Fact, fiction, and green bond investing – a central bank's perspective

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Abstract

Building on Narodowy Bank Polski's several years of experience in the green bond market, this article discusses a number of questions surrounding green bond investing. Trying to separate fact from fiction and concepts from misconceptions, the essay looks at the size and depth of the green bond universe, pricing patterns, risk profile and performance, as well as the potential for engineering real environmental impact.

JEL classification: G12, G14, G20.

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1. Introduction

Green bonds refer to any type of debt instrument where the use of proceeds is directed exclusively towards financing/refinancing environmentally sustainable projects. The asset class was born in 2007, when the European Investment Bank (EIB) issued its first "climate awareness bond", but began to gain ground in earnest several years later, when the 2015 Paris Agreement ushered in a renewed sense of urgency around transitioning to a low-emissions economic growth. Despite a certain divergence of views around the various technological aspects of achieving carbon neutrality, there appears to be a consensus that reaching net zero will in any case require massive investment, the estimated value of which ranges between $50 trillion almost $300 trillion.[2] And while a large part of the financing for all these sustainable projects will come in the form of equity (eg when a company issues new shares or retains earnings to finance the greening of its production processes), it is estimated that only about 40% of global emissions originate from listed companies (Generation IM (2021)), and therefore debt instruments do have a role to play as well – especially in view of their importance for financing government expenditures. Thus, green bonds, along with their slightly more general cousins "sustainable" bonds,[3] have become a much sought-after product among investors – both public and private – seeking to incorporate climate change objectives in their portfolios, either on their own or as part of a broader ESG strategy.[4]

Narodowy Bank Polski (NBP), Poland's central bank, has been an increasingly active player in the green bond market. Entrusted with managing the country's FX reserves, NBP actively manages a portfolio worth over $100 billion (of the total official reserve assets exceeding $160 billion), investing in predominantly fixed income instruments across eight different currencies, including USD, EUR, GBP, CAD, AUD, NOK and NZD. Beginning with small-scale purchases of labelled bonds in 2018, allocation to the asset class across all currency portfolios grew to about $600 million by 2021. By that time, the Management Board adopted a formal Green Bond Strategy, aiming to provide some structure to the previously somewhat idiosyncratic investment process, and providing allocation targets along with a time frame for achieving them. With close to $900 million invested in green bonds across a range of markets and issuers, NBP can claim to be a significant player in this burgeoning market.

However, the gradual expansion of our exposure has been a learning process, during which we have developed a better understanding of the market itself and

[2] For example, Morgan Stanley (2019) estimates that $50 trillion will need to be invested in new technologies over the next 30 years to reach net zero. A similar number is reported by Oliver Wyman and the World Economic Forum, while the consultancy McKinsey, building on hypothetical scenarios developed by the Network for Greening the Financial System, estimates that spending on physical assets would need to reach about $275 trillion by 2050, or $9.2 trillion per year on average, to achieve net zero.

[3] Whereas green bonds fund strictly designated environmental projects, sustainability bond may fund a mix of environmental and social projects, while sustainability-linked bonds do not fund particular projects but their coupon or principal step up if the issuer fails to meet the pre-agreed environmental or social targets (Kini et al (2021)).

[4] According to Bloomberg data, as of February 2022, there were 100 sustainable fixed income ETFs with total AUM exceeding $50 billion (14 of which were dedicated green bond ETFs with $2 billion in AUM). Owing to the inflow of funds into these vehicles, AUM has increased by almost 40% since the beginning of 2021.

gained a clearer picture of the rationale behind green bond investing and its desired (and sometimes undesired) outcomes. As it would be difficult to distil all the internal discussions and memos into a coherent "lessons learned" narrative, this article opts for a more modest, and perhaps also more entertaining approach – it attempts to retell our educational experience by reviewing the following common questions about green bond investing, framed here in a purposefully provocative and controversial way:

1. **Is the green bond market too small and underdeveloped?**

2. **Does establishing a green bond mandate mean sacrificing returns and should it be a concern?**

3. **Are green bonds "safer" than conventional bonds and do they outperform in risk-off episodes?**

4. **Is reputational risk an important issue in the green bond market?**

5. **Does green bond investing make a positive environmental impact?**

The questions are presented without specific attribution, as the intention is not to engage in polemics, but rather to present important considerations regarding the green bond investment process in an intuitive and entertaining way. That said, each question will be addressed and examined through the prism of relevant up-to-date practitioner and academic literature as well as empirical data and examples.

Readers will doubtless find that the above list is by no means exhaustive and the answers provided – most of which go along the lines of "it's complicated…" – can hardly claim originality. Still, the narrative will hopefully shed some light on important considerations in green bond investing and might help to inform the decision-making of those central banks and public investors who have yet to gain a foothold in the green bond market.

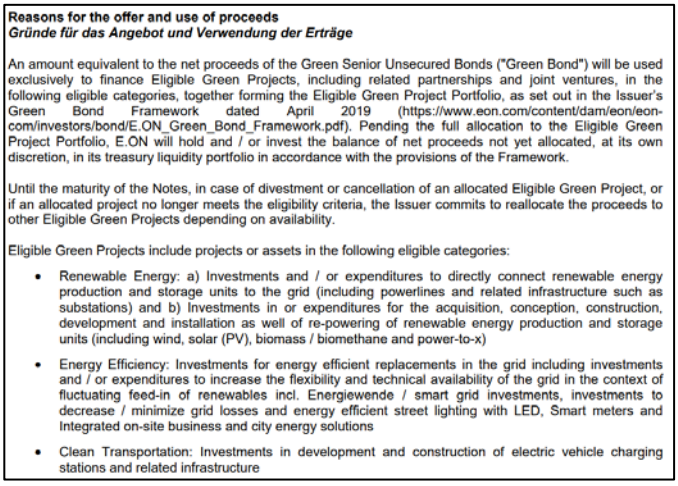
2. Perspective on market structure: is the green bond market too small and underdeveloped?

One of the first issues to arise in discussions around green bonds is often the size, liquidity and development of the market. A natural concern for a public investor with a mandate that implicitly or explicitly requires a large and liquid portfolio to be held might be that the green bond market is still too niche and immature to be tapped in meaningful size, and thus would be best left to "specialised" funds and other players.

Is the green bond market really too small to bother with? Straddling the continuum between "fact" and "fiction", an honest response to such a question should probably be: it's complicated. Before getting a little deeper, it might be useful to reiterate that green bonds are "use of proceeds" debt instruments which fund (but are not secured against!) strictly designated environmental projects. Typically, the designation is performed by the issuer in the bond prospectus, and clarifies how the earmarking of proceeds is going to work, which specific projects are to receive the

funding, and potentially even what impact they are expected to generate (see Graph 2.1 for a snapshot example of a prospectus). A watershed moment in the evolution of the green bond market was the publication in 2017 of the ICMA Green Bond Principles,[5] which sought to provide more transparency for investors and clarify requirements for issuers, pertaining to eligible project types (eg renewable energy, energy efficiency or clean transportation) and best practices with respect to project evaluation and selection, management of proceeds, and reporting.

Sample use of proceeds section of the prospectus of a green bond issue by the energy company E.ON — Graph 2.1



Reasons for the offer and use of proceeds
Gründe für das Angebot und Verwendung der Erträge

An amount equivalent to the net proceeds of the Green Senior Unsecured Bonds ("Green Bond") will be used exclusively to finance Eligible Green Projects, including related partnerships and joint ventures, in the following eligible categories, together forming the Eligible Green Project Portfolio, as set out in the Issuer's Green Bond Framework dated April 2019 (https://www.eon.com/content/dam/eon/eon-com/investors/bond/E.ON_Green_Bond_Framework.pdf). Pending the full allocation to the Eligible Green Project Portfolio, E.ON will hold and / or invest the balance of net proceeds not yet allocated, at its own discretion, in its treasury liquidity portfolio in accordance with the provisions of the Framework.

Until the maturity of the Notes, in case of divestment or cancellation of an allocated Eligible Green Project, or if an allocated project no longer meets the eligibility criteria, the Issuer commits to reallocate the proceeds to other Eligible Green Projects depending on availability.

Eligible Green Projects include projects or assets in the following eligible categories:

- Renewable Energy: a) Investments and / or expenditures to directly connect renewable energy production and storage units to the grid (including powerlines and related infrastructure such as substations) and b) Investments in or expenditures for the acquisition, conception, construction, development and installation as well of re-powering of renewable energy production and storage units (including wind, solar (PV), biomass / biomethane and power-to-x)
- Energy Efficiency: Investments for energy efficient replacements in the grid including investments and / or expenditures to increase the flexibility and technical availability of the grid in the context of fluctuating feed-in of renewables incl. Energiewende / smart grid investments, investments to decrease / minimize grid losses and energy efficient street lighting with LED, Smart meters and Integrated on-site business and city energy solutions
- Clean Transportation: Investments in development and construction of electric vehicle charging stations and related infrastructure

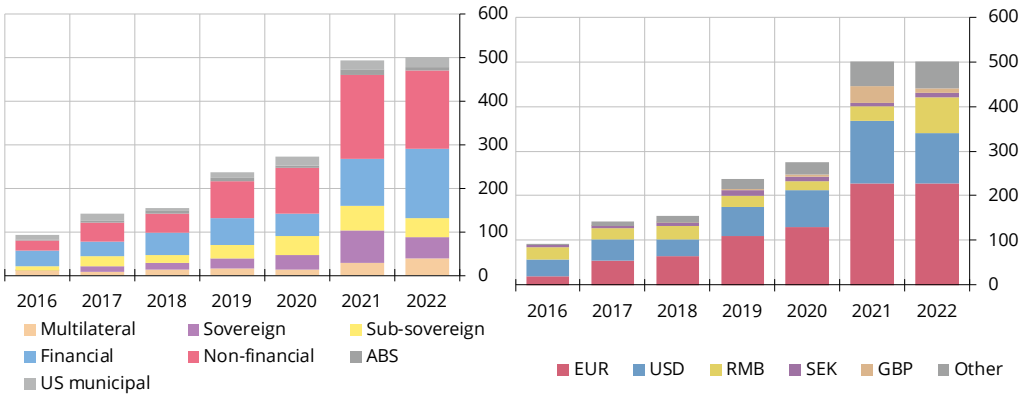
Source: Company website.

As of January 2023, the green bond market stands at over $1.8 trillion, ie roughly equivalent to the total stock of UK government gilts. And while this might correspond to just 15% or so of total global foreign exchange reserves, the market's recent growth has been spectacular, with issuance levels of about $500 billion in 2021–22, up from less than $50 billion in 2014 (Graph 2.2).

On the back of increasing volumes, the market has steadily gained in diversity along both the currency and issuer dimensions. Initially, the market was almost entirely the domain of supranational institutions such as EIB and the World Bank. Gradually, municipalities, local governments and government agencies joined in, and finally in 2013 – with the total market size still at roughly $10 billion – the first corporate green bonds appeared. Importantly for public investors, almost 80% of the outstanding stock originates in developed markets, and 75% is denominated in EUR and USD, ie the currencies preferred by central bank reserve managers.

[5] The 2021 version of the principles is available at: Green-Bond-Principles-June-2021-140621.pdf (icmagroup.org).

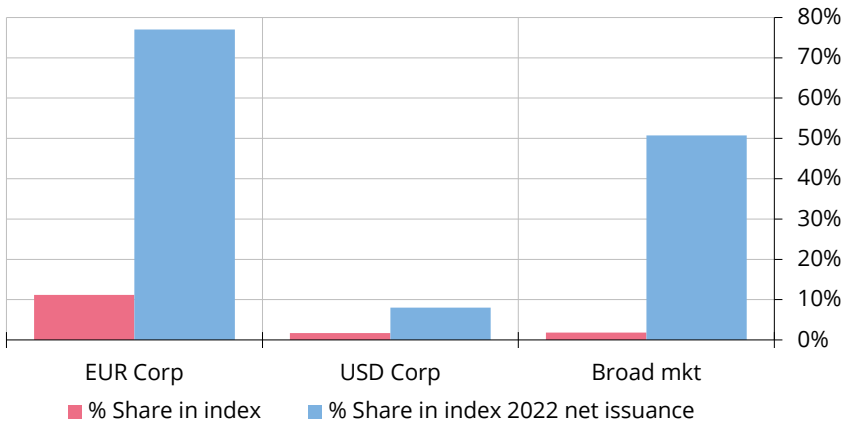
Green bond issuance by issuer type and currency (2016–21, USD bn) Graph 2.2



Source: HSBC, Bloomberg.

The growing importance of green bonds in the broader fixed income universe is well illustrated by their increasing share in the broadly followed benchmark indices – especially within the corporate sector. Thus, for example, of the 156 new issues added to the EUR investment grade corporate bond index in 2022, as many as 138 (or 77% in face-value terms) were green-labelled, which translates into a share of just above 11% in the index. The corresponding numbers for the – much larger – USD sleeve of the IG corp index are lower, accounting for 8% of the 12-month "flow" and about 2% of the "stock". Likewise, for the broad market benchmark, about 50% of new issuance came in the form of labelled bonds, which as of end-2022 make up 2% of the index (Graph 2.3).

Green bonds as a share of corporate and broad market bond indexes Graph 2.3



Bond indexes are ICE/BAML benchmark corporate bond indexes for the United States and euro area: (i) US Corporate Index (C0A0), and (ii) Euro Corporate Index (ER00), and the global broad market benchmark (ICE BofA Global Broad Market Index, GBMI.

Source: ICE, Bloomberg.

The increasing depth and breadth of the green bond market – as manifested in index coverage – improve liquidity as bonds are turned over more frequently as part of portfolio maintenance, in response to index/benchmark rebalancing etc. For example, a recent HSBC study, based on an analysis of the TRAX reporting service, which covers about 50% of all European bond trades, finds that EUR labelled bonds have similar, reported weekly trading volume (as a percentage of nominal) than non-labelled peers (both numbers are around 2% on average throughout 2022; Kini et al (2023)). This seems to be at least partly borne out in trading conditions, as the median bid-ask spread-to-price ratio for the two universes is virtually the same at 48 bp.

Thanks to these structural improvements in market breadth it has become possible to replicate broad fixed income benchmarks using green bonds only. While this necessarily implies some sampling or optimisation, the results are quite encouraging. To appreciate this, consider a simple experiment, whereby each month, the available universe of green corporate bonds, say the almost 500 EUR issues and 375 USD bonds as of March 2023, is used to build portfolios in each currency such as to match the main characteristics of the broad investment grade corporate benchmark indexes, which for the sake of this exercise are the ICE/BAML Euro Corporate Index (ticker ER00) for the euro-denominated corporate bonds and the ICE/BAML US Corporate Master Index (ticker C0A0) for the USD-denominated corporate bonds. As of March 2023, the C0A0 comprised 9,831 securities with a market value of $7.7 trillion. At the same time, ER00 had 4,114 issues with a market cap of EUR 2.6 trillion.

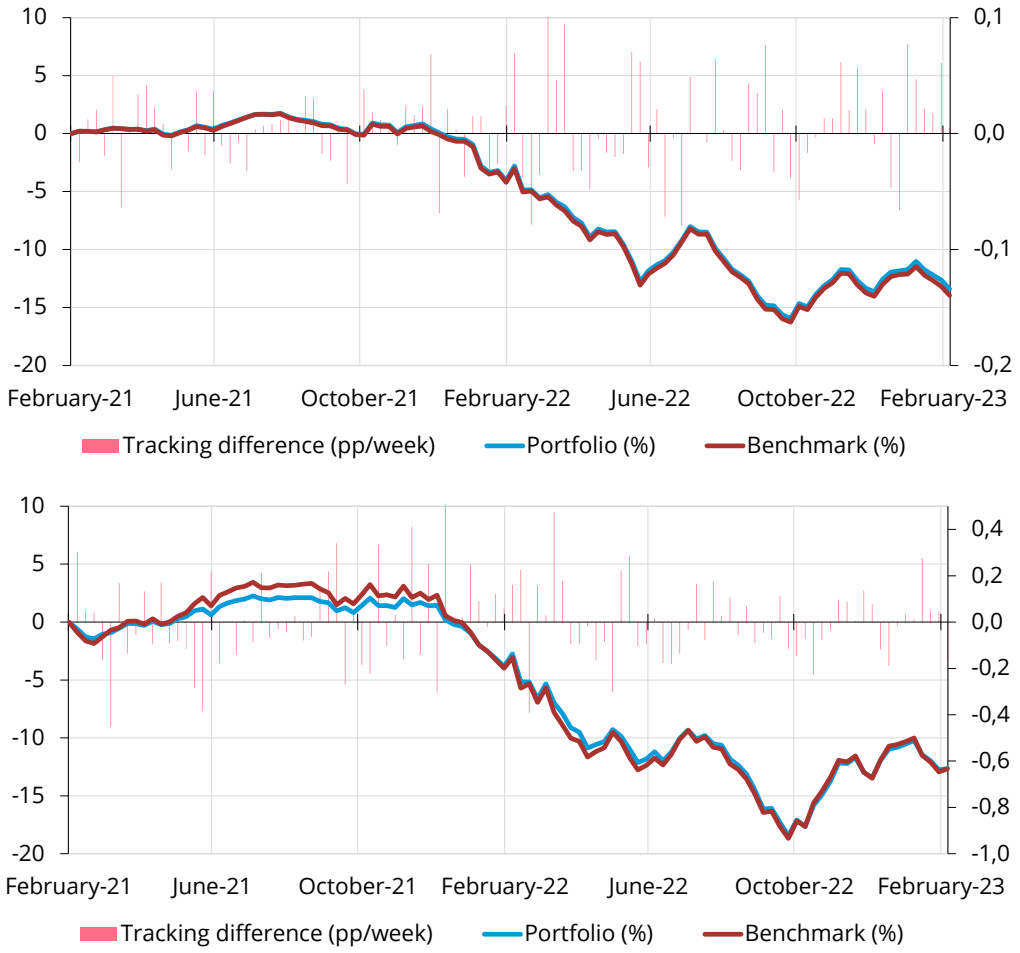
Since the universe of green bonds is evidently much narrower than either index, the replication process needs to be somewhat selective and in this case consists in matching benchmark key rate durations, as well as its overall spread duration, weights of the major rating buckets (AAA, AA, A and BBB), and duration times spread contribution of each of the three key sectors (Financials, Utilities, Industrials). Finally, while the bonds aren't screened for liquidity characteristics, the algorithm imposes a concentration limit of 2% on each issue. The sample used in this exercise runs from January 2021 through February 2023, a period marked by exceptionally high volatility in fixed income markets.[6]

Graph 2.4 illustrates the cumulative performance of the replicating portfolios against their respective benchmarks. In both cases the fit is very good, and the cumulative performance virtually undistinguishable. The total return of the euro replicating portfolio – which held on average about 120 issues – was 13.41% against –13.96% on the ER00 benchmark, with a tracking error of just 4 bp/week. The corresponding figures for the US were –12.65% on the portfolio vs. –12.66% on the C0A0 benchmark index, with a tracking error of 17 bp/week, and an average number of 76 positions in the portfolio. The noticeably larger tracking error for the US portfolio partially stems from the lower breadth and depth of the green bond market in USD (note that there are about half as many USD green corporate issues as EUR

[6] Formally, the optimisation problem is cast as follows: Maximise $\sum_{i=1}^{N} w_i \, OAS_i$ subject to: (i) $\forall i \; 0 \leq w_i \leq 0.02$ (long-only portfolio with concentration limit set to 2%); (ii) $\sum_{i=1}^{N} |(w_i - b_i) \times OASD_i| < 0.2$ (portfolio spread duration constraint); (iii) $\sum_{i=1}^{N} \left|(w_i - b_i) KRD_{i,j}\right| < 0.1$, where $KRD_{i,j}$ is the key rate (partial) duration of i-th position with respect to j-the rate, j=1Y,2Y,3Y,5Y,7Y,10Y,20Y and 30Y (key rate duration constraint); (iv) $\sum_{i \in Rating} |w_i - b_i| < 0.02$, where Rating stands for rating bucket AAA,AA, A, and BBB (rating constraint); $\sum_{i \in Sector} |w_i - b_i| < 10$, where Sector stands for the following sector groups: Industrials, Financials, Utility (sector DTS constraint).

green bonds) and also greater market volatility on the back of the significant monetary policy tightening in 2021–22.

Cumulative performance of EUR (top panel) and USD (bottom panel) corporate green replicating portfolios — Graph 2.4



Note: Benchmark is the ICE BAML Euro and USD Corporate index respectively; Portfolio is a replicating portfolio of green corporate bonds optimised to have minimum ex ante tracking error while matching key rate durations, as well as overall benchmark spread duration, weights for the major rating buckets (AAA, AA, A, and BBB), and duration times spread contribution of each of the three key sectors (Financials, Utilities, Industrials). Replicating portfolio is rebalanced monthly.

Source: ICE, Bloomberg.

3. Perspective on the safety and return characteristics of green bonds

3.1 Does establishing a green bond mandate mean sacrificing returns and should it be a concern?

Unlike fund managers, public investors may not have clearly defined fiduciary duties to uphold, and for some of them – like central bank reserve managers – return maximisation is not even typically a first-order priority. Still, being accountable to the government and the broader society means that they are unlikely to be able to avoid risk-return considerations altogether in developing their investment process. And thus, one of the key questions involved in setting up a green bond portfolio or strategy is likely to be about the financial impact of such a step. Framing this a little more formally, the question is whether, and to what extent, green bonds trade at a premium – astutely called the greenium – relative to conventional counterparts with the same risk profile, and whether that premium then feeds through to returns.

As unsecured instruments, green issues have in principle indistinguishable risk characteristics from conventional bonds of the same issuers. After all, even though the proceeds from the issuance of green bonds are earmarked to particular environmentally friendly projects, their cashflows are ultimately serviced through income from the entirety of the issuer's operations (or tax base, in the case of sovereigns), not just the particular green project. Hence, a priori, there should be little systematic difference in pricing between green and non-green bonds with the same financial features, particularly so if both debt instruments are issued by the same entity. However, it could also be argued, that the green label does in fact impact pricing (up or down) via two distinct channels: (i) higher demand from environmentally conscious investors eager to demonstrate alignment with emerging best practice or regulations (eg Article 8 of the EU's Sustainable Finance Disclosure Regulation); and (ii) higher costs related to additional tracking, monitoring, and reporting processes, as well as up-front investment to define the bond's green criteria and sustainability objectives – all of which could be passed on to investors (eg EIB estimates that the additional cost of issuing its green bonds in terms of dedicated staff, IT systems etc to be at 0.02% of issue size; EIB (2021)). To the extent that this effect (i) outweighs (ii), a green bond may be expected to trade at a premium (greenium) vis-à-vis its non-green counterpart.

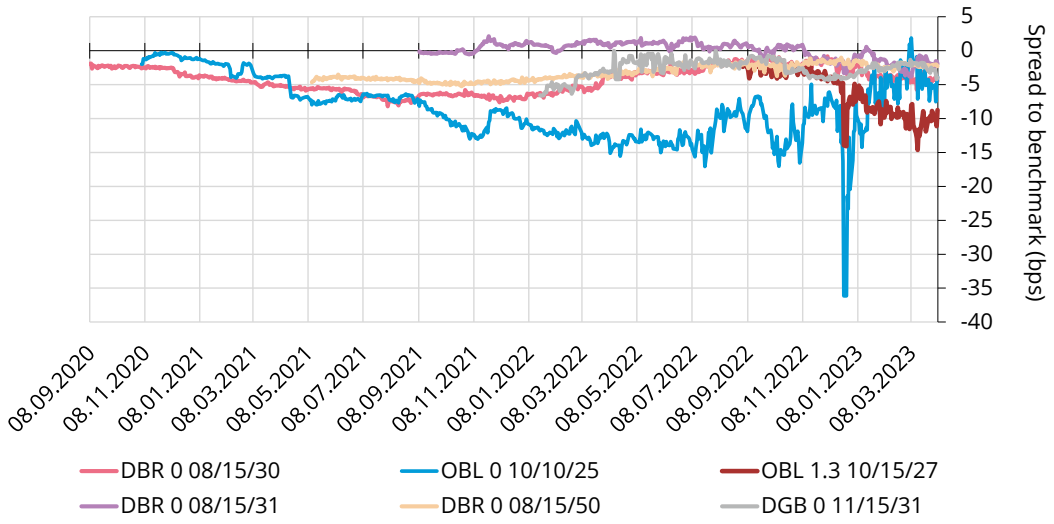
Although there is by now a considerable empirical literature studying the existence of the greenium, the evidence is generally inconclusive and consensus on its size and even sign is yet to emerge (see MacAskill et al (2021) for a comprehensive review of the literature on greenium). Somewhat surprisingly perhaps, there does not even appear to be a consensus on how best to measure the greenium, and the approaches in the academic and practitioner literature differ depending on context. The most straightforward approach involves comparing the spread of a given green bond relative to some benchmark curve vs its non-labelled counterpart, whereby a tighter spread of the green bond (ie a negative spread differential) means it trades richer (is more expensive) than the non-green peer, suggesting a potential greenium.[7] In practice, it is not always straightforward to define a "conventional counterpart" with

[7] We follow the convention that seems to have developed in the literature of speaking of a positive greenium when the spread between green and non-green is negative, and vice versa.

matching maturity – after all, the peer bond should in principle differ from the labelled issue in nothing but its use of proceeds.

One example where this type of approach might be applied is in the context of so called twin bonds issued originally in 2020 by the German federal government, and more recently also by Denmark. The idea consists in always issuing a green bond alongside a conventional one with the same maturity, coupon and even interest dates to facilitate comparison and facilitate price discovery. Although the twins still differ markedly in issuance amounts (eg the amount outstanding of the German green bond maturing in 2030 is EUR 9.5 billion, less than 25% of the amount of its non-labelled twin), this is perhaps as close as one can practically get to a like-for-like comparison. The overall pattern is that green bonds tend to trade slightly richer (with lower yields) than non-green counterparts and the resulting greenium averages about 4 bp for the German issues and about 2 bp for the Danish one (Graph 3.1). Still, the pattern isn't clear or consistent and seems to be at least partly influenced by technical factors, as the greenium is actually largest for the shortest-maturity German bond (OBL 10/10/25) and least pronounced for the longest-maturity one.[8]

Greenium estimates for German and Danish green government bonds Graph 3.1



Note: DBR and OBL denote the German issues while DGB stands for the Danish issue; greenium calculated as the mid-yield spread to the non-green twin benchmark.

Source: Bloomberg.

Even when finding a perfect twin bond is impossible, the greenium can still be calculated as the spread gap between an issuer's green bond and a maturity-matched non-green peer. Granted, some entities are not big or active enough in the market

[8] The technical factors might refer to investors' preferred habitats and market segmentation. As of this writing (May 2023), there are 23 sovereign bond issues in the euro market with an average maturity (weighted by amount outstanding) of about 14 years. This makes the German note maturing in 2025 the only viable investment on the short end of the curve, which may result in additional demand particularly from institutional/public investors constrained in the amount of duration risk they can take.

(in particular in Europe where corporations have traditionally relied to a greater extent on bank credit than on the bond market) as to have a fully developed spread curve that would facilitate such comparisons. In such cases one can construct a theoretical synthetic duration-matched counterpart either by forming a barbell portfolio of two bonds with durations above and below that of the green bond, or via an interpolation/regression scheme or even a fully fledged yield curve model to supplement the missing points on the curve. Finally, an even cruder approach consists in analysing bond spreads for entire groups of issuers belonging to the same category and/or risk bucket. Thus, for example, one could filter out all GBP issues of AA companies, select those labelled as green, and compare their median spread with the one calculated for the rest of the group.

Attempting to sidestep these methodological problems, Jabłecki (2022) looks for evidence of a greenium in EUR and USD investment grade corporate bond universes by running a series of cross-sectional regressions of bond spreads (option-adjusted, or OAS[9]) on a range of explanatory variables including a dummy for "greenness," to check whether it is possible to attribute any part of corporate bond's spread to the green label itself. The regression results are reproduced in Table 3.1. They point to a clear, statistically significant spread greenium in both markets of about 5–8 bp on average, which over the long run should marginally erode the carry on the portfolio (although in , short run, it might still have little impact on returns).[10]

Fama-MacBeth credit spread regressions Table 3.1

	EUR IG		US IG	
	Coeff	t-stat	Coeff	t-stat
Green	-8.00	-10.86	-4.85	-4.46
Spread duration	6.66	24.76	6.58	20.42
Rating	17.22	26.2	21.20	13.48
Industrials	-59.24	-17.77	-81.78	-20.58
Financial	-27.77	-11.93	-67.40	-21.39
Utility	-70.81	-17.59	-83.44	-16.37
R2	0.89		0.87	

Note: EUR IG includes all euro-denominated investment grade corporate bonds within the ICE/BAML Euro Corporate Index (ticker ER00); US IG includes all USD-denominated investment grade corporate bonds within the ICE/BAML US Corporate Master Index (ticker C0A0). The EUR sample covers 60 end-of-month observations for 2017–21; the USD sample covers 36 end-of-month observations for 2019–21. The average number of bonds is 3,159 for the EUR index and 8,447 for USD. The dependent variable in each case is the bond option-adjusted spread (OAS). Rating is index rating according to ICE (2018).

Source: Jabłecki (2022).

Although perhaps unwelcome from a narrow investment perspective, the latter conclusion actually attests to the meaningfulness of green bonds as a vehicle of

9 The option-adjusted spread (OAS) is the number of basis points that needs to be added to the government spot curve so that the present valued of the bond's discounted cashflows matches the traded market price (accounting for any embedded options).

10 Interestingly, a slightly modified set of regressions for bond excess returns (over duration-matched Treasuries), suggests that the green label does not affect excess returns once typical measures of systematic credit risk are taken into account.

change – a topic addressed more directly in Section 4, and apparently gaining in importance on public investors' agenda. Indeed, survey results indicate that one of the main drivers behind implementing green bond portfolios in central banks is the desire to foster long-term sustainable economic growth (Fender et al (2020)). As desirable as this goal sounds, it should be accompanied by a realisation that there are only two channels of influence that can be ultimately traced to specific portfolio choices: (1) control through voting rights; and (2) affecting financing costs which are a key input into any company's, agency's and even government's strategic planning (Jones et al (2023)). Although most of the literature and discussion on impact investing has tended to focus on the former, the latter channel can be just as important – and clearly more relevant for green bond investors.

So how can bond investors – public or otherwise – try to promote sustainable economic growth? On a conceptual level, this would require a greater number of environmentally friendly projects to be promoted, by making them more affordable relative to the unsustainable, wasteful and polluting ones. In practical terms such a course of action entails according a higher price to the debt used to fund sustainable projects – either on the primary or secondary market – ie paying a greenium, or equivalently, accepting a lower spread on a labelled bond relative to non-labelled counterpart.

This need not be a mere signalling effect, though. After all, a greenium may work to the investor's detriment, but it is advantageous for the issuer who must compare the cost of funding with the internal rate of return (IRR) on the projects pursued. Absent a greenium, some projects may not be viable, as their discounted future cashflows would fall short of initial outlays. Of course, a greenium of 1–2 bp is unlikely to be economically significant enough to fundamentally change the budgeting picture. However, owing to the power of compounding, a 50 bp discount rate differential (corresponding to levels seen eg in segments of the HY corporate market) translates into a 5% NPV difference for a cashflow 10 years out, which can already become significant. And although a 1–2 bp greenium may have a more limited mechanical impact on the cost of financing and a project's NPV, it is certainly enough to signal investor preferences, and as such is likely to affect issuers' behaviour.

Thus, even if investors in green bonds sacrifice carry and fail to pocket a return premium, they should find at least some consolation in the fact that the underperformance of green bonds (relative to conventional counterparts) is a sign that the pursuit of environmentally friendly projects is less costly on a relative basis and thus an encouragement for issuers to undertake more of them. Given the enormous scope of investment necessary to reach net zero (see figures referenced in the introduction), such a price incentive may be a small, but important contribution to the greater cause. Virtue is its own reward, as the adage goes.

3.2 Are green bonds "safer" than normal bonds and do they outperform in risk-off episodes?

With safety of investments high on public investors' list of priorities, it is natural to ask how well green bonds fare on that count. As stressed above, since green bonds are serviced from the entirety of an issuer's operations – not merely the projects they were meant to fund – their credit risk characteristics are identical to those of the other, conventional (unsecured) bonds of that issuer. However, although green bonds

individually may not offer a particularly attractive credit profile, they might still do so viewed *collectively*, as a subset of the broader fixed income universe.

Unfortunately, this does not appear to be the case. Consider first the broadly followed Bloomberg Global Aggregate Index, which includes government, government-related, corporate and securitised debt from a multitude of local currency markets, both developed and emerging, and by design aims to represent the global investable investment grade fixed income universe. As of March 2023, the outstanding amount of the roughly 30,000 issues covered by the index amounted to almost $66 trillion, 22% of which were rated AAA, which should come as no surprise given that virtually two thirds of the index comprises government and government-related bonds. Sifting through the broad index for green issues produces a subset of roughly 1,100 bonds with an outstanding of $1.1 trillion (ie 1.6% of the total). Yet owing to the dominant role of corporate bonds in the labelled subsample, the share of AAA-rated issues is just below 15%. What the green universe lacks in the highest-quality names, it more than makes up for in the broad AA bucket, which accounts for 11% of the outstanding, relative to just above 5% in the total. Still, the cumulative share of bonds rated AA– or above is a good percentage point higher in the broad Global Aggregate index and its green subset. The situation does not change materially when – instead of the broad market index – we consider its corporate subsets. Here, again, the broad market features a higher share of AAA-rated issues, in both the USD and EUR, than the labelled sleeve, while the share of securities rated AA– or above is roughly similar across the board.

Cumulative performance of the US green corporate bond index vs US Aggregate Corporate benchmark (2020–22) Graph 3.2

Source: Bloomberg.

Against such a background, it would be difficult to expect that green bonds *as an asset class* should outperform their conventional peers in periods of market stress. Confusingly, such outperformance is sometimes reported based on index-level statistics, which – while accurate – may mask significant compositional differences between the respective indices. Consider, for example, the subset of green bonds in

the corporate sleeve of the US Aggregate index. A simple total return analysis reveals that they easily outperformed the broader benchmark both in 2020 and – even more significantly – in the volatile 2022, by a wide margin at 159 bp (Graph 3.2). However, this was largely the result of a markedly shorter duration of the labelled bonds (6 vs 7). More generally, differences in sector weights and ratings can also impact index-level performance. Once these were methodically controlled for in a regression, the role of greenness during the Covid sell-off turned out to be actually detrimental to corporate bond returns – although the results were only weakly statistically significant at best (see Table 3.2 borrowed from Jabłecki (2022), which reports the results of excess return regressions for EUR and USD corporate bonds controlling for greenness, ratings, duration and sectors).

Cross-sectional regressions of bond excess returns in March 2020 Table 3.2

	EUR IG		US IG		Global	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
Green	-0.26	-1.74	-0.28	-0.52	1.40	1.36
OAS	-0.02	-72.86	-0.03	-110.86	-0.02	-74.17
Spread duration	-0.58	-62.12	-1.01	-100.82	-0.54	-56.83
Rating	0.18	8.62	-0.16	-5.50	0.18	9.80
Industrials	1.60	10.38	5.95	26.06		
Financial	1.81	12.13	6.00	27.23		
Utility	2.08	11.10	5.59	22.15		
Corporate					-1.98	-15.79
Sovereign					3.91	17.86
R2	0.92		0.91		0.78	

Note: EUR IG includes all euro-denominated investment grade corporate bonds within the ICE/BAML Euro Corporate Index (ticker ER00); US IG includes all USD-denominated investment grade corporate bonds within the ICE/BAML US Corporate Master Index (ticker C0A0); Global includes all FX-G10 investment grade (sovereign, corporate and quasi-government) issues within the ICE BofA Global Broad Market Index (ticker GBMI). The dependent variable in each set of regressions is excess return over a synthetic duration-matched treasury security.

Source: Jabłecki (2022).

The results reported above suggest that green bonds do not – in general – offer shelter from market volatility, at least when compared with non-labelled peers on a like-for-like basis. However, perhaps they can play some role in hedging the more fundamental, climate-related risk drivers which are not immediately priced into short-term market moves? The underlying reasoning would be that, if and when environmental risks do materialise, non-labelled bonds issued by "brown" companies may be subject to more significant adverse valuation changes. However, as pointed out by Ehlers and Packer (2017), this need not be the case.

First, and most importantly, just because a bond funds an environmentally friendly project that moves a company – or even an entire country – closer to carbon neutrality, this does not mean that the project itself is protected from climate-related risks. Most hydro plants in the world are subject to either flood or drought, wind farms are exposed to storms and other extreme weather events while solar panels can be damaged by hurricane hailing and flooding. All of these weather events are likely to become more severe and frequent as the climate changes, exposing companies,

especially in the utilities sector, to losses and affecting the income stream on the green bonds funding the respective projects.

A second, somewhat more nuanced point is that, even though issuing green bonds might reflect a company's ambition in reducing carbon emissions,[11] carbon intensity may not go down fast enough in some sectors to shield the business from higher carbon costs (which could materialise through carbon taxes or due to reducing allowances in cap and trade schemes such as the EU's ETS). Investigating a number of hard-to-abate sectors, like cement, chemicals and airlines, White et al (2022) found no correlation between a good emissions reduction strategy and the prospective credit profile. This is particularly acute in the highly carbon-intensive cement sector, where the carbon cost will likely exceed a significant percentage of revenue by 2030, eating into margins and threatening the cash flow that supports interest and debt repayments.

4. Perspective on reputational risk, greenwashing and impact

4.1 Is reputational risk an important issue in the green bond market?

Structurally green bonds are identical to conventional bonds in terms of seniority and cashflows, and thus they neither meaningfully diversify nor expose holders to any additional sources of systematic credit risk. However, green bond investing may be associated with reputational risk in a way that conventional fixed income is not. The paradox lies in the fact that both investing and abstaining from investment may be – depending on context – harmful to a public investor's reputation.

The perils of investing in green bonds come primarily in the form of "greenwashing" concerns. According to the European Securities and Markets Authority (ESMA) – which made tackling greenwashing one of the priorities of its sustainable finance roadmap[12] – the term "refers to market practices, both intentional and unintentional, whereby the publicly disclosed sustainability profile of an issuer and the characteristics and/or objectives of a financial instrument or a financial product either by action or omission do not properly reflect the underlying sustainability risks and impacts associated to that issuer, financial instrument or financial product". Public investors who, owing to their unique charters, at times involving market oversight responsibilities, tend to view their fiduciary duty to stakeholders in the government and the broader society particularly seriously. That is why some are understandably wary of investing in a market still struggling with transparency and information asymmetry.

Just how topical the issue is can be illustrated by a simple search of the Financial Times archive, which yields 248 articles mentioning "greenwashing" in 2022. That's

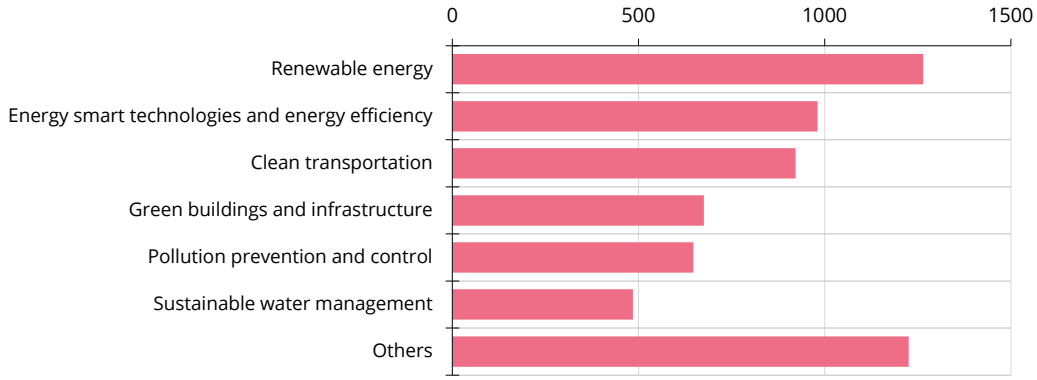
[11] Ehlers et al (2020) show this is actually debatable, as they are unable to find strong evidence that green bond issuance is associated with any reduction in carbon intensities at the firm level.

[12] www.esma.europa.eu/sites/default/files/library/esma30-379-1051_sustainable_finance_roadmap.pdf

roughly an article per business day, and if one were to include all other content, ie videos, podcasts and blog posts the number of references would increase fourfold.

In theory, green bonds are structured in a way that should ensure some form of accountability. Recall, that the "use of proceeds" section in the prospectus lays out specifically which projects a particular issue is going to fund – most of which focus on valid and important climate friendly areas such as renewable energy, clean transportation, pollution prevention and water management (Graph 4.1).

Green bond projects per use of proceeds (since inception; USD billions) Graph 4.1



Source: Bloomberg NEF.

At the same time new legislative initiatives and taxonomies – such as the original ICMA, CBI as well as national and regional standards – all strive to alleviate some of the risks inherent in the self-labelling process, bringing in much-needed clarity and uniformity to the process of selecting eligible projects, the management of proceeds (tracking spending), and post-issuance reporting. Moreover, specialised institutions – such as Sustainalytics, DNG-GL and Vigeo Eiris – offer third-party verification of the use-of-proceeds, which is becoming increasingly popular and reduces the risks of misrepresentation of the use of funds or sustainability of the financed projects.

However, there is also no escaping the fact that the green label is, by design, rather binary –a bond either is or isn't green – and not only is there no distinction between the validity and "greenness" of the underlying project but, more importantly, the green bond itself focuses on the specific projects referenced in the prospectus and not on the issuer's broader operations. In principle, this latter feature can be a virtue, as it allows predominantly "brown" issuers to launch their transition towards carbon neutrality. And indeed, if a company has a poor track record on climate but wishes to change its business profile and use green bond proceeds to do so, the there is no reason to penalise such behaviour. Unfortunately, however, raising funds under the guise of a green label could be a form of a box-ticking exercise, without any intention of making a meaningful change. There is a difference between an energy company which uses green bonds to diversify away from coal and towards renewable sources and one which uses the funding to install wind turbines on its oil platform or solar-powered flaring valves. In the latter case, issuing green bonds could simply be a way of acquiring relatively cheap funding to support current business, and not

necessarily part of a broader, material and intentional transition strategy, thus deserving to be called out as greenwashing.

A practical example to that effect is provided by the case of green bond issuer State Bank of India, the country's biggest lender, which amid some controversy extended a credit facility to the Carmichael coal mine project in Queensland, Australia. The controversy lies in the fact that, although the loan looked similar in size to SBI's green funding, it was estimated to have a CO_2 footprint roughly 20 times higher than what was being saved through the green projects. Thus, although SBI's green bonds were financing (actually – refinancing) legitimate green projects in line with the bank's overall sustainability strategy, their positive impact was being negated (many times over) by the funding provided to the Australian mine. According to the Anthropocene Fixed Income Institute, which published estimates of the carbon intensity inherent in the Carmichael credit facility, such behaviour on the part of SBI was an instance of greenwashing in the sense that it demonstrated SBI's lack of true dedication to sustainable activities and climate transition in general (Erlandsson (2020)).

Given that the investor's stated goal behind investing in green bonds is likely to be to contribute to funding the transition to a net zero economy, it can be problematic to finance notionally green projects that do not change the overall carbon profile of the issuer. Hence, managing the reputational risk involved in investing in labelled bonds might require a more thorough assessment of the issuer's entire operations, not just verifying the alignment of the use-of-proceeds with a chosen set of principles. Mindful of this, some market participants and asset managers have proposed frameworks to screen, assess and compare green bonds so as to reduce the potential risk of greenwashing. Although approaches differ in their specific methodologies, they often rely on issuer-level ESG scores assigned by external providers. Thus, for example, the IFC/Amundi EGO bond fund focusing on green bonds in emerging markets explicitly states that selection process of green bonds is to ensure "that such investments contribute to a specific sustainable objective without significantly harming other objectives". Specifically, the fund follows an exclusion policy at the issuer level "based on Issuers' ESG score, taking into account portfolio exposure to high ESG risk and carbon-intensive sectors and to projects associated with potentially significant environmental and social risks and impacts, and/or sector-exclusion".[13]

Granted, relying on ESG scores to assess issuers can be problematic, since ESG ratings providers can significantly disagree on company ratings. For example, a recent study found that the correlation between the ESG scores of different ESG ratings providers was only 0.54, and even lower when looking at the individual E, S, and G pillars (Berg et al (2022); Boffo and Patalano (2020)).[14] All this is not say that managing reputational risk in green bond investing is impossible – rather, the point is that green bonds do carry their own specific risks and public investors should acknowledge them and establish rules and internal procedures to protect themselves against potential charges of naïveté or malpractice. This is particularly important given that abstaining from investment in green bonds may in some cases have an adverse impact on

[13] ezjscamundibuzz::sfForwardFront::paramsList=service=ProxyGedApi&routeId=_dl_dacdf4fa-c323-46d9-8f4f-973f2a72c9e0_download See also "Green & Sustainable bonds: a label is not enough", Generali Investments, 2022, Microsoft Word - White Paper#3 Green Bonds vfinal (002).docx (generali-investments.com) and Barclays ESG Bond Handbook, 2020.

[14] For comparison, the correlation between credit ratings assigned to issuers by Moody's and S&P stood at 0.99.

reputation as well – specifically, if stakeholders in the government or the society at large expect central banks and other public investors to contribute to funding the transition to net zero (Fender et al (2020)).

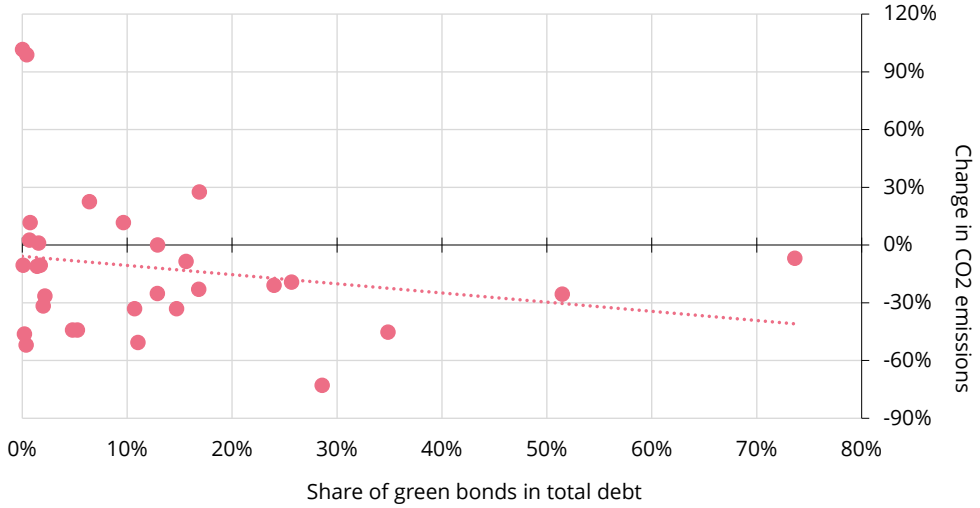
4.2 Does green bond investing make a positive environmental impact?

By definition, green bonds finance eligible environmental projects. However, investors might be asking themselves if, and to what extent, their purchases of green bonds are actually helping make a real difference in terms of facilitating the transition to a less carbon-intensive economy. Borrowing terminology from Busch et al (2021), we could rephrase the question and ask whether buying green bonds is an instance of true impact-generating investment or merely impact-aligned one. The difference is subtle, yet crucial, and goes back to the green/impact-washing concerns discussed above. Unfortunately, given limitations in data coverage and quality, providing a conclusive answer is not straightforward.

A recurring theme of the preceding pages was a palpable, strong momentum behind green finance. And certainly this could be taken as a first sign of impact – a "wall of money" flowing towards sustainable projects, rendering them more economically viable, as evidenced by the small greenium detectable at issue, particularly among some issuers. On the flip side, companies have also made big strides in trying to make it easier to assess their environmental credentials. An increasing number have formally adopted near- and long-term emissions reduction targets approved by the non-profit Science Based Targets (SBTi) initiative.

However, the relationship between progress on decarbonisation and green bond issuance is weak at best. One way to illustrate this is to screen the entire universe of close to 1,000 companies from around the world with approved decarbonisation targets, narrow down the sample to those who fund themselves even partially using green bonds, and compare their progress (relative to the chosen base year) against the share of green bonds in total debt outstanding. The result – plotted in Graph 4.2 – is rather underwhelming. The use of green bonds as a funding vehicle for decarbonisation activities appears to explain just about 4% of the variation in the reported change of generated emissions, and the association, while directionally consistent with intuition, is practically insignificant (t-stat of 1.12). A similar conclusion is derived more formally in a recent paper by Ehlers et al (2020), who confirm that there is no strong evidence that green bond issuance is associated with any reduction in carbon intensities over time at the firm level.

Companies' CO2 emissions reduction as a function of green financing Graph 4.2



Note: the original sample includes close to 1,000 companies with approved decarbonisation targets as of 2022, which is subsequently narrowed down to only 420 for which it was possible to calculate actual decarbonisation progress (Scope 1 and 2 emissions relative to a base year); from these around 30 have placed green bond issues with at least $250 million outstanding; fitted regression line has R2 of 0.04.

Source: Bloomberg, Science-based Targets Initiative.

Echoing Ehlers et al (2020), this does not mean that green bonds haven't delivered – it is merely an indication that labelled instruments, while perhaps useful, are not a sine qua non of a successful decarbonisation strategy. In practice, sustainable projects may be financed only partially by green bonds, or even without recourse to such use-of-proceeds instruments altogether. A case in point is a recent purchase of Atchison Renewable Energy Center, a 300 MW wind farm, by Ameren Missouri, a large US energy utility. Of the project's purchase price of about $500 million, only $42.6 million was allocated from the proceeds of the issuance of a green bond. A large related project, a 400 MW farm called High Prairie Renewable Energy Center in Missouri, cost roughly $615 million, of which only $500 million was covered by the issuance of a green bond. Both projects clearly serve to reduce emissions in the region – a point we shall return to below – but their financing structure is determined by the company's broader funding plan which includes among others retained earnings and equity issuance and weighs their relative costs and merits against the company's objectives.

Although green bonds may fail as a proxy for the extent of decarbonisation taking place in the corporate sector en bloc, their underlying premise of ringfencing the use of proceeds and allocating them to specific projects invites investors to assess and compare green bonds not only in terms of their risk/return profile, but also in terms of the difference they are making to the corporations and societies in which they operate. In this context, Ehlers et al (2020) call for a carbon intensity-based rating system, while Partnership for Carbon Accounting Financials (PCAF), an industry-led initiative to improve greenhouse gas accounting standards for financial institutions, s actually suggested a related methodology to account for the carbon emissions of green bonds in December 2021. Although such approaches have yet to find their way into standard packages offered by commercial data vendors and rating agencies, and

individual disclosures might be patchy and inconsistent, still post-issuance green bond reports coupled with academic studies and publicly available sources seem to actually provide quite a trove of useful information facilitating a relative-impact value analysis. The point of such comparisons would be to comprehensively assess the "greenness" of a particular issue, taking into account not just the nature of the project funded, or its alignment with a set of taxonomy criteria, but also the amount of greenhouse gas emissions it helped to prevent. To use a clichéd example – all things equal, one should probably prefer to finance a wind farm in a heavily coal-reliant emerging market economy than in an advanced economy already fully powered by renewable sources.

The question is, however, whether – and to what extent – things really are equal, and in particular whether a bond's environmental impact is already reflected in pricing. In a recent report, HSBC (2022) found little evidence to support that view and the updated results presented below confirm that initial finding.[15] The sample used in this example comprises 28 green bonds issued by eight largest US utilities[16] with sufficiently detailed disclosures to allow meaningful comparison. To reflect how bond proceeds are translated into real-world impact, and capture the distinction between the marginal benefit of a renewable project in a country with a clean vs a dirty grid, each issue is characterised by the emissions it helps displace or prevent. The latter category is scaled to account for the share of project cost covered by a given green bond. Finally, to account for the economic relative value of the bonds, each issue is represented by the ratio of its option-adjusted spread to duration (ie a measure showing roughly how much of a spread uplift an investor receives for a unit of duration risk exposure).

For example, consider the $550 million Ameren green bond issue mentioned above. The bond has a modified duration of 17 and trades at a spread of about 112 bp. But what is the climate "bang for the buck," ie how much real environmental change does the 112 bp help achieve and how does that compare with other available bonds? To get a handle on this, note that according to the post issuance report, the bond's net proceeds were allocated to fund the acquisition of two wind farms – the 400 MW High Prairie Renewable Energy Center ($500 million) and the 300 MW Atchison Renewable Energy Center ($42.6 million). Taking into account project costs (estimated at $555 million and $416 million, respectively, based on US averages reported by Irma), the green bond can be estimated to have financed 390.92 MW of total capacity. Now, according to the avoided emissions calculator provided by the US Environmental Protection Agency – which takes into account the grid composition in the US Midwest – the bond-financed renewable energy generation is estimated to have replaced roughly 1 million tons of CO_2 emissions. Relating the avoided emissions to green bond proceeds yields 1,946 CO_2 displaced per year per million dollars. Repeating an analogous analysis for all bonds in the sample yields a climate relative value estimate for US utilities (Graph 4.3).[17]

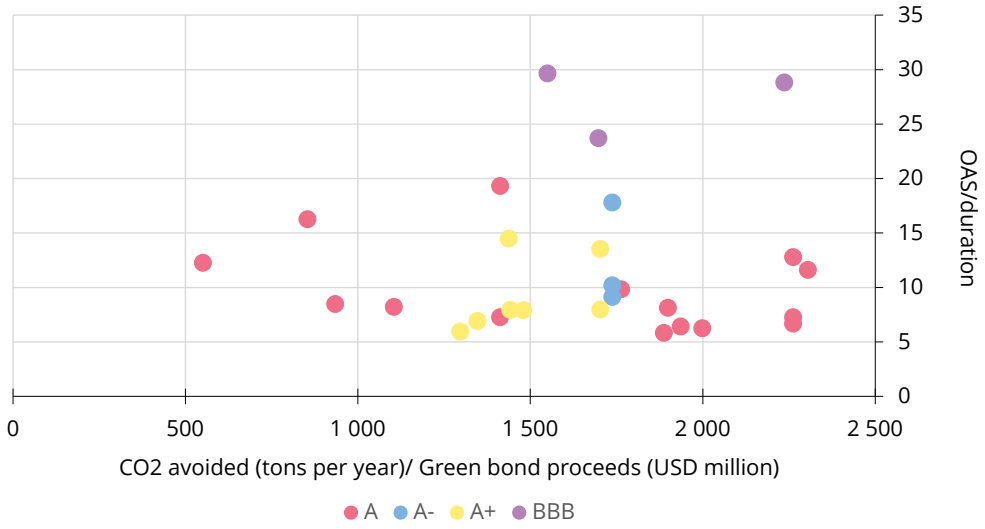
[15] In a related recent study, Jarno and Richardson (2023) found that there was little differentiation in bond and CDS pricing levels for companies in the high-emitting oil and gas sector despite companies' widely differing progress in decarbonisation.

[16] Xcel, DTE, Southern, Algonquin, MidAmerican, Duke, AEP and Ameren.

[17] Note that this is a scoring exercise aimed not so much at *explaining* differences in bond spreads per unit of duration, but rather at comparing bonds in terms of their direct environmental impact, while taking into account their market risk characteristics. The latter, of course, can also be affected by other factors, over and above any environmental impact priced in by investors.

Climate-relative value: bond spread (per unit of duration) as a function of attributable avoided emissions

Graph 4.3



Note: the sample includes green bonds issued by the major US utility companies: Xcel, DTE, Southern, Algonquin, MidAmerican, Duke, AEP and Ameren for which relevant data could be ascertained.

Sources: adapted and updated from HSBC (2022), Bloomberg data.

Viewed against comparables, the Ameren bond delivers a substantial impact, but one could do better by considering debt issued by Southwestern Public Services, which finances a project associated with greater amount of averted emissions while offering a similar risk-return profile (a 118 bp spread with modified duration of 16). But an even more attractive proposition, if one were willing to go down a notch on the rating spectrum, might be the bond of Algonquin Power & Utilities Corporation, which funds a particularly high-impact wind farm in Kansas and offers an attractive spread of about 190 bp at moderate duration of just over 6.

While the scoreboard is just a starting point, and data availability/reliability issues might limit its broader use across the entire green bond universe, it does nonetheless demonstrate how one can go about building or tilting portfolio so as to achieve maximum impact subject to risk-return constraints. More importantly, perhaps, the scoreboard also demonstrates how investors can go about constructing/tilting their portfolios for maximum environmental impact, because the latter does not seem to be fully priced into the green bond market.

Concluding thoughts

As many central banks and public investors already invest in green bonds and many others are considering whether to start the journey, this article has attempted to discuss a number of issues that may be important in forming a coherent view of the labelled asset class and possibly also in formulating a green investment strategy. Not all of the questions listed in the introduction have clear-cut and straightforward

answers (and arguably some answers provided above raise a whole set of new questions). It seems fairly obvious, for example, that over the past couple of years the green bond market has made tremendous gains in size, breadth and overall investability, making it an attractive proposition for public investors, typically focused on safety and liquidity of their portfolios. However, issues surrounding risk characteristics and return profile of green bonds are trickier.

We have seen that it would be naïve to expect that green bonds should outperform their conventional counterparts on a comparable basis, and there also seems to be little of a "safety premium" attached to them, and no meaningful diversification benefits – as evidenced in the Covid pandemic and later during a tumultuous 2022. In fact, a small greenium – ie spread give-up – seems to be more typical in the both the primary and secondary markets, leading over time to the erosion of carry and long-term returns. But we have also argued that a proper interpretation of this phenomenon requires a little bit of nuance. Although the pricing pattern is hardly an advantage from the narrow perspective of a risk-return-oriented portfolio optimisation, it does nevertheless spark hope that green bonds could actually be making a difference by improving the NPV, and hence also the attractiveness, of environmentally friendly projects. Yet it is not easy to pinpoint the extent to which green bonds as an asset class are making an impact in meaningfully speeding up the transition towards net zero.

What does seem clear, though, is that investors should be aware of shades of green, in that green bonds can significantly differ in the degree of impact they generate, eg in terms of emissions they help to avert. Perhaps more importantly, there is little evidence that these differences in carbon profile and impact level are fully reflected in the market pricing of green bonds. This suggests that there may still be avenues for investors to materially improve the impact they are exercising through their investments without necessarily sacrificing much in terms of pure risk-return trade-off.

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