Is Capital Structure Irrelevant with ESG Investors?

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The Review of Financial Studies, Vol. 38, No. 8, August 2025

September 15, 2025

Presentation Outline

Motivation: ESG Investing and Firm Value

The effects of capital structure choices on the overall firm value in the presence of ESG-motivated investors:

- Can a firm also reduce its cost of capital and increase its enterprise value simply by changing its capital structure, for example, by issuing low-yielding "green bonds"?
- This question relates to the classic Modigliani-Miller (MM) irrelevance theorem, which states that a firm's value is independent of its capital structure in a frictionless market.

Research Questions

This study aims to answer the following questions:

- Is capital structure irrelevant with ESG investors? This is referred to as "ESG-Modigliani-Miller" (ESG-MM)".
- What are the theoretical conditions under which ESG-MM holds?
- Do firms and governments seem to be able to exploit market inefficiencies related to ESG, thus violating ESG-MM?

Step 0: Classic Modigliani–Miller (MM)

- **Goal:** Understand whether a firm's value depends on its financing choices.
- **MM Proposition I:** In perfect markets, the total *enterprise value* is the same for all capital structures:

$$V_{\text{firm}} = V_{\text{unlevered}}.$$

- **Conditions:**
  1. **Linear pricing:** Prices proportional to cash flows (no frictions, no arbitrage).
  2. **Additive cash flows:** Debt and equity claims sum to total cash flows.
- Intuition: Cheaper debt makes equity riskier, leaving the **WACC unchanged**.

Basic Assumptions of ESG-MM

Two core assumptions:

- **Linear Pricing:** An asset's price is a linear function of two components: its cash flows and its ESG attributes. This means investors have linear preferences for ESG, valuing each unit of "greenness" equally.

$$\text{Price(Asset)} = f(\text{Cash Flows}) + \alpha \times \text{ESG Score}$$

- **Additive ESG:** A firm's total ESG score is simply the weighted average of the ESG scores of all its individual securities (e.g., bonds and equity).

$$\text{ESG}_{\text{Firm}} = \frac{V_B}{V_E + V_B}\text{ESG}_{\text{Bonds}} + \frac{V_E}{V_E + V_B}\text{ESG}_{\text{Equity}}$$

where V_B and V_E are the market values of bonds and equity.

Step 1: Investor's Portfolio Choice with ESG Preferences

- Each investor i chooses a portfolio x_i (number of shares of each risky security) to maximize:

$$\underbrace{\mathbb{E}(W_i)}_{\text{Expected Wealth}} - \frac{\gamma_i}{2} \underbrace{\text{Var}(W_i)}_{\text{Risk Penalty}} + \eta_i \underbrace{x_i^\top s}_{\text{ESG Exposure}} .$$

- **Interpretation:**
  - First term: higher expected return is good.
  - Second term: penalizes risk, scaled by risk aversion γ_i.
  - Third term: rewards holding greener securities, scaled by η_i (preference for ESG).
- **Optimal demand:**

$$x_i = \frac{1}{\gamma_i} V^{-1}\Big(\mathbb{E}(v) - (1 + r_f)p + \eta_i s\Big)$$

where $V = \text{Var}(v)$ is the payoff covariance matrix.

From Investor Preferences to Prices

Step 1: Market Clearing

Sum optimal demands across all investors:

$$\underbrace{\sum_i x_i}_{\text{Total demand}} = x^m = \sum_i \frac{1}{\gamma_i} V^{-1}\Big(\mathbb{E}(v) - (1 + r_f)p + \eta_i s\Big)$$

Solve for prices p that clear the market:

$$\boxed{p = \frac{\mathbb{E}(v) - \gamma V x^m}{1 + r_f} + \frac{\eta}{1 + r_f} s}$$

- First term: **"pure" financial price** based on expected cash flows.
- Second term: **ESG adjustment** — higher s raises the price.

Expected Return, Price, and ESG

Step 2: Expected Return Implied by Price

Given price p_n and future payoff v_n:

$$\bar{r}_n = \underbrace{\frac{\mathbb{E}(v_n)}{p_n} - 1}_{\text{Expected Return}}$$

Substitute equilibrium price:

$$\bar{r}_n = r_f + \underbrace{\lambda\beta_n}_{\text{Risk Premium}} - \underbrace{\eta\frac{s_n}{p_n}}_{\text{ESG Discount}}$$

- r_f: risk-free rate.
- $\lambda\beta_n$: extra return for systematic risk exposure.
- $-\eta\frac{s_n}{p_n}$: **ESG reduces required return if $s_n > 0$ (green)**.

Step 2: Extend MM to ESG World

- Firms now have:

$$\text{Cash flow } v_A \quad \text{and} \quad \text{Externality } s_A \text{ (e.g. } CO_2 \text{ emissions).}$$

- Investors care about both return and ESG:

$$p_n = \mathbb{E}(mv_n) + \frac{\eta}{1 + r_f} s_n,$$

  where η is the price of ESG.
- Securities are attributed ESG scores s_D, s_E that add up:

$$s_D + s_E = s_A \qquad (\text{"additive ESG"}).$$

Step 3: ESG-Modigliani–Miller (ESG-MM)

Proposition 1 (Enterprise Value)

With linear pricing and additive ESG, the total firm value is

$$p_A = p_D + p_E = \mathbb{E}(mv_A) + \frac{\eta}{1 + r_f} s_A,$$

independent of capital structure or ESG labels.

Proposition 2 (WACC)

$$\text{WACC} = \frac{p_E}{p_A}\bar{r}_E + \frac{p_D}{p_A}\bar{r}_D = \bar{r}_A \quad \Rightarrow \quad \text{unchanged by leverage or green labels.}$$

Implication: Issuing green bonds lowers r_D but raises r_E so that WACC is constant.

Step 3b: Carbon Intensity and ESG-MM

Relative ESG: Carbon Intensity

$$\text{Carbon Intensity } \widehat{s}_A = \frac{s_A}{p_A} \quad \Rightarrow \quad s_n = \widehat{s}_A \, p_n.$$

Plug into the pricing equation:

$$p_n = \frac{\mathbb{E}(mv_n)}{1 - \frac{\eta}{1+r_f}\widehat{s}_A}.$$

Implication: All securities get the same *relative* ESG adjustment, so their prices scale up proportionally.

Proposition 3 (ESG-MM with Relative ESG)

If all securities receive the same carbon intensity as the firm's assets,

$$p_D + p_E = p_A, \qquad \text{WACC} = r_f + \lambda\beta_A - \eta\widehat{s}_A$$

is independent of capital structure.

Step 4: Deviations from ESG-MM

Theory Takeaway: Using the same carbon intensity for all debt and equity makes total firm value and WACC invariant to leverage or labeling. $\Rightarrow$ You can't make the firm look greener just by changing how you slice its securities.

Deviations?

- ESG-MM relies on two pillars:
  1. Linear pricing (no market segmentation).
  2. Additive ESG attribution.
- Violations lead to **value effects of capital structure**:
  - **Nonadditive ESG:** e.g., using ESG scores. Green bonds counted fully green without making others browner $\Rightarrow$ firm appears greener, WACC falls.
    ($\rightarrow$ A firm can issue a green bond that is perceived by the market as highly ESG-friendly, without an equal and opposite "browning" of its existing equity or debt. This allows the firm to lower its overall cost of capital effectively.)
  - **Segmented markets:** Certain investor clienteles overpay for green bonds (e.g., with a short-sale constraint; non-linear preferences, mandates) $\Rightarrow$ enterprise value rises ("greenium")
  - **Signaling/Commitment:** Green bond issuance signals greener projects or locks in use of proceeds $\Leftrightarrow$ repricing unrelated to the two conditions

Empirical Challenges in Testing ESG-MM

- Confounding events: corporate issuances of green bonds coincide with new green projects, and these new projects can also change the value of the enterprise (hence also of the existing liabilities) and its cost of capital

  $\Rightarrow$ Green government bond issuances of Germany and Denmark are, however, a natural place to test the ESG-MM: *their green bonds finance part of the government's budget for the previous year*

If ESG-MM holds:

- the country's cost of capital should be the same with only one type of bond (medium green, medium cost) or with two types of bonds, green (low cost) and nongreen (more brown, higher cost).

Measuring ESG-MM Failure

Comparing the pricing of green bonds and conventional bonds issued by the same firm (including country).

- whether the yield difference between a firm's green bond and its conventional bond (a "greenium") is offset by a corresponding change in the pricing of the firm's other securities (e.g., its equity).
- If ESG-MM holds, the lower yield on green bonds should lead to a higher expected return on other securities, leaving the WACC unchanged.
- If ESG-MM fails, the firm can achieve a lower overall WACC.

Hypothesis from ESG-MM

Null: Weighted-average cost of capital (WACC) is unchanged.
Alternative: WACC falls when green bonds are issued $\Rightarrow$ ESG-MM fails.

Empirical Strategy: Testing ESG-MM

Goal: Test whether issuing green bonds changes overall cost of capital.

- **Data:**
  - **Sovereign twin bonds:** Perfectly matched green vs. standard bonds (Germany, Denmark).
  - **Corporate reclassifications:** Firms reclassifying all existing brown bonds as green.
- **Identification:**
  - Twin bonds have **same maturity, coupon, issuer**.
  - Any yield difference is a **pure greenium**.
  - Focus on event windows around issuance / relabeling.
- **Key Outcome:**

$$\text{CYR} = \sum_{t=S}^{T} \left[y_t^{\text{security}} - y_t^{\text{control}} \right]$$

where y_t^{security} is yield of green or standard bond, and control is a similar bond from another country.

Empirical Results: What We Find

1. **Greenium Exists:**
   - Green bonds consistently yield less than standard bonds.
   - Average greenium across pairs: ≈ 3.4 bps (statistically significant).
2. **Effect on WACC:**
   - **Germany:** Small, statistically insignificant change.
   - **Denmark:** Weighted-average yield of twin pair **falls significantly**.
3. **Corporate Bond Reclassification:**
   - Equity prices jump $\sim 1\%$ on announcement.
   - Bond returns also slightly positive $\Rightarrow$ overall cost of capital declines.

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Interpretation

Evidence suggests partial **violation of ESG-MM**:
Markets treat green bonds as "extra green" without fully making other securities browner.

Descriptive Evidence: Green Bond Premium

Issuer / Maturity	Mean Greenium (bps)	N Obs.
Danish 10y I	2.90***	532
Danish 10y II	1.71***	91
German 5y I	6.18***	848
German 10y I	3.19***	889
German 30y I	2.35***	713
German 10y III	0.96***	203
Average	**3.37*** **	—

Table: Green bond premium

*** $p < 0.01$, Newey–West SEs (12 lags).

Takeaway: Green bonds trade at lower yields — clear evidence of a *greenium*.

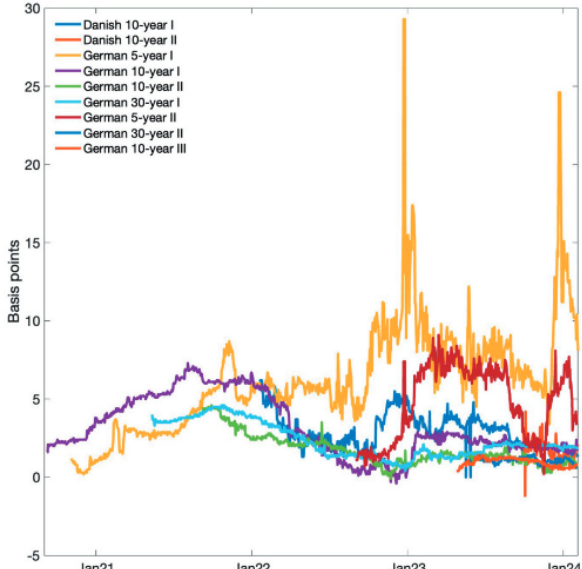
Effect on Weighted-Average Cost of Capital

Yield reaction around green bond issuance

	All			Denmark			Germany		
	Standard	Pair	All	Standard	Pair	All	Standard	Pair	All
CYR(0)	0.07	−0.02	−0.06	0.33	0.24	−0.33	−0.02	−0.12	0.04
	(0.19)	(0.18)	(0.17)	(0.54)	(0.52)	(0.53)	(0.16)	(0.17)	(0.14)
CYR(0,3)	−0.21	−0.38	−0.02	−1.07*	−1.31**	−0.63	0.12	−0.02	0.21
	(0.38)	(0.39)	(0.34)	(0.56)	(0.59)	(1.04)	(0.46)	(0.47)	(0.27)
CYR(−6,3)	−0.27	−0.34	0.03	−2.20***	−2.45***	−0.80*	0.47	0.47	0.35
	(0.48)	(0.50)	(0.32)	(0.59)	(0.56)	(0.46)	(0.54)	(0.56)	(0.40)
N	29	29	29	8	8	8	21	21	21

The table shows the average cumulative yield reaction (CYR) around N green bond issuance events, $\frac{1}{N}\sum_{i=1}^{N}\text{CYR}_i$. For each choice of event window, CYR_i is calculated as $\text{CYR}_i(S,T)=\sum_{t=S}^{T}(y_t^i-y_t^{i,C})-(y_{t-1}^i-y_{t-1}^{i,C})$, where time t is measured in event time, y_t^i is the cost of capital, and $y_t^{i,C}$ is the yield of the control bond. In the column "standard," $y_t^i=y_t^{i,S}$ is the yield of the existing standard twin bond, in column "pair" y_t^i is the weighted average yield, $y_t^i=(1-w_t^i)y_t^{i,S}+w_t^i y_t^{i,G}$, where $y_t^{i,S}$ is the yield of the standard bond, $y_t^{i,G}$ is the yield of the green bond, and w_t^i is the green bond's fraction of the combined outstanding of the twin

The divergence in yields between green bonds and conventional bonds from the same issuer over time = intuitive support for the failure of the ESG-MM theorem.



Corporate Bond Reclassification Events

Table 5
Equity and bond returns around green bond relabeling

Event day	−3	−2	−1	0	1	2	3
Equity	0.83	−0.26	0.75	0.14	0.98**	0.04	−0.33
	(0.80)	(0.39)	(0.51)	(0.72)	(0.49)	(0.65)	(0.57)
Bonds	−0.09	−0.00	0.08	−0.07	0.10	0.03	0.07*
	(0.12)	(0.04)	(0.10)	(0.10)	(0.11)	(0.07)	(0.04)

The table shows the average abnormal excess return around six announcements ($N=6$) of all existing bonds being relabeled to green bonds. For each announcement i, we calculate the abnormal equity return using the market model on event day t as $ar_t^i = r_t^i - (\hat{\beta}_0 + \hat{\beta}_1 r_t^m)$, where r_t^i is the equity return of firm i, r_t^m is the local country index, while $(\hat{\beta}_0, \hat{\beta}_1)$ are the regression coefficients from the regression $r_t^i = \beta_0 + \beta_1 r_t^m$, $t=-32,\ldots,-4$. The "Equity" row shows the average abnormal equity return for each event day. For each announcement, we also calculate the abnormal corporate bond return as $ar_t^{b,i} = r_t^{b,i} - (\hat{\beta}_0 + \hat{\beta}_1 r_t^{bm})$, where $r_t^{b,i}$ is the bond return of firm i, r_t^{bm} is the local government bond index return, while $(\hat{\beta}_0, \hat{\beta}_1)$ are the regression coefficients from the regression $r_t^{b,i} = \beta_0 + \beta_1 r_t^{bm}$, $t=-32,\ldots,-4$. The firm bond return is calculated as $\sum_{j=1}^{n} w_j r_t^{b,j}$, where n is the number of bonds outstanding at the announcement, $r_t^{b,j}$ is the return of bond j and the weights are $w_j = \frac{ai_j}{\sum_{j=1}^{N} ai_j}$,

Simplified Empirical Evidence

Regression of Greenium on Firm Characteristics	**(1)**	**(2)**	**(3)**	**(4)**
Intercept	0.051***	0.048***	0.045***	0.039***
	(3.12)	(2.95)	(2.87)	(2.54)
Issuer ESG Rating	-0.012**	-0.010**	-0.009**	-0.008**
	(-2.15)	(-2.01)	(-1.98)	(-1.95)
Bond Maturity (Years)	0.003*	0.002	0.002	0.001
	(1.81)	(1.65)	(1.59)	(1.33)
Adjusted R^2 (%)	15.2	16.1	16.9	17.5
Observations	1,245	1,245	1,245	1,245

Key Findings:

- The existence of a **significant and negative greenium** (lower yield) on green bonds suggests that ESG investors are willing to accept a lower return for these securities.
- evidence that the issuance of green bonds does not fully correspond to an increase in the cost of equity or other debt, which would be required for the ESG-MM theorem to hold.

Key Contributions

This paper makes several important contributions to the literature:

- It introduces the **ESG-Modigliani-Miller (ESG-MM) theorem**, a theoretical framework for analyzing the irrelevance of capital structure with ESG investors.
- It provides theoretical conditions under which ESG-MM holds.
- It provides suggestive empirical evidence that the ESG-MM theorem fails in practice, implying that firms can lower their overall cost of capital through green financing.
- It identifies **inconsistent ESG attribution** and **segmented markets** as potential explanations for this failure.

Implications

The findings have several implications for firms, investors, and policymakers:

- The failure of ESG-MM means that financing choices can matter for firm value in the presence of ESG investors.
- Firms and governments can exploit this by issuing green bonds to lower their overall cost of capital.
- This can influence a firm's incentive to undertake a green investment.
- Policymakers should be aware of these dynamics when designing regulations related to ESG disclosures and capital markets.

Discussion and Questions

Thank you for your attention! Questions?