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Is Capital Structure Irrelevant with ESG Investors?

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This paper examines whether capital structure is irrelevant for enterprise value and investment when investors care about environmental, social, and governance issues, which we refer to as "ESG-Modigliani-Miller" (ESG-MM). Theoretically, we show that ESG-MM holds with linear pricing and additive ESG. ESG-MM means that issuing low-yielding green bonds does *not* lower the overall cost of capital because it makes the issuer's other securities browner. Hence, a firm's incentive to make a green investment does not depend on its financing choice. We provide suggestive evidence of failure of ESG-MM, implying that firms and governments can exploit inconsistent ESG attribution or segmented markets. (*JEL* E22, G12, G32, G4, H23, Q56)

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In the presence of ESG investors, a firm can lower its cost of capital by polluting less, but can the cost of capital also be reduced by the design of the capital structure? For example, many companies and governments issue green bonds and other "labeled" securities,[1] but does such labeling lower the issuer's overall cost of capital? We show empirically that the answer appears to be "yes."

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[1] The most common labeled securities are green bonds (earmarked for environmental projects), blue bonds (earmarked for projects related to healthy oceans), social bonds (earmarked for projects with positive social outcomes), sustainable bonds (earmarked for sustainable projects), and sustainability-linked bonds (where terms like the interest payments depend on reaching certain sustainability goals).

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This answer is surprising since labeling certain securities as "green" need not in itself lower the firm's or government's emission, for example. Indeed, we show theoretically that the issuer's cost of capital should *not* be affected by capital structure, including labeling of securities, under certain conditions. These results have implications for whether green bonds create an incentive, or distort the incentive, to lower carbon emissions.

Understanding how security design affects the cost of capital and enterprise value is an old question in finance. Indeed, the Modigliani-Miller (MM) "propositions are the finance equivalents of conservation laws" of physics, as noted in the Nobel Lecture of Miller (1990). MM show that the total value of the firm is the same for all capital structures under two conditions: (i) market pricing is linear in cash flows (also called "perfect markets" or the "law of one price") and (ii) the cash flows attributed to all liabilities add to the asset's total cash flows.

We generalize this insight to an economy in which investors care about ESG, for example, carbon emissions. If investors care about carbon, then a greener firm has a lower cost of capital — but, given how green a firm is, does issuing green bonds lower the cost of capital? Our ESG-MM result says "no": the enterprise value is the same for all capital structures, including all choices of labeling of securities, under two generalized conditions: (i) linear pricing of cash flows and ESG and (ii) additive cash flows and ESG.

This ESG-MM result is a benchmark, not a certainty. We test the ESG-MM empirically, finding evidence against it. Nevertheless, just like the original MM, the ESG-MM benchmark can help investors and regulators evaluate whether an investment approach or regulation is consistent in the sense that it aggregates to the firm level.

Let us first understand each of the two conditions ((i) and (ii)) that underlie ESG-MM. Condition (i) states that prices are linear in cash flows and ESG, generalizing the same notion for the standard MM. This condition means that, if a firms' profits double, then its value doubles, everything else equal; and, likewise, if its pollution doubles, then the resultant value discount doubles.

Condition (ii) is that cash flows are additive—just as in the standard MM—and, also, ESG is additive, meaning that the externalities attributed to all liabilities add to the total externality imposed by all the firm's activities. For example, some pension funds use various tools to estimate their portfolio's overall "carbon footprint," and, to measure this footprint, investors must attribute a certain amount of emission to each security, for example the number of tons of carbon dioxide (CO_2) attributed to each security. The simplest way to do this attribution is to assume that each security has the same "carbon intensity," measured as CO_2 per market value (or sales), as the overall enterprise.[2] In any event, investors must attribute the firm's emission to the

[2] Industry and regulatory tools for reporting a portfolio's carbon footprint often consider each firm's carbon intensity computing in different ways based on the enterprise-level figures (see, e.g., Frankel et al. 2015).

various securities, and we say that these attributed emissions are additive if the total attributed CO_2 emission is the same for all capital structures, that is, add to the same as the firm's actual total emissions. For example, Partnership for Carbon Accounting Financials (2022, p. 40) states that one of their recommended ways of attributing carbon emissions to securities has the benefit that it "ensures 100% attribution of emissions over equity and debt providers and avoids double counting"; that is, additive ESG is satisfied.

When markets have linear pricing of additive ESG, then our ESG-MM result implies that the weighted-average cost of capital (WACC) is the same for all capital structures. In summary, the ESG-MM result can be presented as follows:

$$\begin{pmatrix}\text{linear}\\ \text{pricing}\end{pmatrix}+\begin{pmatrix}\text{additive cash flows}\\ \text{additive ESG}\end{pmatrix}\overset{\text{ESG-MM}}{\Longrightarrow}\begin{pmatrix}\text{enterprise value and WACC}\\ \text{same for all capital structures}\end{pmatrix}.$$

Recall that the standard MM theorem says that, even though debt has a lower cost of capital, increasing debt does not lower the WACC because it makes equity riskier. Similarly, our ESG-MM says that, even though green bonds have lower cost of capital, issuing green bonds does not lower the WACC because it makes the equity browner. In other words, since issuing green bonds does not in itself reduce the firm's overall carbon emission, it should not affect its overall cost of capital.

When investors have green preferences, a green investment has a lower cost of capital, encouraging such investments. However, under ESG-MM, a firm's incentive to pursue a green project does not depend on the financing method, for example, whether the project is financed by green bonds. This may seem surprising since green bonds may have an especially low cost of capital. But, again, the cost of capital for the other liabilities adjusts accordingly, making the net present value independent of financing decisions under ESG-MM. Said differently, if the WACC is the same for all sources of financing, we have:

$$\ldots\overset{\text{ESG-MM}}{\Longrightarrow}\begin{pmatrix}\text{enterprise value and WACC}\\ \text{same for all capital structures}\end{pmatrix}\Longrightarrow\begin{pmatrix}\text{investment}\\ \text{independent of financing}\end{pmatrix}.$$

Does ESG-MM hold in practice? Before we address this question with evidence, we note that ESG investing and sustainable finance regulation are starting to affect a large part of the financial system,[3] and we find that ESG-labeled bonds are a large fraction of all new issues of all government bonds in some countries and of all corporate bonds in some sectors.

Do real-world investors and regulators assess ESG, for example, carbon, in an additive way? Most ESG ratings are done at the firm level, and applying

3 As a proxy for how widespread ESG investing is, the asset under management of signatories of the Principles of Responsible Investment (PRI) is worth about half the combined market value of global equity markets and global fixed income markets. As a proxy for sustainable finance regulation, a group of 121 global central banks and financial supervisors have joined the "Network of Central Banks and Supervisors for Greening the Financial System," and these regulators come from 90 countries, which cover 91% of global GDP (Pedersen 2023).

the same firm-level score across all the firm's securities is consistent with additivity. As noted above, Partnership for Carbon Accounting Financials (2022, p. 50) puts forth a method of attributing carbon emissions that is additive, but then later states that green bonds "are not covered" by this methodology. If investors consider green bonds as different—for example, wholly green—then this can lead to a violation of additive ESG, depending on how the carbon is attributed to the rest of the securities. As another example, Funk (2020) presents a range of carbon attribution methods, where several do not satisfy additivity. Further, some pension funds consider both their carbon footprint and the fraction of their assets invested in green securities.[4] Considering the green securities as a fraction of all assets means that ESG is evaluated in a binary way (green vs. nongreen), which leads to a failure of ESG additivity: the same firm can choose a capital structure where all liabilities are nongreen or another where some liabilities are green and others are not. Similarly, sustainable finance regulation may encourage investors and creditors to support green bonds.[5] In summary, in the real world, investors, data providers, and regulators use a variety of methods for attributing ESG—some additive, some not—so it is ultimately an empirical question whether ESG-MM holds.

Turning to the evidence, when firms issue green bonds, their stock price tends to increase (Flammer 2021). This finding could suggest a violation of ESG-MM, but such corporate issuances of green bonds coincide with new green projects, and these new projects can also change the value of the enterprise and its cost of capital, making a test of ESG-MM difficult.

Green government bond issuances of Germany and Denmark are, however, a natural place to test the ESG-MM. When these countries issue green bonds, the bonds finance part of the government's budget for the previous year.[6] Hence, the projects are already signed into law, so the issuance of green bonds does not coincide with new green projects. If the green bonds finance the green part of the budget, then the remaining (nongreen) bonds must finance the nongreen projects. Hence, these bonds are less green than they would be if they financed

[4] For example, Capital Monitor reports that AkademikerPension "aims to more than treble its near 7% allocation to green assets to 22.5% by 2030" (Mair 2021).

[5] For example, on January 3, 2023, the EU made a statement titled "Sustainable Finance: Commission welcomes political agreement on European green bond standard" in which the Commissioner for Financial Services, Financial Stability and Capital Markets Union, Mairead McGuinness, said: "Led by Europe and European issuers, the green bond market is growing into an important source of funding for companies that need to fund large-scale climate-friendly investments, such as renewable energy, clean transportation, and energy-efficient buildings. With the European Green Bond Standard, we are creating a new gold standard available to those companies that want to be at the forefront of the sustainability transition."

[6] The German Federal Ministry of Finance states that "the use of proceeds from Green German Federal Securities always corresponds to federal expenditure from the previous year" (https://www.bundesfinanzministerium.de/Content/EN/Standardartikel/Topics/Priority-Issues/Climate-Action/green-german-federal-securities-restricted/green-german-federal-securities.html). The Danish Ministry of Finance writes that "upon signing of the annual Budget Act, the Ministry of Finance will inform Danmarks Nationalbank of the amount of eligible green expenditures in the coming year." (https://fm.dk/media/25347/kingdom-of-denmark-green-bond-framework.pdf).

the entire budget (i.e., in the absence of green bonds). If investors recognize this "conservation of green," then 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).

However, the data suggest otherwise. When governments issue green bonds, these green bonds trade at a lower yield than perfectly matched standard bonds. This lower yield is not in itself a violation of ESG-MM, because it could be compensated by a rise in the yield of the standard bonds. For Danish bonds, we find that the overall cost of capital falls, providing suggestive evidence against ESG-MM, but the yield change is statistically insignificant in our overall sample of sovereign bonds.

We find stronger evidence against ESG-MM in connection with events in which firms reclassify their bonds as green. During such events, we see that both the firm's bonds and equity increase in value, on average.

If these empirical findings mean that some investors consider green bonds as fully green without making the remaining securities browner, then this could have broader implications. For example, suppose that a firm's assets consist of half coal and half wind turbines. The firm considers two alternative capital structures: (a) all equity, evaluated as half brown and half green; (b) green bonds financing the wind turbines, evaluated as all green, and equity, evaluated based on the enterprise-level ESG score, making it half green and half brown. Here, (b) corresponds to a much greener capital structure with lower cost of capital. Indeed, with capital structure (b), half of the liabilities (debt) are all green and the other half (equity) are half brown, making the liabilities only one quarter brown in total. In essence, capital structure (b) allows the firm to get rid of half its carbon emissions on paper in this hypothetical example — without actually reducing its real emissions!

Our paper is related to several literatures. First, our model of capital markets with ESG-motivated investors follows Pástor et al. (2021), Pedersen et al. (2021), and Zerbib (2022). Second, the empirical relation between ESG and stock returns is considered by Hong and Kacperczyk (2009), Bolton and Kacperczyk (2021), Pedersen et al. (2021), and Eskildsen et al. (2024) while the relation between ESG ratings and bond returns is considered by Polbennikov et al. (2016). Gormsen et al. (2023) find that green firms have lower perceived costs of capital and discount rates than brown firms.

The yield of corporate green bonds has been found to be lower than corresponding bonds without this label (Zerbib (2019), Baker et al. (2022), Caramichael and Rapp (2024)), although Flammer (2021) questions this finding because of the difficulties in matching green and nongreen bonds. Our data on sovereign bonds provide clear evidence of a lower yield for green bonds with perfectly matched standard bonds, echoing similar findings for German government bonds by Pástor et al. (2022) and D'Amico et al. (2022).

Our paper is also related to the broader literature on corporate social responsibility (CSR). In particular, Zivin and Small (2005) derive a conservation result, showing that firms' charitable giving does not affect firm value when it is a perfect substitute for investors' own charitable giving, while Baron (2007) presents limitations and extensions.

We complement all these literatures by considering the effects of capital structure choices on the overall firm value in the presence of ESG-motivated investors. While the cited literature considers each type of security in isolation, we show theoretically if and how ESG choices affect the overall cost of capital for a government or firm, and we provide evidence that labeling of securities can lower the cost of capital.

1. Theory: Capital Structure Irrelevance with ESG

Just like the standard MM results, our ESG-MM results rely on a notion of linear pricing (sometimes called perfect capital markets). To set the stage for our MM results, we first make precise what linear pricing means and how it can arise with ESG (Section 1.1). We then present our ESG-MM results (Section 1.2) and how they can break down (Section 1.3).

1.1 Capital markets with ESG-motivated investors

We consider an economy with $n=1,\dots,N$ risky securities and a risk-free rate, r^f. Each security n has a future cash flow, v_n, and an externality, s_n. Here, $s_n>0$ is a positive social impact while $s_n<0$ is a negative externality such as carbon emission (measured in tons of carbon, say). The price p_n in a capital market with linear pricing can be written as

$$p_n = \mathrm{E}(m v_n) + \frac{\eta}{1+r^f} s_n, \tag{1}$$

where m is the pricing kernel and $\eta \geq 0$ is the value of externalities.

While such a linear pricing scheme holds in many models,[7] we present here a simple example for concreteness. The economy has $i=1,\dots,I$ investors, where investor i chooses her portfolio $x_i \in \mathbb{R}^N$, measuring the numbers of shares of each risky security. This portfolio choice generates a future wealth of $W_i=\bar{W}_i(1+r^f)+x_i'(v-p(1+r^f))$ and an ESG exposure of $x_i's$, where $\bar{W}_i$ is the initial wealth, v is the vector of security payoffs, p is the vector of prices, and s is the vector of ESG. The investor maximizes her expected utility

$$\mathrm{E}(W_i) - \frac{\gamma_i}{2}\mathrm{Var}(W_i) + \eta_i x_i' s \tag{2}$$

with risk aversion γ_i and ESG preference η_i. The optimal portfolio follows from the first-order condition, $0=\mathrm{E}(v)-(1+r^f)p-\gamma_i V x_i+\eta_i s$, with $V=\mathrm{Var}(v)$:

$$x_i = \frac{1}{\gamma_i} V^{-1}\left(\mathrm{E}(v)-(1+r^f)p+\eta_i s\right). \tag{3}$$

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[7] See Pástor et al. (2021), Pedersen et al. (2021), and Zerbib (2022).

In equilibrium, the total demand for shares must equal the supply, given by x_m:

$$x_m = \sum_i x_i = \sum_i \frac{1}{\gamma_i} V^{-1}\left(\mathrm{E}(v) - (1+r^f)p + \eta_i s\right). \tag{4}$$

The vector of equilibrium prices is therefore

$$p = \frac{\mathrm{E}(v) - \gamma V x_m}{1+r^f} + \frac{\eta}{1+r^f} s, \tag{5}$$

where γ is the aggregate risk aversion defined by $\frac{1}{\gamma} = \sum_i \frac{1}{\gamma_i}$ and η is the aggregate ESG preference defined by $\frac{\eta}{\gamma} = \sum_i \frac{\eta_i}{\gamma_i}$. So we see that (1) holds with $m = \frac{1-\gamma(v-\mathrm{E}(v))' x_m}{1+r^f}$.

Lastly, each security has a return of $r_n = \frac{v_n}{p_n} - 1$ and an expected return, $\bar{r}_n = \mathrm{E}(r_n)$, given by

$$\bar{r}_n = r^f + \gamma\, p_m \mathrm{Cov}(r_n, r_m) - \eta \frac{s_n}{p_n} \tag{6}$$

where $p_m = p' x_m$ and $r_m = \frac{v' x_m}{p_m} - 1$ is the market return. Applying this expression for the market and combining with (6) yields a natural ESG-adjusted capital asset pricing model (CAPM) relation:

$$\bar{r}_n = r^f + \lambda \beta_n - \eta \frac{s_n}{p_n}, \tag{7}$$

where $\beta_n = \frac{\mathrm{Cov}(r_n, r_m)}{\mathrm{Var}(r_m)}$ and $\lambda = \bar{r}_m - r^f + \eta \frac{s_m}{p_m}$ is the risk premium with $s_m = s' x_m$.

1.2 ESG-Modigliani-Miller theorems

Next, we consider a firm (or government) with assets (A) that deliver future cash flows of v_A with an overall externality of s_A. The firm considers its choice of capital structure. A capital structure consists of a set of securities, which are claims to the firm's overall cash flows and externalities. For simplicity, we consider a firm with two securities, debt (D) and equity (E), although the results naturally extend to any set of securities. These securities are attributed cash flows v_D and v_E, which add to the total cash flow, $v_D + v_E = v_A$. In close parallel, these securities are attributed externalities s_D and s_E, which add to the total externality ("additive ESG"):

$$s_D + s_E = s_A. \tag{8}$$

For example, if the firm has 100 tons of carbon emissions, then the carbon emissions attributed to all securities should remain 100 tons. If debt is 60% of liabilities, then Partnership for Carbon Accounting Financials (2022, fig. 4-2) attribute 60 tons to debt and 40 tons to equity, yielding an additive attribution. Such additive ESG scores together with linear pricing ensure capital structure irrelevance, as seen from the next proposition.

Proposition 1 (ESG-MM I). With linear pricing (1) and additive ESG scores (8), the total enterprise value is equal to the value of cash flows and externalities and is not affected by capital structure.

Proof. For any capital structure, the total value of the firm is

$$p_E + p_D = \mathrm{E}(mv_E) + \frac{\eta}{1+r^f} s_E + \mathrm{E}(mv_D) + \frac{\eta}{1+r^f} s_D = \mathrm{E}(mv_A) + \frac{\eta}{1+r^f} s_A = p_A. \tag{9}$$

That is, the enterprise value equals that of an unleveraged firm for any capital structure. ■

The standard MM result is also presented in terms of cost of capital in the typical textbook, so we next present a similar result with ESG. For any security with price p_n and cash flow v_n, the corresponding cost of capital (or expected return) is $\bar{r}_n = \frac{\mathrm{E}(v_n)}{p_n} - 1$, and the firm's weighted-average cost of capital (WACC) is defined as

$$\mathrm{WACC} = \frac{p_E}{p_E + p_D} \bar{r}_E + \frac{p_D}{p_E + p_D} \bar{r}_D. \tag{10}$$

Proposition 2 (ESG-MM II). With linear pricing (1) and additive ESG scores (8), the WACC is independent of capital structure, including each security's ESG label. Increasing the ESG of debt (s_D) decreases the cost of debt capital ($\bar{r}_D$) and raises the cost of equity capital ($\bar{r}_E$) for given v_A and s_A. Similarly, increasing s_E decreases $\bar{r}_E$ and raises $\bar{r}_D$.

Proof. Since $p_E + p_D = p_A$ and future cash flows are distributed among debt and equity, we have

$$p_E r_E + p_D r_D = (p_E + p_D) r_A \tag{11}$$

which shows that WACC is always the same as $\bar{r}_A$:

$$\frac{p_E}{p_E + p_D} \bar{r}_E + \frac{p_D}{p_E + p_D} \bar{r}_D = \bar{r}_A. \tag{12}$$

Further, $\bar{r}_D$ is decreasing in s_D since (1) implies that $\bar{r}_D = \frac{\mathrm{E}(v_D)}{p_D} - 1 = \frac{\mathrm{E}(v_D)}{\mathrm{E}(mv_D) + \frac{\eta}{1+r^f} s_D} - 1$. Clearly, $\bar{r}_E$ is decreasing in s_E for the same reason. Since $s_D + s_E = s_A$, we see that increasing the ESG rating of one security comes at the expense of lowering that of the other security. We also see that $\bar{r}_E = \bar{r}_A + \frac{p_D}{p_E}(\bar{r}_A - \bar{r}_D)$ as in the usual MM. ■

To make carbon emissions comparable across firms of different sizes, investors and regulators often look at carbon emission as a fraction of firm value, denoted "carbon intensity" (or as a fraction of sales or other financial ratios). So, in the case where s_A is the (negative) of carbon emissions, the corresponding carbon intensity is $\hat{s}_A = \frac{s_A}{p_A}$.

More broadly, suppose that investors assign a *relative* ESG score (such as a carbon intensity), $\hat{s}_n$, to any security n, such that $s_n = \hat{s}_n p_n$. Then the pricing equation (1) becomes

$$p_n = \mathrm{E}(mv_n) + \frac{\eta}{1+r^f} \hat{s}_n p_n. \tag{13}$$

We see that the price is on both sides of the equation, but we can rewrite this relation as

$$p_n = \frac{1}{1-\frac{\eta}{1+r^f}\hat{s}_n} \mathrm{E}(mv_n). \tag{14}$$

Further, the cost of capital (7) can now be written as

$$\bar{r}_n = r^f + \lambda\beta_n - \eta\hat{s}_n, \tag{15}$$

which shows how carbon intensity (or relative ESG) affects required returns.

A common market practice (when no securities are labeled) is to assign the same relative ESG to all securities, namely the relative ESG of the issuer's overall assets. Our next result shows that the ESG-MM conservation result continues in this case.

Proposition 3 (ESG-MM with relative ESG or carbon intensity). With linear pricing (14) and if all the firm's securities receive the same relative ESG (e.g., carbon intensity) as unleveraged assets, then total enterprise value and WACC are not affected by capital structure.

Proof.

$$p_D + p_E = \frac{1}{1-\frac{\eta}{1+r^f}\hat{s}_A}\mathrm{E}(mv_D) + \frac{1}{1-\frac{\eta}{1+r^f}\hat{s}_A}\mathrm{E}(mv_E) = \frac{1}{1-\frac{\eta}{1+r^f}\hat{s}_A}\mathrm{E}(mv_A) = p_A. \tag{16}$$

When the enterprise value is unaffected, then so is the WACC. We can also see this directly via (15), which shows that the WACC is

$$\frac{p_E}{p_E+p_D}(r^f + \lambda\beta_E - \eta\hat{s}_A) + \frac{p_D}{p_E+p_D}(r^f + \lambda\beta_D - \eta\hat{s}_A) = r^f + \lambda\beta_A - \eta\hat{s}_A. \tag{17}$$

■

So far, we have been considering a firm with fixed assets, but it is also interesting to consider a firm's incentive to invest, for example, in a green project. The firm has assets in place, v_A, s_A, and now also considers investing in a new project with cash flow v_a and externality s_a at a cost of c.

The investment cost c is financed by issuing new securities. The new securities have cash flows v' and externalities s'. These new securities must be able to just finance the cost of the investment, that is, $c = \mathrm{E}(mv') + \frac{\eta}{1+r^f}s'$. Naturally, the owners of the old securities are therefore left with cash flows of $v_A + v_a - v'$ and externalities $s_A + s_a - s'$.

Defining the net present value of the investment as $\mathrm{NPV} = \mathrm{E}(mv_a) + \frac{\eta}{1+r^f} s_a - c$, we have the following irrelevance result:

Proposition 4 (Investment). With linear pricing (1) and additive ESG scores (8), consider an investment financed by issuing new securities. Regardless of its financing, the post-investment enterprise value is the same, and the value of existing liabilities increase by the investment's NPV.

Proof. The post-investment enterprise value is:

$$\mathrm{E}(m(v_A+v_a))+\frac{\eta}{1+r^f}(s_A+s_a). \tag{18}$$

The post-investment value of the existing liabilities minus their pre-investment value is

$$\begin{aligned}\mathrm{E}(m(v_A+v_a-v'))+\frac{\eta}{1+r^f}(s_a+s_A-s')-\left(\mathrm{E}(mv_A)+\frac{\eta}{1+r^f}s_A\right)\\ =\mathrm{E}(mv_a)+\frac{\eta}{1+r^f}s_a-c=\mathrm{NPV}\end{aligned} \tag{19}$$

for any choice of v',s' satisfying the financing condition $c=\mathrm{E}(mv')+\frac{\eta}{1+r^f}s'$. ■

So we see that, under the conditions of ESG-MM, making a green investment is not more attractive if it can be financed by green bonds. Such a green investment is attractive, simply if its NPV is positive. While the NPV calculation takes into account investors' preference for green, it does not matter whether the investment is financed by green new bonds or financed in a way that makes all the liabilities greener. For example, if the firm issues very green bonds (high s'), then it needs only sell fewer of them (low v'), but the remaining liabilities are browner (lower s_A+s_a-s'). If it sells standard bonds (s' at the enterprise level), it needs to sell more, but the existing liabilities become greener.

1.3 Deviations from ESG-Modigliani-Miller

We have seen that ESG-MM follows from additive ESG measures (8) and linear pricing (1). Next, we discuss how a failure of either of these conditions can lead to a failure of ESG-MM. In other words, we highlight some potentially empirically relevant ways in which firms can increase their enterprise value via their choice of capital structure and ESG labeling.

1.3.1 Exploiting nonadditive ESG scores Suppose that linear pricing holds, (1) or (14), but ESG scores do not add up as in (8). In this case, a firm can benefit from choosing a capital structure that is perceived as particularly green, as shown in the following proposition.

Proposition 5 (Nonadditive ESG). Consider a firm with existing liabilities that are assigned the same relative ESG (e.g., carbon intensity) as the overall enterprise. The firm makes a new investment financed by issuing green bonds with higher ESG scores. Then the post-investment enterprise value (and the value of the existing liabilities) are increasing in the green bond's ESG score. Therefore, the hurdle rate of the new investment is lower if it can be financed by greener bonds (or a larger fraction of green bonds).

Proof. Using the notation from Propositions 3 and 4, given investment cost c, the green bonds must be assigned a cash flow v' satisfying $c = \frac{1}{1-\frac{\eta}{1+r^f}\hat{s}'}\mathrm{E}(mv')$, where $\hat{s}'$ is the relative ESG score assigned to green bonds (based on (14)). The post-investment enterprise value is the sum of the new value of existing liabilities and the value of the green bonds:

$$\frac{\mathrm{E}(m(v_A+v_a-v'))}{1-\frac{\eta}{1+r^f}\hat{s}_{post}}+\frac{\mathrm{E}(mv')}{1-\frac{\eta}{1+r^f}\hat{s}'}\geq\frac{\mathrm{E}(m(v_A+v_a))}{1-\frac{\eta}{1+r^f}\hat{s}_{post}}, \tag{20}$$

where $\hat{s}_{post}$ is the post-investment relative ESG score at the enterprise level. Clearly the post-investment enterprise value, the left-hand side of (20), increases in $\hat{s}'$. Hence, the inequality follows from $\hat{s}' \geq \hat{s}_{post}$. The post-investment value of the existing liabilities is the new enterprise value less the value of the green bonds, c. Hence, if the post-investment enterprise value increases by more, then so does the value of existing liabilities. Finally, when the green bonds have the same relative ESG score as the rest of the post-investment firm (the right-hand side of (20)), then existing liabilities increase with the investment's NPV (Proposition 4), so the increase is higher with higher ESG scores. Therefore, a firm that maximizes the market value of the enterprise (or the equity) can use a lower hurdle rate for investments that can be financed by more green bonds—because these bonds require a lower coupon and, under the stated assumptions, do not make the rest of the liabilities browner (as they should under ESG-MM). ■

To understand this result, consider the following example. A firm n has assets that are partly green and partly brown. The firm considers a new investment of the same type as the existing assets. The firm's relative ESG score is therefore the same before and after the investment, $\hat{s}$. If the investment is financed using nonlabeled securities that are evaluated based on the project's relative ESG score, then the cost of capital is $r^f + \lambda\beta_n - \eta\hat{s}$ using (15).

If instead the firm finances the project using a fraction w of green securities and the rest $1-w$ with nonlabeled securities, then the cost of capital is lowered. In particular, if the green securities have a relative ESG score of $\hat{s}' > \hat{s}$, then these green securities have a lower cost of capital of $r^f + \lambda\beta_n - \eta\hat{s}'$. If the other securities still have the same relative ESG score as the firm, then the total cost of capital for the project is

$$r^f + \lambda\beta_n - \eta\hat{s} - w\eta(\hat{s}' - \hat{s}). \tag{21}$$

We see that the cost of capital is lower when the fraction of green bonds w is higher.

1.3.2 Exploiting nonlinear pricing: Segmented markets Another potential source of failure of the ESG-MM theorems is that markets are segmented such that (1) does not hold. For example, markets can be segmented in the sense that different investor clienteles buy different types of securities at differing pricing schemes. In this case, a firm can increase its enterprise value by creating the securities that each clientele (over)values the most.

As a specific example, segmentation can arise from short-sale constraints that "sideline" non-ESG investors when green investors pay a high enough premium for green securities. To see how this works, we introduce short-sale constraints in the capital markets of Section 1.1. With short-sale constraints, the investor's first-order condition becomes

$$0=\mathrm{E}(v)-(1+r^f)p-\gamma_i V x_i+\eta_i s+\theta_i, \tag{22}$$

where $\theta_i \in \mathbb{R}_+^N$ is the vector of Lagrange multipliers for the constraints $x_i \geq 0$ of agent i. The vector of equilibrium prices is therefore

$$p=\frac{\mathrm{E}(v)-\gamma\, V x_m+\theta}{1+r^f}+\frac{\eta}{1+r^f}s=E(mv)+\frac{\theta}{1+r^f}+\frac{\eta}{1+r^f}s, \tag{23}$$

where $\theta \in \mathbb{R}_+^N$ is the aggregate shadow cost of short-sale constraints for each security, defined by $\frac{\theta}{\gamma}=\sum_i \frac{\theta_i}{\gamma_i}$. These security-specific shadow costs, θ, depend on the ESG scores, s, in equilibrium. Hence, prices are not linear in payoffs and externalities in the equilibrium with short-sale constraints (23), and some firms can potentially exploit the nonlinearity coming from θ.

For example, suppose that a firm considers two different capital structures: (i) issuing securities with average ESG scores and no binding constraint, that is, $\theta_n=0$ for all their liabilities, or (ii) issuing green bonds with $\theta_{green}>0$ and equity with no binding constraint. Even with additive ESG scores (8), the second capital structure raises the enterprise value by $\frac{\theta_{green}}{1+r^f}$ due to the extra premium on green bonds.

1.3.3 Alternative hypotheses: Signaling, commitment, and preferences In our empirical tests, we look for evidence against ESG-MM. In this connection, it is relevant to consider alternative hypotheses (i.e., effects unrelated to failure of linear pricing and additive ESG) that could also lead to issuance of green bonds and associated repricing of the issuer's securities.

One alternative hypothesis is that the issuance of a green bond signals valuable green projects. To understand the signaling story, consider the issuance of a green bond to finance a green investment when ESG-MM holds or fails. Failure of ESG-MM (Proposition 5) means that green bonds are issued at a low yield and the existing liabilities (e.g., equities) increase in value, even if the investment is zero NPV, consistent with the evidence of Flammer (2021). However, if the investment has positive NPV, then the existing liabilities increase in value even if ESG-MM holds (Proposition 4). So the signaling story is that the issuance signals a positive NPV, which makes it difficult to test ESG-MM. Empirically, we seek to address this challenge by studying sovereign issues related to past budgets and relabeling of existing bonds.

A broader version of the signaling story is that the issuance of a green bond signals more green behavior in the future, which could be a sign of more positive NPV projects to come or a lower cost of capital due to future green behavior. However, since a green bond issue is related to a current investment, it seems unclear why the issuer could not make such promises in a more effective way.

Another alternative hypothesis is commitment: The firm wants a favorable ESG rating for a green project, but the market is afraid that, once the money is raised, it will be spent in a less green fashion. In this case, the green bonds can be a way to contractually commit to spending the money in a specific way (Chowdhry et al. (2019), Oehmke and Opp (2024)). Commitment is a relevant issue, which can also help explain the use of sustainability-linked bonds. So, to distinguish this effect from a violation of ESG-MM, we must search for specific examples with less commitment problems. In particular, our study of sovereign green bonds exploits that these bonds are financing the past budget, which is already signed into law.

Yet another alternative hypothesis is related to the nature of investors' ESG preferences. The linear pricing (1) is based on the idea that investors have a separate nonfinancial motive to hold green assets, consistent with the evidence of Riedl and Smeets (2017). Further, additive ESG means that investors attribute the firm's actions across its securities, but investors might alternatively consider the "impact" of their investments (Moisson 2022). In particular, Oehmke and Opp (2024) consider a large social fund with an "impact mandate," meaning that it "incorporates social costs relative to a counterfactual scenario in which the SR fund does not invest in a given firm." In this case, the firm's capital structure could influence investors' ability to have impact, in particular through the commitment argument above.

However, consistent with our model, Bonnefon et al. (2022) find experimental evidence that "non-pecuniary benefits of firms' externalities only accrue through stock ownership, not through the actual impact of investment decisions." Further, Bonnefon et al. (2022) find that "non-pecuniary preferences are linear and additive," consistent with our model.

Lastly, a behavioral story is that the issuer's green activities simply become more salient to investors when issuing a green bond. In other words, if investors have limited attention and become more aware of the issuer's green projects when they see a green bond issue, then the cost of capital could be reduced if the perceived social value s increases in the mind of some investors, increasing their valuation or broadening the investor base.

2. Empirical Results: Testing ESG-MM

This section tests our ESG-MM result using data on sovereign bond issuance events (Section 2.3) and corporate bond relabeling events (Section 2.4). Before we present these tests, we introduce our data (Section 2.1) and show that ESG-related bonds are becoming prevalent globally (Section 2.2).

2.1 Data

2.1.1 Sovereign bonds To test the ESG-MM in the sovereign bond market, we use data on green sovereign bonds, paired with identical nongreen bonds in terms of coupon and maturity issued by the same country. Flammer (2021) argues that imperfect matching between green and nongreen bonds has led to conflicting results in the literature regarding the existence and size of a potential green bond premium, so focusing on perfectly matched twin bonds allows us to address this issue.

In addition to studying the spread between green and standard bonds, we are also interested in their weighted average yield (in the spirit of the WACC). Since yields also change for reasons unrelated to green bond issuance events, we look at yield spreads relative to a "control bond," which is a similar bond from another country. We collect end-of-day mid yields for all the bonds from Bloomberg BGN from January 1, 2019, to February 5, 2024.

Table 1 shows the bonds included in our study. There are seven pairs of green-and-standard bonds issued by Germany and two pairs issued by Denmark. As control bonds, we use matched government bonds from the Netherlands, a nearby EU country with the same AAA rating as Denmark and Germany.[8] While the twin bonds are perfectly matched in terms of maturity and coupon, the control bonds are slightly different.

All bonds are later reopened after their initial issuance, meaning that additional bonds are issued into the same bond series, and the sample consists of 9 new-issue events and 20 reopening events, for a total of 29 event dates. The green bond's share of the total issue is between 7% and 24%. The auction is announced 6 business days before in Germany and at least 3 business days before in Denmark. The settlement date is 2 business days later in both countries. In addition to the actual auction date, we therefore also investigate a broader event window from 6 days before to 3 days after the auction.

2.1.2 Corporate bonds In the corporate bond market, we test the ESG-MM using a subset of firms that reclassify all their existing brown bonds as green. We manually search for firms that convert all their existing bonds into green bonds, and Table 2 shows the cases. The reclassified bonds have been issued at least 5 months before the announcement and some as far back as 2016. The table shows that debt-to-equity is between 16% and 72%, so debt is a significant part of the capital structure and a reclassification of debt could materially affect the greenness of equity. We collect daily adjusted closing prices for bonds and equity from Bloomberg in the period around the announcement date.

[8] The government of Netherlands issued a green bond on May 19, 2019, and October 17, 2023, and the dates of issuances and reopenings do not occur in any of our event windows.

Table 1
Government bonds and green bond issuance

	ISIN	Coupon	Issue date	Maturity
Danish 10-year bond I				
Green bond	DK0009924375	0	January 19, 2022	November 15, 2031
Standard bond	DK0009924102	0	January 20, 2021	November 15, 2031
Control bond	NL00150006U0	0	February 11, 2021	July 15, 2031
Danish 10-year bond II				
Green bond	DK0009924615	2.25	September 26, 2023	November 15, 2033
Standard bond	DK0009924532	2.25	February 8, 2023	November 15, 2033
Control bond	NL0015001AM2	2.5	February 16, 2023	July 15, 2033
German 5-year bond I				
Green bond	DE0001030716	0	November 4, 2020	October 10, 2025
Standard bond	DE0001141828	0	July 8, 2020	October 10, 2025
Control bond	NL0015031501	0	May 28, 2020	January 15, 2027
German 5-year bond II				
Green bond	DE0001030740	1.30	August 31, 2022	October 15, 2027
Standard bond	DE0001141869	1.30	June 28, 2022	October 15, 2027
Control bond	NL0012171458	0.75	February 6, 2017	July 15, 2027
German 10-year bond I				
Green bond	DE0001030708	0	September 2, 2020	August 15, 2030
Standard bond	DE0001102507	0	June 17, 2020	August 15, 2030
Control bond	NL0014555419	0	March 12, 2020	July 15, 2030
German 10-year bond II				
Green bond	DE0001030732	0	September 10, 2021	August 15, 2031
Standard bond	DE0001102564	0	June 18, 2021	August 15, 2031
Control bond	NL00150006U0	0	February 11, 2021	July 15, 2031
German 10-year bond III				
Green bond	DE000BU3Z005	2.3	April 25, 2023	February 15, 2033
Standard bond	DE000BU2Z007	2.3	January 11, 2023	February 15, 2033
Control bond	NL0015001AM2	2.5	February 9, 2023	July 15, 2033
German 30-year bond I				
Green bond	DE0001030724	0	May 11, 2021	August 15, 2050
Standard bond	DE0001102481	0	August 21, 2019	August 15, 2050
Control bond	NL0015614579	0	September 24, 2020	January 15, 2052
German 30-year bond II				
Green bond	DE0001030757	1.8	June 13, 2023	August 15, 2053
Standard bond	DE0001102614	1.8	October 11, 2022	August 15, 2053
Control bond	NL00150012X2	2.0	September 29, 2022	January 15, 2054

This table shows the twin bond pairs used in the event study as well as the control bond used to calculate changes in the overall cost of capital.

Table 2
Corporate bonds and green bond relabeling

Firm	# bonds	Size (bill.)	D/E	Currency	Announcement date	Equity index	Bond index
Merlin Properties	6	3.100	61%	EUR	April 25, 2022	IBEX	Spain
Gecina SA	12	6.150	70%	EUR	April 14, 2021	CAC	France
Colonial Group	7	3.225	72%	EUR	December 22, 2021	IBEX	Spain
Covivio SA	7	2.894	46%	EUR	April 14, 2021	CAC	France
Energy Harbor Corp.	2	1.000	16%	USD	October 23, 2022	S&P 500	U.S.
PSP Swiss Property	10	1.830	38%	CHF	November 11, 2022	SMI	Swiss

This table shows summary statistics for six events where the firm relabeled all existing outstanding corporate bonds from ordinary bonds to green bonds. “# bonds” is the number of bonds outstanding at the announcement date, and “Size (bill.)” is the combined notional amount outstanding in local currency. “D/E” is the notional amount outstanding of bonds divided by the market value of equity the day before the announcement. “Equity index” is the stock market index used in calculation of excess equity returns, and “Bond index” is the local Treasury index used when calculating bond excess returns. Data are from Bloomberg.

2.1.3 Issuance and outstanding amounts We use data from Refinitiv Eikon to calculate the fraction of issued and amount outstanding ESG bonds relative to all bonds. They provide for each bond their amount issued converted to USD, the industry classification and a green bond and/or ESG bond indicator.[9]

2.2 How prevalent are green and other ESG-related bonds

Before we analyze whether a green bond issuance is associated with a failure of ESG-MM, it is interesting to consider how prevalent such bonds are. To address this issue, Figure 1 shows the fraction of ESG-related bond issuance for, respectively, corporations and governments. For corporate bonds, Figure 1 shows that ESG-related bonds issuance is growing rapidly and already a nontrivial fraction of all issues globally (panel A) and a large part of all issues in some industries (panel B). Panel C shows that a large part of government bond issues are green for several developed countries.

Additionally, ESG loans is also rising fast, approximately 11.7% of global loans issuance in 2022 based on data from Refinitiv Eikon. More broadly, a large part of financial systems is becoming affected by sustainable finance regulation (see Footnote 3).

We note that, since ESG-related bonds are a relatively new phenomenon, they are still a modest part of all bonds outstanding in most cases. Figure 2 shows the fraction of ESG-related bonds to total bonds outstanding. Globally, although increasing rapidly, ESG corporate bonds were around 3.5% of all corporate bonds outstanding in 2022 (panel A). Yet, they are already a significant fraction in some sectors (panel B). Although the fraction of green bonds outstanding is still modest for governments (panel C), Figure A.2 (in the internet appendix) shows that the fraction of ESG bonds outstanding is significant in some African countries. In other words, since investors only recently started to price ESG, any failure of the ESG-MM could only have started recently. Even if ESG already affects the cost of capital of firms and governments, ESG first affects new issues since issuers only change their total capital structure sluggishly.

2.3 Testing ESG-MM using green government bonds

Before we analyze whether green bonds affect the overall cost of capital, we consider whether green bonds have a lower yield than comparable standard bonds. Figure 3 shows a measure of the "green bond premium" for each pair of twin bonds in our study. Specifically, the figure shows the time series of the standard-minus-green yield spread, $y_t^S - y_t^G$, where y_t^S is the yield-to-maturity of the standard bond, and y_t^G is the yield-to-maturity of the corresponding

9 We downloaded the issuance data on June 30, 2023, and it appears that the amount issued is the total amount outstanding at download date. While this corresponds to amount issued in most cases, it may be different for some bonds in case of reopenings and buybacks. We downloaded the amount outstanding data on February 5, 2024, and defined the amount outstanding at a date as all bonds issued before the date and maturing after the date.

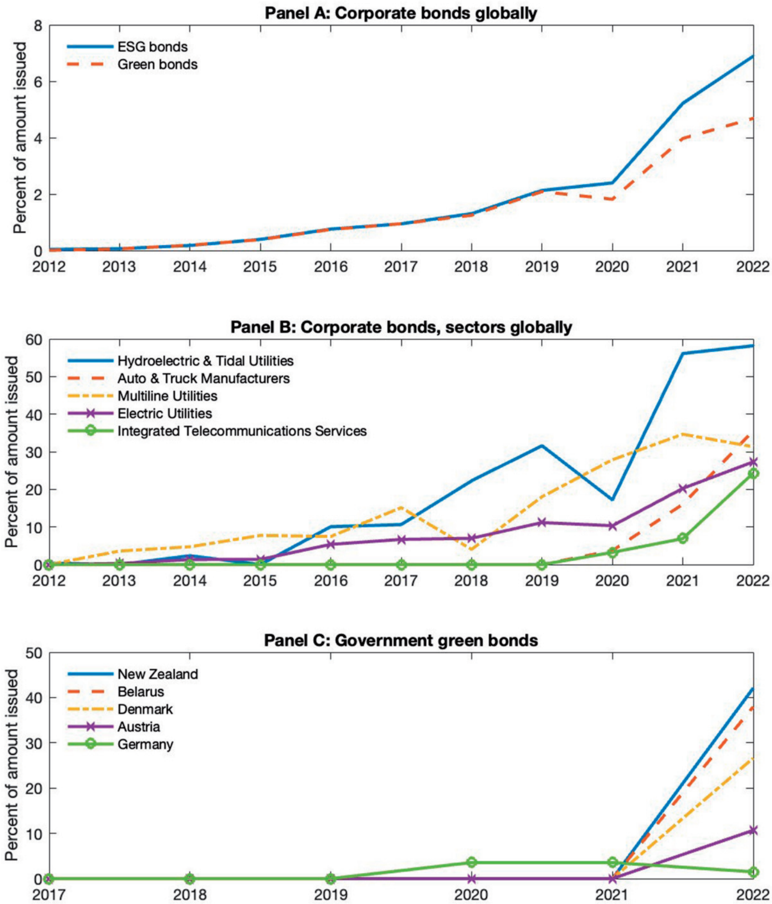

Figure 1
ESG bond issuance
Panel A shows the percentage of ESG or green corporate bonds of the total amount issued globally. Panel B shows the percentage of ESG corporate bonds of the total amount issued globally for the five sectors that had the highest ESG bond percentage in 2022. Panel C shows the percentage of sovereign green bonds of the total amount issued globally for the four countries with the highest green bond issuance percentage in 2022 as well as Germany.
ALT TEXT: The issuance of ESG and green bonds has tended to increase over the past decade.

green bond. (We note that the reverse spread, $y_t^G - y_t^S$, is sometimes denoted as the bond greenium.)

As seen in Figure 3, the green bond premium is positive for all the bonds we study at almost all times (only 6 of 4,444 observations are negative). The consistently positive green bond premium is statistically significantly different from zero, as seen in Table 3. Given that these pairs of standard and green bonds are perfectly matched, these results provide strong evidence that green bonds have a lower cost of capital than corresponding standard bonds.

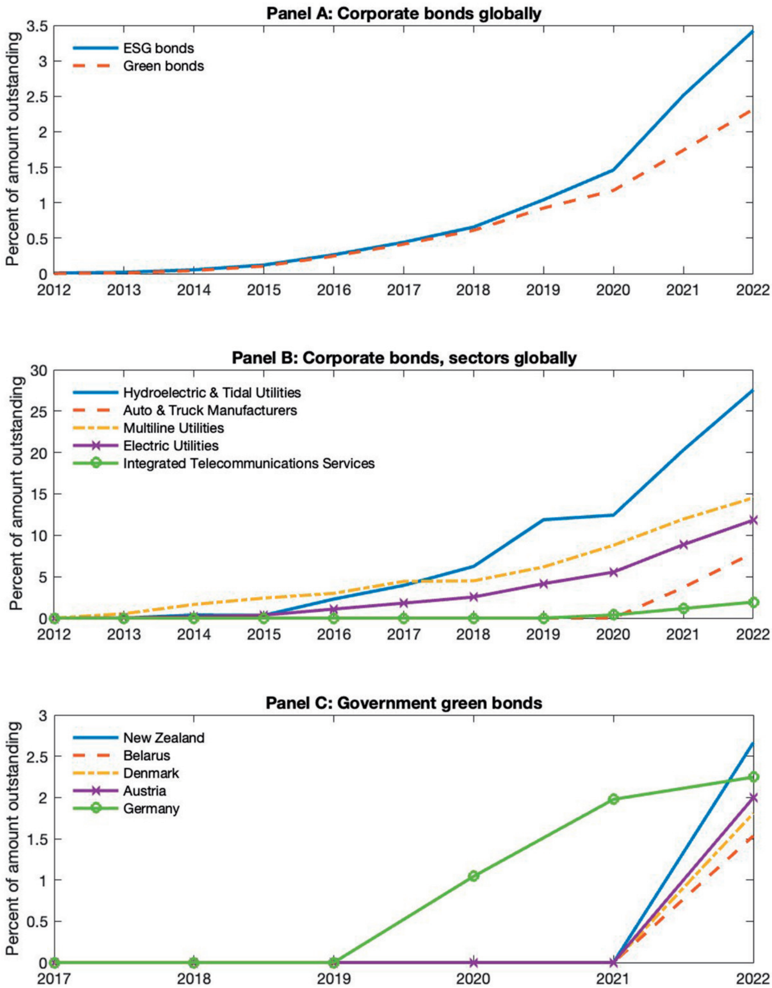

Figure 2
ESG bonds outstanding
Panel A shows the percentage of ESG or green corporate bonds of the total amount outstanding at the end of the year. Panel B shows the percentage of ESG corporate bonds of the total amount outstanding at the end of the year for the five sectors that had the highest ESG issuance percentage in 2022. Panel C shows the percentage of sovereign green bonds of the total amount outstanding. The data are from Refinitiv Eikon.
ALT TEXT: The total amount outstanding of ESG and green bonds has increased over the past decade.

The fact that green bonds face lower costs of capital opens the door for such bonds also lowering the overall cost of capital, which is our main object of interest. In other words, does issuing green bonds lower the government's cost of capital? This conclusion clearly does not follow by default. Instead, the yield of the government's other bonds could adjust such that the overall cost of capital remains unchanged.

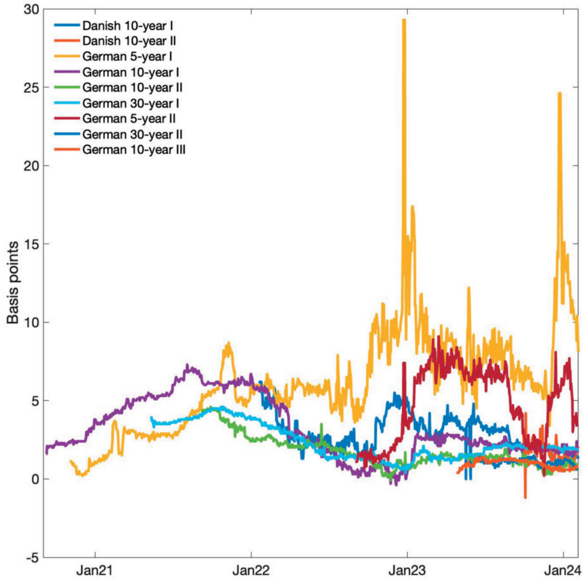

Figure 3
Green bond premium
For each pair of twin bonds we plot the time series of $y_t^S - y_t^G$ where y_t^S is the yield-to-maturity of the standard bond and y_t^G is the yield-to-maturity of the green bond.
ALT TEXT: The yield difference between ordinary and green bonds is nearly always positive for Danish and German twin bonds.

We examine this ESG-MM conservation property in Table 4. For each issuance event of twin bond i with green bond yield $y_t^{i,G}$, we consider the following three metrics in a time window around each issuance event: (1) the yield, $y_t^{i,S}$, of the corresponding standard bond in excess of the yield, $y_t^{i,C}$, of the control bond from the Netherlands, that is, $y_t^{i,S} - y_t^{i,C}$; (2) the weighted-average cost of capital, $(1-w_t^i)y_t^{i,S} + w_t^i y_t^{i,G} - y_t^{i,C}$, across the twin pair (in excess of the control bond), where w_t^i is the green bond's fraction of the combined outstanding of the twin bonds; and (3) the weighted-average yield of all government bonds issued by this country (green and standard) in excess of the control bond. These results are averaged across, respectively, (a) all events, (b) all events in Denmark, and (c) all events in Germany.

As seen in Table 4, when looking across all events in both countries, the yield changes are not significant. The yield of the standard bond goes down on average, not up as predicted by the theory if these standard bonds become less green, but the magnitude is economically small and statistically insignificant overall. In the sample of Danish bonds, the effects is significant, however. For the Danish bonds, we see that the standard bond yields go down around the issuance event, as does the average twin pair yield and also because the green bonds become a larger fraction of the pair. The point estimate of the average yield across all Danish bonds is smaller, since most of the bonds are not part

Table 3
Green bond premium.

	Mean	Median	Min	Max	N
Danish 10-year I	2.90***	2.80	0.00	6.20	532
	(0.16)				
Danish 10-year II	1.71***	1.70	−1.20	4.20	91
	(0.12)				
German 5-year I	6.18***	5.80	0.20	29.30	848
	(0.39)				
German 10-year I	3.19***	2.50	−0.40	7.30	889
	(0.23)				
German 10-year II	1.72***	1.50	−0.10	4.60	628
	(0.14)				
German 30-year I	2.35***	2.00	0.40	4.60	713
	(0.15)				
German 5-year II	4.79***	5.55	0.20	9.10	372
	(0.42)				
German 30-year II	1.07***	1.10	0.60	1.50	168
	(0.04)				
German 10-year III	0.96***	1.00	0.40	1.40	203
	(0.06)				
Average	3.37***	3.28	1.30	7.33	889
	(0.12)				

This table shows descriptive statistics for the green bond premium, $y_t^S - y_t^G$, for each of the twin bond pairs. “Mean” is the average difference in yield between the standard and green bond, with standard errors in parentheses (estimated using Newey-West with 12 lags). “Average” is the average daily premium. The time period is from September 8, 2020, to February 5, 2024. $*p<.1$; $**p<.05$; $***p<.01$.

Table 4
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 bonds. In the column “all” y_t^i is the weighted average yield, $y_t^i = \sum_{j=1}^{N} w_t^i y_t^i$, where N is the number of bonds outstanding around the event and w_t^i is the bond's fraction of the combined outstanding of all N bonds. Standard errors are calculated as $\text{std}(\overline{CYR}) = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(CYR_i - \overline{CYR})^2})$. $*p<.1$; $**p<.05$; $***p<.01$.

of this pair. These results provide suggestive evidence that ESG-MM may be violated, at least for Danish bonds, but the magnitude is small relative to the amount of noise in the data.

As in any event study, the interpretation of the result depends on when the market knows what. As described in Section 2.1, the event window includes the announcement of the issuance (days -6 to -1), the auction date (day 0), and the settlement date (day 2). So, if the market did not know for sure whether such a green bond issue would happen, then the reduction in the cost of capital violates ESG-MM. However, the market may be able to anticipate these bond issues, especially since the government has already passed into law the budget for the previous year and computed how much of the budget is eligible as green. If the market already knew that the green issue would happen, then the standard bond prices may have already reflected that they are browner, which would imply no change in their yield — so even under this interpretation, the drop in the yield of standard Danish bonds is inconsistent with ESG-MM. To justify ESG-MM, we would need to assume that the market was surprised at how small the green issuance was, but this interpretation seems a stretch given that an actual issuance event would normally increase the expected total issuance amount.

2.4 Relabeling of corporate bonds to green bonds

As an alternative test of ESG-MM, we next consider events in which firms relabel standard corporate bonds into green bonds. Table 2 describes our sample of such events, which is admittedly small since such events are a new phenomenon.

For each event, we calculate the abnormal returns on bonds and equity using the market model in an event window of 3 days before to 3 days after the announcement of the relabeling.[10] For equities, we use 30 days with available prices before the event window to compute regression coefficients $(\hat{\beta}_0, \hat{\beta}_1)$ from the regression

$$r_t^i = \beta_0 + \beta_1 r_t^m + \epsilon_t, t = -32, \ldots, -4, \tag{24}$$

where r_t^i is the daily return (including dividends) of firm i's equity and r_t^m is the daily return of the local equity index. The abnormal equity return on day t in the event window is then computed as $ar_t^i = r_t^i - (\hat{\beta}_0 + \hat{\beta}_1 r_t^m)$.

For corporate bonds, we must address that each firm has multiple corporate bonds. Therefore, we first calculate each firm's overall bond return 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 $w_j = \frac{\text{Amount issued}_j}{\sum_{n=1}^{N} \text{Amount issued}_n}$ are weights based on each bond series' issuance size. Based on these firm-level corporate bond returns, we calculate abnormal bond returns in the same way as abnormal equity returns by regressing the firm-level bond return on the local Treasury index return.

Table 5 shows the abnormal returns of equity and bonds during the event window. As seen in the table, there is a significant positive equity price reaction

10 A day in the event study is a day for which we observe the firm equity price in Bloomberg, and any days with missing firm equity returns drop out of the sample. Likewise, days without firm bond-returns drop out of the sample when studying abnormal bond returns.

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 $w_j = \frac{ai_j}{\sum_{j=1}^{N} ai_j}$, where ai_j is the amount issued of bond j. Standard errors are calculated as $\sqrt{\frac{1}{N-1} \sum_{i=1}^{N} (ar_i - \overline{ar})^2}$. $*p < .1$; $**p < .05$; $***p < .01$.

of 0.98% on the day following the announcement. The fact that the effect comes the day following the announcement is likely because the announcements occur after the close of the stock market (our data does not include the time of the announcement).

Turning to the effects on the corporate bonds, Table 5 also shows positive bond returns. The largest point estimate of the bond reaction is at day 1, and there is also a large reaction on day 3, which is statistically significant at the 10% level. The delayed reaction on day 3 is likely because corporate bonds are less liquid than equities and therefore prices may be stale.

These findings appear inconsistent with ESG-MM, since they imply that the overall enterprise value (bonds plus equity) increases around the announcement. Said differently, if the bonds increase in value because they are perceived as greener after the relabeling, then, according to ESG-MM, the equity should become browner, resulting in a negative equity reaction, not the observed positive equity reaction.

The relabeling is a violation of ESG-MM in as much that it is simply a reclassification of existing securities, but we must consider the alternative hypothesis that the event signals a positive NPV project as in Proposition 4. The relabeling is part of the firm's ESG strategy, but, the announcement of a new ESG strategy typically comes before the announcement of the bond reclassification. For example, Merlin Properties announced the bond conversion the week after it presented its plan to become a net zero emissions company by 2050. The internet appendix describes each event, explaining that four out of six events happen after an ESG strategy announcement and the remaining two events do not appear to have any value-related information. Our results are similar if we leave out the two latter events, as also shown in the internet appendix.

Consistent with the idea that the relabeling event is not a major signal about these firms or how green they are, there is no change in their Sustainalytics ESG score in the 3 months after the announcement for all but one of the firms.[11]

3. Conclusion

We show theoretically that, when the market has linear pricing and allocates ESG characteristics such as CO_2 emissions additively across securities, then the overall cost of capital should only depend on the overall cash flows and overall emissions, regardless of capital structure or security labels. Therefore, an issuer's incentive to pursue a green project should not depend on how the project is financed. Said differently, a firm's cost of capital should depend on its total pollution, not on whether certain nonpolluting elements are financed with green bonds.

Empirically, finding a clear causal link between asset prices and security characteristics is challenging, but we find evidence suggesting a violation of this ESG-MM property in that an issuer may lower its cost of capital by issuing green bonds. Future research should further explore whether labeling of securities complements or distorts the more meaningful task of reducing overall emissions and externalities.

Code Availability: The replication code and data are available in the Harvard Dataverse at https://doi.org/10.7910/DVN/BQFHNQ.

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[11] Energy Harbor Corp's ESG score improves in the month after the announcement and then drops out of the Sustainalytics database. Our results are robust if we exclude Energy Harbor from the analysis.

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