarcity. We only identified 32 articles specifically discussing the SLB as a financial instrument in depth, limiting the empirical data for analysis. The focus on writing the paper in English is one noteworthy limitation. Future studies could examine research on SLBs written in other languages and confront the findings with those presented in this paper.

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Appendix A

The appendix contains the list of 32 articles used for bibliometric analysis.

Table A1. Bibliometric analysis reference list.

Author	Title
Affolter et al. (2024).	Signaling sustainability: Differential reaction of the stock market following the announcement of sustainability-linked bonds.
Auzepy et al. (2023).	Are sustainability-linked loans designed to effectively incentivize corporate sustainability? A framework for review.
Berrada et al. (2022).	The Economics of Sustainability-Linked Bonds.
Boermans (2023).	Preferred habitat investors in the green bond market.
Bolton et al. (2023).	On Debt and climate.
Borlaf-Mena et al. (2023).	Unlocking sustainability: leveraging BIG EO data analytics for bonding a greener future.

Table A1. *Cont.*

Author	Title
Bouzidi and Papaioannou (2021).	Sovereign Sustainability-Linked Bonds–Opportunities, Challenges and Pricing Considerations.
Bracking et al. (2023).	Turning investments green in bond markets: Qualification, devices and morality.
Chen et al. (2023).	Valuation and Design of Sustainability-Linked Bonds.
Cheng et al. (2022).	Sovereigns and sustainable bonds: challenges and new options.
Erlandsson et al. (2022).	Notes on risk-neutral pricing of SLBs and step-down structures.
Feldhütter et al. (2023).	Pricing of Sustainability-Linked Bonds.
Flugge et al. (2021).	Striking the Right Note: Key Performance Indicators for Sovereign Sustainability-Linked Bonds.
Giráldez and Fontana (2022).	Sustainability-linked bonds: the next frontier in sovereign financing.
Haq and Doumbia (2022).	Structural Loopholes in Sustainability-Linked Bonds.
Jukonis (2022).	Modelling ESG Linked Bank Debt Issuance.
Kölbel et al. (2022).	Who Pays for Sustainability? An Analysis of Sustainability-Linked Bonds.
Korangi and Erlandsson (2023).	SLBs: No cal (l) amity.
Lefournier (2023).	The design flaw in Sustainability-Linked Bonds.
Lehmann et al. (2023).	The potential of sovereign sustainability-linked bonds in the drive for net-zero.
Liberadzki et al. (2021)	Spread Analysis of the Sustainability-Linked Bonds Tied to an Issuer's Greenhouse Gases Emissions Reduction Target.
Lupo-Pasini (2022).	Sustainable Finance and Sovereign Debt: The Illusion to Govern by Contract.
Maino (2022).	Sustainability-linked bonds and their role in the energy transition.
Meyer and Affolter (2023)	Do Sustainable Companies Receive More Debt? The Role of Sustainability Profiles and Sustainability-related Debt Instruments.
Mielnik and Erlandsson (2022).	An Option Pricing Approach to Sustainability-linked Bonds.
Mutarindwa et al. (2024).	Certification against greenwashing in nascent bond markets: lessons from African ESG bonds.
Poggensee (2023).	The Pricing of Sustainability-Linked Bonds on the Primary and Secondary Bond Market.
Povilonis (2022).	Contracting for ESG: Sustainability-Linked Bonds and a New Investor Paradigm.
Rashad Abdel-khalik (2023).	Do Sustainability-Linked Notes have Embedded Derivatives.
Vejarano and Swinkels (2023).	Social, Sustainability, and Sustainability-Linked Bonds.
Vulturius et al. (2024).	Sustainability-linked bonds–their potential to promote issuers' transition to net-zero emissions and future research directions.
Wang et al. (2023).	Could Sustainability-Linked Bonds Incentivize Lower Deforestation in Brazil's Legal Amazon?

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