

Can Green Bonds Lower the Cost of Financing Renewable Energy? An Integrative Review of Pricing, Signalling and Investor-Base Effects, with a Research Agenda for India

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Abstract

Renewable energy plants are capital-intensive, so the terms on which their developers borrow shape the price of the electricity they sell. Green bonds, whose proceeds are earmarked for environmental projects, are often presented as a way of making that capital cheaper. This paper asks whether the evidence supports that expectation. Through an integrative review of peer-reviewed and policy research on renewable energy finance and green bond markets, it organises the literature around three channels through which green bonds could affect financing costs: a direct pricing channel, in which investors accept lower yields on green debt; an investor-base channel, in which green issuance attracts long-term and environmentally motivated holders; and a signalling channel, in which credible green issuance conveys an issuer's environmental commitment. The review finds that the pricing advantage is small, of the order of a few basis points where it exists at all, and unevenly distributed in favour of large, highly rated issuers. The evidence on the other two channels is stronger: equity markets respond favourably to green bond announcements, particularly first issues and externally certified bonds, and issuers subsequently attract more long-term and institutional investors. Because the financing disadvantage faced by renewable energy in India arises mainly from the high cost and short tenor of debt, the review argues that the value of green bonds for India lies less in the yield discount than in widening and lengthening the pool of capital available to renewable energy. Five propositions and a research agenda are set out for Indian sovereign and corporate green bond markets.

Keywords: Green Bonds, Greenium, Renewable Energy, Cost of Capital, Signalling, Sovereign Green Bonds.

Introduction

The economics of solar and wind power are dominated by upfront investment. Once a plant is built, its fuel is free and its operating costs are modest, so the price at which it can sell electricity depends heavily on how its construction was financed. Empirical work on German solar and onshore wind projects shows how much this matters: financing conditions for such projects improved markedly over almost two decades, driven by falling general interest rates and by experience accumulated within the renewable energy finance industry, and these improvements alone account for a meaningful part of the decline in the levelised cost of electricity from both technologies (Egli et al., 2018). The implication is that a renewable energy programme can be made cheaper not only by better technology but by cheaper money.

For India this point carries particular weight. Financial modelling of actual Indian renewable projects found that the higher cost and inferior terms of debt raised the cost of renewable electricity by roughly a quarter to a third compared with the United States, and that short loan tenors and variable interest rates added further to the gap (Shrimali et al., 2013). The authors concluded that Indian policy should give priority to the provision of low-cost, long-term debt. A decade later, the Government of India began issuing sovereign green bonds, auctioning a first tranche of ₹8,000 crore in five-year and ten-year securities in January 2023 as part of a planned ₹16,000 crore issue, with proceeds directed to public projects that reduce the carbon intensity of the economy (Reserve Bank of India, 2023).

Green bonds have attracted both enthusiasm and scepticism. Supporters see them as a means of channelling long-term, environmentally motivated capital toward clean infrastructure (Tolliver et al., 2019); sceptics note that the projects they finance could often have been financed in other ways, so that the environmental benefit is not necessarily additional. For a policymaker or a renewable energy developer, the practical question is narrower: does financing through green bonds make capital for renewable energy cheaper or more abundant, and if so, through what mechanism?

This paper addresses that question through an integrative review. Its contribution is threefold. First, it brings together two literatures that are usually discussed separately: research on the financing of renewable energy projects and research on the pricing of green bonds. Second, it organises the evidence around three distinct channels through which green bonds could affect the cost of capital, which clarifies why studies that look only at bond yields can understate their effect. Third, it translates the evidence into propositions and a research agenda for India, where the binding constraint on renewable energy finance differs from that in the markets on which most of the evidence is based.

Method

The paper follows the integrative review approach, which synthesises findings from different research designs and disciplines to develop a conceptual framework, rather than pooling effect sizes statistically. Studies were identified through keyword searches of academic databases and through backward citation tracking from influential articles, using combinations of terms such as green bond, greenium, renewable energy finance, cost of capital and de-risking. Studies were retained if they were published in peer-reviewed journals or as working papers of central banks or comparable institutions, and if they provided either empirical evidence on the pricing or market effects of green bonds or evidence on the financing conditions and investment decisions for renewable energy. The retained studies were read in full and coded by research question, setting, method and principal finding, and then grouped into themes. Because the purpose is conceptual synthesis, the review is selective rather than exhaustive, and its conclusions should be read with that limitation in mind. Table 1 summarises the empirical studies on which the synthesis principally rests.

Why the Cost of Capital Matters for Renewable Energy

Three strands of research establish why financing deserves the attention of anyone concerned with the cost of renewable electricity. The first shows that financing conditions are not fixed but evolve. In the German projects studied by Egli et al. (2018), the cost of financing fell as interest rates declined and as lenders gained experience with the technologies, and the authors warned that a rise in general interest rates could raise the cost of renewable electricity, casting doubt on plans to withdraw policy support as technologies mature. The cost of capital is therefore a moving and policy-relevant variable.

The second strand concerns risk. Low-carbon investments, especially in developing countries, are often perceived as riskier than conventional ones, and this perceived risk translates directly into a higher required return. Schmidt (2014) argued that the most effective way for policymakers to mobilise private capital is to reduce this downside risk, a process he described as de-risking. A systematic review of 96 empirical studies later reached a related conclusion: renewable energy policies are most effective in attracting private finance when they address investment risk and investment return at the same time, and instruments such as feed-in tariffs, auctions and renewable portfolio standards work best when designed to reduce project risk while raising returns (Polzin et al., 2019).

The third strand recognises that investors differ. Wüstenhagen and Menichetti (2012) emphasised that renewable energy investment decisions are shaped by risk-return perceptions, portfolio considerations and path dependence, and that the heterogeneous universe of investors calls for a segmentation of policies. Mazzucato and Semieniuk (2018), analysing global renewable energy asset finance between 2004 and 2014, showed that different types of financial actors build portfolios of different

size, technological skew and risk, so that who provides the finance shapes which technologies are deployed. Together these strands suggest that an instrument which changes the composition of investors, and not only the price they charge, can matter for renewable energy.

Evidence on Green Bonds

- **The Pricing Channel: Is there a Greenium?**

The most direct way in which green bonds could lower the cost of capital is if investors accept a lower yield on them than on otherwise similar conventional bonds, a difference known as the greenium. The evidence suggests that this effect is real but small. Using a matching method on bonds issued between 2013 and 2017, Zerbib (2019) estimated an average premium of about two basis points, more pronounced for financial and low-rated bonds, and concluded that investors' environmental preferences have only a limited effect on bond prices. Larcker and Watts (2020), comparing green and conventional municipal bonds issued by the same issuers in the United States, found essentially no difference in yields. In a study of firms in 28 countries, Tang and Zhang (2020) likewise did not find a consistently significant premium for green bonds.

More recent evidence suggests that the premium may be emerging as the market matures. In a global panel, Caramichael and Rapp (2022) estimated that green bonds carried yield spreads about eight basis points lower than conventional bonds on average, an advantage that appeared from 2019 onward with the growth of sustainable asset management. Importantly for an emerging economy, they found that this advantage was concentrated among large, investment-grade issuers, mainly banks in developed economies. Early indications from India's own sovereign issue point in the same direction: in the first auction, yields were reported to be five to six basis points below those on conventional government securities of the same tenor (Business Standard, 2023).

Taken together, the evidence on the pricing channel suggests that a greenium of a few basis points is plausible for large and highly rated issuers, but that it is far too small to close a financing gap of the magnitude identified for Indian renewable energy by Shrimali et al. (2013).

- **The Investor-Base Channel**

If green bonds offer little direct saving, why do issuers use them? A consistent finding is that they change who holds the issuer's securities. Tang and Zhang (2020) found that institutional ownership, particularly by domestic institutions, increased after firms issued green bonds, and that the liquidity of their shares improved. Flammer (2021) reported that issuers experienced an increase in ownership by long-term and green investors after issuance. Because long-term investors are better suited to holding the long-dated claims that renewable energy assets generate, a shift in the investor base toward such holders may matter more for the financing of renewable energy than a reduction of a few basis points in yield.

- **The Signalling Channel**

A third mechanism is information. Flammer (2021) found that equity investors responded positively to announcements of corporate green bond issues, that the response was stronger for first-time issuers and for bonds certified by independent third parties, and that issuers subsequently improved their environmental performance, with higher environmental ratings and lower carbon dioxide emissions. She interpreted these results as consistent with a signalling argument: by issuing green bonds, companies credibly signal their commitment to the environment. Tang and Zhang (2020) similarly found that stock prices responded positively to green bond issuance, even though the bonds themselves did not carry a consistent yield advantage, which suggests that the benefit to shareholders operates through channels other than a cheaper coupon.

- **Integrity and Additionality**

The value of the signal depends on its credibility. Tolliver et al. (2019) noted that green bonds are sometimes credited with environmental benefits that belong to the assets they finance, and that because such projects could often be financed through other mechanisms, their environmental impact is not necessarily additional. The stronger market response to externally certified bonds documented by Flammer (2021) can be read in the same light: investors appear to reward verified commitments more than labels alone.

Table 1: Principal Empirical Studies Synthesised in the Review

Study	Setting and Method	Principal Finding
Egli et al. (2018)	133 utility-scale solar and onshore wind projects, Germany; project finance data over about 18 years	Financing conditions improved strongly, driven by lower interest rates and lender experience, contributing to lower generation costs
Shrimali et al. (2013)	Financial modelling of actual renewable projects, India	High cost and inferior terms of debt raised the cost of renewable energy by 24–32% relative to the United States
Polzin et al. (2019)	Systematic review of 96 empirical studies	Policies mobilise private finance most effectively when they address risk and return together
Mazzucato & Semieniuk (2018)	Global renewable energy asset finance, 2004–2014	Different financial actors finance portfolios of different size, skew and risk
Zerbib (2019)	Matched green and conventional bonds, 2013–2017	Small negative premium of about 2 basis points
Larcker & Watts (2020)	US municipal bonds from the same issuers	No meaningful yield difference between green and conventional bonds
Tang & Zhang (2020)	Green bond issuers in 28 countries, 2007–2017	No consistent premium; positive stock response; higher institutional ownership and liquidity
Flammer (2021)	Corporate green bonds, global sample	Positive announcement returns, stronger for first-time and certified issues; better environmental performance; more long-term and green investors
Caramichael & Rapp (2022)	Global panel of green and conventional bonds	Average greenium of about 8 basis points since 2019, concentrated among large investment-grade issuers in developed economies

Source: Compiled by the authors from the studies cited.

Synthesis: Three Channels and Propositions for India

The evidence suggests that the effect of green bonds on the cost of renewable energy finance should be assessed through three channels rather than one. The pricing channel, which most empirical work has examined, is the weakest: where a greenium exists, it is measured in single-digit basis points and accrues mainly to large, highly rated issuers. The investor-base channel appears stronger, because green issuance draws in long-term and institutional holders whose investment horizons match those of renewable energy assets. The signalling channel can also be material, but only when the commitment it conveys is credible, which in practice means externally verified.

This reframing matters for India because the financing disadvantage of Indian renewable energy lies chiefly in the cost and tenor of debt rather than in a missing yield discount (Shrimali et al., 2013). An instrument that lengthens tenors and broadens the investor base could therefore be more valuable to India than its modest pricing benefit implies. Five propositions follow.

- *Proposition 1.* The yield advantage of Indian green bonds will be small and concentrated among sovereign and highly rated issuers; its absence for smaller renewable energy developers should not be read as evidence that green bonds are ineffective.
- *Proposition 2.* The principal benefit of green issuance for Indian renewable energy developers will appear in the tenor of available debt and in the share of long-term institutional investors, rather than in the coupon rate.
- *Proposition 3.* Externally certified green bonds will attract a stronger market response and a broader investor base than self-labelled ones, and the difference will be larger for first-time issuers.

- *Proposition 4.* Because green bonds do not by themselves reduce project risk, their effect on the cost of renewable energy will be greatest when combined with policies that reduce risk and secure returns, consistent with the risk-return evidence of Polzin et al. (2019).
- *Proposition 5.* The sovereign green bond programme can lower the cost of renewable energy finance indirectly, by establishing a domestic green yield curve and a pool of experienced green investors on which corporate issuers can later draw.

A Research Agenda for India

The propositions point to several questions that Indian data can answer. First, the greenium on sovereign green bonds should be measured not only at auction but in the secondary market, and compared with matched conventional securities over time, to establish whether the early advantage persists. Second, studies of corporate green bonds issued by Indian renewable energy developers could compare the tenor, covenants and investor composition of green and conventional issues by the same firms, testing Proposition 2 directly. Third, the effect of external review on pricing and investor demand in India could be examined by comparing certified and uncertified issues. Fourth, event studies of equity market responses to green bond announcements by Indian listed companies would test whether the signalling effect documented internationally holds in an emerging market. Finally, research could examine whether the investor base built through sovereign issuance subsequently migrates to corporate green debt, as Proposition 5 suggests.

Implications and Conclusion

For issuers, the review suggests that the decision to issue green bonds should rest less on the expectation of a cheaper coupon than on the prospect of reaching long-term investors and signalling a credible environmental commitment, and that external certification is worth its cost when the issuer is new to the market. For policymakers, it suggests that green bonds complement, but do not replace, measures that reduce the risk of renewable energy investment, and that the sovereign programme is best viewed as market infrastructure that lowers the cost of capital for later issuers. For researchers, it argues that evaluations of green bonds that examine only yields are likely to understate their effect on the financing of renewable energy.

The review has limitations. It is selective rather than systematic, much of the evidence comes from developed markets, and the Indian green bond market is too young for its effects to be judged with confidence. The propositions are offered as hypotheses to be tested as data accumulate. The central conclusion is nonetheless clear: green bonds are unlikely to make renewable energy finance markedly cheaper through their price alone, but they may make it more abundant and longer-term, and for India that may be the more valuable contribution.

Declarations

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- *Conflict of interest.* The authors declare that they have no conflict of interest.
- *Author contributions.* Geetanjali Shrivastava: conceptualisation, supervision, review and editing.
- Vishwa Ahuja: conceptualisation, literature search, synthesis, writing of the original draft.

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