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On the corporate use of green bonds

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Abstract

When do wholesalers issue green bonds to finance their socially responsible activities instead of charging a premium for the products they produce? We show that in less competitive retail markets when retailers can "skim" more of the premium that end consumers pay for socially responsible products, green bonds provide additional funds to help cover the cost of a wholesaler's socially responsible activities. Similar incentives arise if the wholesaler's input is a small component of the end consumers' product, or if it is difficult for end consumers to identify the wholesaler's socially responsible activities.

KEYWORDS

corporate social responsibility, green bonds, intermediate good producer, retail competition

1 | INTRODUCTION

Many studies explore the financial benefits from selling socially responsible products (SRPs) or linking the sale of a firm's product(s) to its socially responsible activities (see, e.g., Bagnoli & Watts, 2003; Baron, 2001; Besley & Ghatak, 2007 and the surveys by Lyon & Maxwell, 2008; Orlitzky, Siegel, & Waldman, 2011).[1] The basic idea is that a firm may find it profitable to sell SRPs when consumers are willing to support the firm's socially responsible activities by paying more for its product. With the recent development of a reasonably liquid market for (what are generically referred to as) green bonds—and with it, the development of Green Bond Principles, the Climate Bond Initiative and the creation of green bond indices and exchange-traded funds, firms have begun to access capital markets by issuing these new debt instruments.[2] Green bonds are standard bonds with a key difference: the proceeds from the issue are contractually pledged to fund the firm's socially responsible activities.[3] They are usually issued at a premium which allows the issuer to collect some of society's willingnesses to contribute to socially responsible activities.[4] Using equity-type securities, which would also need to be purchased at a premium, is more problematic because the buyers would find it difficult or impossible to ensure that the funds are used for the issuer's socially responsible activities unless they have voting control of the firm.

We develop a model that offers initial insights into the optimality of issuing green bonds. The model focuses on wholesalers, firms that do not sell directly to end consumers, to improve our understanding how such firms garner financial support for their socially responsible activities. We focus on these "upstream" or intermediate good producers (wholesalers) because it is more difficult for them to capture the financial benefits of selling SRPs. That is, the part of the premium consumers pay for the SRP that flows to the wholesaler may not be sufficient to warrant the wholesaler engaging in socially responsible activities. In such cases, contributions made by paying a premium for the firm's green bonds may allow it to collect sufficient payments to profitably engage in these activities.

In our model, a wholesaler first decides whether to offer a socially responsible input or not (an SR input or an nSR input) and, if it offers the SR input, whether to finance the SR input's fixed production costs with green bonds. The wholesaler then chooses the price it charges retailers for the input. The retailers use the wholesaler's input and other inputs to produce the product sold to end consumers. If the wholesaler chooses to sell the SR input to retailers, they use it to make the product they sell socially responsible.[5] We solve for the wholesaler's equilibrium profits in each case

(when it sells the SR input and issues green bonds, when it sells the SR input but does not issue green bonds, and when it sells the nSR input) and develop conditions under which the wholesaler chooses to sell the SR input and when it chooses to finance its production using green bonds.

Our analysis highlights the key forces that (a) impact the wholesaler's ability to profitably fund its socially responsible activities and (b) motivate the wholesaler to finance using green bonds. One key force that affects the wholesaler's ability to extract profits from sale of the SR input is the magnitude of the double-marginalization problem. A less competitive retail market allows retailers to "skim" more of the extra profits generated by consumers' contributions to fund the wholesaler's socially responsible activities. The more competitive the retail market is, the greater the profits the wholesaler extracts.[6] Interestingly, for moderate levels of competitiveness in the retail market, the wholesaler's ability to capture contributions from the retail market is greater but still insufficient to warrant producing the SR input. However, because the wholesaler captures a relatively small share of the contributions from the product market, it now finds it optimal to divert some of the contributions from the purchase of the SRP to the purchase of green bonds. Thus, with more competition, the wholesaler shifts from selling the nSR input to selling the SR input and issuing green bonds. With even more competition, the wholesaler's ability to capture contributions from the retail market rises until diversion becomes the less profitable option. At that point, the wholesaler switches from issuing to not issuing green bonds.[7]

This feature of equilibrium is common in the most important cases we study. For example, as the SR input becomes more important in the production of the SRP, the wholesaler switches from selling the nSR input to selling the SR input and issuing green bonds, and as the SR input becomes even more important to the production of the SRP, the wholesaler switches to not issuing green bonds. Intuitively, when the wholesaler's input is a small component of the retail products' marginal costs, the wholesaler finds it difficult to extract a sufficient portion of the end consumers' contributions to warrant selling the SR input. As the input's importance grows, the wholesaler is able to extract more of their contributions but finds it optimal to divert some of the contributions to the purchase of green bonds. As the input becomes even more important, the wholesaler finds it is able to extract more contributions from the retail market and, at some point, diverting contributions to the purchase of green bonds is less profitable than having the consumers buy (i.e., contribute) in the retail market. The same pattern and intuition holds as the wholesaler's socially responsible activities become more visible to the end consumers.[8]

We also show that when end consumers are willing to contribute more to the socially responsible activity, the equilibrium changes from the wholesaler selling the nSR input to selling the SR input and issuing green bonds. For even larger values, the wholesaler switches to selling the SR input without issuing green bonds. Intuitively, if end consumers are only willing to make small contributions, it does not pay the wholesaler to engage in socially responsible activities. For intermediate willingness to contribute, the wholesaler finds it optimal to capture some of their contributions directly through the sale of green bonds and some indirectly through the sale of the product the end consumers purchase. Finally, if their willingness to contribute is even larger, the losses from diverting contributions from the purchase of the end product to buying green bonds rise until it is no longer worthwhile and the wholesaler stops issuing green bonds.

Thus, in the extremes, the wholesaler sells either the nSR input or the SR input without issuing green bonds. It is in the intermediate cases where the benefits from issuing green bonds at a premium offer the wholesaler the opportunity to supplement the funding of its socially responsible activities (see Figure 1). There are two exceptions to this general pattern. First, if the premium and other benefits that accrue to issuing green bonds increases, it is strictly more likely that the wholesaler issues green bonds. Second, if the fixed costs of producing the socially responsible input increase, the wholesaler is strictly less likely to sell the socially responsible input.

Our results offer insights into some of the financing choices we observe in practice. For example, our model suggests that the growing importance of clean and/or sustainable energy sources to consumers should lead to issuing green bonds and may help to explain why sustainable energy projects were among the first to be financed using green bonds. Similarly, the extreme visibility and importance (to end consumers) of organic farming suggest why wholesalers capture contributions in the retail market only rather than using the green bond market to help finance their socially responsible activities.

Our analysis of the importance of the SR input in the production of the product purchased by end consumers may also help explain the differential market responses to the use of conflict diamonds and conflict minerals. Specifically, because conflict minerals are a very small part of the cost of producing electronics, our results suggest that it is unlikely that the wholesaler can capture a sufficient share of the end consumers' contributions to allow it to voluntarily provide conflict-free minerals profitably. In contrast, because conflict diamonds are a large part of the production technology for

	Wholesaler's Production and Financing Decisions		
Variable of interest	nSR input	SR input, issues green bonds	SR input, don't issue green bonds
Number of retailers	Low	Moderate	High
Importance of the wholesaler's input in the production of the retail product	Low	Moderate	High
Visibility of the wholesaler's socially responsible activities to end consumers	Low	Moderate	High
Consumers' willingnesses to contribute to the wholesaler's socially responsible activities	Low	Moderate	High

FIGURE 1 Description of the wholesaler's equilibrium production and financing choices

diamond jewelry, our analysis suggests that diamond wholesalers are likely to provide conflict-free diamonds voluntarily. This also offers a possible explanation for why the U.S. Securities and Exchange Commission (SEC) is enforcing required disclosure of the use of conflict minerals, but not conflict-free diamonds.

Transportation costs for many end products are usually a small component of their production costs. Our analysis suggests that this should make it difficult for shipping companies to capture contributions through retail markets for the products they ship. Thus, our results may offer insight into why many believe that the only viable means of funding the retrofitting of large ocean-going freight vessels to reduce pollution is to access the green bond market (*The Economist*, 2017). Similarly, our results may help explain why Apple chose to issue green bonds to fund new facilities to recycle iPhones: recycling costs are not a large component of the costs of producing iPhones but recycling is an important socially responsible activity for many of its customers.[9]

The next section discusses the green bonds and related literature. We present our model in Section 3. Section 4 contains our analysis of when issuing green bonds is optimal for the wholesaler and we conclude in Section 5.

2 | GREEN BONDS AND RELATED LITERATURE

The proceeds from issuing green bonds, sustainable bonds, social bonds or social impact bonds are pledged to support the issuer's socially responsible activities (EY, 2015a; KPMG, 2015). Initially, the term "green bonds" was reserved for bonds issued to finance environmentally friendly activities and the terms "social," "social impact," or "impact" bonds were reserved for bonds issued to finance projects with social or community benefits. However, following the Paris Accords (COP21), the definition of projects satisfying the Green Bond Principles was expanded to include socially responsible projects, not just environmentally friendly projects (Klevan, 2016). As a result, and because the distinction is not important for our analysis, we refer to any bond whose funds are pledged to finance socially responsible activities (including environmentally friendly activities) as green bonds.

The first *corporate* green bond was issued in 2013. In that year, Toyota issued the largest green bond to finance leases and loans for fuel-efficient cars and those that use hybrid engines (Moodie, 2016).[10] Since then, there has been a substantial increase in the issuance of green bonds with more than $90 billion issued in 2016, a 90% increase from 2015 (Hirtenstein, 2017; Larsen, 2017). In 2016, Apple issued one of the largest corporate green bonds and Starbucks issued the largest bond to fund sustainability initiatives along its supply chain in 2016 (Wolf, 2017).[11]

There are a number of benefits to issuing corporate green bonds. First, green bond issues are often oversubscribed (Climate Bond Initiative, 2015). Second, they offer the issuing firm a powerful opportunity to market its CSR activities (NEPC, 2015) and attract institutional investors that are required to incorporate sustainability into their investment process (Klevan, 2016).[12] Finally, and perhaps more important to the issuer, green bonds sell at a premium to equally risky, non-green bond issuances. Zerbib (2019) offers the first systematic evidence that investors in green bonds earn

less than investors in non-green bonds (approximately 6.7% on non-AAA grade investments). The implied premium paid by purchasers of green bonds based on Zerbib's results is similar to the 20 basis point estimate made by Preclaw and Bakshi (2015) and RILA's (2017) estimate that Regency Centers' green bond was issued with a yield of 11–60 basis points less than similar REIT offerings. Recently, Flammer (2018) has documented that the stock market response to the announcement of the issuance of green bonds is positive and issuers exhibit better long-term financial performance than firms that do not issue green bonds. She also documents that issuers exhibit a greater improvement in their environmental impact than non-issuers suggesting that they abide by the promise inherent in the green bond issuance and/or the verification described below is effective.

In contrast, issuing stock (or securities whose value is derived from the firm's stock price) is generally more problematic for financing socially responsible activities because the purchasers would need to expect that (as a group) they own sufficient stock to ensure that their preferences for supporting the firms SR activities are respected. Preferred stock is also more problematic for financing socially responsible activities because purchasers do not acquire the rights to impact firm decisions (as do common stockholders) and the preferred stock does not include contractual obligations on the use of the funds raised. Bonds contractually ensure this subject to external verification as discussed in the next paragraph.

The main difficulty facing issuers of green bonds is skepticism with the issuer's pledge that funds raised will actually fund socially responsible activities.[13] In response, 55 institutions, including most large banks, developed and support voluntary Green Bond Principles overseen by the International Capital Market Association (JP Morgan, 2014). While voluntary, Green Bond Principles define projects that qualify for green bond financing. They also define processes for evaluating and selecting green projects and for managing the proceeds from the issuance. Finally, they require at least annual reporting on the use of the funds. Perhaps more important, they encourage issuers to obtain second-party review and consultation and third-party auditing or certification (International Capital Market Association, 2017).[14] Similar voluntary "verification" is provided by the Climate Bond Initiative and other organizations are springing up to help investors be confident that they are, in fact, investing in green bonds.[15]

While ours is the first paper to analyze the role of issuing green bonds as part of a firm's strategic CSR strategy, the literature on corporate social responsibility is vast.[16] The CSR literature initially argued that firms have a moral responsibility to engage in socially responsible activities. However, following Friedman's (1970) assertion that profit-maximizing firms engaging in socially responsible activities was evidence of agency problems, a branch of the CSR literature turned to studying when it was profitable for firms to engage in socially responsible activities. Baron (2001) was the first to offer support for this view (now commonly referred to as strategic CSR).[17] Subsequently, Bagnoli and Watts (2003), Baron (2009, 2011), Besley and Ghatak (2007), McWilliams, Siegel, and Wright (2006), Siegel and Vitaliano (2007) among others, have clarified the benefits to selling products linked to socially responsible activities and explored the impact of alternative competitive environments.[18] Our paper complements these papers by focusing on the wholesaler's, rather than the retailers', ability to capture (a portion of) end consumers' willingness to pay for socially responsible activities. This allows us to highlight key features that impact the wholesaler's problem that are unimportant for retailers. Further, our analysis of green bond issuance allows us to explain how issuing green bonds (linking financing to socially responsible activities) can substitute for or complement linking socially responsible activities to the sale of a private good.

Our work focusing on issuing green bonds also complements a small literature on the impact of CSR activities on the linkage between product market competition and stock market activity. Graff Zivin and Small (2005) analyze a model in which firms provide CSR activities and agents contribute toward the CSR activities by either investing in these firms or giving directly to not-for-profits. Baron (2007) extends their analysis by allowing corporate social giving to be an imperfect substitute for direct giving by agents. Baron shows that costs of anticipated corporate social giving are borne by entrepreneurs rather than stockholders and that firms that engage in corporate social giving survive because only entrepreneurs willing to absorb the costs establish and "take public" such firms. Our model complements this literature by extending the analysis to investing in green bonds rather than equity and by allowing agents to contribute to the firms' CSR activities by purchasing the firms' products. Thus, unlike in Graff Zivin and Small and Baron, our firms need to choose how to attract contributions from agents (from selling the SRP, by offering green bonds or both) rather than how to divert these contributions from not-for-profits.

We also contribute to the growing literature on socially responsible supply chains. Much of that literature focuses on the use of pricing, contracts or more generally mechanism design choices by the firm to motivate suppliers to be socially responsible (Chen & Lee, 2017; Cho, Fang, Tayur, & Xu, 2016; Plambeck & Taylor, 2015, among others). Our work complements this literature by focusing on the wholesaler's incentives to provide socially responsible activities without

additional incentives from retailers through their contracts with the wholesalers. Another part of this literature includes Arya and Mittendorf (2014) and Guo, Lee, and Swinney (2016). Arya and Mittendorf show that strategic benefits from a firm's charitable giving may arise as a result of its supply chain response even in the absence of direct benefits from selling to socially responsible customers. Guo, Lee, and Swinney study the firm's sourcing decisions when some of its potential suppliers may not be socially responsible and some of the firm's customers are socially conscious. Our work complements these papers by focusing on the wholesaler's decision to finance the production of a socially responsible input using green bonds rather than simply extracting contributions indirectly from end consumers.

3 | THE MODEL

In our model, a wholesaler has the option to produce a socially responsible input (SR input) that, when used in the production of the product sold to end consumers, makes it an SRP. We focus on the wholesaler's problem rather than the retailers' problem because we expect that it is more difficult for the wholesaler to capture end consumers' willingness to contribute to socially responsible activities. The added difficulties for a wholesaler arise because retailers selling to the end consumers will "skim" a portion of their contributions off as additional profit from selling the SRP. In addition, if other inputs are sold in markets that are not perfectly competitive, those input providers will also "skim" a portion of the retailers' extra profits from selling the SRP, leaving less for the wholesaler who produces the SR input to capture. Further, the wholesaler's ability to extract extra profits by selling the input that allows consumers to purchase the SRP depends on how important the wholesaler's input is in the production of the SRP. If the input is important in the production of the SRP the wholesaler can extract more profits from the retail market and is thus more likely to choose to produce and sell the SR input. Finally, because the socially responsible activity is undertaken by the wholesaler, it may not be as salient to end consumers as it would be if retailers engaged in the activity themselves. Our model incorporates many of these issues and shows that selling an SR input (and thus an SRP to end consumers) may not be sufficient to enable a *wholesaler* to capture a sufficient portion of the contributions to cover added costs of producing a socially responsible input.

To develop our formal model, assume there is a continuum of individuals with mass 1. Each is willing to purchase at most one unit of the product sold by retailers and is willing to contribute no more than $\beta > 0$ toward the socially responsible activity. The retailer can capture some of this willingness to contribute by selling SRPs, products that are produced with socially responsible methods (e.g., using recycled packaging or other sustainable materials including recycled products; products or inputs grown organically; manufactured without using conflict diamonds or minerals; or simply producing SRPs like solar powered electronics) or products linked to socially responsible activities (fair trade coffee, ethical labor policies, corporate volunteerism, energy efficiency, recycling activities, etc.). Formally, we are assuming that each consumer is willing to pay up to β more for the retailer's SRP than for an identical product that is not produced using the socially responsible input.

We assume that there are n retailers selling differentiated SRPs. To simplify the analysis without altering the underlying forces, let each retailer i's demand for its SRP be:

$$p_i = \alpha + \tau\beta - q_i - \lambda\sum_{j\neq i} q_j \quad i = 1, 2, ..., n,$$

where q_i is the quantity of retailer i's SRP and q_j is the quantity of retailer j's SRP with $j \neq i$. λ represents the degree of product differentiation with $\lambda \in (0, 1]$ and $\tau \in [0, 1]$ represents the fraction of individuals' (hereafter contributors) willingness to contribute to socially responsible activities that the retailer can capture by selling a SRP.[19] We interpret τ as how visible the socially responsible activity is to contributors buying the SRP. In some cases, such as when the SRP is produced using conflict-free diamonds, the socially responsible activity is very visible to the consumers and so they would be willing to pay a larger increment for the SRP (τ would be large). In other cases, such as when the SRP uses conflict-free minerals in the production of electronics, the socially responsible activity is not very visible to the consumers and so they would be willing to pay only a small increment for the SRP (τ would be small). Perhaps better examples of low visibility socially responsible activities by a wholesaler are its efforts to enhance diversity, treat labor ethically, or provide humanitarian relief.

To focus on the wholesaler's decision to issue green bonds, we specialize the SRP to be one produced using a SR input such as recycled packaging or sustainable materials. To capture this idea, let each retailer's cost of producing their SRP be

$$C(q_i) = \left(w + \sum_{k=2}^{m+1} \gamma_k w_k\right) q_i.$$

That is, each SRP is produced with $m + 1$ inputs. We normalize so that one unit of the first input is required to product one unit of the SRP and the γ_k's represent the normalized amount of each of the other inputs needed to produce one unit of the SRP. The first, the socially responsible input, is purchased from a upstream firm at w and the remaining m inputs are purchased by the retailer in competitive input markets at prices w_k.[20]

Turning to the wholesaler, its cost of producing the SR input which makes the retailers' products socially responsible is

$$C_w(Q) = xQ + F,$$

where Q is the amount of the SR input sold (equivalently the amount of the SRP sold by retailers), $x > 0$ is the marginal cost of making the input and $F > 0$ is the fixed cost of production. Finally, we assume that the retailers and wholesaler seek to maximize profits and, to ensure interior solutions, we assume that $\alpha > x + \sum_{k=2}^{m+1} \gamma_k w_k$.

The structure of the game is as follows. First, the wholesaler chooses whether to sell the socially responsible input or not and the price it charges for the input it sells. Next, retailers observe that price (and the prices of all other inputs) and simultaneously choose how much of the SRP to sell. Finally, the consumers purchase the product from the retailer of their choice so long as the price the retailer charges is not greater than their willingness to pay for the product plus the maximum the consumer is willing to contribute to the socially responsible activity. We seek a subgame perfect Nash equilibrium to the game. Specifically, we solve for the equilibrium when the wholesaler chooses to sell the SR input but not issue green bonds. We then solve for the equilibrium when the wholesaler chooses to sell the nSR input. Next, we solve for the equilibrium when the wholesaler finances the fixed costs of producing the SR input with green bonds. Finally, we compare the wholesaler's profits in each of these cases to determine when it chooses to issue green bonds.

3.1 | Equilibrium when the wholesaler sells the SR input

Assuming the wholesaler chooses to sell the SR input at w without issuing green bonds, we begin by considering the retailers' equilibrium quantity choices. Retailer i takes the prices of all inputs as given and chooses q_i to maximize its profits:

$$\max_{q_i}\left(\alpha + \tau\beta - q_i - \lambda\sum_{j\neq i} q_j - w - \sum_{k=2}^{m+1} \gamma_k w_k\right) q_i \quad i = 1, 2, ..., n,$$

where the term in parentheses is price minus marginal cost. Computing the first-order condition for each firm's maximization problem and solving in the usual way yields the following Proposition.

Proposition 1. *There is a unique equilibrium in which each retailer chooses to sell $q^*(w)$ where*

$$q^*(w) = \left(\frac{1}{2 + \lambda(n-1)}\right)\left[\alpha + \tau\beta - w - \sum_{k=2}^{m+1} \gamma_k w_k\right]$$

and the retailers buy $Q^*(w)$ units of the socially responsible input where

$$Q^*(w) = n\left(\frac{1}{2 + \lambda(n-1)}\right)\left[\alpha + \tau\beta - w - \sum_{k=2}^{m+1} \gamma_k w_k\right].$$

Before turning to the wholesaler's problem, there are some important features of the equilibrium choices by retailers that should be noted. First, retail sales are greater (both for each retailer and the market as a whole) if (a) the retail market is larger (α is larger), (b) the social responsibility embedded in the SRP is more visible to the consumers (τ is larger), or (c) contributors are willing to pay more for socially responsible activity (β is larger). More important, increases in the price the wholesaler charges for the SR input (w) reduces retail sales of the SRP.

Turning to the wholesaler's problem, it correctly anticipates the retailers' demand for the socially responsible input and chooses its price to maximize its profits:

$$\max_{w}(w - x)Q^*(w) - F,$$

where $Q^*(w)$ is defined in Proposition 1.[21]

Proposition 2. *If the wholesaler chooses to supply the socially responsible input, in equilibrium, the wholesaler sells it for*

$$w^* = \frac{1}{2}\left(\alpha + \tau\beta + x - \sum_{k=2}^{m+1}\gamma_k w_k\right)$$

and earns profits of

$$\pi^* = \frac{1}{4}\left(\frac{n}{2 + \lambda(n-1)}\right)\left[\alpha + \tau\beta - x - \sum_{k=2}^{m+1}\gamma_k w_k\right]^2 - F.$$

It is intuitive that greater demand for the retailers' products (an increase in either α, the size of the market; β, the amount end consumers are willing to contribute to socially responsible activities; or τ, how visible socially responsible activities are to end consumers) leads the wholesaler to charge a higher price and make greater profits. Thus, if consumers are willing to contribute more to socially responsible activities, they buy more units of the SRP at a higher price. As a result, the wholesaler can and does charge more for the SR input and increases its profits by capturing some of the consumers' contributions. The wholesaler's equilibrium price of the SR input is also increasing in the wholesaler's marginal cost of producing it but, as expected, this increase results in the wholesaler earning less profits.

More interesting is how the wholesaler's price and profits relate to the magnitude of the expense of buying the other inputs retailers use to produce the SRP. Specifically, if $\sum_{k=2}^{m+1}\gamma_k w_k$ increases either because one or more of the prices of these inputs increase or if the production technology requires more of one or more of these inputs relative to the socially responsible input, both the price the wholesaler charges for the socially responsible input and the wholesaler's equilibrium profits decline. Intuitively, if the wholesaler's input is less important in the retailers' cost structures, the wholesaler can't price as aggressively. This results in the wholesaler earning less profit and capturing less of the consumers' contributions to socially responsible activities.[22]

Finally, note that while the wholesaler's equilibrium price of the SR input is independent of the number of retailers competing in the final goods market, the wholesaler's profits are not,

$$\frac{\partial\pi^*}{\partial n} = \frac{1}{4}\left(\frac{1}{2 + \lambda(n-1)}\right)^2\left[\alpha + \tau\beta - x - \sum_{k=2}^{m+1}\gamma_k w_k\right]^2 > 0.$$

The wholesaler's equilibrium profits are greater when there are more firms competing in the final goods market. Said differently, as the final goods market becomes more competitive, the wholesaler is able to extract more profits including more of the contributions made by consumers when they purchase the SRP. The reason for this is that the double-marginalization problem facing the wholesaler is reduced. Increased retail competition reduces the retailers' ability to skim part of the extra profits created by capturing part of the consumers' contributions when the SRP is sold.

3.2 | Equilibrium when the wholesaler sells the nSR input

In this subsection, we analyze equilibrium prices and quantities when the wholesaler sells an input not linked to socially responsible activities. The analysis is basically the same as in the prior section with two differences. First, β needs to be set equal to zero to reflect the fact that the products sold by retailers are not socially responsible. Second, the wholesaler's costs of producing the input change. Specifically, we assume that there are no fixed costs of producing an input that is not socially responsible and the marginal cost of producing the input, x_n, is not greater than the marginal cost of producing the SR input, x. That is, $x \geq x_n$.[23]

The following proposition describes equilibrium choices by retailers and the wholesaler.

Proposition 3. *If the wholesaler chooses to supply the not socially responsible input, there is a unique equilibrium in which each retailer chooses to sell* $q_n^*(w)$ *where*

$$q_n^*(w) = \left(\frac{1}{2 + \lambda(n-1)}\right)\left[\alpha - w - \sum_{k=2}^{m+1} \gamma_k w_k\right]$$

and the retailers buy $Q_n^*(w)$ *units of the not socially responsible input where*

$$Q_n^*(w) = n\left(\frac{1}{2 + \lambda(n-1)}\right)\left[\alpha - w - \sum_{k=2}^{m+1} \gamma_k w_k\right].$$

The wholesaler sells the input not connected to socially responsible activities for

$$w_n^* = \frac{1}{2}\left(\alpha + x_n - \sum_{k=2}^{m+1} \gamma_k w_k\right)$$

and earns profits of

$$\pi_n^* = \frac{1}{4}\left(\frac{n}{2 + \lambda(n-1)}\right)\left[\alpha - x_n - \sum_{k=2}^{m+1} \gamma_k w_k\right]^2.$$

Because we have assumed that $\alpha > x + \sum_{k=2}^{m+1} \gamma_k w_k$ and that $x \geq x_n$, in equilibrium, the wholesaler sells a positive amount of the nSR input and earns positive profits from doing so. Since the comparative static results are essentially the same as if the wholesaler sells the SR input, we forgo repeating them.

3.3 | The wholesaler's choice of which input to sell absent a market for green bonds

Before examining the wholesaler's decision to issue green bonds, we examine its input choice when green bonds are not available. We do this for three reasons. First, until recently, there was limited (or no) access to a green bond market and so these choices represented the wholesaler's only options. Second, many of the results will be useful in the next section when we examine the conditions under which the wholesaler finds it optimal to issue green bonds. Third, the analysis highlights the difference between retailers' decisions to offer an SRP or not and the wholesaler's decision to offer retailers an SR input or not.

Because we have assumed that all retailers and the wholesaler maximize profits, none are willing to forgo profits to directly contribute to the socially responsible activity.[24] As a result, the wholesaler chooses to sell the SR input to retailers if and only if it earns greater profits from doing so. This occurs when $\pi^* \geq \pi_n^*$, equivalently

$$\frac{1}{4}\left(\frac{n}{2+\lambda(n-1)}\right)\left[\alpha+\tau\beta-x-\sum_{k=2}^{m+1}\gamma_k w_k\right]^2-F\geq\frac{1}{4}\left(\frac{n}{2+\lambda(n-1)}\right)\left[\alpha-x_n-\sum_{k=2}^{m+1}\gamma_k w_k\right]^2.$$

Rearranging, the wholesaler chooses to sell the socially responsible input if

$$(\tau\beta-x+x_n)\left[\left(\alpha+\tau\beta-x-\sum_{k=2}^{m+1}\gamma_k w_k\right)+\left(\alpha-x_n-\sum_{k=2}^{m+1}\gamma_k w_k\right)\right]\geq\left(\frac{4(2+\lambda(n-1))}{n}\right)F. \quad (1)$$

Equation (1) allows us to describe the conditions under which the wholesaler is more likely to choose to sell the nSR input collected in the following proposition.[25]

Proposition 4. *The wholesaler chooses to sell the nSR input if $\tau\beta \leq x - x_n$. If $\tau\beta > x - x_n$, the wholesaler is more likely to sell the nSR input if:*[26]

(i) *F is large,*
(ii) *n is small or λ is large,*
(iii) *$\sum_{k=2}^{m+1}\gamma_k w_k$ is large,*
(iv) *α or $\tau\beta$ is small,*
(v) *x or $x - x_n$ is large.*

The term in brackets in Equation (1) is positive because it is the sum of the equilibrium retail markups on the SRP and the nSRP. The sign of the first term is positive when $\tau\beta > x - x_n (\geq 0)$. Thus, a necessary condition for the wholesaler to sell the SR input is that the price increase because consumers are willing to pay $\tau\beta$ more for the SRP as their contribution to the socially responsible activity exceeds the incremental marginal cost of producing the SR input. If it doesn't, the wholesaler's variable profit (revenues minus variable costs) from selling the SR input is smaller than its variable (and total) profit from selling the nSR input. For the remainder of this discussion, we assume that $\tau\beta > x - x_n$.

If the fixed costs of producing the SR input, F, are large, the wholesaler is less likely to produce the SR input because larger fixed costs require the wholesaler's incremental variable profits from selling the SR input be large enough to cover the increased fixed costs of producing it. Thus, for example, our analysis suggests that, absent a market for green bonds, wholesalers are less likely to introduce greener production technologies and less likely to employ greener shipping methods because both are likely to have large fixed production costs.

Proposition 4 also indicates that when the SR input is a smaller share of the marginal costs of producing the SRP, when $\sum_{k=2}^{m+1}\gamma_k w_k$ is large, the wholesaler is less likely to sell the SR input. When the wholesaler's input is a smaller share of the retailers' marginal costs, the wholesaler is less able to extract incremental variable profits from selling the SR input and is thus less able to cover its fixed production costs. As a result, our analysis suggests that if the SR input is a relatively small part of the production technology for the retailer, such as conflict minerals are for the production of electronics, it is unlikely that the wholesaler will voluntarily provide/use conflict-free minerals. In contrast, because conflict diamonds are a large part of the production technology for diamond jewelry, our analysis suggests that diamond wholesalers are likely to provide conflict-free diamonds voluntarily. Perhaps this offers an explanation for why the SEC is enforcing required disclosure of the use of conflict minerals, but not conflict-free diamonds: it is an attempt to raise the profile of conflict-free minerals and motivate their use.

Finally on the cost side, Proposition 4 indicates that when the marginal cost of producing the SR input, x, is large or if the incremental marginal cost of producing the SR input, $x - x_n$, is large the wholesaler is less likely to sell the SR input. Intuitively, when the incremental cost of producing the SR input is smaller than $\tau\beta$, increasing the marginal cost of producing it reduces incremental variable profits making it more difficult to cover the fixed costs of producing the SR input. Similarly, if the difference in the marginal costs of producing the SR input is larger, the incremental profits from selling the SR input are smaller reducing the likelihood that the wholesaler will be able to cover the fixed costs of producing the SR input. This is intuitive because the more expensive it is to produce the SR input, the less likely it is that the wholesaler profits from switching and selling the SR input. As a result, our analysis suggests that if, for example, the costs of sustainable fishing (fishing in less accessible waters or avoiding fishing during certain times of the year) are large, it is less likely that the wholesaler will adopt sustainable fishing techniques and/or technologies.

Interestingly, this also offers an explanation for the relatively rapid adoption of dolphin-safe fishing technologies—the incremental cost was small.

On the demand side, Proposition 4 indicates that when the retailers' products are more similar, λ is large, the wholesaler is less likely to sell the SR input. The reason is that the more homogeneous the retailers' products are, the less profitable they are to sell, making it more difficult for the wholesaler to extract sufficient incremental variable profits to cover the fixed costs of producing the SR input. Similarly, if the retailers compete in a "niche" market, α is small, it is also less likely the wholesaler will offer the SR input. Intuitively, if the retailers' market is small, the profits the wholesaler can extract from selling the SR input are less likely to cover the fixed costs of producing the SR input. Further, if consumers are relatively unwilling to pay extra for the SRP, β is small or if the social responsibility of the retail product is difficult to discern, τ is small, we obtain the same result. In each case, the wholesaler is unable to extract sufficient incremental variable profits from selling the SR input to cover the fixed costs of production. Taken together, wholesalers are less likely to offer the SR input if the profits that can be extracted from the retail market are small.

Finally, Proposition 4 indicates that when there are fewer retailers, n is small, the lack of competition at the retail level makes it more likely the wholesaler offers the nSR input. Intuitively, the reason is that with less retail competition, retailers are able to skim more of the added profits from selling the SRP making it harder for the wholesaler to capture enough of them to make selling the SR input profitable. Thus, our analysis predicts that wholesalers servicing relatively competitive retail markets are more likely to offer the SR input. It also suggests an explanation for the empirical relation that firms in more competitive markets engage in more CSR activity (e.g., Fernandex-Kranz & Santalo, 2010 among others).

Having determined whether the wholesaler offers the SR input when green bonds are not available, we now introduce the option of issuing green bonds and compute the wholesaler's equilibrium profits from doing so.

3.4 | Equilibrium when the wholesaler issues green bonds

Recall that each contributor is willing to pay β in total for the SRP. Since some of these consumers may not be willing or able to participate in the bond market, we assume that only a fraction $\xi \in (0, 1)$ of them participate. Thus, if the wholesaler issues green bonds, it can capture at most $\xi\beta$ of the contributions of socially responsible consumers. Then, because we are assuming that a consumer's total willingness to pay is β, at most $(1 - \xi)\beta$ of their willingness to contribute to having SRPs is available to be captured by the sale of SRP (those products made with the SR input).[27]

As noted above, green bonds are sold at a premium over equivalently risky non-green debt instruments and offer additional benefits to the issuer. As a result, the cost of borrowing through the use of green bonds is lower than the cost of borrowing with standard debt.[28] To capture the benefits of financing the fixed costs of producing the SR input with green bonds, we assume that $\delta\xi\beta$ represents the savings from financing at a lower cost of borrowing where δ represents the share of the contributions toward socially responsible activities provided in the form of paying a premium for green bonds.[29]

Given this, the expressions for the equilibrium quantities of the SRP sold by retailers and their total sales of the SRP (equivalently, total purchases of the SR input) can be obtained from Proposition 1 by substituting $\tau(1 - \xi)\beta$ for $\tau\beta$. Finally, let q_g^* and Q_g^* be the equilibrium quantities of the SRP that each retailer sells and the total sales of the SRP respectively. Thus, the wholesaler's profits when it issues green bonds can be written as

$$\pi_g = (w - x)Q_g^*(w) - (F - \delta\xi\beta).$$

We present the wholesaler's equilibrium price for the SR input and its profits when financing with green bonds in the following proposition.[30]

Proposition 5. *If the wholesaler funds the fixed costs of producing the SR input with green bonds, the wholesaler charges w_g^* for the SR input where*

$$w_g^* = \frac{1}{2}\left(\alpha + \tau(1 - \xi)\beta + x - \sum_{k=2}^{m+1}\gamma_k w_k\right)$$

and earns profits of

$$\pi_g^* = \frac{1}{4}\left(\frac{n}{2+\lambda(n-1)}\right)\left[\alpha + \tau(1-\xi)\beta - x - \sum_{k=2}^{m+1}\gamma_k w_k\right]^2 - (F - \delta\xi\beta).$$

Proposition 5 allows us to determine when the wholesaler prefers financing the fixed costs of producing the SR input with green bonds to selling the nSR input. The wholesaler opts for issuing green bonds if $\pi_g^* \geq \pi_n^*$, equivalently

$$\frac{1}{4}\left(\frac{n}{2+\lambda(n-1)}\right)\left[\alpha + \tau(1-\xi)\beta - x - \sum_{k=2}^{m+1}\gamma_k w_k\right]^2 - (F - \delta\xi\beta) \geq \frac{1}{4}\left(\frac{n}{2+\lambda(n-1)}\right)\left[\alpha - x_n - \sum_{k=2}^{m+1}\gamma_k w_k\right]^2.$$

Rearranging, the wholesaler chooses to sell the socially responsible input and finance the fixed costs of production with green bonds if

$$(\tau(1-\xi)\beta - x + x_n)\left[\left(\alpha + \tau(1-\xi)\beta - x - \sum_{k=2}^{m+1}\gamma_k w_k\right) + \left(\alpha - x_n - \sum_{k=2}^{m+1}\gamma_k w_k\right)\right] \geq \left(\frac{4(2+\lambda(n-1))}{n}\right)(F - \delta\xi\beta). \tag{2}$$

Comparing Equations (2) and (1) offers insight into differences in the conditions that lead the wholesaler to offer the SR input with and without green bond financing. When $\tau(1-\xi)\beta - x + x_n > 0$, comparing the equations shows that the left-hand side of (2) is smaller than the left-hand side of (1) and the reverse is true of the right-hand sides. Intuitively, if the wholesaler issues green bonds, it captures contributions through the issue price premium making the right-hand side of (2) larger than the right-hand side of (1). On the other hand, the wholesaler forgoes capturing some contributions from the end consumers' purchase of the SRP (captured in the price the wholesaler charges for the SR input) because they already "contributed" though their purchase of the green bonds.

In addition, Equation (2) allows us to describe the conditions under which the wholesaler is more likely to choose to sell the nSR input rather than sell the SR input and issue green bonds.[31]

Proposition 6. *The wholesaler chooses to sell the nSR input if $\tau(1-\xi)\beta \leq x - x_n$. If $\tau(1-\xi)\beta > x - x_n$, the wholesaler is more likely to sell the nSR input rather than sell the SR input and issue green bonds if:*

(i) *F is large,*
(ii) *n is small or λ is large,*
(iii) *$\sum_{k=2}^{m+1}\gamma_k w_k$ is large,*
(iv) *α or $\tau\beta$ is small,*
(v) *x, or $x - x_n$ is large,*
(vi) *δ is small,*
(vii) *ξ is large (small) when τ is large and δ is small (τ is small and δ is large).*

Most of the results are similar to those in Proposition 4 because the same forces are at work even though the wholesaler now captures part of the consumers' contributions through their purchase of green bonds. The important differences arise from the impact of issuing green bonds. Specifically, because some contributors buy green bonds, the contributions the wholesaler can capture from selling the SR input are smaller. They fall from $\tau\beta$ to $\tau(1-\xi)\beta$. As a result, it is more likely that $\tau(1-\xi)\beta \leq x - x_n$ when compared to the likelihood that $\tau\beta \leq x - x_n$. Consequently, it is more likely that the wholesaler will choose to sell the nSR input if it would have financed the fixed costs of producing the SR input with green bonds.

Another difference is associated with the premium contributors are willing to pay for green bonds. If contributors are willing to pay a large premium for green bonds, δ is larger, it is less difficult for the wholesaler to cover the fixed costs of producing the SR input. Consequently, it is more likely that it issues green bonds and sells the SR input. Finally,

the fraction of consumers who are willing to buy green bonds, ξ, impacts the wholesaler's decision in a complex way: it depends on the relative magnitudes of τ and δ. To see why, recall that τ describes the portion of contributions that can be accessed by selling a SRP and δ describes the portion that can be accessed by selling green bonds. If τ is large and δ is small, the wholesaler more readily accesses contributions by selling the SR input whereas if τ is small and δ is large, the wholesaler more readily accesses contributions by selling green bonds. Thus, if the fraction of consumers willing to buy green bonds is larger (ξ is larger), the impact on the incremental variable costs of selling the SR input is smaller when τ is large because a larger fraction of consumers are contributing by buying green bonds and not contributing by buying the SRP. Further, the benefits from using green bonds to finance the fixed costs are small when δ is small meaning that the larger fraction of consumers willing to buy green bonds has a smaller effect on the reduction in the fixed costs of producing the SR input. Together these features imply that the wholesaler is more likely to sell the nSR input and not issue green bonds when ξ and τ are large but δ is small and vice versa.

4 | WHEN DOES THE WHOLESALER CHOOSE TO ISSUE GREEN BONDS?

The wholesaler chooses to issue green bonds if its profits from doing so exceed both its profits from simply selling the SR input and its profits from selling the nSR input. That is, when $\pi_g^* \geq \max\{\pi^*, \pi_n^*\}$. In this section, we analyze the conditions under which that inequality holds.

Equation (2) describes the conditions under which selling the SR input while accessing the green bond market is more profitable than selling the nSR input ($\pi_g^* \geq \pi_n^*$). To complete our analysis, we develop conditions under which the wholesaler finds it more profitable to sell the SR input while accessing the green bond market than selling the SR input without accessing the green bond market ($\pi_g^* \geq \pi^*$). Substituting equilibrium profits from Propositions 5 and 2, the inequality becomes

$$\frac{1}{4}\left(\frac{n}{2+\lambda(n-1)}\right)\left[\alpha+\tau\xi\beta-x-\sum_{k=2}^{m+1}\gamma_k w_k\right]^2-(F-\delta\xi\beta)\geq\frac{1}{4}\left(\frac{n}{2+\lambda(n-1)}\right)\left[\alpha+\tau\beta-x-\sum_{k=2}^{m+1}\gamma_k w_k\right]^2-F.$$

Rearranging, $\pi_g^* \geq \pi^*$ is equivalent to

$$4\delta\geq\left(\frac{n}{4(2+\lambda(n-1))}\right)\tau\left[\left(\alpha+\tau\xi\beta-x-\sum_{k=2}^{m+1}\gamma_k w_k\right)+\left(\alpha-x_n-\sum_{k=2}^{m+1}\gamma_k w_k\right)\right]. \tag{3}$$

Intuitively, (3) requires that the portion of contributions captured by issuing green bonds exceed the profits lost from selling the SR input without diverting contributions to the purchase of green bonds. The expression on the right-hand side of (3) represents the additional fraction of contributions captured by selling the SR input when the wholesaler does not issue green bonds.

As a result, Equation (3) implies that the wholesaler prefers to issue green bonds to finance the fixed costs of producing SR input rather than just selling the SR input when (a) the premium contributors are willing to pay above a comparable-risk, non-green bond is large, δ is large; (b) the visibility of the socially responsible activity associated with producing the SR input to consumers of the SRP is low, τ is small; and (c) when the number of retail competitors is small, n is small.

Since the wholesaler will only choose to issue green bonds when (2) and (3) both hold, we can combine the conditions under which issuing green bonds is optimal in the following proposition.

Proposition 7. *It is optimal for the wholesaler to issue green bonds to finance the fixed costs of producing the SR input if the following three conditions hold:*

(i) $\tau(1-\xi)\beta > x - x_n$,
(ii) $4\delta \geq \left(\frac{n}{4(2+\lambda(n-1))}\right)\tau\left[\left(\alpha+\tau\xi\beta-x-\sum_{k=2}^{m+1}\gamma_k w_k\right)+\left(\alpha-x_n-\sum_{k=2}^{m+1}\gamma_k w_k\right)\right]$, *and*

(iii) $(\tau(1-\xi)\beta - x + x_n)\left[\left(\alpha + \tau(1-\xi)\beta - x - \sum_{k=2}^{m+1}\gamma_k w_k\right) + \left(\alpha - x_n - \sum_{k=2}^{m+1}\gamma_k w_k\right)\right] \geq \left(\frac{4(2+\lambda(n-1))}{n}\right)(F - \delta\xi\beta)$.

Condition 7.i is the same as the condition in Proposition 6 because a necessary condition for the wholesaler to choose to issue green bonds is that the incremental revenue from selling the SR input rather than the nSR input exceed the incremental marginal cost of doing so. It is necessary because otherwise the wholesaler strictly prefers to sell the nSR input and forgo the portion of contributions it can capture when retailers sell the SRP. The condition differs from the condition in Proposition 4 because the issuance of green bonds allows the wholesaler to capture part of the contributors' willingness to pay for social responsibility by selling green bonds at a premium. Doing so diverts contributions that can be captured through the sale of the SR input reducing the incremental revenue from selling the SR input and making it more difficult to earn incremental profits. Condition 7.ii requires that the portion of contributions captured by selling green bonds at a premium exceed the portion the wholesaler forgoes in the product market. Condition 7.iii ensures that the wholesaler earns greater profits issuing green bonds to finance the fixed costs of producing the SR input than it does selling the nSR input (i.e., $\pi_g^* \geq \pi_n^*$).

As just noted, for all parameter constellations that result in condition 7.i failing, the wholesaler chooses to sell the nSR input because it cannot charge enough for the SR input to cover the increased marginal costs of producing it. Thus, for the remainder of this discussion, we assume that condition 7.i holds. Further, since the magnitude of the fixed costs only impact condition 7.iii, the results are exactly the same as in Proposition 4, for exactly the same reasons. Increases in the fixed costs of producing the SR input reduce the profitability of selling it making it less likely that the wholesaler chooses to sell the SR input (with or without issuing green bonds).[32] Similarly, because an increase in the green bond premium, δ, makes it more likely that both conditions 7.ii and 7.iii are satisfied, the increase makes it more likely the wholesaler chooses to produce the SR input and issue green bonds.

The impact of changes in the remaining parameters on the wholesaler's decision is complex and so we focus on "interior" solutions where parameters are such that the wholesaler chooses all three options (selling the nSR input, issuing green bonds and selling the SR input and selling the SR input without issuing green bonds) as a function of the parameter under consideration. For example, since 7.iii holds for smaller values of n and 7.ii holds for larger values, the interior case has the wholesaler selling the nSR input for small values of n, selling the SR input and issuing green bonds for somewhat larger values of n and selling the SR input without issuing green bonds for the largest values of n. Thus, for an interior solution, for small n we have $\pi_n^* \geq \{\pi_g^*, \pi^*\}$, for intermediate values of n, we have $\pi_g^* \geq \{\pi_n^*, \pi^*\}$ and for large values of n, we have $\pi^* \geq \{\pi_n^*, \pi_g^*\}$. For the remaining parameters, 7.ii (7.iii) holds for smaller (larger) values of α, τ, and β and holds for larger (smaller) values of x, x_n and $\sum_{k=2}^{m+1}\gamma_k w_k$.

Consider first the impact of changes in the level of retail competition, the value of n. For relatively competitive retail markets (large n), the wholesaler chooses between issuing green bonds to finance the fixed costs of producing the SR input and not issuing them while selling the SR input. In this case, as the number of retailers (n) increases, the impact of diverting contributions from sales of the SRP to purchasing green bonds increases because, as competition among retailers intensifies, they skim less of the extra profits from selling the SRP. Thus, as competition among the retailers becomes more intense, the wholesaler's lost profits from diverting contributions (relative to selling the SR input without issuing green bonds) increases and, at some point overcomes the benefits from capturing contributions by selling green bonds.[33]

In contrast, when there is relatively little retail competition (n is small), the wholesaler chooses between selling the nSR input and selling the SR input while issuing green bonds to finance the fixed costs of its production. In this case, as the number of retailers (n) increases, the impact of retailers skimming part of the extra profits from selling the SRP declines making it more likely that the wholesaler finds it more profitable to sell the SR input that the nSR input. There are two possibilities. In the interior solution, the benefits from capturing contributions by issuing green bonds is large enough that switching to selling the SR input and financing the fixed costs with green bonds is the preferred option. Alternatively, if the impact of diverting contributions to pay for the green bond premium is too great, the wholesaler switches to selling the SR input without issuing green bonds.

Since the impact of increases in α, β, and τ have similar effects as an increase in n, we obtain similar results. We describe them for changes in τ but the analysis is the same if τ is replaced by α or β. Specifically, when the wholesaler's socially responsible activity is very visible to the end consumers (τ is large), the wholesaler chooses to sell the SR input without issuing green bonds. As its socially responsible activity declines in visibility, it switches to issuing green bonds. The reason is that the impact of diverting contributions from the purchase of the SRP to buying green bonds is smaller for less visible socially responsible activities. Finally, as the wholesaler's socially responsible activity becomes even less

visible, the wholesaler finds that it cannot extract sufficient additional profits from the sale of the SR input and switches to offering the nSR input. Our model thus offers the empirical implication that as consumers become more concerned with carbon emissions due to fears over the consequences of climate change (τ and/or β rise), wholesalers will be more inclined to issue green bonds to finance the use of green energy sources in the production of the SR input. This result may offer a foundation for the optimism for the use of green bonds to finance cleaner engines for ocean-going transport vessels expressed in *The Economist* (2017) mentioned above.

Next, consider the impact of changes in how important the wholesaler's input is in the production of the SRP, the value of $\sum_{k=2}^{m+1} \gamma_k w_k$. When the wholesaler's input makes up a large part of the marginal cost of producing the SRP ($\sum_{k=2}^{m+1} \gamma_k w_k$ is small), the wholesaler chooses between selling the SR input and issuing green bonds and selling the SR input and not issuing green bonds. In this case, as the wholesaler's input becomes less important in the production of the SRP, the wholesaler becomes more likely to finance the fixed costs of producing the SR input by issuing green bonds. Intuitively, as the input becomes less important in the production of the SRP, the extra profits lost from diverting some of the contributions from the purchase of the SRP to buying green bonds decrease. At some point, they become small enough to induce the wholesaler to switch from not issuing to issuing green bonds. As the input becomes even less important, the extra profits the wholesaler can extract by selling the SR input continue to decline until, when the input is a small portion of the marginal costs of producing the SRP, the wholesaler chooses to sell the nSR input. This empirical implication of our analysis may explain why green bonds have been issued by Apple to fund an environmentally friendly approach to dismantling and recycling used phones since such activities are a small portion of the cost of producing an iPhone.

5 | CONCLUSIONS

The strategic CSR literature (Bagnoli & Watts, 2003; Baron, 2001; Besley & Ghatak, 2007 and many others) has focused on understanding conditions when a firm does well by doing good: privately providing a public good by engaging in socially responsible activities. The key idea is that a retailer can *profitably* fund its socially responsible activities by charging more for its product because end consumers are willing to pay more to support those activities. With the recent development and significant growth of the green bond market, firms now have an alternative method for financing their socially responsible activities—they can issue green bonds (bonds whose proceeds are pledged to finance the firm's socially responsible activities).

We develop a model of a wholesaler's decision to produce a socially responsible input and whether to (partially) finance its production by issuing green bonds.[34] We focus on the wholesaler's problem because it is more difficult to fund socially responsible activities indirectly by selling to retailers rather than selling directly to socially aware end consumers. This added difficulty allows us to highlight incentives to issue green bonds that are not relevant to a retailer's decision.

In our model, socially aware consumers purchase from a number of retailers selling differentiated end products and are willing to contribute to socially responsible activities by paying more for those end products. The wholesaler decides whether or not to sell a socially responsible input (SR input) to retailers. The retailers' products become socially responsible if the socially responsible input is used in their production. If the wholesaler decides to sell the SR input, it also decides whether or not to fund its activities by issuing green bonds. We determine the wholesaler's equilibrium profits in each of the three cases: when it sells the nSR input, when it sells the SR input and issues green bonds and when it sells the SR input without issuing green bonds. We then compare equilibrium profits in each of the cases to understand when the wholesaler chooses to sell the SR input and when it chooses to issue green bonds.

We show that one of the keys to whether the wholesaler sells the SR input and whether it issues green bonds is how effectively it extracts consumer contributions through the sale of its input to retailers. Specifically, while selling the end product to consumers, retailers "skim" part of their contributions off as additional profits. How much of the consumers' contributions flow through to the wholesaler is a key to determining its choice. The other key to determining the choice is how consumers determine whether they will contribute to socially responsible activities by buying socially responsible end products or paying a premium for the wholesaler's green bonds. The issuance of green bonds diverts some contributions from the product market to the bond market. We show that the magnitude of the diversion

combines with the amount retailers skim from retail sales to determine whether the wholesaler issues green bonds or not.

Our main results focus on how the wholesaler's choice varies with the main parameters of our model. Consider, for example, the impact of competition in the retail market as measured by the number of retailers. If competition is weak, the number of retailers is small, they are able to skim a larger portion of the consumers' contributions making it difficult for the wholesaler to profitably engage in socially responsible activities. This is a previously unrecognized aspect of the well-known double-marginalization problem. Thus, in interior solutions (when all three of the wholesaler's options are chosen for different levels of competition), when competition is weak, the wholesaler sells the nSR input. It is just not profitable to sell a SR input. However, as competition in the retail market increases, the amount of contributions the wholesaler can capture increases. But, because the retailers are still skimming a significant portion of them, the wholesaler finds it optimal to divert some consumer contributions to the purchase of green bonds. We show that, by using both methods for capturing contributions, the wholesaler captures more of the contributions in total than by selling the SR input without issuing green bonds. Finally, when the retail market is very competitive, the retailers skim so little of the consumers' contributions that diverting them to the purchase of green bonds is not optimal. Thus, the wholesaler reverts to simply selling the SR input without issuing green bonds.

We obtain similar results when we study the effect of changes in (a) the importance of the wholesaler's input in the production of the end product, (b) the consumers' willingness to contribute to socially responsible activities, and (c) how visible the wholesaler's socially responsible activities are to consumers. In each of these cases, in an interior solution, the wholesaler chooses to sell the nSR input when its ability to capture the consumers' contributions from the retail market is low, sells the SR input and issues green bonds when its ability to capture the consumers' contributions from the retail market is moderate and sells the SR input without issuing green bonds when its ability to capture the contributions is high. (See Figure 1) In contrast, increases in the premia paid for green bonds strictly increase the likelihood that the wholesaler issues green bonds and increases in the fixed costs of producing the SR input strictly reduce the likelihood that the wholesaler sells the SR input.

Our results on the importance of the wholesaler's input in the production of the product sold by retailers may help explain why Apple chose to issue green bonds to finance recycling of used iPhones. Recycling costs are a small enough portion of the production costs of a new iPhone that Apple may not be able to extract sufficient contributions from the sale of new iPhones without issuing green bonds.[35] It may also help to explain why ocean-going transport vessels have not been converted to greener engines (transport costs are usually a very small portion of the costs of producing retail products) and why environmentalists are hopeful that growth of the green bond market will offer a means for financing the conversion. These results also offer an explanation for why jewelers readily adopted conflict-free diamonds (they are a significant input in the production of diamond jewelry) but electronics sellers seem to require government intervention to reduce the use of conflict minerals (conflict minerals are a small portion of the costs of producing electronics).

Our results on the effects of the magnitude of consumers' contributions and visibility suggest that the significant increase in consumer awareness of the impact of climate change may be partly responsible for why green bonds were initially focused on financing green energy projects. These results may also explain why cereal manufacturers purchase sustainably grown grains without their suppliers issuing green bonds. Consumers highly value these socially responsible activities and their use is quite visible making it more profitable for the wholesaler to extract their contributions from the sale of socially responsible inputs without diverting contributions to the purchase of green bonds. Finally, our model suggests that funding ethical labor practices, promoting diversity or providing humanitarian aid will likely involve issuing green bonds because these types of wholesaler socially responsible activities are relatively invisible to end consumers.

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ENDNOTES

[1] Examples of SRPs are those produced using sustainable materials (green energy, grown organically, etc.), those that avoid conflict minerals as inputs, or those whose purchase is linked to the seller's socially responsible efforts (supporting fair trade coffee, ethical labor policies, corporate volunteerism, energy efficiency, recycling activities, disaster relief, etc.).

[2] Originally, green bonds funded environmentally friendly projects and social, social impact or impact bonds funded other socially responsible projects. However, following the Paris Accords, projects satisfying the Green Bond Principles were expanded to cover all qualifying socially responsible projects, not just environmentally friendly projects (Klevan, 2016). For this reason, and because the distinction is not important in this paper, we will simplify our discussion by referring to all types of bonds where the issuer pledges to use the proceeds to support socially responsible activities, including environmentally friendly activities, as green bonds.

[3] Investors in green bonds need to be concerned that the funds may not be used to support socially responsible projects. To help resolve this concern over greenwashing, the International Capital Market Association developed the Green Bond Principles—guidelines issuers can voluntarily agree to follow (International Capital Market Association, 2015, 2017). In addition to the principles (discussed below), issuers are strongly encouraged to employ auditors and third-party assurance to further relieve concerns about the use of funds raised through the sale of green bonds.

[4] Flammer (2018), Preclaw and Bakshi (2015), RILA (2017), and Zerbib (2019) document the financial benefits to the issuer of corporate green bonds. Interestingly, Flammer (2018) shows that the stock market response to the issuance of green bonds is positive and issuers have better long-term performance as measured by ROA and Tobin's *Q*. Flammer also shows that the environmental performance of issuers improves suggesting that the commitment to socially responsible activities is kept. A more complete discussion of the benefits from issuing green bonds is presented in the next section.

[5] Examples that fit this structure are retailers who purchase packaging using postconsumer recycled paper from a wholesaler; retailers who purchase environmentally friendly shipping methods to transport inputs; or retailers who sell organic products made with organic inputs supplied by wholesalers.

[6] Here and throughout the paper, we focus our discussion on "interior" solutions: when all three choices (selling the nSR input, selling the SR input and issuing green bonds (when possible) and selling the SR input without issuing green bonds) are the wholesaler's optimal choice for different sets of parameters. "Corner solutions" arise, for example, when the increased costs of producing the SR input exceed the end consumers' willingness to contribute to the socially responsible activity or when the costs of producing the SR input and nSR input are identical. In the first case, regardless of how competitive the retail market is, the wholesaler only chooses to sell the nSR input. In the second case, the wholesaler only chooses to sell the SR input.

[7] This result also offers an alternative explanation for the empirical observation that firms engage in more corporate social responsibility (CSR) activity when they are in more competitive markets. See Fernandex-Kranz and Santalo (2010) and the references therein.

[8] The wholesaler's socially responsible activities that likely are less visible to end consumers include ethical labor practices, disaster relief assistance, and diversity initiatives. These are likely less visible partly because end consumers may find it difficult to "verify" the activity and partly because the end consumers would need to know which firms are in the retailer's supply chain.

[9] Technically, Apple is not a pure wholesaler in that it sells iPhones directly to consumers as well as selling them to other retailers. This deviation from our formal model should not have a significant impact on our results.

[10] According to Mirova (2014), the first social impact bond, a vaccine bond, was issued in 2006. Others attribute the issuance of the first social impact bond to Social Finance, LTD, and the British Ministry of Justice who issued the bond in 2010 to fund projects that sought to reduce prisoner recidivism (Cision, 2011). The first green bond appears to have been issued in 2007 by the European Bank for Reconstruction and Development (Schroders, 2015).

[11] Other corporate issuers include GDF Suez, Vestas, Unilever, Solar City, Regency Centers, Stockland, Southern Company and Credit Agricole CIB (Loveless, 2015; Moody's, 2017; RILA, 2017). Recently, a number of U.S. banks have issued green bonds to create funds used to lend to smaller businesses that seek to finance socially responsible projects. See Moody's (2017) for a list of all green bonds issued in 2016.

[12] Anecdotally, 40% of Unilever's issuance of sterling-denominated green bonds were purchased by those outside Britain, an uncommon feature of sterling issued bonds (*The Economist*, 2014).

[13] For example, the Massachusetts State College Building Authority issued "green bonds" to fund new parking garages. Despite their claim that the bonds were green because they intended to reserve spots for carpoolers and to provide electric car charging stations, most investors were skeptical that they qualified as green bonds (Cherney, 2015).

[14] An example of third-party auditing and certification is EY's reasonable assurance statement regarding ANZ's 2015 green bond issuance (EY, 2015b).

[15] Academic literature on "private" certification includes Bagnoli and Watts (2017), Fischer and Lyon (2014), Heyes and Martin (2017), Kotowski, Weisbach, and Zeckhauser (2014), and Lyon and Maxwell (2011).

[16] There are excellent surveys of the CSR literature. See, for example, Crane, McWilliams, Matten, Moon, and Siegel (2008) or Lyon and Maxwell (2008) who offer thorough overviews of the CSR literature, Orlitzky et al. (2011) who synthesize three strands of the strategic CSR literature, Kitzmuller and Shimshack (2012) who offer a taxonomy that relates the strategic with the non-strategic CSR literature,

Crifo and Forget (2015) who link strategic CSR and ethical CSR and Schmitz and Schrader (2015) who review the theoretical and empirical CSR literature. Benabou and Tirole (2010) offer an interesting perspective on how individual and corporate social responsibility interact to attain social goals.

[17] There is a substantial empirical literature that evaluates whether firms that engage in CSR activities are more profitable. Much of this literature is discussed in the surveys mentioned previously and generally finds mixed support for a positive relationship between firm profits and CSR activities. However, this literature struggles to address the endogeneity problem (unobservable characteristics likely impact both the firm's profitability and its decision to engage in CSR activities). Flammer (2015a) has recently offered a means of addressing this endogeneity issue using a regression discontinuity approach and provides evidence that CSR activities do increase firm performance whether measured by stock prices or accounting performance measures. Flammer (2015b) uses exogenous trade liberalization to address the endogeneity issue and again finds that increases in competition (from foreign competitors) motivates domestic firms to increase their CSR activity.

[18] Newer papers that explore different aspects of strategic CSR include Arya, Mittendorf, and Ramanan (2019), Becchetti, Palestini, Solferino, and Tesstore (2014), Belhadj, Gabszewicz, and Tarola (2013), Garcia-Gallego and Georgantzis (2009), Galbreth and Ghosh (2013), and Toolsema (2009).

[19] Most of these assumptions can be relaxed along the lines of the model used in Bagnoli and Watts (2003). Specifically, the model can be generalized so that contributors have different willingness to contribute to the socially responsible activity, including introducing a measurable set who are unwilling to contribute anything. The model can also be extended to allow retailers to choose whether the product they sell is an SRP. Doing so makes the analysis more complex but does not alter the nature of our results.

[20] The assumption that the other inputs are purchased in competitive markets allows the wholesaler selling the SR input to capture more of the contributions to the socially responsible activity. If the other inputs are not sold in competitive markets, these suppliers can and will "skim" off part of the retailers' extra profits from selling the SRP leaving less for the producer of the SR input.

[21] If the wholesaler's maximal profits are negative, it would prefer to sell no units of the SR input. We ignore this issue for the moment because, when we compare the wholesaler's profits from selling the SR input to its profits from selling an input not connected to socially responsible activities, the issue will disappear.

[22] Our model simplifies the retailers' supply chain by assuming that they buy the SR input directly from the wholesale manufacturer. Had we assumed that the SR input was used in the production processes of firms in the retailers' supply chains, we would have obtained a similar result. The more firms in the supply chain between the retailer and the manufacturer of the SR input, the more difficult it is for the producer of the SR input to capture contributions to the socially responsible activity from end consumers.

[23] The wholesaler's choice is much less interesting if the marginal cost of producing the SR input is smaller than the marginal cost of producing the nSR input which is why we assume that $x \geq x_n$.

[24] If any retailer or the wholesaler "personally" benefits from contributing to the socially responsible activity, this would come at the expense of profits and bias our results in favor of the wholesaler offering the SR input.

[25] If there are frictions such as switching costs, they bias this decision in favor of not changing the choice. That is, if the wholesaler is offering the SR input, it is willing to switch to selling the nSR input only if $\pi_n^* - \pi^*$ exceeds the cost of switching. Similarly, if the wholesaler is offering the nSR input, the profit benefit to switching to selling the SR input must exceed the costs of switching.

[26] "More likely" is formalized as follows. Let $\phi \equiv (\alpha, \beta, \tau, \lambda, n, F, x, x_n, \sum_{k=2}^{m+1} \gamma_k w_k) \in \Phi \subseteq \mathscr{R}^9$ and let $\phi_{\sim i}$ be ϕ with the i^{th} element deleted. Next, assume that $f(\phi) > 0$ is a probability density function defined on Φ and $f_i(\phi_{\sim i}) > 0$ is a probability density function defined on $\Phi_{\sim i}$. Let G be the set of ϕ such that (1) is satisfied and N the set such that (1) fails. Given this, "more likely" is defined as an increase in the probability that $(\phi_{\sim i}, i) \in N$.

[27] Intuitively, we are assuming that a consumer's willingness to contribute to the socially responsible input does not depend on how the wholesaler seeks to capture (part of) this willingness to pay. It would be straightforward to extend the analysis to allow consumers to have preferences for owning green bonds beyond their willingness to contribute to socially responsible input. Such an extension would not qualitatively alter our analysis.

[28] Recall that these arguments require that buyers of green bonds be assured that receipts will be applied to green activities. The green bond market seems to be solving this concern by developing and adhering to the voluntary principles for identifying bonds as green bonds, as discussed in the previous section.

[29] To avoid added complications, we are assuming that all other benefits that accrue to the issuer of green bonds can be captured in δ too. Also, if the issuance of green bonds alters the consumers' willingness to pay to support socially responsible activities either because it enhances the credibility of the wholesaler's socially responsible activities or makes them more visible, then β would increase. This would enhance the value of issuing green bonds but otherwise not affect the qualitative nature of our results.

[30] If we introduced Cournot competition at the wholesale level, it would reduce each wholesalers profits relative to the expression in Proposition 5 and reduce the potential benefits from selling the SR input. As long as we continue to focus on interior solutions, competition alters the specifics of our analysis but not our qualitative results.

[31] Again, introducing frictions such as switching costs requires the profit benefit to switching to exceed the switching costs but does not qualitatively alter our results.

[32] Throughout, we have referred to the proceeds from the issuance of green bonds as funding the wholesaler's fixed costs of producing the SR input. If, instead, the financial benefits from issuance were used to lower the wholesaler's total variable costs, our analysis would still apply. The key is that issuing green bonds provides funds that are not obtained on a per-unit of input produced basis and thus cannot lower x.

[33] If we were not examining an interior solution, it is possible that the lost profits never exceed the benefits from issuing green bonds and the wholesaler would never choose to sell the SR input without issuing green bonds.

[34] By a socially responsible input we mean that the input embodies the wholesaler's socially responsible activities. Examples would include producing inputs using sustainable materials or sources (e.g., green(er) energy, organic inputs, sustainable wood products, or sustainable fishing), avoiding conflict minerals or diamonds, engaging in ethical labor policies or financing product recycling services.

[35] Apple is not a pure wholesaler because it sells some iPhones directly to consumers and the rest through retailers. Including the wholesaler as a retailer in our model should not impact our main results.

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REFERENCES

Arya, A., & Mittendorf, B. (2014). *A supply side explanation for the use of cause marketing* (working paper). The Ohio State University, Columbus, OH.

Arya, A., Mittendorf, B., & Ramanan, R. (2019). Beyond profits: The rise of dual-purpose organizations and its consequences for disclosure. *The Accounting Review*, *94*(1), 25–43.

Bagnoli, M., & Watts, S. (2003). Selling to socially responsible consumers: Competition and the private provision of public goods. *Journal of Economics and Management Strategy*, *12*(3), 419–445.

Bagnoli, M., & Watts, S. (2017). Voluntary assurance of voluntary CSR disclosure. *Journal of Economics & Management Strategy*, *6*(1), 205–230.

Baron, D. (2001). Private politics, corporate social responsibility and integrated strategy. *Journal of Economics and Management Strategy*, *10*(1), 7–45.

Baron, D. (2007). Corporate social responsibility and social entrepreneurship. *Journal of Economics and Management Strategy*, *16*(3), 683–717.

Baron, D. (2009). A positive theory of moral management, social pressure, and corporate social performance. *Journal of Economics and Management Strategy*, *18*(1), 7–43.

Baron, D. (2011). Credence attributes, voluntary organizations, and social pressure. *Journal of Public Economics*, *95*(2011), 1331–1338.

Becchetti, L., Palestini, A., Solferino, N., & Tesstore, M. (2014). The socially responsible choice in a duopolistic market: A dynamic model of "ethical product" differentiation. *Economic Modelling*, *43*(1), 114–123.

Belhadj, N., Gabszewicz, J. J., & Tarola, O. (2013). *Social awareness and duopoly Competition* (CORE discussion paper). Louvain-la-Neuve, Belgium. Retrieved from http://www.uclouvain.be/cps/ucl/doc/core/documents/coredp2013_43web.pdf

Benabou, R., & Tirole, J. (2010). Individual and corporate social responsibility. *Economica*, *77*(1), 1–19.

Besley, T., & Ghatak, M. (2007). Retailing public goods: The economics of corporate social responsibility. *Journal of Public Economics*, *91*(9), 1645–1663.

Chen, L., & Lee, H. (2017). Sourcing under supplier responsibility risk: The effects of certification, audit and contingency payment. *Management Science*, *63*(9), 2773–3145.

Cho, A., Fang, X., Tayur, S., & Xu, Y. (2016). Combating child labor: Incentives and information disclosure in global supply chains (working paper). Carnegie Mellon University, Pittsburgh, PA.

Climate Bond Initiative. (2015). *Bonds and climate change: The state of the market in 2015*. Retrieved from https://www.climatebonds.net/files/files/CBI-HSBC%20report%207July%20JG01.pdf

Cherney, M. (2015, March 12). Green bonds' for a parking garage? *The Wall Street Journal*. Retrieved from https://www.wsj.com/articles/green-bonds-for-a-parking-garage-1426176294

Cision PR Newswire. (2011, February 17). *Social Finance, Inc. to bring social impact bonds to the U.S*. Retrieved from https://www.prnewswire.com/news-releases/social-finance-inc-to-bring-social-impact-bonds-to-the-us-116415969.html

Crane, A., McWilliams, A., Matten, D., Moon, J., & Siegel, D. (2008). *The oxford handbook of corporate social responsibility*. Oxford: Oxford University Press.

Crifo, P., & Forget, V. (2015). The economics of corporate social responsibility: A firm-level perspective survey. *Journal of Economic Surveys*, *29*(1), 112–130.

EY. (2015a). *Impact bonds*. Ernst & Young. Retrieved from www.ey.com/Publication/vwLUAssets/ey-impact-bonds/$FILE/ey-impact-bonds.pdf

EY. (2015b, April). *Independent reasonable assurance report to the directors and management of ANZ*. EY report. Retrieved from https://www.climatebonds.net/standards/latest-certifications/anz-bank

Fernandex-Kranz, D., & Santalo, J. (2010). When necessity becomes a virtue: The effect of product competition on corporate social responsibility. *Journal of Economics and Management Strategy*, *19*(2), 453–487.

Fischer, C., & Lyon, T. (2014). Competing environmental labels. *Journal of Economics and Management Strategy*, *23*(3), 692–716.

Flammer, C. (2015a). Does corporate social responsibility lead to superior financial performance? A regression discontinuity approach. *Management Science*, *61*(11), 2549–2568.

Flammer, C. (2015b). Does product market competition foster corporate social responsibility? Evidence from trade liberalization. *Strategic Management Journal*, *36*(10), 1469–1485.

Flammer, C. (2018). *Corporate green bonds* (working paper). Boston University, Boston, MA.

Friedman, M. (1970, September 13). The social responsibility of business is to increase its profits. *The New York Times Magazine*.

Garcia-Gallego, A., & Georgantzis, N. (2009). Market effects of changes in consumers' social responsibility. *Journal of Economics and Management Strategy*, *18*(1), 235–262.

Galbreth, M., & Ghosh, B. (2013). Competition and sustainability: The impact of consumer awareness. *Decision Sciences*, *44*(1), 127–159.

Graff Zivin, J., & Small, A. (2005). A Modigliani-Miller theory of altruistic corporate social responsibility. *The BE Journal of Economic Analysis and Policy*, *5*(1), 1–21.

Guo, R., Lee, H., & Swinney, R. (2016). Responsible sourcing in supply chains. *Management Science*, *62*(9), 2722–2744.

Heyes, A., & Martin, S. (2017). Social labeling by competing NGOs: A model with multiple issues and entry. *Management Science*, *63*(6), 1800–1813.

Hirtenstein, A. (2017, January 19). Green bond giant awakened by countries spending to save climate. *Bloomberg Markets*. Retrieved from https://www.bloomberg.com/news/articles/2017-01-20/green-bond-giant-awakened-by-countries-spending-to-save-climate

International Capital Market Association. (2015). *Green bond principles 2015: Voluntary process guidelines for issuing green bonds*. Retrieved from https://www.icmagroup.org/assets/documents/Regulatory/Green-Bonds/GBP_2015_27-March.pdf

International Capital Market Association. (2017). The green bond principles 2017. Retrieved from https://www.icmagroup.org/Regulatory-Policy-and-Market-Practice/green-social-and-sustainability-bonds/green-bond-principles-gbp/

JP Morgan.(2014, January 13). *Green bond principles created to help issuers and investors deploy capital for green projects*. Retrieved from https://www.jpmorgan.com/country/US/en/detail/1389155300983

Kitzmuller, M., & Shimshack, J. (2012). Economic perspectives on corporate social responsibility. *Journal of Economic Literature*, *50*(1), 51–84.

Klevan, Y. (2016, October 24). *Fixed income investments in a carbon conscious world*. Lazard Asset Management Research Report. Retrieved from http://www.lazardnet.com/investment-research/

Kotowski, M., Weisbach, D., & Zeckhauser, R. (2014). Audits as signals. *University of Chicago Law Review*, *81*(1), 179–202.

KPMG. (2015, May). Gearing up for green bonds. *KPMG International Sustainable Insight*. Retrieved from https://home.kpmg.com/bh/en/home/insights/2015/10/sustainable-insight-gearing-up-for-green-bonds.html

Larsen, K. (2017, January 25). *Why green bonds are reaching record highs*. Retrieved from https://www.greenbiz.com/article/why-green-bonds-are-reaching-record-highs

Loveless, B. (2015, March 29). Corporate bonds show green shoots. *USA TODAY*. Retrieved from https://www.usatoday.com/story/money/business/2015/03/29/green-bonds-clean-efficient-energy-technology/70558344/

Lyon, T., & Maxwell, J. (2008). Corporate social responsibility and the environment: A theoretical perspective. *Review of Environmental Economics and Policy*, *26*(2), 164–181.

Lyon, T., & Maxwell, J. (2011). Greenwash under the threat of audit. *Journal of Economics and Management Strategy*, *20*(1), 3–41.

McWilliams, A., Siegel, D., & Wright, P. (2006). Corporate social responsibility. *Journal of Management Studies*, *43*(1), 1–18.

Mirova. (2014, May 2). *SRI bond funds are set to sail on the rising tide of green and social bonds*. Mirova Responsible Investing Focus report.

Moodie, A. (2016, March 20). Can Apple's $ 1.5bn green bond inspire more environmental investments? *The Guardian*. Retrieved from https://www.theguardian.com/sustainable-business/2016/mar/20/apple-green-bond-environment-energy-toyota-climate-change

Moody's. (2017, January 13). *Record year for green bonds likely to be eclipsed again in 2017*. Moody's Investor Service. Retrieved from https://www.moodys.com/research/Moodys-Global-green-bond-issuance-could-rise-to-USD206B-in-PR_360880

NEPC. (2015, November). *Green bonds: An overview*. NEPC Impact Investing Committee. Retrieved from www.nepc.com/insights/green-bonds-an-overview

Orlitzky, M., Siegel, D., & Waldman, D. (2011). Strategic corporate social responsibility and environmental sustainability. *Business & Society*, *50*(1), 6–27.

Plambeck, E., & Taylor, T. (2015). Supplier evasion of a buyer's audit: Implications for motivating supplier social and environmental responsibility. *Manufacturing & Service Operations Management*, *18*(2), 184–197.

Preclaw, R., & Bakshi, A. (2015, September 18). *The cost of being green*. Barclay's Credit Research. Retrieved from https://www.environmental-finance.com/content/research/the-cost-of-being-green.html

RILA. (2017). *Green bonds.* Retail Industry Leaders Association. Retrieved from www.rila.org/sustainability/./Documents/GreenBondsPrimer.pdf

Schroders. (2015, July). Green bonds—A primer. *Schroders TalkingPoint.* Retrieved from http://www.schroders.com/en/uk/tp/markets2/markets/green-bonds-nascent-market-to-play-vital-role/

Schmitz, J., & Schrader, J. (2015). Corporate social responsibility: A microeconomics review of the literature. *Journal of Economic Surveys*, *29*(1), 27–45.

Siegel, D., & Vitaliano, D. (2007). An empirical analysis of the strategic use of corporate social responsibility. *Journal of Economics and Management Strategy*, *16*(3), 773–792.

Social Finance, Inc. (2011, February 17). Social Finance, Inc. to Bring Social Impact Bonds to the U.S. *Cision PR Newswire*. Retrieved from www.prnewswire.com/news-releases/social-finance-inc-to-bring-impact-bonds-to-the-us-116415969.html

The Economist. (2014, July 4). *Green grow the markets, O. The Economist*. Retrieved from https://www.economist.com/news/finance-and-economics/21606326-market-green-bonds-booming-what-makes-bond-green-green-grow

The Economist. (2017, March 11). Green finance for dirty ships. *The Economist*. Retrieved from https://www.economist.com/news/finance-and-economics/21718519-new-ways-foot-hefty-bill-making-old-ships-less-polluting-green-finance

Toolsema, L. (2009). Interfirm and intrafirm switching costs in a vertical differentiation setting: Green versus nongreen products. *Journal of Economics and Management Strategy*, *18*(1), 263–284.

Wolf, D. (2017, April 7). Bond of the year: Social and sustainability—Starbucks. *Environmental Finance*. Retrieved from https://www.environmental-finance.com/content/awards/green-bond-awards-2017/winners/bond-of-the-year-social-and-sustainability-starbucks.html

Zerbib, O. (2019). The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *Journal of Banking and Finance*, *98*(1), 39–60.

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APPENDIX A

Proof of Proposition 1. When the wholesaler sells the SR input, the first-order condition for each retailer's profit maximization problem can be written as

$$q_i(w) = \frac{1}{2}\left[\alpha + \tau\beta - w - \sum_{k=2}^{m+1}\gamma_k w_k - \lambda\sum_{j\neq i} q_j\right], \quad i = 1, 2, ..., n.$$

Solving this system of equations yields

$$q_i^*(w) = \left(\frac{1}{2 + \lambda(n-1)}\right)\left[\alpha + \tau\beta - w - \sum_{k=2}^{m+1}\gamma_k w_k\right], \quad i = 1, 2, ..., n.$$

Summing yields the total sales of the SRP by all retailers which is also equal to their demand for the SR input. □

Proof of Proposition 2. The first-order condition for the wholesaler's profit maximization problem when it chooses to sell the SR input is

$$0 = Q^*(w) + (w - x)\frac{\partial Q^*(w)}{\partial x}.$$

Substituting for $Q^*(w)$ rearranging yields

$$w^* = \frac{1}{2}\left(\alpha + \tau\beta + x - \sum_{k=2}^{m+1}\gamma_k w_k\right).$$

Substituting w^* into the wholesaler's profits yields the expression in the proposition. □

Proof of Proposition 3. When the wholesaler sells the nSR input, the first-order condition for the retailer's profit maximization problem is

$$q_i(w) = \frac{1}{2}\left[\alpha - w - \sum_{k=2}^{m+1}\gamma_k w_k - \lambda\sum_{j\neq i} q_j\right], \quad i = 1, 2, ..., n.$$

Solving this system of equations yields

$$q_n^*(w) = \left(\frac{1}{2 + \lambda(n-1)}\right)\left[\alpha - w - \sum_{k=2}^{m+1}\gamma_k w_k\right], \quad i = 1, 2, ..., n.$$

Summing yields the total sales of the not SRP by all retailers which is also equal to their demand for the nSR input,

$$Q_n^*(w) = n\left(\frac{1}{2 + \lambda(n-1)}\right)\left[\alpha - w - \sum_{k=2}^{m+1}\gamma_k w_k\right].$$

The first-order condition for the wholesaler's profit maximization problem when it chooses to sell the nSR input is

$$0 = Q_n^*(w) + (w - x)\frac{\partial Q_n^*(w)}{\partial x}.$$

Substituting Q_n^* into the wholesaler's first-order condition and rearranging yields

$$w_n^* = \frac{1}{2}\left(\alpha + x - \sum_{k=2}^{m+1}\gamma_k w_k\right).$$

Substituting w_n^* into the wholesaler's profit function yields

$$\pi_n^* = \frac{1}{4}\left(\frac{n}{2 + \lambda(n-1)}\right)\left[\alpha - x - \sum_{k=2}^{m+1}\gamma_k w_k\right]^2$$

the expression in Proposition 3. □

Proof of Proposition 4. A shown in the text, if Equation (1) is satisfied, then the wholesaler earns great profits from selling the SR input than from selling the nSR input. Since $[4(2 + t(n-1))/n]F > 0$ when $F > 0$, the condition fails if $\tau\beta - x + x_n \leq 0$ because variable profits from selling both the SR input and the not SR input are positive.

Turning to the other case, when $\tau\beta - x + x_n > 0$, consider a parameter constellation $\phi = (\alpha, \beta, \tau, t, n, F_2, x, x_n, \sum_{k=2}^{m+1}\gamma_k w_k)$ when (1) holds with equality and consider $F > F_2$ such that

$$(\tau\beta - x + x_n)\left[\left(\alpha + \tau\beta - x - \sum_{k=2}^{m+1}\gamma_k w_k\right) + \left(\alpha - x_n - \sum_{k=2}^{m+1}\gamma_k w_k\right)\right] < \left(\frac{4(2 + \lambda(n-1))}{n}\right)F. \tag{A1}$$

Thus, there is an open neighborhood around $\phi_{\sim F}$ that maintains the inequality in (A1) which implies that the set of $\phi_{\sim F}$ for which (A1) holds is larger. Since $f > 0$, this implies that the probability that $(\phi_{\sim F}, F) \in N$ rises. The

remaining claims are proved the same way by letting i_2 (another element of ϕ) satisfy (1) with equality and choosing i so that the RHS of (1) exceeds the LHS. □

Proof of Proposition 5. When the wholesaler sells the SR input, the first-order condition for each retailer's profit maximization problem can be written as

$$q_i(w) = \frac{1}{2}\left[\alpha + \tau(1-\xi)\beta - w - \sum_{k=2}^{m+1}\gamma_k w_k - \lambda\sum_{j\neq i} q_j\right], \quad i = 1, 2, ..., n.$$

Solving this system of equations yields

$$q_i^*(w) = \left(\frac{1}{2+\lambda(n-1)}\right)\left[\alpha + \tau(1-\xi)\beta - w - \sum_{k=2}^{m+1}\gamma_k w_k\right], \quad i = 1, 2, ..., n.$$

Summing yields the total sales of the SRP by all retailers which is also equal to their demand for the SR input, $Q_g^*(w)$.

The first-order condition for the wholesaler's profit maximization problem when it chooses to sell the SR input is

$$0 = Q_g^*(w) + (w - x)\frac{\partial Q_g^*(w)}{\partial x}.$$

Substituting for $Q_g^*(w)$ rearranging yields

$$w_g^* = \frac{1}{2}\left(\alpha + \tau(1-\xi)\beta + x - \sum_{k=2}^{m+1}\gamma_k w_k\right).$$

Substituting w_g^* into the wholesaler's profits yields the expression in the proposition. □

Proof of Proposition 6. A shown in the text, if Equation (2) is satisfied, then the wholesaler earns great profits from selling the SR input than from selling the nSR input. Since $[4(2 + t(n-1))/n]F > 0$ when $F > 0$, the condition fails if $\tau(1-\xi)\beta - x + x_n \leq 0$ because variable profits from selling both the SR input and the nSR input are positive.

Turning to the other case, when $\tau(1-\xi)\beta - x + x_n > 0$, consider a parameter constellation $\phi = (\alpha, \beta, \tau, t, n, F_2, x, x_n, \xi, \delta, \sum_{k=2}^{m+1}\gamma_k w_k)$ when (2) holds with equality and consider $F > F_2$ such that

$$(\tau(1-\xi)\beta - x + x_n)\left[\left(\alpha + \tau(1-\xi)\beta - x - \sum_{k=2}^{m+1}\gamma_k w_k\right) + \left(\alpha - x_n - \sum_{k=2}^{m+1}\gamma_k w_k\right)\right] < \left(\frac{4(2+\lambda(n-1))}{n}\right)F. \tag{A2}$$

Thus, there is an open neighborhood around $\phi_{\sim F}$ that maintains the inequality in (A2) which implies that the set of $\phi_{\sim F}$ for which (A2) holds is larger. Since $f > 0$, this implies that the probability that $(\phi_{\sim F}, F) \in N$ rises. The remaining claims are proved the same way by letting i_2 (another element of ϕ) satisfy (2) with equality and choosing i so that the RHS of (2) exceeds the LHS. □

Proof of Proposition 7. The wholesaler chooses to sell the SR input and issue green bonds if its profits π_g^* exceed its profits from selling the nSR input (π_n^*) *and* its profits from selling the SR input without issuing green bonds (π^*). $\pi_g^* \geq \pi_n^*$ if (2) holds (equivalently condition (iii) of Proposition 7). Since the right-hand side is strictly positive and since the term in brackets is strictly positive because variable profits from selling the SR input and the nSR input are positive, a necessary condition for (iii) to hold is $\tau(1-\xi)\beta - x + x_n > 0$. If it fails, then both

Equations (1) and (2) are not satisfied and the wholesaler optimally chooses to sell the nSR input. Thus, condition (i) is necessary for the wholesaler to sell the SR input.

When condition (i) holds, the wholesaler chooses to sell the SR input and issue green bonds if $\pi_g^* \geq \pi^*$ and $\pi_g^* \geq \pi_n^*$. As shown in the text, Equation (3) ensures that $\pi_g^* \geq \pi^*$ which is condition (ii) of the proposition. Similarly, Equation (2) ensures that $\pi_g^* \geq \pi_n^*$ which is condition (iii) of the proposition. □