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On the non-neutrality of socially responsible investing in the presence of a greenium☆

Fabian Alex[1]

University of Regensburg, Department of Economics, 93 040 Regensburg, Germany

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ABSTRACT

The neutrality of SRI in the AD-GE model by Arnold (2023) ceases to hold once the law of one price is violated for an asset that sufficiently many individuals (a single one may suffice) are not indifferent towards. The introduction of a green bond priced at a premium leads to an illusory gain, that is, a pure utility gain accompanied by a reduction of consumption, of green investors. Their financial losses are allocated to those that were sufficiently un-green to not buy too many green bonds themselves. To profit financially this way, an individual needs to start out as (partial) owner of a firm that "turns out" to be a green bond issuer. Impact investing still does not generate environmental impact in this model.

1. Introduction

This paper serves as an extension of the model by Arnold (2023), which builds on the classical general equilibrium model with financial markets and different states of nature that can materialize over time due to Arrow (1964) and Debreu (1959) (AD-GE model). The version at hand is augmented to include Socially Responsible Investing (SRI). There, social responsibility takes the form of investor "tastes" for assets as introduced by Fama and French (2007). Related contributions encompass Pedersen et al. (2021) and Baker et al. (2022).

SRI is found to be neutral under four conditions, the first of which is separability of the overall utility function of households $U_i(u_i(\boldsymbol{c}_i, \boldsymbol{k}), \boldsymbol{\theta}_i, \boldsymbol{a}_i, \boldsymbol{k}, \boldsymbol{v})$. This means that consumption utility $u_i(\boldsymbol{c}_i, \boldsymbol{k})$ (where dependence on physical capital formation $\boldsymbol{k}$ depicts production externalities) must not interact with asset holdings $\boldsymbol{\theta}_i$ (stocks) and $\boldsymbol{a}_i$ (bonds) or firm values $\boldsymbol{v}$ per se in granting overall utility U_i. The latter three arguments refer to a "warm glow" or "cold prickle" that i may experience when being invested into certain firms (see also Dangl et al., 2024). Furthermore, market completeness must be given for any individual when she is restricted to assets that grant her no (dis-)utility, a property dubbed *Spanning With Assets with No Social returns*, in short *SWANS*. At least one consumer has to be neutral, i.e., must not care about any characteristic of firms other than their assets' payoffs (or, equivalently, for each firm there must exist an indifferent one). Lastly, for anyone who invests under social responsibility criteria, there has to

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E-mail address: fabian.alex@ur.de.

[1] I, Fabian Alex, research associate at the University of Regensburg, declare that I am the sole author of the paper "On the Non-Neutrality of Socially Responsible Investing in the Presence of a Greenium".

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be satiation in SRI. This ensures that there is an optimum portfolio for any consumption vector, such that no-one wishes to take infinite long positions in assets they consider favorable, financed by infinite short positions in unfavorable or neutrally viewed ones.

Our contribution lies within the augmentation of this model to further include a green bond price differential, in short, a "greenium". That is, there is an asset—a green bond—that some individuals like so much that they wish to hold it even if that implies sacrificing wealth. So the green bond essentially takes on the role of a consumption good for people who favor the firm that issues it. Thus, its emittent is in a position to violate the law of one price and extract additional profits.

The paper is organized as follows. In Section 2, we review the empirical case of the greenium. Section 3 sets up the model and describes its equilibrium in the presence of a greenium. Section 4 establishes the comparison between this new equilibrium and the one that would result without SRI and price differentials, ultimately assessing welfare statements. Section 5 concludes.

2. Is there a greenium?

As hinted in the introduction, the existence of a greenium may indicate that the law of one price does not hold. We wish to incorporate this idea into a GE model to discuss its welfare implications. Before moving on to build such a model with a greenium, it seems adequate to appropriately define that greenium and to discuss whether the existence of it is given in the real world. Simply put, a (positive) greenium is present whenever the return of a green asset deceeds that of a non-green counterpart. So the term "greenium" refers to the return differential between two assets, a non-green and a green one (in that order), that have otherwise identical characteristics such as risk or maturity. In other words, the greenium is the capital cost advantage a firm has when financing green projects.

There is a vast empirical literature on the subject which shall be briefly reviewed here. It is highly supportive of the idea of green bonds paying lower returns, i.e., a positive greenium. This supports our claim that interest income is sacrificed by green investors in order to finance firms whose business activity aligns with their ideals. It is difficult to say where exactly this wealth ends up. However, abnormal stock price increases of green bond emitters as documented by Flammer (2021) and Badía et al. (2024) suggest that it is partly claimed by firm owners, i.e., shareholders.

Indeed, the discussion on whether or not green assets are traded at a premium is ongoing. The literature survey provided by Cheong and Choi (2020, cf. p. 184) suggests that studies that do find a positive greenium constitute a majority. We shall review some of the more recent literature here. Attention is focused on green bonds (as opposed to green stocks) as the model to be discussed will only temper with green bond prices. Green stocks still obey the law of one price.

An exemplifying comparison of the discussion between results indicating no greenium and those documenting a positive greenium is available when inspecting the works on municipal bonds by David and Watts (2020) and Baker et al. (2022). Despite the fact that both teams of authors analyze the same dataset, they reach opposite conclusion: David and Watts (2020) find no significant greenium, while Baker et al. (2022) do. The reason for this discrepancy is a different used methodology: David and Watts (2020) only consider bonds as comparable when they come from the same issuing entity. Thus, they require individuals to truly believe that the fact that they themselves purchase a green bond of a municipality will tilt that municipality's policy plan towards more greenness. The same argument would thus need to hold for an individual investor's perceived own effect on a firm's business plan if one expects to find a within-firm corporate bond greenium. Indeed, Flammer (2021) applies the methodology of David and Watts (2020) to within-firm greeniums of corporate bonds and documents an insignificant return difference.[2] However, one should expect real world investors to value firm greenness, not asset greenness (see also Jan et al., 2023).

The greenium in primary bond markets seems to be small in absolute size, but statistically significant, as shown, for example, in the study of Caramichael and Rapp (2022). They document an average greenium of 8–9 basis points (bps), despite excluding firms from their analysis that issue only green bonds, i.e., no conventional ones at all. Arguably, those firms should have the most convincing green branding. Furthermore, in their sample, a disproportionately high share of green bonds (28% as opposed to 10% of conventional bonds) is used for refinancing existing operations, where it should be clear that the purchase of that bond does not generate additional greenness on behalf of the issuer. Restricting the sample to bonds issued after adoption of the Sustainable Finance Disclosure Regulation by the EU Parliament in 2019 or considering only green bonds included in approved indices adds a few bps to the greenium, hinting at the importance of the credibility of green promises.

Dorfleitner et al. (2022) show that the greenium does not entirely disappear in secondary markets. It remains statistically significant despite dropping to a single bp on average. Again, certification as a means of credibly conveying actual greenness increases the greenium.

Recent work by Eskildsen et al. (2025) documents a bond greenium of 18 bps, with the 95% confidence interval spanning 11 bps in either direction. They find similar, mostly larger (in absolute terms) yield spreads for stocks, where the greenium seems to be increasing over time, presumably because investors are becoming greener on average.

A small greenium thus seems to exist. This raises the question where the foregone returns end up. Do they finance new green activities or are they reaped by owners of the emitting corporations for personal use? Of course, which of the two is true in the real world is an empirical question. The greenium literature merely suggests that foregone returns exist. However, to what degree this influences corporate activities is unclear. While there is evidence that green bond issuers act more environmentally sound after placing these bonds (see, for example, Badía et al. 2024), the true (within-firm) question hinges on a counterfactual concerning that very firm: would it have acted differently after issuing a regular instead of a green bond? That question remains impossible to answer. The rest of this paper gives a perspective using the AD-GE model.

[2] Despite having performed an extensive matching procedure from green and brown firms to assess their ownership and environmental performance, Flammer (2021) does not compare bond yields between those sets, but only within firms.

3. An AD-GE model of SRI with a greenium

Adopting notation from Arnold (2023), we inspect individuals $i = 1, \ldots, I$ with endowments of y_{i0} in $t = 0$. They can use these endowments to finance consumption of the single $t = 0$-good, c_{i0}, at a price of p_0. It can be converted one-to-one into physical capital k_{jl} of any firm (j,l). In $t = 1$, there are several goods, where each good $l = 1, \ldots, L$ is produced by a number J_l of firms. Individual i holds a share of $\bar{\theta}_{ijl}$ in the jth firm producing good l, (j,l). She is obliged to finance that corporation's capital formation at a cost of $p_0 k_{jl}$, which it needs for production, in accordance with her initial shareholdings, but is in return entitled to an analogous part of the issue proceeds $R_{jl} b_{jl}$ that the firm receives from issuance of b_{jl} bonds at price R_{jl}. Bond holdings a_{ijl} can, consequently, be purchased at this price R_{jl}. Departing from the baseline model, we assume that there is a single *green* firm $(j,l)^g$. It is immaterial what exact good that corporation produces. It differs from regular firms by issuing bonds at a premium:

$$R_{jl} = \begin{cases} R^g, & \text{if } (j,l) = (j,l)^g \\ R, & \text{else }. \end{cases} \tag{1}$$

Obviously, the green firm is the sole issuer of these green bonds. Green bonds cost $R^g > R$ but still pay off one unit of money in each state $s = 1, \ldots, S$, so their return is lower. This corresponds to a greenium as discussed in the previous Section. An assumption we have to uphold here is no risk of bankruptcy. Assuming this is, in fact, innocuous since the only firm we temper with compared to the original model generates additional emission profits.

Shareholdings can be altered to θ_{ijl} at a price measured by firm values v_{jl}. Finally, there are M securities in zero net supply traded among individuals, indexed by z_{im} and priced at q_m, $m = 1, \ldots, M$. The budget constraint (BC) for $t = 0$ reads

$$p_0(c_{i0} - y_{i0}) + \sum_{l=1}^{L} \sum_{j=1}^{J_l} [\bar{\theta}_{ijl}(p_0 k_{jl} - R_{jl} b_{jl}) + (\theta_{ijl} - \bar{\theta}_{ijl}) v_{jl} + R_{jl} a_{ijl}] + \sum_{m=1}^{M} q_m z_{im} \leq 0, \tag{2}$$

which differs from the version at Arnold (2023) by the jl-index on R, allowing to discriminate between the green firm's bonds and all others. The S BCs for $t = 1$ are identical to those in the basal paper (see Arnold, 2023, p. 71). There is one such constraint for every state $s = 1, \ldots, S$ that can materialize at $t = 1$:

$$\sum_{l=1}^{L} p_{ls} c_{ils} - \sum_{l=1}^{L} \sum_{j=1}^{J_l} [\theta_{ijl}(p_{ls} y_{jls} - b_{jl}) + a_{ijl}] - \sum_{m=1}^{M} x_{ms} z_{im} \leq 0, \;\; s = 1, \ldots, S. \tag{3}$$

Define $(\boldsymbol{c}_i^*, \boldsymbol{\theta}_i^*, \boldsymbol{a}_i^*, \boldsymbol{z}_i^*)$ as the equilibrium consumption and portfolio choice without SRI where individuals seek to maximize $u_i(\boldsymbol{c}_i, \boldsymbol{k})$, and $(\boldsymbol{c}_i^{**}, \boldsymbol{\theta}_i^{**}, \boldsymbol{a}_i^{**}, \boldsymbol{z}_i^{**})$ as the equilibrium choice variables with SRI and a greenium, where the objective function is $U_i(u_i(\boldsymbol{c}_i, \boldsymbol{k}), \boldsymbol{\theta}_i, \boldsymbol{a}_i, \boldsymbol{k}, \boldsymbol{v})$. Without SRI, there can be no green bonds: no-one is willing to pay $R^g > R$, so $R^g = R$ and the entire model is as known.

With SRI, some i's may be willing to hold $a_{i(j,l)^g} > 0$ despite $R^g > R$. We call these individuals *green*, accordingly. The intuition as to why they would purchase an overpriced asset is that $\boldsymbol{c}_i^{**} < \boldsymbol{c}_i^*$ can be reconciled with $U_i^{**} \geq U_i^*$ if $dU_i/da_{i(j,l)^g}$ is sufficiently large at the $a_{i(j,l)^g}$-value that would grant $\boldsymbol{c}_i^*$.[3] Note that U_i^* refers to the utility level i could have obtained from sticking with her former consumption and portfolio choice, $(\boldsymbol{c}_i^*, \boldsymbol{\theta}_i^*, \boldsymbol{a}_i^*, \boldsymbol{z}_i^*)$, although the SRI-component was added to utility (such that $U_i \neq u_i$). Whether real world investors are in fact willing to forego returns in exchange for alignment with the financed corporation is an empirical question. The experimental evidence provided by Green and Roth (2025), for example, suggests that this is the case for about 63% of investors.

We need to ensure that the green firm's bonds cannot be sold short at R^g such that no arbitrage opportunities arise. After all, there is always some i who does not derive utility from the green firm's assets per se (for example, the completely neutral one). Aside from the option to directly prohibit short sales of that firm's bonds, two ways of achieving this are conceivable.

Firstly, the price differential may disappear in secondary markets, which is in line with the miniscule greenium found there by Dorfleitner et al. (2022). While this is intuitively plausible—trading does not generate environmentally friendly activities—it is tedious to include into the two-period framework at hand.

Secondly, one can let green i's only draw utility from bonds bought directly from the firm (intuitively, no-one is willing to pay more for the same stream of payoffs). Assuming that individuals can, in fact, distinguish this seems realistic: in reality, when buying a bond through a broker, the asset is shorted by someone else, while from an ETF or company directly it is not (Royal & Durana, 2025). Additionally, Broccardo et al. (2022), cf. p. 3118) point out that the owners of socially responsible assets cannot be expected to lend those assets for the purpose of shortselling.

Since the information whether a bond one buys is someone else's short sale is costlessly available, we can formally employ

$$\frac{dU_i}{da_{i(j,l)^g}} = \begin{cases} = 0, & \text{if } \exists i' : a_{i'(j,l)^g} < 0 \\ \geq 0, & \text{else }. \end{cases}$$

Note that the above formulation proscribes utility derived from the green bond once anyone, i.e., not even necessarily i's own trading partner, has shorted it. One can think of this as i internalizing the fact that someone else might "fall for" the short sale.

[3] By saying $\boldsymbol{c}_i^{**} < \boldsymbol{c}_i^*$, we mean that no element in the vector $\boldsymbol{c}_i^{**}$ exceeds its counterpart in $\boldsymbol{c}_i^*$ while at least one strictly deceeds it.

As only initial stock holders obtain parts in issue proceeds, we need not worry about infinite demand for stocks of $(j,l)^g$. While everyone would have liked to profit from the high bond price indirectly that way, they simply cannot.

Firm values still follow

$$v_{jl} = \sum_{s=1}^{S} r_s(p_{ls}y_{jls} - b_{jl}) = \sum_{s=1}^{S} r_s p_{ls} y_{jls} - Rb_{jl} \tag{4}$$

even for $(j,l)^g$: the green corporation is faced with the same repayment debts in every state of nature $s = 1,\dots,S$, leading of course to the same state price-weights r_s determining present value. The intuition for this is that, at the moment when firm values become relevant for trading, issue proceeds have already been allotted to individuals (they have already been "realized") and are, hence, removed from the calculation. Still, the firm issuing a green bond generates additional payoffs to its initial shareholders, which is in line with higher stock payoffs as documented by Flammer (2021).[4]

A study aimed more precisely at the stock performance of green bond issuers is conducted by Badía et al. (2024), who build on the classical five-factor model (Fama & French, 2015, see). Comparing firms issuing green bonds with matched counterparts, they find that a portfolio that goes long in the former and short in the latter generates a positive alpha, i.e., a return above what can be explained by firm characteristics. It is statistically significant at the 10%-level for a 12-month investment horizon, that is, in the medium run, and seems to fade out in the long run. This largely aligns with our model predictions.

The neutrality result in Arnold (2023) is based on his Lemma 3 (p. 73) which states that the maximands of consumption utility $u_i(\boldsymbol{c}_i,\boldsymbol{k})$ and overall utility $U_i(u_i(\boldsymbol{c}_i,\boldsymbol{k}),\boldsymbol{\theta}_i,\boldsymbol{a}_i,\boldsymbol{k},\boldsymbol{v})$ partly coincide. To be precise, any choice of consumption and portfolio $(\boldsymbol{c}_i^*,\boldsymbol{\theta}_i^*,\boldsymbol{a}_i^*,\boldsymbol{z}_i^*)$ that maximizes the latter also maximizes the former, while for every $(\boldsymbol{c}_i^*,\boldsymbol{\theta}_i^*,\boldsymbol{a}_i^*,\boldsymbol{z}_i^*)$ that maximizes u_i there exists a $(\boldsymbol{c}_i^*,\boldsymbol{\theta}_i^{**},\boldsymbol{a}_i^{**},\boldsymbol{z}_i^{**})$ that maximizes U_i. That is, with SRI, individuals finance the same consumption expenditures as without, possibly via new portfolios to suit their tastes. This result breaks down once the law of one price is violated. Without SRI, the equilibrium portfolio and consumption choice $(\boldsymbol{c}_i^*,\boldsymbol{\theta}_i^*,\boldsymbol{a}_i^*,\boldsymbol{z}_i^*)$ maximized consumption utility u_i. But it does not under SRI if $a_{i(j,l)^g} > 0 \in \boldsymbol{a}_i^*$ because R_{jl} has risen for that firm. The implication is that, without further reallocations, a reduction in c_{i0} will follow if i's updated costs from buying green bonds, $R^g a_{i(j,l)^g}$, exceed her generated emission surplus, $\bar{\theta}_{i(j,l)^g} R^g b_{(j,l)^g}$. Under monotonicity, this state of affairs materializes in a decrease in u_i. Further intertemporal consumption reallocations cannot fully offset the decline in consumption utility, since the latter was optimized before with more wealth implied. Individuals with $\bar{\theta}_{i(j,l)^g} > 0$ experience a relaxation of their BC, but will not be willing to use that for $a_{i(j,l)^g}$ without social responsibility criteria involved, even if that permitted them just the former c_{i0}^*.[5]

We refer to the set of green individuals as I^g. If such a green i has $a^*_{i(j,l)^g} > 0$, she is prepared to accept a decrease in consumption utility. The only rationale for that can be $U_i|_{a_{i(j,l)^g}>0} \geq U_i|_{a_{i(j,l)^g}=0}$. For ease of exposition, we assume

$$\lim_{a_{i(j,l)^g}\to 0+} dU_i/da_{i(j,l)^g} = +\infty,\ i \in I^g$$

and increasing concave utility[6] of green bond holdings for those individuals in what follows. Assume, at first, a fixed price R^g. Then, if i is sufficiently green or there are sufficiently many green i's, market clearing of the green bond market is still achievable: $\sum_{i=1}^{I} a^*_{i(j,l)^g} = b_{(j,l)^g}$. It is important to note that the number of bonds emitted by the green firm is exogenous, just as every other one's. One might object that the firm could generate additional wealth by issuing more green bonds. Indeed, it is restrictive to prevent the green firm, possessing essentially a monopoly on green bonds, from setting both price and quantity rather than just the former. However, it is necessary in order to ensure that there is no desire of that corporation itself to issue an ever-increasing amount of bonds, which would lead to an arbitrage opportunity by simultaneously buying other firms' bonds.[7] A reasonable candidate for the corporate debt level would be total debt financing of capital expenditures, that is, to set $b_{(j,l)^g}$ such that $R^g b_{(j,l)^g} = p_0 k_{(j,l)^g}$. Without further specification, we restrict attention to an arbitrary but fixed level of $b_{(j,l)^g}$.

Now let R^g be chosen endogenously by its emittent $(j,l)^g$. Note that this violates the conventional definition of a Walrasian economy where all agents are assumed to act as price takers. R^g is determined such that market clearing is just given.[8] To see how, note that i is prepared to buy more green bonds as long as the associated benefit $dU_i/da_{i(j,l)^g}$ outweighs the cost. That cost is composed of two factors. The first one poses a physical cost, given by additional expenditures from buying a green bond compared to the purchase of an ordinary bond from a firm i is indifferent towards or satiated by, that is, $R^g - R$. The second one comes from the implied reduction in $t = 0$-consumption, the effect of which is determined by marginal utility of c_{i0} as well as that good's price p_0. Hence, we must have

$$\frac{dU_i}{da_{i(j,l)^g}} = \frac{dU_i/dc_{i0}}{p_0}(R^g - R), i \in I^g \tag{5}$$

[4] This does not contradict the inferior stock returns documented by Eskildsen et al. (2025) since a firm that is considered to be green need not issue green bonds in the sense that these bonds are priced at a premium.

[5] The latter is, in fact, always possible $\forall i$ via the usual argument of a neutralization strategy: each i can hold $a_{i(j,l)^g} = \bar{\theta}_{i(j,l)^g} b_{(j,l)^g}$, so that the BC is just as tight as it was without SRI. If the equilibrium without SRI involved different bond holdings, they can just be shifted around. But, due to unwillingness of neutral i's to do so, this cannot be implemented except by government intervention.

[6] This violates satiation in SRI for the green bond, which, however, turns out to be irrelevant due to the overpricing of that asset.

[7] Note that monotonically increasing utility in green bonds for $i \in I^g$ implies $R^g > R$ even for arbitrarily large $b_{(j,l)^g}$.

[8] Alternatively, we could let $(j,l)^g$ emit both green and regular bonds at a fixed price, thereby amplifying their price differential. We refrain from extending the model in that direction for two reasons. Firstly, such an extension would not allow novel conclusions to be drawn. Secondly, the greenium empirically seems to disappear once the issuing entity coincides (David & Watts, 2020, see, for example,), indicating that individuals value the greenness of issuers as a whole rather than that of their different projects.

to be in equilibrium if the green firm is allowed to set its own bond price.

Lemma 1. *Any equilibrium of the economy with SRI entails* $dU_i/da_{i(j,l)^g} = [(dU_i/dc_{i0})/p_0](R^g - R), i \in I^g$.

Proof. The individual utility maximization problem can be set up using the Lagrangian function, which is carried out in Appendix A.1. Naturally, any deviation from the utility-maximizing choice of $a_{i(j,l)^g}$ decreases utility. □

Each green i holds that amount of green bonds which makes her indifferent towards buying another marginal unit of them. So every green bond purchase but the last marginal one grants her additional utility. That is, the inequality $U_i|_{a_{i(j,l)^g}>0} \geq U_i|_{a_{i(j,l)^g}=0}$ is strict and all of i's willingness to pay extra for greenness of a bond is skimmed.

Furthermore, we can show that there are no effects hailing from the production side of the economy:

Lemma 2. *The green firm's production decision is unaltered when the price they can charge on bonds increases.*

Proof. For a discussion of Shareholder Value (SV) maximization as the goal of all firms even in the presence of SRI, see Arnold (2023, pp. 73–74). We are looking for the maximand of SV when replacing R with R^g,

$$SV_{jl} = v_{jl} - (p_0 k_{jl} - R^g b_{jl}). \tag{6}$$

There, firm values are

$$v_{jl} = \sum_{s=1}^{S} r_s (p_{ls} y_{jls} - b_{jl}), j = 1, \dots, J_l, l = 1, \dots, L,$$

and the choice variable is k_{jl}. Setting

$$\frac{\partial SV_{jl}}{\partial k_{jl}} \overset{!}{=} 0$$

obtains the FOC

$$\sum_{s=1}^{S} r_s p_{ls} f'_{jls}(k_{jl}) = p_0, \tag{7}$$

which is independent of the bond emission surplus. □

4. Equilibria with and without SRI

This Section establishes that the introduction of SRI, if accompanied by mispriced assets, is not neutral. We then move on to assess who gains and who loses from it and by how much.

4.1. Non-neutrality of the introduction of SRI

Our next step is to show that there are wealth reallocations and, thus, a non-neutrality result for the introduction of SRI when a greenium exists. This step can be carried out via a comparison of the budget constraint before introducing SRI and the green bond,

$$p_0(c_{i0} - y_{i0}) + \sum_{l=1}^{L} \sum_{j=1}^{J_l} [\bar{\theta}_{ijl}(p_0 k_{jl} - R b_{jl}) + (\theta_{ijl} - \bar{\theta}_{ijl}) v_{jl} + R a_{ijl}] + \sum_{m=1}^{M} q_m z_{im} \leq 0, \tag{8}$$

with that afterwards,

$$p_0(c_{i0} + \Delta c_{i0} - y_{i0}) + \sum_{l=1}^{L} \sum_{j=1}^{J_l} \left[\bar{\theta}_{ijl}(p_0 k_{jl} - R_{jl} b_{jl}) + (\theta_{ijl} - \bar{\theta}_{ijl}) v_{jl} + R_{jl}(a_{ijl} + \Delta a_{ijl})\right] + \sum_{m=1}^{M} q_m z_{im} \leq 0. \tag{9}$$

There, we implicitly assume an unaltered choice of capital formation in accordance with Lemma 2 as well as constant prices of goods and assets (save for the green bond). It seems rather intuitive that asset prices remain constant, since the same production decisions are made (see (7)), leaving available resources in each period and state constant. Furthermore, the financial market is complete after changing bond prices for the green firm given it was complete beforehand.

Lemma 3. *Let R and q remain constant when introducing SRI. Then the price of the $t = 0$-good and physical capital, p_0, must also stay constant.*

Proof. The proof is delegated to Appendix A.2.

Lemmata 2 and 3, that is, constant capital decisions and prices,[9] respectively, lay the groundwork for showing that consumption possibilities shift with the introduction of SRI including a greenium. Assume the existence of an $i \notin I^g$ with $\bar{\theta}_{i(j,l)^g} > 0$. Then the material wealth of that i unambiguously increases. So we have the following:

Theorem 4. *Let* $\left((c_i^*, \theta_i^*, a_i^*, z_i^*)_{i=1}^I, k^*, p^*, v^*, R^*, q^*\right)$ *be an equilibrium of the stock-and-debt economy without SRI. Then an equilibrium with SRI and a green bond priced above R,* $\left((c_i^{**}, \theta_i^{**}, a_i^{**}, z_i^{**})_{i=1}^I, k^*, p^*, v^*, \boldsymbol{R}^*, q^*\right)$ *with an* $i \notin I^g$ *with* $\bar{\theta}_{i(j,l)^g} > 0$*, encompasses different consumption levels* $c_i^{**} \neq c_i^*$ *for some i.*

Proof. Define $\boldsymbol{R}^*$ as the $\sum_{l=1}^L J_l$-dimensional vector of bond prices according to (1). Lemmata 2 and 3 imply identical market conditions. An $i \notin I^g$ with $\bar{\theta}_{i(j,l)^g} > 0$ gains new consumption possibilities due to increased bond emission profits from $\bar{\theta}_{i(j,l)^g} R^g b_{(j,l)^g} > \bar{\theta}_{i(j,l)^g} R b_{(j,l)^g}$. She does not invest this money in overpriced assets: $a_{i(j,l)^g} = 0$. Since U_i is increasing in u_i, which is in turn increasing in c_{i0} (and all c_{ils}), she will choose a different consumption vector c_i^{**} in order to increase her utility. □

As consumption has been shifted between individuals (rather than time), the introduction of SRI was not neutral.[10] It is noteworthy that the non-neutrality result is focused on consumption rather than production decisions (see Lemma 2). So investors' desire to perform impact investing still does not generate environmental impact.

4.2. Value of consumption gains and losses

Having arrived at the result that the equilibrium differs if the introduction of SRI comes with a bond price differential raises the question about profiteers and losers from this new situation. Financially speaking, those who profit are, of course, those able to pose themselves as net-seller of the overly expensive asset.

Theorem 5. *The net wealth of non-green individuals* $i \notin I^g$ *with* $\bar{\theta}_{i(j,l)^g} > 0$ *and of green individuals* $i \in I^g$ *with* $\bar{\theta}_{i(j,l)^g} > (a_{i(j,l)^g} + \Delta a_{i(j,l)^g})/b_{(j,l)^g}$ *increases through the introduction of SRI. Accordingly, if individuals of either type exist, the net wealth of some other* $i \in I^g$ *decreases.*

Proof. Comparing the BCs before and after the introduction of SRI, the difference between (8) and (9) is given by

$$p_0 \Delta c_{i0} - \bar{\theta}_{i(j,l)^g}(R^g - R) b_{(j,l)^g} + (R^g - R) a_{i(j,l)^g} + R^g \Delta a_{i(j,l)^g} + R \sum_{(j,l)\neq(j,l)^g} \Delta a_{ijl},$$

which we set equal to zero in order to determine the present value of additional consumption possibilities. This delivers

$$p_0 \Delta c_{i0} = (R^g - R)\left[\bar{\theta}_{i(j,l)^g} b_{(j,l)^g} - a_{i(j,l)^g}\right] - R^g \Delta a_{i(j,l)^g} - R \sum_{(j,l)\neq(j,l)^g} \Delta a_{ijl}. \tag{10}$$

A meaningful interpretation of $p_0 \Delta c_{i0}$ from (10) as additional consumption possibilities requires that consumption in all states for $t = 1$ remains constant. That is, we assume that i front-loads all additionally arising consumption, notwithstanding her utility-increasing option to spread this gain over time and states. Therefore, we simultaneously set

$$\sum_{(j,l)\neq(j,l)^g} \Delta a_{ijl} + \Delta a_{i(j,l)^g} = 0. \tag{11}$$

By doing so, the consumption losses in $t = 1$ incurred by reduced investments are just offset. An i that is indifferent towards the green firm will reasonably choose $\Delta a_{i(j,l)^g} = -a_{i(j,l)^g}$ in order to avoid the unduely expensive asset.[11] Thus, for them (11) becomes

$$\sum_{(j,l)\neq(j,l)^g} \Delta a_{ijl} = -\Delta a_{i(j,l)^g} = a_{i(j,l)^g}, \; i \notin I^g.$$

Hence, the genuine present value of consumption gains for a non-green i is

$$p_0 \Delta c_{i0} = (R^g - R)\bar{\theta}_{i(j,l)^g} b_{(j,l)^g}, \; i \notin I^g, \tag{12}$$

which is unambiguously positive for $R^g > R$ as long as i was an initial shareholder of the green company ($\bar{\theta}_{i(j,l)^g} > 0$).

The argument is similar for green individuals. Inserting (11) into (10) reveals

$$p_0 \Delta c_{i0} = (R^g - R)\left[\bar{\theta}_{i(j,l)^g} b_{(j,l)^g} - a_{i(j,l)^g} - \Delta a_{i(j,l)^g}\right], \tag{13}$$

[9] Strictly speaking, it was not explicitly shown that the prices of all goods in all states at $t = 1$ stay the same. So this posits an additional assumption. However, given the constant production decision, no good becomes scarcer or more abundant in any state. Furthermore, financial market completeness is also warranted. So we should, in fact, not expect changes in the p_{ls}'s.

[10] We rule out one special case in making such a general statement. If, by chance, we have $\bar{\theta}_{i(j,l)^g} = a_{i(j,l)^g}^{**}/b_{(j,l)^g}, i \in I^g$, implying $\bar{\theta}_{i(j,l)^g} = 0, i \notin I^g$ and $a_{i(j,l)^g}^{**} = a_{i(j,l)^g}^*, i = 1, \ldots, I$, then, as everyone who purchases the green bond just makes up for the extra expenses via stakes to bond emission surplus, no wealth effects arise and $c_i^* = c_i^{**}, i = 1, \ldots, I$. In such a situation, every green i with initial shares in the green firm just "buys back" all of these bonds, that is, she uses exactly her part of emission proceeds to acquire them. The non-green individuals, on the other hand, would never have purchased any of those bonds anyways. Obviously, this makes the existence of all bonds issued by the green firm superfluous.

[11] If short sales of that bond were possible, she would choose $\Delta a_{i(j,l)^g} = -\infty$, making the model intractable.

which is positive as long as

$$\bar{\theta}_{i(j,l)^g} > \frac{a_{i(j,l)^g} + \Delta a_{i(j,l)^g}}{b_{(j,l)^g}}, \tag{14}$$

just as asserted in the Theorem. □

The values of consumption gains for non-green and green individuals are given by (12) and (13), respectively. It can readily be stated that (12) is a special case of (13) that imposes a specific structure on bond holding changes. As shown, (12) has a positive sign, indicating non-green individuals as real-term winners of SRI. Further, (13) shows that there can also be green individuals that experience a wealth increase: any $i \in I^g$ with bond holdings such that the inequality $\bar{\theta}_{i(j,l)^g} b_{(j,l)^g} > a^{**}_{i(j,l)^g}$ is satisfied in equilibrium experiences a dual increase in utility, namely a warm glow one from social responsibility as well as a financially motivated one from higher wealth. However, the mere existence of real-term winners from an overpriced green bond also implies the existence of real-term losers. Concretely, the latter consist of all $i \in I^g$ with $\bar{\theta}_{i(j,l)^g} b_{(j,l)^g} < a^{**}_{i(j,l)^g}$. After all, changing prices in a general equilibrium framework is just a zero-sum game in terms of material wealth. This can be verified by summing (12) over all $i \notin I^g$ and (13) over all $i \in I^g$. Naturally, those two sums total to zero.

We can conclude that the main real-term profiteers of SRI and the introduction of relatively expensive green bonds are those individuals who own the green firm but do not value its greenness too much themselves.

Even if the model predictions are true, buying a green bond need not imply a financial loss in the real world. An investor willing to purchase this bond without having to accept below-market returns could buy shares of that very firm before the green bond is issued, thus becoming one of the profiting initial shareholders. Choosing $\bar{\theta}_{ijl}$ to be the RHS of (14) implies identical consumption opportunities for i despite buying the green bond, as hinted in footnote 4. Note, however, that $\bar{\theta}_{ijl}$ is exogenous in the model as it stands. In other words, when the green bond is issued, it is already too late to become a profiteer from this act.

The preceding argument yields an individual portfolio policy implication: if one's goal is to support the environment without sacrificing returns, one should not become a green bond holder without having become a green stock holder beforehand. Again, this resembles the empirical findings of Flammer (2021) and Badía et al. (2024).

4.3. Welfare analysis

Note that, in the following welfare analysis, we compare indeed the same individuals, but with different utility functions when addressing the two worlds with and without SRI. Ultimately, this implies that welfare is, in fact, enhanced by experienced warm glow. Thus, the interpretations below should be taken with a grain of salt. Nevertheless, we consider this to be the only reasonable approach. Comparing consumption and portfolios with and without SRI employing the utility without it, u_i, collapses to a comparison of material wealth (found below). Using U_i for both cases, instead, gives rise to the obvious conclusion that if individuals changed their portfolios, they did so simply because this made them better-off.

The allocation determined after the introduction of SRI seems to constitute a Pareto-improvement compared to that without SRI: One part of individuals acquires new assets at higher prices, which they would not if that were at their own net disadvantage, while the rest gains additional wealth. A conceivable objection is that, since nothing restricts individuals from drawing disutilities out of some asset holdings, their utility may still decrease. This argument has no bite: Under *SWANS*, each i can just substitute an unfavorable asset for a portfolio of assets she is indifferent towards and will, thus, not hold unfavorable assets in equilibrium. So no equilibrium with SRI can feature the actual experience of cold prickle by any investor.

There is, on the contrary, a utility gain of all green i's via green bond holding since they now experience utility from the mere act of holding that bond which exceeds the additional costs of doing so for every marginal unit but the last one. Also, there are wealth increases of (possibly, non-green) i's with $\bar{\theta}_{i(j,l)^g} > 0$. Of course, these are accompanied by wealth losses for the buyers, who are compensated for this by, say, a good conscience.

If we introduce SRI and the green bond price differential separately into our economy, the question of Pareto-superiority becomes less clear-cut. Intuitively, if the preference for responsible firms arises first, it will increase utility of those who "feel good" when holding such a corporation's assets. But if the price of these assets goes up after this utility increase has been realized, it will hurt those very individuals by reducing their monetary wealth. That loss is potentially reduced through a lower amount of green bonds in their utility-maximizing portfolio, but cannot be fully mitigated that way.[12] Hence, a caveat to our result of a Pareto-improvement rests within the fact that the reference point must not feature SRI.

It is also possible, of course, to employ other welfare measures, such as utilitarianism. Doing so, one can easily obtain the result that, even after the introduction of SRI was internalized, a greenium may altogether enhance welfare. This is the case if the greenium profiteers' utility functions are sufficiently steep in consumption compared to the greenium payers'. Obviously, this represents a backward loop towards the question about desirability of any redistributive measure, potentially supporting expropriation of the miserable (see, for example, Sen, p. 10) and should thus be handled with caution.

[12] Note that introducing the intermediate step of SRI but no green bond price differential requires the re-establishment of satiation in that bond. As a result, we need a tedious compromise between infinite demand at zero holdings and satiation at some finite positive value.

5. Outlook

Using the SRI-adjusted AD-GE model by Arnold (2023), we can conclude that SRI is neutral not even from a general equilibrium perspective once we allow for mispricings of assets, such as a greenium. More precisely, we show that the introduction of green bonds with a price differential may lead to an indirect wealth transfer from green to non-green individuals. All remaining model assumptions are as in the referenced starting paper.

Our analysis suggests that large shareholders of a green firm that are not at the same time large bond holders of that very firm cannot be considered as genuinely green. Indeed, owning a large part of a firm that generates a high bond emission surplus is primarily attractive from a financial viewpoint. The reluctance to re-use these proceeds to invest in that green firm can be interpreted as a revelation of green preferences taking on low levels for those individuals. In other words, going green may be a profit-enhancing business strategy rather than a socially oriented measure from our model's viewpoint.

Importantly, the issuance of a green bond cannot impinge upon financial market completeness: every firm issues a bond, so even if all i that do not favor $(j,l)^g$ will no longer be willing to buy that corporation's bonds, they can just buy another one's. Hence, the result of non-neutrality is entirely due to SRI and mispricings per se, and not to some other more subtle argument.

The welfare analysis of this paper suggests that there is "something for nothing". However, this is true only in a utility sense: $t = 0$-wealth is reallocated among individuals. This process is in favor of neutral investors who directly gain through their shares in the green firm (if they have any). The socially conscious ones with new additional utility from holding the green bond, which includes a price differential, end up with less of the consumption good. Their overall utility never decreases from the introduction of that green bond, but they sacrifice real wealth in order to achieve this. That sacrifice is, however, in vain: the production process and, thus, environmental damages, remain unaltered.

There are interesting policy implications to be drawn from the analysis in this paper. In the modeling framework above, the green firm became "green" by simply labeling itself that way. While it may very well have low emissions, generate clean energy or be green in whatever other way, investors buying its bonds at a premium have no additional environmental effect. If their goal is not to donate money to the less responsible, they would need to make sure that the green bond is actually financing new green corporate activities. Sustainability-linked bonds that pay higher returns if pre-specified environmental targets are missed may constitute a promising solution to this, provided that these targets are sufficiently ambitious.

Our goal is not to entirely denounce greenia. In fact, they can serve an important purpose. To see this, assume that an individual only wants to invest in bonds of firms that are backed by some environmentally sound activity. Then a firm intending to appeal to this investor needs to signal its greenness in some costly way, e.g. via third-party certification or reporting on the environmental impact of its activities. The investor should be prepared to bear (part of) these associated costs to incentivize their incurrence by the corporation. That is, a small greenium, as the one typically found, is not just acceptable, but may even be optimal. Large greenia, on the other hand, should raise suspicion.

CRediT authorship contribution statement

Fabian Alex: Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

I, Fabian Alex, research associate at the University of Regensburg, declare that I am the sole author of the paper "On the Non-Neutrality of Socially Responsible Investing in the Presence of a Greenium" submitted to The North American Journal of Economics and Finance. I hereby assure that there are no conflicts of interest.

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Appendix A

The Appendix collects proofs that would compromise the flow of reading if left in the main body.

A.1. Utility maximization with respect to the green bond

The optimum number of green bond holdings is determined via standard utility maximization calculus. The problem is to maximize overall utility $U_i(u_i(\boldsymbol{c_i},\boldsymbol{k}),\boldsymbol{\theta_i},\boldsymbol{a_i},\boldsymbol{k},\boldsymbol{v})$ with respect to $S+1$ constraints, the latter being given by (2) and (3). The corresponding Lagrangian can thus be set up as

$$\mathcal{L} = U_i(u_i(\boldsymbol{c_i},\boldsymbol{k}),\boldsymbol{\theta_i},\boldsymbol{a_i},\boldsymbol{k},\boldsymbol{v}) - \lambda_{i0}\left\{ p_0(c_{i0}-y_{i0}) + \sum_{l=1}^{L}\sum_{j=1}^{J_l}[\bar{\theta}_{ijl}(p_0k_{jl}-R_{jl}b_{jl}) + (\theta_{ijl}-\bar{\theta}_{ijl})v_{jl} + R_{jl}a_{ijl}] + \sum_{m=1}^{M} q_m z_{im} \right\} - \sum_{s=1}^{S}\lambda_{is}\left\{ \sum_{l=1}^{L} p_{ls}c_{ils} - \sum_{l=1}^{L}\sum_{j=1}^{J_l}[\theta_{ijl}(p_{ls}y_{jls}-b_{jl}) + a_{ijl}] - \sum_{m=1}^{M} x_{ms}z_{im} \right\}. \tag{A.1}$$

Instead of writing out the numerous optimality conditions of this problem, we restrict attention to three relevant ones, the first of which is, of course, the one implied by $d\mathcal{L}/da_{i(j,l)^g} = 0$. It reads

$$\frac{dU_i}{da_{i(j,l)^g}} = \lambda_{i0} R^g - \sum_{s=1}^{S} \lambda_{is}.$$

Secondly, we consider $d\mathcal{L}/da_{ij'l'} = 0$ for an arbitrary $(j', l') \neq (j, l)^g$. Since $dU_i/da_{ij'l'} = 0$ due to either indifference or satiation, it simplifies to

$$\lambda_{i0} R = \sum_{s=1}^{S} \lambda_{is}.$$

Taken together, these constraints yield

$$\frac{dU_i}{da_{i(j,l)^g}} = \lambda_{i0}(R^g - R).$$

To eliminate λ_{i0}, we look at $d\mathcal{L}/dc_{i0} = 0$, or

$$\lambda_{i0} = \frac{dU_i/dc_{i0}}{p_0},$$

and plug it in to reveal

$$\frac{dU_i}{da_{i(j,l)^g}} = \frac{dU_i/dc_{i0}}{p_0}(R^g - R).$$

Since this condition cannot hold for $i \notin I^g$, who have $dU_i/da_{i(j,l)^g} = 0$ and, hence, only costs and no compensating utility from buying green bonds, its validity is limited to $i \in I^g$. Thus, it is just the condition (5). □

A.2. Constant prices

If the good's price changes from p_0 to p_0' after the introduction of SRI, (9) becomes

$$p_0'(c_{i0} + \Delta c_{i0} - y_{i0}) + \sum_{l=1}^{L}\sum_{j=1}^{J_l} \left[\bar{\theta}_{ijl}(p_0 k_{jl} - R_{jl} b_{jl}) + (\theta_{ijl} - \bar{\theta}_{ijl}) v_{jl} + R_{jl}(a_{ijl} + \Delta a_{ijl})\right] + \sum_{m=1}^{M} q_m z_{im} \leq 0. \tag{A.2}$$

The difference between (8) and (A.2) is given by

$$(p_0' - p_0)(c_{i0} - y_{i0}) + p_0'\Delta c_{i0} - \bar{\theta}_{i(j,l)^g}(R^g - R) b_{(j,l)^g} + (p_0' - p_0)\sum_{l=1}^{L}\sum_{j=1}^{J_l}\bar{\theta}_{ijl} k_{jl} + (R^g - R) a_{i(j,l)^g} + R^g \Delta a_{i(j,l)^g} + R \sum_{(j,l)\neq(j,l)^g} \Delta a_{ijl}.$$

Since real economic activity does not change, summing these changes for all individuals must deliver zero. Therefore,

$$(p_0' - p_0)\sum_{i=1}^{I}(c_{i0} - y_{i0}) + p_0'\sum_{i=1}^{I}\Delta c_{i0} + (R^g - R)\left(b_{(j,l)^g}\sum_{i=1}^{I}\bar{\theta}_{i(j,l)^g} - \sum_{i=1}^{I} a_{i(j,l)^g}\right)$$
$$+ (p_0' - p_0) k_{jl}\sum_{i=1}^{I}\bar{\theta}_{ijl} - R^g\sum_{i=1}^{I}\Delta a_{i(j,l)^g} - R\sum_{(j,l)\neq(j,l)^g}\sum_{i=1}^{I}\Delta a_{ijl} = 0.$$

Of course, we have to set $\sum_{i=1}^{I}(c_{i0} - y_{i0}) = 0$ and $\sum_{i=1}^{I}\Delta c_{i0} = 0$ due to resource constraints as well as $\sum_{i=1}^{I}\bar{\theta}_{ijl} = 1$, $\sum_{i=1}^{I} a_{ijl} = b_{jl}$ and $\sum_{i=1}^{I}\Delta a_{ijl} = 0$ for every firm (j, l) to ensure market clearing. Hence, we need

$$(p_0' - p_0)\sum_{l=1}^{L}\sum_{j=1}^{J_l} k_{jl} = 0,$$

implying $p_0' = p_0$. □

Data availability

No data was used for the research described in the article.

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