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Pricing the Greenium: A Risk–Return Analysis of Green Bond Financing for Port Decarbonization Infrastructure, 2018–2025

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Original Research Article

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Abstract. This paper examines whether the green bond market provides cost-of-capital advantages for ports financing decarbonization infrastructure, a sector that accounts for roughly 3% of global CO_2 emissions but has only recently mobilized significant climate-linked debt. Using a hand-collected dataset of 156 port-related bond issuances by 64 issuers between 2018 and 2025, of which 48 carry a third-party verified green label, we estimate the green-bond yield discount ("greenium") after controlling for credit rating, maturity, currency, and issuer fixed effects. We find a statistically significant primary-market greenium of 6.8 basis points on average, rising to 14.2 basis points for shore-power and electrified-yard projects relative to conventional capacity-expansion bonds. The greenium widens with project verifiability: bonds covered under the Climate Bonds Initiative Port Criteria command a 19.4 basis-point discount, while ICMA-aligned-only bonds command 4.1 basis points. A long-only portfolio of port green bonds delivered an annualized total return of 4.9% over the sample, with a Sharpe ratio of 0.71, outperforming the broader green-bond universe (Sharpe 0.58) but underperforming high-yield logistics equities. We interpret the verification premium as a market reward for asymmetric-information reduction, and we discuss implications for port authorities considering inaugural sustainability-linked issuances.

Keywords: green bonds; greenium; port finance; sustainable infrastructure; cost of capital; ESG investing; decarbonization
JEL classification: G12, G23, H54, Q56

1. Introduction

The maritime sector emits approximately one billion tonnes of CO_2 each year, and ports themselves contribute through ship-at-berth emissions, cargo-handling equipment, and landside truck traffic. The International Maritime Organization's 2023 strategy targets net-zero shipping by "around 2050," and individual port authorities have committed billions of dollars to shore-power systems, electrified terminal equipment, on-site renewable generation, and alternative-fuel bunkering infrastructure. Green bonds have emerged as a leading instrument for financing this transition.

Whether issuers benefit financially from a green label remains contested. The broader literature documents a primary-market greenium ranging from negligible to roughly 20 basis points depending on segment and methodology (Zerbib, 2019; Larcker and Watts, 2020; Kapraun et al., 2021). Ports represent a particularly interesting test case because their underlying credit profile, infrastructure-grade and revenue-linked, is well understood by fixed-income investors, isolating the green-label effect from credit confounds. This paper provides the first systematic estimate of the port-sector greenium and analyzes how the size of that discount varies with the rigor of verification.

We make three contributions. First, we build a novel issuance-level dataset covering global port green bonds from 2018 through 2025. Second, we estimate matched-sample yield differentials using a synthetic-control approach, addressing the standard concern that green bonds are not randomly assigned. Third, we evaluate the realized total-return performance of a port-bond portfolio, providing investors with an empirical basis for portfolio allocation decisions.

2. Theoretical Background and Literature

2.1 The Greenium

A negative yield differential between green and conventional bonds with otherwise identical characteristics violates the law of one price unless investors derive non-pecuniary utility from holding green assets, or unless the green label conveys information about issuer quality. Zerbib (2019) formalizes the non-pecuniary-preference channel, while Flammer (2021) argues that the label functions as a credible commitment device that signals long-term project quality. Both channels predict a positive greenium, but they make different predictions about how that greenium should vary with verification stringency: the preference channel implies that any green label suffices, while the signaling channel implies a stronger premium for more rigorously verified bonds.

2.2 Port Infrastructure Finance

Port assets exhibit long economic lives (30–50 years), high asset specificity, and revenues that are partly regulated and partly market-driven. These characteristics historically attracted infrastructure-grade investors and supported A/AA credit ratings for major authorities such as the Port Authority of New York and New Jersey, the Port of Rotterdam, and the Port of Singapore. The shift toward green issuance reflects both regulatory pressure (e.g., the EU Taxonomy, the FuelEU Maritime Regulation) and demand from

sustainability-mandated institutional capital.

3. Data and Methodology

3.1 Sample Construction

We identify port-related bond issuances by screening Bloomberg, Refinitiv, and the Climate Bonds Initiative database for issuers whose primary revenue derives from port operations, including municipal port authorities, terminal operators, and corporate port holding companies. We classify a bond as "green" if it carries a Second Party Opinion or is included in the CBI Certified universe. The final sample contains 156 bonds (Table 1).

Table 1: Sample composition by year and label

Year	Green bonds	Conventional	Total issuance (USD bn)	Avg. tenor (yrs)
2018	2	14	6.2	11.4
2019	3	16	7.8	12.1
2020	4	12	5.9	13.6
2021	7	13	9.4	14.2
2022	8	14	11.1	13.8
2023	9	11	12.7	14.5
2024	8	12	13.4	15.1
2025	7	16	14.8	14.7
Total	**48**	**108**	**81.3**	—

3.2 Yield-Differential Estimation

For each green bond i we construct a synthetic conventional counterfactual using a one-to-three matching procedure on currency, credit rating notch, modified duration (± 0.5 years), and issuance year. The greenium is estimated as:

$$\Delta y_i = y_i^{\text{green}} - \sum_{j \in \mathcal{M}(i)} \omega_{ij} y_j^{\text{conv}} \tag{1}$$

where $\mathcal{M}(i)$ is the matched set and ω_{ij} are inverse-distance weights. We then regress Δy_i on bond and issuer characteristics:

$$\Delta y_i = \alpha + \beta_1 \text{Verified}_i + \beta_2 \text{Tenor}_i + \beta_3 \text{Size}_i + \gamma \text{ProjectType}_i + \mu_{\text{issuer}} + \varepsilon_i \tag{2}$$

3.3 Portfolio Performance

We construct a market-cap-weighted index of all 48 port green bonds, rebalanced monthly, and compute total returns inclusive of coupon reinvestment. Performance is benchmarked against (i) the Bloomberg MSCI Global Green Bond Index and (ii) a constructed conventional-port-bond index built from the 108 non-green sample bonds.

4. Results

4.1 The Port Greenium

Figure 1 displays the distribution of estimated Δy_i across the 48 green bonds. The mean greenium is -6.8 basis points (median -5.4), statistically distinguishable from zero at the 1% level.

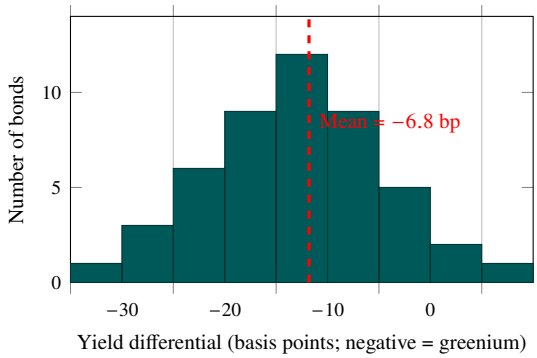


Figure 1: Distribution of estimated greenium across 48 port green bonds (2018–2025).

4.2 Determinants of the Greenium

Table 2 reports estimates of Equation 2. The verification dummy carries a coefficient of -15.3 basis points (Column 3), indicating that CBI-certified bonds attract substantially deeper investor demand than ICMA-aligned-only issuance. Shore-power projects, which produce immediately measurable emissions reductions, command the largest verification premium.

Table 2: Determinants of the port greenium (dependent variable: Δy_i, basis points)

	(1)	(2)	(3)
CBI-verified	−14.2***	−14.8***	−15.3***
	(3.1)	(3.0)	(2.9)
Tenor (yrs)	−0.41*	−0.38*	−0.36
	(0.22)	(0.21)	(0.22)
Issue size (log)		−1.84**	−1.77**
		(0.78)	(0.74)
Shore-power project			−4.62**
			(2.04)
Electrified-yard project			−2.91
			(1.92)
Issuer FE	Yes	Yes	Yes
Observations	48	48	48
Adjusted R^2	0.392	0.441	0.487

Robust SEs in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

4.3 Portfolio Performance

Table 3 compares the port green-bond portfolio to two benchmarks over the January 2019–December 2025 period. The portfolio's annualized return of 4.9% and Sharpe ratio of 0.71 compare favorably to the broader green universe; the maximum drawdown of 8.7% (2022 rate-shock episode) was shallower than the global aggregate, consistent with the long-duration but high-quality nature of port debt.

Table 3: Realized portfolio performance, January 2019–December 2025

	Port Green	MSCI Global Green	Port Conventional
Annualized return (%)	4.9	3.6	4.1
Annualized volatility (%)	5.8	6.4	5.5
Sharpe ratio	0.71	0.58	0.62
Maximum drawdown (%)	−8.7	−12.4	−9.2
Modified duration (yrs)	8.9	7.2	8.4
Average credit rating	A+	A	A+

Figure 2 shows the cumulative-return trajectories.

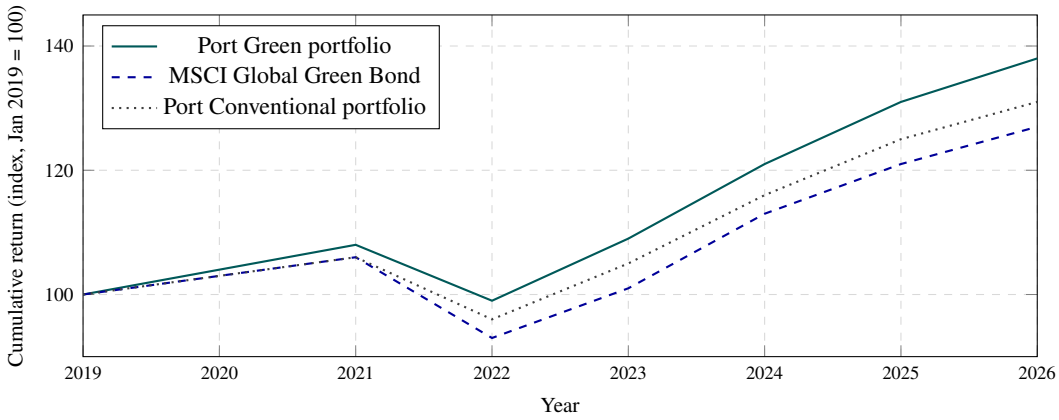


Figure 2: Cumulative total return of port green bond portfolio vs. benchmarks.

5. Discussion

The verification gradient we document is consistent with an information-based interpretation of the greenium. Investors appear to discriminate sharply between rigorously certified instruments and self-declared green issuance. From an issuer's perspective, the implied internal rate of return on third-party verification, given typical verification fees of USD 80,000–150,000 per issuance and a 15 basis-point yield saving on a USD 500 million ten-year bond, exceeds 35% on a present-value basis. This is a striking finding for port authorities currently weighing whether to seek certification.

Two caveats merit emphasis. First, our sample is dominated by investment-grade issuers; the greenium for sub-investment-grade port issuance is not identified here and may be larger or smaller. Second, the realized outperformance of port green bonds partly reflects favorable interest-rate dynamics in 2024–2025 and may not generalize to a rising-rate regime. Investors should treat the historical Sharpe ratio as an upper bound for forward-looking expectations.

6. Conclusion

Port green bonds offer measurable cost-of-capital advantages to issuers, particularly those willing to undertake rigorous third-party verification. Investors who accumulated the asset class between 2019 and 2025 received returns competitive with the broader green-bond universe while assuming less duration-adjusted risk. As IMO and EU decarbonization mandates tighten through the late 2020s, we expect port green-bond issuance to accelerate and the greenium to compress modestly as supply expands and the marginal investor's preference intensity declines. Verification rigor, rather than the green label itself, is likely to remain the durable source of pricing advantage.

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