Financial Market Structure for ESG Integration

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Abstract

ESG integration is difficult to be achieved because borrowers can often deviate from their promises *ex-post*. We find that borrowers prioritize ESG to reduce borrowing costs when their interest repayment steeply increases with financial returns. Competition between green and brown lenders could indeed lower the overall borrowing rate and induce borrowers to pursue financial profits. Nevertheless, when borrowers privately know their genuine preferences for ESG and when green lenders finance brown borrowers first, subsequent brown lenders perceive the holdout borrowers as ESG-friendly and demand a high borrowing rate. This in turn incentivizes the borrowers to minimize their borrowing costs by pursuing ESG.

Keywords: Socially responsible investments, ESG, moral hazard, adverse selection, financial market structure, greenwashing

JEL Codes: D82, D86, G23, G31

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1 Introduction

ESG integration is difficult to be achieved because borrowers can deviate from their promises ex-post. Indeed, no accounting standard has yet defined and guided how to measure firms' ESG performance. Furthermore, the claims that firms make on ESG are mostly voluntary disclosure and hard to verify. All these informational frictions around ESG activities make proper monitoring of the ESG follow-through difficult (U.S. Securities and Exchange Commission, 2022; Bebchuk and Tallarita, 2020; Christensen, Hail and Leuz, 2021).

This paper theoretically identifies the financial market structures that can facilitate ESG integration. In our model, a firm can undertake one of two investment projects: *(i)* the ESG-friendly (henceforth "green") project that yields a binary stochastic financial return with a low probability of success while generating social return realized in the form of externality, or *(ii)* the non-ESG (henceforth "brown") project that yields a binary stochastic financial return with a high probability of success but zero social return. The firm is assumed to value both net financial income and social return from its investment but with different weights. The firm is further assumed to be cashless, so it must borrow from one of the outside lenders to finance its project with a promise to repay, contingent on the success of its investment. Two different groups of lenders compete to finance the firm's project. One group of lenders is the "green" type, which equally values the financial income and the externality generated by the firm's investment. The other group of lenders is the "brown" type that cares only about the financial payoff.

A crucial assumption in our model is that no lender can attach a binding covenant to her financial contract that restricts the borrowing firm's investment decision (i.e., the firm cannot commit to its project selection *ex-ante*). That is, lenders can offer a contract only with a financial repayment term — an amount of the financial return promised to be repaid. Our assumption incorporates the idea that claims of ESG investment practices are difficult to verify due to the lack of a disclosure mandate for such ESG claims. This unverifiability of ESG claims can easily lead to greenwashing, as empirically documented by Raghunandan and Rajgopal (2022*a*), Baker et al. (2023), Kim and Yoon (2022) and Liang, Sun and Teo (2022). Under our assumption, the repayment amount is the only contractual instrument influencing the firm's incentive to make ex-post project selections. Indeed, the most favorable contract offer to the firm will be the one that charges the smallest repayment.

We find that the firm has an incentive to choose the green project only if the repayment term is sufficiently high. The intuition is twofold. First, the firm can effectively save the total expected repayment by shifting risk to the green project, which has a smaller probability of success and thus fulfilling the repayment obligation. This benefit of lowering the borrowing cost increases with the repayment amount, thereby incentivizing the firm to save the repayment by choosing the green project (Chang, Rhee and Yoon, 2024). Second, the firm endogenously values social return more than the financial payoff from its investment as the repayment increases. This is because a large portion of the financial return will be paid out to the lender regardless of the likelihood of the firm's project generating a high financial return (Chowdhry, Davies and Waters, 2019). In this regard, a high financial repayment term effectively aligns the incentives between the firm and green lenders.

We further find that the presence of brown lenders deters, rather than facilitates, green investments. Suppose there are only green lenders in the capital market first. Recall that green lenders fully incorporate the externality of the firm's investment into their payoffs. Thus, any green lender, even if she deviates and offers a contract to induce brown investment, must charge a "dirty" premium for forgoing the positive externality of green investments. This "dirty" premium attached to the financial repayment raises the cost of borrowing from the deviating green lender, leading the firm either to reject the deviation offer outright or to accept it but choose the green project.

However, if present in the market, brown lenders would be willing to charge a small repayment as long as the firm, in response, is believed to choose the brown project with a small default risk. Under the competition with brown lenders, green lenders cannot effectively raise the firm's borrowing cost in equilibrium. Indeed, the firm strictly prefers lowering the cost of borrowing no matter which of the two projects it selects *ex-post*. Thus, the firm will reject any offer with a financial repayment larger than the brown lenders' offer, resulting in brown investments.

Nevertheless, green lenders can play a crucial role in achieving ESG integration in the presence of adverse selection on the firm's preference for social value. Specifically, we extend our model by assuming that the firm can be of two types: *(i)* the "green" firm that values the social return from its investment, or *(ii)* the "brown" firm that places a smaller weight on the social return than the green type. Only the firm privately knows its type, which can create an adverse selection problem in the capital market. In this extension, a key question is whether and how the brown firm is incentivized to choose the green project. Particularly, we analyze the role of competition structure in ESG integration. In this context, we consider some green lenders place bids to finance first, whereas the rest of the lenders subsequently offer only after the firm rejects all offers from the first-moving green lenders.[1] In such a structure, the firm's rejection to borrow in the earlier market may endogenously provide additional information to the later lenders about the firm's inherent preference for social value.

An endogenous posterior belief formation naturally leads to multiple equilibria. Among them, we find an equilibrium in which the brown firm with certainty invests in the green project. In this equilibrium, the first-moving green lenders "cleanse" the capital market by funding, and thus taking out, the brown firm first. By doing so, the holdout firm that does not borrow in the earlier market is likely to be the green type. The subsequent brown lenders then require a large financial repayment because they anticipate the holdout firm will choose the green project with a high financial risk. This large repayment in turn incentivizes the firm, regardless of its type, to select the green project. That is, the first-moving green lenders cleanse the subsequent market by leaving the green firm as the likely borrower to whom brown lenders provide capital. Furthermore, the green lenders in the earlier market rationally infer that the brown firm cannot finance its project cheaply in the subsequent market after rejecting to borrow in the earlier market. Hence, it is optimal for the green lenders in the earlier market to offer the same hefty financial repayment as the subsequent brown lenders. Thus, the brown firm must borrow from the first-moving green lenders with a large repayment obligation and choose the green project correspondingly for the purpose of saving the repayment. In sum, green lenders cleanse the earlier capital market by raising the overall borrowing cost of the brown firm, eventually incentivizing the brown firm to choose the green project.

Currently, regulators are considering potential ESG mandates. Still, there are serious challenges to this because the scope of ESG disclosure is not agreed upon and is in the nascent stages of being verified. As a result, the costs and benefits of regulating ESG performance are not well assessed (Christensen, Hail and Leuz, 2021; Gipper, Ross and Shi, 2022; Serafeim and Yoon, 2022). Against this backdrop, our analysis has an important policy implication for facilitating ESG integration. First, promoting competition between brown and green lenders must be accompanied by proper monitoring of the firms' follow-through. Particularly, in the presence of brown lenders, competition between green and brown lenders will lower the overall borrowing cost, which may adversely incentivize firms to behave privately against the interest of green lenders. Second, given that some green lenders hold an incumbency advantage in the capital market (e.g., the case of Japanese GPIF), granting fair competition opportunities

[1] We note that this is a very plausible scenario. For example, the Japanese Government Pension Investment Fund (GPIF), the world's largest pension fund and advocate of ESG, has been allocating only to asset managers and firms that incorporate ESG. Given their market power and existing relationships with borrowers, borrowers are likely to seek out the GPIF again to finance their projects.

to new entrant lenders may weaken the role of the incumbent green lenders in "cleansing" the market. Such policies can adversely reduce the efficiency of resource allocation to ESG integration.

The remainder of this paper proceeds as follows. Section 2 presents our model and Section 3 analyzes a baseline case. In Section 4, we provide equilibrium analysis in adverse selection. Section 5 discusses related literature and Section 6 concludes. Proofs are deferred to the Appendix.

2 Model

Consider an economy that consists of a firm and lenders. Lenders make contract offers to fund the firm's financial project. The firm accepts the most favorable offer and then chooses a financial project. The firm's project generates returns at the game's end, which will be accrued to the lenders and the firm according to the financial contract.

The firm can undertake a financial project that generates financial and social returns. Specifically, the firm can undertake either "green" (indexed by G) or "brown" (indexed by B) project.[2] Both projects require a unit of initiation cost paid in financial wealth. However, the firm is assumed to be endowed with zero wealth, so it must externally finance its project by borrowing from outside lenders. If the firm invests in the green project, it generates a positive financial return R with probability $p_G \in (0, 1)$ and nothing with probability $1 - p_G$. The investment in the green project also generates a non-financial positive externality $\phi > 0$, which refers to the social benefit from ESG integration, which is commonly shared by all players. If the firm invests in the brown project, it generates the same positive financial return R with probability $p_B \in (0, 1)$ and nothing with probability $1 - p_B$. However, unlike the green project, the brown project does not generate any externality.

For the relevance of the analysis, we assume the following:

Assumption 1. *(i)* $p_G < p_B$; *(ii)* $p_G R \geq 1$.

Assumption 1-(i) means that the net present (financial) value (NPV) of the brown project is strictly higher than the green project. Assumption 1-(ii) means that both projects

[2] Our primary focus is a potential incentive (mis-)alignment between the firms who conduct capital budgeting of new ESG projects and new outside lenders who finance the firms' new projects. For analytical simplicity, we abstract an agency problem within the firm from the current paper.

are non-negative NPV. This assumption is introduced to rule out a trivial outcome in which the green project is not funded simply because of a negative NPV. Furthermore, this assumption is also consistent with papers such as Edmans (2011), Khan, Serafeim and Yoon (2016), and Bolton and Kacperczyk (2021) that find certain ESG investments can enhance shareholder value.

We further assume that the firm is risk neutral, and its utility is a linear weighted sum of net financial income and externality. Formally, the firm's utility is calculated by adding the externality of the firm's investment with weight $\lambda \geq 0$ to the firm's net financial income. The parameter λ herein represents the firm's innate preference for the non-financial social return of its new investment project during the capital budgeting process. The higher λ, the more the firm cares about the social consequences of the new investment than financial profit.

This assumption of the firm's innate preference for social value can be justified by the previous studies that find socially responsible investors willingly forgo some expected financial returns for social or moral considerations (Renneboog, Ter Horst and Zhang, 2008; Barber, Morse and Yasuda, 2021). Another strand of literature documents how corporate executives financially benefit from pursuing sustainability in the long run. For example, active community engagements can bring favorable regulatory, legislative, and fiscal treatments by the local government (Berman et al., 1999; Freeman, 2010; Hillman and Keim, 2001; Waddock and Graves, 1997). Furthermore, improving employee benefits enhances the productivity and morale of current employees and increases the likelihood of recruiting talent (Turban and Greening, 1997). Moreover, corporate philanthropy is an effective business strategy to build a good reputation towards customers and stakeholders (Freeman, Harrison and Wicks, 2007; Fombrun and Shanley, 1990).

Each lender is endowed with a unit of financial wealth and competes to finance the firm's project in the capital market. When the market opens, the lenders make contract offers to the firm. The firm borrows from a lender who makes the most favorable offer. If multiple lenders are making the same offer when the firm chooses to accept one of them, these lenders are equally likely to be chosen by the firm.[3] The lenders are risk-neutral and classified into two types: "green" and "brown." First, there is a finite but large number of brown lenders who

[3]In other words, we assume that the firm cannot distinguish between the identities of lenders who offer the same contract. Therefore, the firm can only sign the contract with one lender randomly chosen among these lenders.

do not have inherent preferences for the externality generated by the firm's project.[4] That is, brown lenders are akin to conventional lenders in a standard corporate finance model whose utility is equal to the net expected financial payoffs. In contrast, there is also a finite but large number of green lenders who heavily consider the social impact of the firm's investment. Specifically, the utility of green lenders is a sum of the financial payoff and the externality of the firm's investment with equal weights.

There are several assumptions about the financial market structure. First, the externality of the firm's investment is added to the utility of each green lender, although she does not fund the firm's project. Thus, when making an offer to the firm, each green lender must consider *(i)* how much financial payoff she will get and *(ii)* whether she can increase the externality of the firm's investment by financing the firm's project directly.

Second, no lender can attach any binding covenant to her contract offer that enforces the firm's ex-post project selection. We assume that a financial repayment obligation D is the only term that each lender can offer to the firm. Since the firm's project yields zero return when unsuccessful, the lenders can offer how much they will get repaid conditional on the high financial return of the firm's project.[5] This assumption is introduced to incorporate the greenwashing problem into our model. Since it is impossible for any lender to earmark the proceeds she lends to the firm for a specific project, the firm will select the financial project that serves its private interest but possibly harms some, particularly green, lenders. We will analyze how the lack of a binding green-investing covenant influences the integration of green investments.

Third, to analyze how different competition structures influence the realization of green investments, we set a baseline model and compare the equilibrium analysis results to those with alternative models with different competition structures. Specifically, we construct the baseline model by assuming that green lenders make contract offers to the firm before brown

[4]The assumption of finitely many lenders is introduced primarily for analytical convenience. Indeed, the finiteness of the lenders can rule out any perverse equilibrium in which lenders make a contract offer yielding a negative payoff ex-post. However, the equilibrium analysis remains unchanged even if there are infinitely many lenders in the model by adding the assumption that any lender, after winning the competition, has the option to default on funding if performing the contract obligation is expected to yield a net loss (Board, 2007).

[5]A state-contingent repayment $D \in [0, R]$ is equivalently expressed as a borrowing rate $r \equiv D - 1$. Furthermore, under the assumption that the firm's project yields zero return when unsuccessful, there is no issue with foreclosure when the firm fails to fulfill its repayment obligation. Indeed, offering a repayment D is the only feasible form of contract under the firm's limited liability. That is, our analysis does not depend on a specific type of security that the firm issues to finance the project. See Chang, Rhee and Yoon (2024) for a more detailed analysis of the impacts of capital structure on corporate borrowers' incentive for ESG integration.

lenders.[6] In contrast, brown lenders can make contract offers only after the firm rejects all the offers made by green lenders. Put differently, the lenders of the same type compete to fund the firm *à la* Bertrand. In contrast, green lenders have a competitive advantage *à la* Stackelberg over brown lenders. The assumption of competitive advantage held by green lenders is also consistent with the notion that some ESG-endorsing institutional lenders had opened up this new capital market and thus hold an incumbency advantage.[7]

We also consider alternative models with different competition structure, a model with Bertrand competition between all lenders and the other model without brown lenders. By comparing the total surplus between the former alternative model and the baseline model, we can highlight how the competitive advantage held by established green lenders influence the incentive structure of the green investment. Furthermore, we can figure out whether the entry of traditional financial lenders into the ESG capital market promotes or hampers the green investment by comparing the analysis under the latter alternative model to that under the baseline model.

Lastly, we assume the following regularity condition:

Assumption 2. $p_G R + \phi > p_B R$.

Assumption 2 means that the green project yields a strictly higher surplus to the green lenders than the brown project. In the main analysis, we investigate how various market structures influence the firm's project selection. Lastly, for analytical convenience, we assume the following choice rules in the event of indifference: the firm breaks a tie by investing in the brown project; every lender, regardless of her type, breaks a tie by offering a contract that yields a higher probability of funding.

[6] The main analysis in the baseline model is qualitatively unchanged even if at least one green lender bids for funding first and the other green lenders bid simultaneously with the brown lenders in the later market.

[7] For example, there are several asset owners that committed to ESG integration, such as the Japanese GPIF ($1.8 trillion), the Norwegian Sovereign Wealth Fund ($1.3 trillion), the Korea National Pension Fund ($766 billion), the California Public Employees' Retirement System (CalPERS) ($426 billion), and the California State Teachers Retirement System (CalSTRS) ($259 billion) (go to `https://www.pionline.com/interactive/worlds-largest-retirement-funds-2021` for more details). The total size of these funds is sizable compared to the entire US market capitalization that is estimated at $ 40 trillion in 2022 (go to `https://siblisresearch.com/data/us-stock-market-value/` for more details). These owners are already requiring asset managers to integrate the ESG metrics into their investment process and to engage with their portfolio companies on critical ESG issues of their choosing (Henderson et al., 2019). Confirming this notion, Kim and Yoon (2022) finds that the Principles for Responsible Investment (PRI) signatories attracted significantly larger fund inflows from asset allocators after committing to incorporate ESG into their investment decisions.

3 Baseline Analysis

We first characterize the equilibrium in a baseline model in which all lenders fully know λ representing the firm's inherent preference for the social value of its investment. We first analyze how the amount of financial repayment influences the firm's incentive for project selection *ex-post*. We next establish pure-strategy Perfect Bayesian equilibrium, which we refer to as equilibrium hereafter.[8] Note that all lenders with the same type will symmetrically offer the same repayment term that breaks them even in equilibrium since they compete in a Bertrand fashion.

3.1 The Firm's Incentive Conditions

Due to the lack of a binding covenant in project selection, only the terms of financial repayment term will shape the firm's incentive for project selection. Let $D \in [0, R]$ be an arbitrary amount of repayment the firm is obligated to repay for borrowing from a lender. Then the firm gets the expected payoff $p_G(R-D)+\lambda\phi$ from the green project and $p_B(R-D)$ from the brown project. Thus the firm chooses the green project if and only if

$$p_G(R-D)+\lambda\phi > p_B(R-D).$$

Then, we can derive the following incentive condition for the firm's project selection.

Lemma 1. *Let D be the financial repayment the firm is obliged to the lender. Then, the firm chooses the green project if and only if $D > \overline{D}(\lambda)$, where $\overline{D}(\lambda)$ is defined as*

$$\overline{D}(\lambda) := R - \lambda\frac{\phi}{p_B - p_G}. \tag{1}$$

Lemma 1 highlights an important necessary condition for green investments: lenders must charge a large financial repayment when funding the firm's investment. Indeed, a large repayment incentivizes the firm to choose the green project. Facing a large repayment obligation, the firm can reduce its expected repayment by shifting risk, i.e., investing in a project

[8] Baye and Morgan (1999) and Kaplan and Wettstein (2000) show that the standard Bertrand competition with complete information may admit a mixed-strategy equilibrium that yields a non-zero equilibrium profit. However, as some of the assumptions for their analysis fail in our model, the necessary and sufficient condition for the existence of such a mixed-strategy equilibrium is not directly applicable to our setting.

with a smaller probability of high return than the other project. Because $p_G < p_B$, the firm can save the expected repayment by $(p_B - p_G)D$ by switching to the green project. Notably, the firm's incentive for risk-shifting increases with the repayment term D, i.e., the repayment steeply changes with the firm's project selection.[9] Chowdhry, Davies and Waters (2019) similarly argues that the firm primarily pays attention to the social impact of its investment as the lender requires a significantly large share of the financial return from the firm's investment. Specifically, the firm could get little net financial income with a large financial repayment obligation, leading the firm to focus on the externality of the project, which the firm fully enjoys without distributing to the lender.[10,11] In a nutshell, a large financial repayment obligation increases the total benefit of pursuing social value.

Another interesting observation is that the firm always prefers a contract requiring a small financial repayment, no matter who offers and how large λ is.

Lemma 2. *The firm always prefers the offer that charges the smallest financial repayment.*

Namely, the firm's payoff is a strictly decreasing function of D as follows:

$$\max\left\{p_B(R-D), p_G(R-D)+\lambda\phi\right\}.$$

If a lender (particularly the green one) can influence the firm's investment decision, she must charge the smallest financial repayment. However, intense competition among lenders may force each lender to excessively lower her repayment term, possibly leading the firm to pursue the brown investment. In Section 3.2 below, we will show how the competition structure influences the equilibrium outcome.

It is also worth noting that the threshold value $\overline{D}(\lambda)$ in (1) is decreasing in λ. Specifically, the firm takes more social value into account as λ increases, so the firm will primarily focus on the externality rather than the financial return from its investment. Lastly, the green

[9] The economic relationship between capital structure and incentive structure of ESG integration is of interest itself. Chang, Rhee and Yoon (2024) adopts a security design framework from DeMarzo, Kremer and Skrzypacz (2005) and finds that equity financing achieves green investments most likely, while debt financing achieves green investments least likely.

[10] This may seem counterintuitive but it is not unique to our setting. In the non-profit sector, Hansmann (1979) finds that nonprofit employers offer salaries below those in the for-profit sector to attract those that are likely to pursue the social good. Furthermore, Bond and Glode (2014) highlights that highly skilled human capital often chooses to work in regulatory roles with lower pay than those in the banking sector due to their motivation to work in the public sector.

[11] Choi, Kim and Kim (2022) empirically finds that fund managers can signal their commitment to ESG by complying with costly self-regulations. Our analysis provides an additional interpretation that the total borrowing cost also influences the opportunity cost incurred by keeping the firms' pledge to ESG integration.

investment can be made only if $\lambda > 0$: if $\lambda = 0$, then $\overline{D}(\lambda) = R$, so there is no feasible contract that induces the firm to make green investments. In Section 3.2 below, we will analyze how the equilibrium is pinned down by λ.

Lastly, Lemma 1 and 2 hint an important policy implication: restricting competition between lenders can improve rather than obstruct ESG integration. That is, a less competitive capital market raises the overall borrowing cost, which indeed lowers the opportunity cost of pursuing social returns and thus incentivizes borrowing firms to allocate their resources to ESG.

3.2 Equilibrium

We establish equilibrium by applying the incentive conditions we derived in Section 3.1. Indeed, any equilibrium is represented by the amount of financial repayment D: there should be no other contract offer $D' \neq D$ that strictly benefits any lender; of all contract offers, the firm gets the highest payoff from accepting D; given D, the firm selects the project that serves it best.

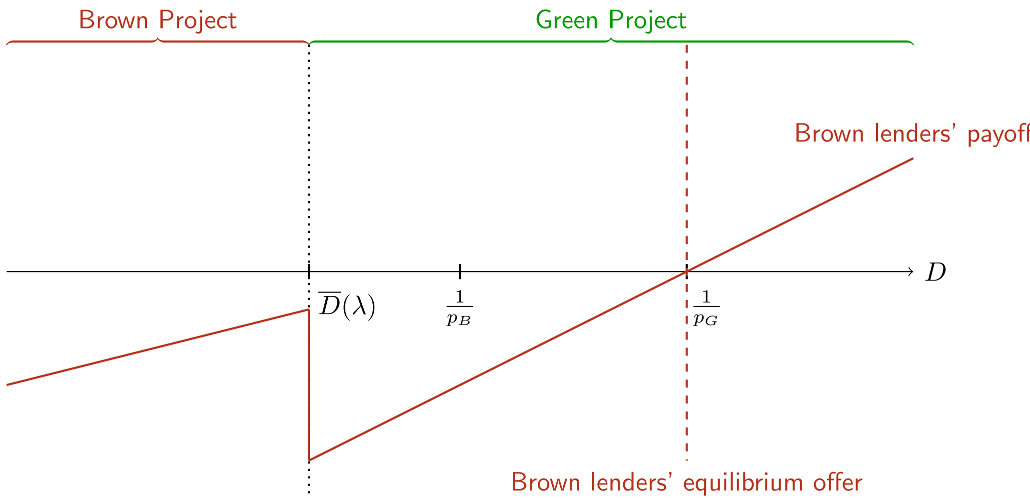
To characterize the equilibrium, it is essential to check how the lenders infer the firm's ex-post project selection and its feedback effect on the firm's ex-ante incentive for project selection. Thus, the main question is how the lenders' belief about the firm's project selection is determined. The following statement reveals that the equilibrium belief is pinned down by $\overline{D}(\lambda)$ in (1), representing the firm's actual willingness to invest in the green project.

Theorem 1. *In every equilibrium, the equilibrium financial repayment D^* is uniquely determined. Specifically, the equilibrium is characterized as follows:*

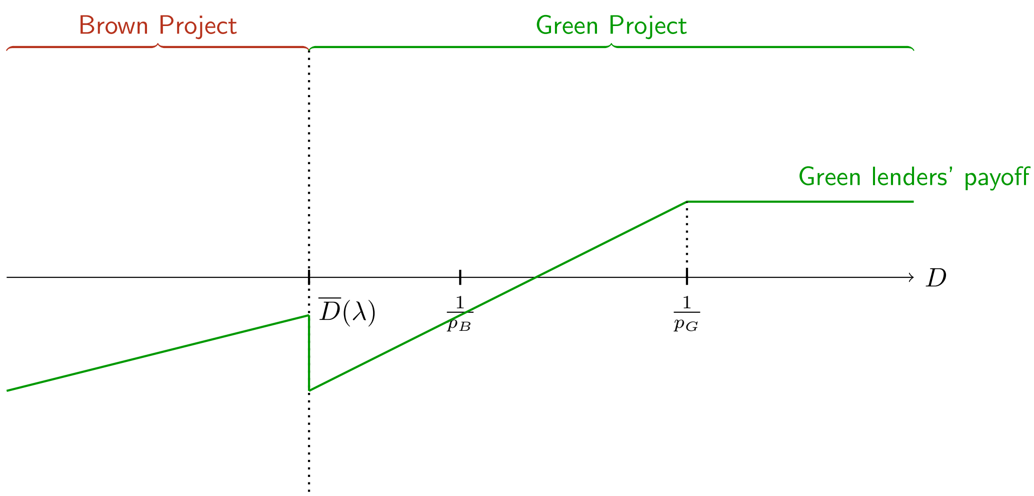
(i) If $\overline{D}(\lambda) < \frac{1}{p_B}$, lenders offer $D^* = \frac{1}{p_G}$ and the firm invests in the green project;

(ii) If $\overline{D}(\lambda) \geq \frac{1}{p_B}$, lenders offer $D^* = \frac{1}{p_B}$ and the firm invests in the brown project.

Suppose that $\overline{D}(\lambda)$ is relatively low, i.e., $\overline{D}(\lambda) < \frac{1}{p_B}$, first. Figure 1-(a) depicts the payoff of brown lenders as a function of the financial repayment D. First, brown lenders rationally believe that the firm borrowing from the brown lenders will choose the green project in equilibrium. To explain the intuition, suppose to the contrary that the firm is believed to choose the brown project in equilibrium. The Bertrand competition among the brown lenders yields the equilibrium offer $D = \frac{1}{p_B}$. However, such an offer cannot be the equilibrium



(a) Brown lenders' payoff function



(b) Green lenders' payoff function

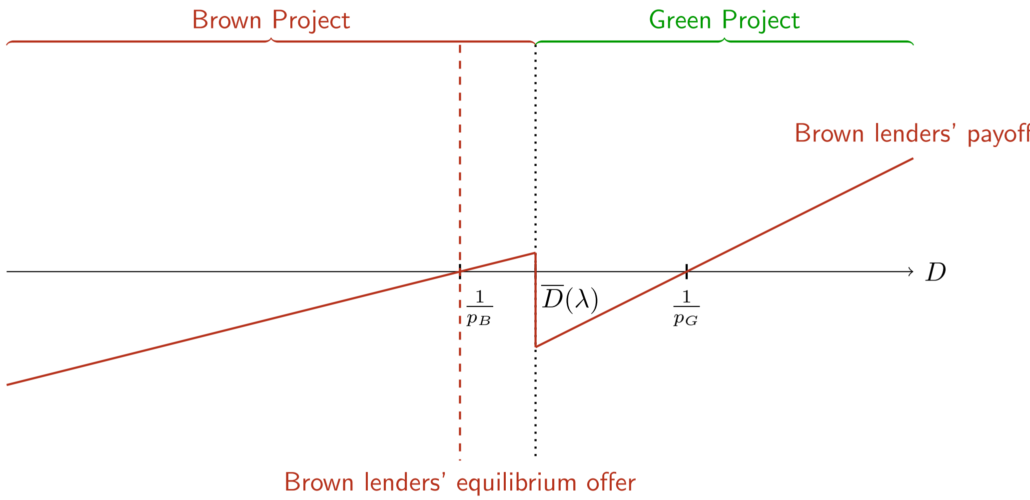
Figure 1 – Equilibrium payoff functions under $\overline{D}(\lambda) < \frac{1}{p_B}$

strategy: the firm will choose the green project since $\frac{1}{p_B} > \overline{D}(\lambda)$, so the brown lender that actually finances the firm will suffer a financial loss $p_G \frac{1}{p_B} - 1 < 0$, which is a contradiction. Hence, with the belief that the firm will surely choose the green project, brown lenders expect that the project will yield a low expected financial return, so they require a large financial repayment $D^* = \frac{1}{p_G}$ correspondingly. Such a large financial repayment obligation in turn incentivizes the firm to choose the green project consistently.

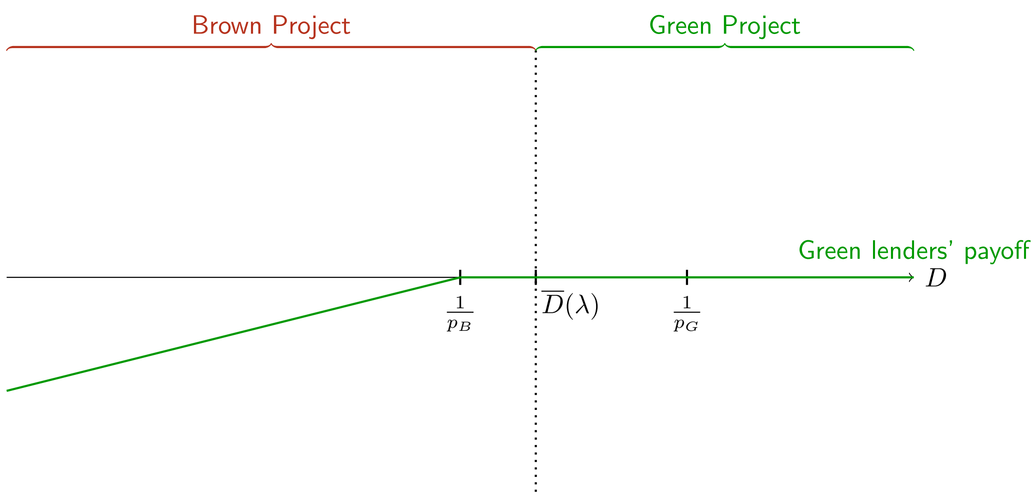
Next, green lenders know that the firm will choose the green project if it borrows from brown lenders. Figure 1-(b) depicts the payoff of green lenders as a function of the financial repayment D, given that brown lenders offer $D^* = \frac{1}{p_G}$. If green lenders want to fund the firm's project directly, they must offer a financial repayment term strictly lower than $D^* = \frac{1}{p_G}$. However, green lenders do not prefer playing such a strategy for two reasons. First, any financial repayment term $D' \in (\overline{D}(\lambda), D^*)$ will make a financial loss while generating the same externality as D^* would do, yielding a lower total payoff than offering D^*. Alternatively, if green lenders offer an excessively small financial repayment $D' \leq \overline{D}(\lambda)$, the firm will invest in the brown project that yields a strictly lower payoff to green lenders than offering D^*. Hence, green lenders have no incentive to offer a contract with a financial repayment strictly smaller than D^*, which supports the firm's project selection in equilibrium.

Next, suppose $\overline{D}(\lambda)$ is relatively high, that is, $\overline{D}(\lambda) \geq \frac{1}{p_B}$. Figure 2-(a) depicts the payoff of brown lenders as a function of the repayment term D. Then, brown lenders believe that the firm will choose the brown project if it borrows from the brown lenders. To explain why, suppose to the contrary that the firm chooses the green project. Then, the equilibrium offer must equal $\frac{1}{p_G}$, and the brown lenders, if they finance the firm, get the zero expected payoff. However, suppose one brown lender deviates and offers $D' \in [\frac{1}{p_B}, \overline{D}(\lambda)]$. In that case, the firm will accept such a deviating offer because it always prefers lowering the borrowing cost by Lemma 2. Furthermore, since $D' \leq \overline{D}(\lambda)$, the deviating offer will still induce the firm to choose the brown project, yielding a high financial return with a high probability. Therefore, the deviating brown lender can make a non-negative expected payoff from $D' \geq \frac{1}{p_B}$, which is a contradiction. Therefore, the firm borrowing from the brown lenders will choose the brown project. The brown lenders then offer a relatively low repayment term $D^* = \frac{1}{p_B}$ because the brown project generates a high expected financial return.

Figure 2-(b) depicts the payoff of green lenders in the earlier capital market as a function of the repayment term, given that brown lenders offer $D^* = \frac{1}{p_B}$. Green lenders know that the firm will choose the brown project if the green lenders do not make a strictly more favorable offer than the brown lenders. To influence the firm's investment decision in their



(a) Brown lenders' payoff function



(b) Green lenders' payoff function

Figure 2 – Equilibrium payoff functions $\overline{D}(\lambda) \geq \frac{1}{p_B}$

favor, the green lenders must offer a repayment term $D' < \frac{1}{p_B}$. However, since such an offer is lower than $\overline{D}(\lambda)$, the firm will stick with the brown project even though it borrows from green lenders. Moreover, the green lenders will make a strict financial loss since $p_B D' < 1$. In sum, the green lenders find it optimal to offer a repayment term weakly greater than $D^* = \frac{1}{p_B}$, which supports the firm's project selection in equilibrium.

A noteworthy feature is that facing competition with brown lenders, green lenders cannot effectively influence the firm's investment decision without a binding covenant that enforces the project selection. Where possible, green lenders would like to offer a generously small loss-making financial repayment once the borrowing firm pledges to the green investment in exchange. In doing so, the green lenders can increase the investment surplus by preventing the firm from borrowing from the brown lenders and choosing the brown project (Oehmke and Opp, 2024). However, as seen in Lemma 1, a small financial repayment will only adversely incentivize the firm to invest in the undesirable brown project when the project selection is not contractible. Instead, it is necessary for the financial repayment to be sufficiently high to provide the firm with the incentive to choose the green project. However, competition with brown lenders forces the equilibrium financial repayment to be small, possibly leading to the brown investment. The brown investment can be avoided only if the borrowing firm inherently appreciates the social return of its investment, which is referred to as a sufficiently low value of $\overline{D}(\lambda)$ (i.e., $\overline{D}(\lambda) < \frac{1}{p_B}$) in our analysis.

We next study whether the capital market structure influences the firm's investment decision. First, the next theorem states that the firm's project selection does not depend on whether the lenders place bids for the project financing simultaneously or sequentially.

Theorem 2. *Even if the brown lenders either simultaneously compete with green lenders or make contract offers ahead of green lenders, the firm chooses the green project if* $\frac{1}{p_B} > \overline{D}(\lambda)$ *and the brown project if* $\overline{D}(\lambda) \geq \frac{1}{p_B}$ *in equilibrium, respectively.*

Theorem 2 reaffirms an important economic force determining the firm's investment decision: whether the green lenders bid first or not, brown lenders determine the equilibrium financial repayment term. First, if the firm is believed to choose the green project with a low NPV, brown lenders will charge a large financial repayment ($\frac{1}{p_G}$) to finance the project with low profitability. In this case, green lenders have no incentive to make an offer a contract with a smaller financial repayment than $\frac{1}{p_G}$. Indeed, such an offer either only incurs financial loss or incentivizes the firm to switch to the brown project against the favor of green lenders. Next, if the firm is believed to choose the brown project with a high NPV, brown lenders in Bertrand competition will offer a breakeven contract with a financial repayment $\frac{1}{p_B}$. Once again, green lenders have no incentive to offer a different financial repayment term: any repayment strictly larger than $\frac{1}{p_B}$ will be rejected by the firm outright; a strictly smaller repayment will only harm the green lenders since it is strictly loss-making but does not alter the firm's project selection.

Second, we investigate whether the competition between lenders with different preferences for social value facilitates green investment. The following statement answers it does not.

Theorem 3. *Suppose that there are only green lenders in the market, who simultaneously compete in Bertrand fashion.*

(i) If $\frac{1}{p_B} \leq \overline{D}(\lambda) < \left(\frac{1+\phi}{p_B}\right) \wedge \frac{1}{p_G}$, there exist two equilibria, one where the firm chooses the green project and the other where the firm chooses the brown project.

(ii) If $\overline{D}(\lambda) < \frac{1}{p_B}$, the firm chooses the green project in all equilibria.

(iii) If $\overline{D}(\lambda) \geq \left(\frac{1+\phi}{p_B}\right) \wedge \frac{1}{p_G}$, the firm chooses the brown project in all equilibria.

Since $\overline{D}(\lambda)$ is decreasing in λ and $\phi > 0$, the equilibrium with green investment can arise from relatively low values of λ such that $\overline{D}(\lambda) \geq \frac{1}{p_B}$. Thus, Theorem 3-(i) suggests that the capital market with only green lenders can yield green investment even if the firm has a relatively weak preference for social value, so it would invest in the brown project when both green and brown lenders compete in the market. To explain the intuition clearly, suppose $\overline{D}(\lambda) < \frac{1}{p_G}$ and all green lenders offer a financial repayment $D_G = \frac{1}{p_G}$. Then a green lender can profitably deviate only by offering different terms of financial repayment $D' \leq \overline{D}(\lambda)$ that will induce brown investment. However, unlike brown lenders, the deviating green lender must add a "dirty" premium to the financial repayment as compensation for forgoing the high social value generated by the green investment (Bolton and Kacperczyk, 2021). This dirty premium will obviously raise the cost of borrowing. This increased cost of borrowing makes the deviation offer for brown investment infeasible; the firm will choose the green project even after accepting the deviating offer. The infeasibility of counteroffers that weakly better off the deviating green lender and induces brown investment sustains the equilibrium with green investment, even for relatively low values of λ which would induce brown investment in the presence of competitive brown lenders.[12]

[12] This result holds true whether some green lenders bid for funding first or all the lenders simultaneously compete in the capital market.

Theorem 3 suggests an important policy implication: with the lack of institutional capability of monitoring borrowers' ESG claims, opening the capital market for ESG to brown lenders can deter rather than facilitate ESG integration. Given that brown lenders do not appreciate the social value generated by the firm's investment, they do not charge any dirty premium even though their contract offers may induce the brown investment. Indeed, brown lenders are willing to finance the firm at a significantly lower borrowing rate because such an offer yields brown investment with a smaller default probability. However, no effective contractual term is available that can help green lenders overcome weak price competence against brown lenders in the capital market. As a result, unless the firm has a sufficiently strong innate preference for social value, the firm cannot resist accepting brown lenders' offers with a low borrowing rate and then choosing the brown project.

Our result differs from Oehmke and Opp (2024), which argues that competition between green and brown lenders enhances green investments. Their analysis finds that green lenders can attach a binding covenant to their contract offers, which enforces green investment in exchange for cheap financing. Equipped with such a binding covenant, green lenders can give the firm a "clean" discount in exchange for green investment. Particularly, competition with brown lenders further incentivizes green lenders to give a more "clean" discount to the borrowing rate, facilitating green investment. On the other hand, our analysis shows that any competitive pressure that lowers the equilibrium borrowing rate deters green investment without the firm's commitment to its project selection. Therefore, before setting a direction for competitive policies in ESG credit markets, policymakers should carefully examine and find ways to facilitate the contractual enforceability of ex-post execution of ESG projects.

4 Adverse Selection and Green Investments

So far, we have assumed that the value of λ — representing the firm's inherent preference for the social value of its investment — is publicly known to all lenders. However, it is more natural to believe that only the borrowing firm privately knows how seriously it takes the long-term social consequences when making an investment decision. For example, Kim and Yoon (2022) finds that asset managers who claimed to engage in ESG integration attracted more fund flows but did not exhibit a follow-through increase in ESG performance. Furthermore, Cappucci (2018) and Kotsantonis and Serafeim (2019) point out the lack of standards on ESG is a significant impediment to monitoring ESG integration. All these studies suggest that the adverse selection problem has not yet been appropriately addressed.

A pertinent research question is how the firm's investment decisions may change when lenders face an adverse selection problem regarding the firm's preference for social value. To address this question, we extend our model by assuming that nature randomly draws λ from the set $\{\lambda_B, \lambda_G\}$ with a distribution function $Pr(\lambda = \lambda_G) = q \in (0,1)$ before the financial market opens, where $\lambda_G > \lambda_B$. The firm privately knows the true value of λ. We refer to the realized value of λ as the firm's "type." In what follows, we characterize financial market structures that obtain green investment by both types of the firm. To this end, we analyze two different market structures: a market where both green and brown lenders compete to finance, and the other where only green lenders exist.

4.1 The Capital Market with Both Brown and Green lenders

First, suppose both green and brown lenders compete to finance the firm. We assume the following regularity conditions:

Assumption 3. *(i)* $\frac{1}{p_G} > \overline{D}(\lambda_B) \geq \frac{1}{p_B} > \overline{D}(\lambda_G)$; *(ii)* $\overline{D}(\lambda_B) \geq \frac{1}{qp_G+(1-q)p_B}$.

Assumption 3-(i) has two features. First, the firm with type λ_G has a strong inherent preference for the social return to the extent that it would invest in the green project without adverse selection. In this context, the firm with type λ_G will be referred to as the "green" firm. Second, the firm with type λ_B would choose the brown project without asymmetric information. In this respect, we will call the firm with type λ_B as the "brown" firm. Furthermore, from the feature that $\frac{1}{qp_G+(1-q)p_B}$ is increasing in q, Assumption 3-(ii) means that the lenders hold the prior belief that the firm is highly likely the brown type. This assumption is introduced to rule out the uninteresting cases: the firm, whichever type it may be, invests in the green project in equilibrium if the firm is believed to be of the green type with a high likelihood such that $\overline{D}(\lambda_B) < \frac{1}{qp_G+(1-q)p_B}$.[13]

Lastly, we assume that lenders in the later capital market can only observe whether the firm accepts the offers made by early-bidding green lender(s) but cannot observe the exact terms of financial repayment that the firm accepts or rejects. This assumption is made primarily to simplify the analysis by shutting off the channels of dynamic belief updating. Nevertheless, this assumption is justified given that hedge fund firms and private equity firms,

[13] We provide the formal proof in Proposition B.1 of Appendix.

managing a sizeable amount of capital intended for ESG, privately negotiate fee structures (i.e., the additive inverse of repayment terms) with their clients.[14]

Multiple equilibria may exist due to the endogeneity of the posterior beliefs held by brown lenders; different beliefs about the firm contacting the brown lenders can give rise to different incentives for rejecting the green lenders' offer. A key question is then whether there exists an equilibrium in which the brown firm surely chooses the green project. The following statement reveals that such an equilibrium does indeed exist under a certain financial market structure.

Theorem 4.

(i) Suppose that green lenders make offers before brown lenders do. There exists an equilibrium in which both green and brown firms invest in the green project with probability one. In such an equilibrium, the brown firm is highly likely to be funded by green lenders, while the green firm is highly likely to be funded by brown lenders.

(ii) If green lenders no longer make offers before brown lenders do (i.e., if all brown and green lenders bid simultaneously or at least one brown lender bids first), the equilibrium in which the brown firm invests in the green project with probability one cannot exist.

Green lenders can play an important role in the investment maximizing the social return — i.e., the firm, regardless of its type, invests in the green project — by funding the *brown* firm early and letting the green firm borrow from brown lenders later. To establish such an equilibrium, suppose that brown lenders hold the posterior belief that the firm rejecting the green lenders' offers is of the green type with a sufficiently high probability, say, close to one. With this belief, brown lenders expect that the borrowing firm will likely choose the green project and thus require a large financial repayment $\frac{1}{p_G}$, like in the baseline model without adverse selection. Green lenders in the early financial market then have no incentive to offer any different terms of financial repayment strictly smaller than the later offer made by the brown lenders. Indeed, offering a small financial repayment will only lead to either a financial loss or an undesirable selection of the brown project (or both). Therefore, the lenders of both types find it optimal to offer the large financial repayment $\frac{1}{p_G}$ to the firm.

[14]Under this assumption, brown lenders need to form off-the-path beliefs only in the case that both types of the firm were to accept a green lender's offer in the first stage of the game. Such off-the-path beliefs never arise in all equilibria constructed in the proof of Theorem 4 and 5. As a result, all of those equilibria survive with any standard equilibrium refinement that imposes restrictions on off-the-path beliefs.

We next discuss why it is optimal for both firms to select the green project. Since both green and brown lenders offer the same financial repayment $\frac{1}{p_G}$, the brown firm weakly prefers accepting the green lenders' offer and exiting the capital market early, which eventually supports the posterior belief held by the brown lenders. By the same token, the green firm weakly prefers waiting to borrow from brown lenders in the subsequent capital market. Lastly, by Lemma 1, both green and brown firms find it optimal to choose the green project at the large financial repayment term $\frac{1}{p_G}$.

The key feature of the financial market structure that can yield the highest social return is that some green lenders (and green lenders only) have a competitive advantage *à la* Stackelberg. A necessary condition for achieving green investment by the brown firm is that brown lenders must charge a sufficiently large financial repayment to the firm. One way to realize this outcome is that brown lenders hold a posterior belief that the holdout firm arriving in the later market is the green type with a sufficiently high likelihood.[15] By making offers earlier than brown lenders, green lenders can "cleanse" the financial market through dynamic information revelation. Specifically, green lenders finance and thus take out the brown firm first, which makes the holdout firm approaching brown lenders perceived as the green firm with a high likelihood. With such a posterior belief, brown lenders in the subsequent market expect the holdout firm to choose the green project, and thus charge a large financial repayment in exchange for the low NPV of the green investment, inducing the actual green investment. In this respect, green lenders cleanse the subsequent financial market by inducing brown lenders to fund the green firm's green investment.

Interestingly, this anticipated cleansing effect on the subsequent financial market feeds back into the early financial market, inducing the brown firm to make the green investment. Indeed, the brown firm expects it expensive to borrow from brown lenders in the subsequent market; the firm going to the subsequent market is believed as the green type with a high likelihood. Green lenders in the early market know that the brown firm cannot get cheap financing from brown lenders. Hence, green lenders can also offer the same large financial repayment $\frac{1}{p_G}$ as brown lenders will do. Then, the brown firm has no choice but to accept this term of the large financial repayment and choose the green project afterward. Consequently, green lenders also cleanse the early market by endogenously raising the overall cost of borrowing of the brown firm in both early and subsequent financial markets.

The function of the sequential bidding for ESG integration is analogous to the public

[15] We formally prove this claim in Proposition B.2 in Appendix.

bailouts during financial crises to the extent that both can alleviate adverse selection problems. For instance, Philippon and Skreta (2012), Tirole (2012), and Che, Choe and Rhee (2023) argue that the government bailouts launched during financial crises effectively address the adverse selection problem and thus rejuvenate market lending by (endogenously) taking low-quality firms out of private markets. However, to entice these firms to the bailout programs, governments must withstand financial losses by offering undeniably generous terms. Similar to public bailouts, green lenders take the brown firm out of the subsequent financial market and thus make brown lenders believe that the holdout firm is likely to be the green type. In contrast to the public bailouts, green lenders do not suffer any financial loss because they take the anticipated high repayment term offered in the subsequent market as leverage to offer a significantly high repayment term under which the brown firm chooses the green project *ex-post*.

We found that sequential bidding by lenders in the capital market is crucial to obtaining ESG integration. A natural follow-up question is what will occur when the green lenders are no longer the first movers. Theorem 4-(ii) argues that the welfare of green lenders may not be improved once green lenders lose their first-mover advantage. Recall from Lemma 1 that the green investment can be obtained only if the lenders can offer a contract with a sufficiently large financial repayment terms. However, brown lenders will compete to finance the firm only for the sake of the financial payoff, bringing the firm's borrowing cost down to the levels that induce the brown investment. There is no effective way for green lenders to keep the firm's borrowing cost high when they cannot bid for funding earlier than brown lenders. Rather, the firm, whether it is the green or brown type, would rather borrow cheaply from brown lenders and leave the market early before receiving offers from green lenders in the subsequent capital market.

4.2 The Capital Market with Green Lenders Only

Next, suppose only green lenders exist in the capital market. We replace Assumption 3 with new regularity conditions as follows:

Assumption 4. *(i)* $\frac{1}{p_G} > \overline{D}(\lambda_B) \geq \frac{1+\phi}{p_B} > \overline{D}(\lambda_G)$; *(ii)* $\overline{D}(\lambda_B) \geq \frac{1+(1-q)\phi}{qp_G+(1-q)p_B}$.

Assumption 4-(i) means that the green (brown) firm with type λ_G (λ_B) would choose the green (brown) project in the absence of adverse selection. Assumption 4-(ii) rules out an uninteresting outcome: even in the case that all green lenders simultaneously compete, there always exists an equilibrium in which both brown and green firms invest in the green project if $\overline{D}(\lambda_B) < \frac{1+(1-q)\phi}{qp_G+(1-q)p_B}$.[16]

Like the analysis in Section 4.1, the main question is whether there exists an equilibrium where the brown firm chooses the green project. The following statement shows that it is still crucial for some lenders to be first movers in the capital market, even though every lender exhibits the same (strong) preference for social value.

Theorem 5.

(i) If all green lenders simultaneously compete in the capital market, there exists no equilibrium in which both brown and green firms choose the green project.

(ii) If at least one green lender can bid for funding in the first stage and the rest of the green lenders simultaneously bid in the second stage, there exists an equilibrium in which the brown firm chooses the green project.

A key market condition for achieving green investment is that some green lenders must be able to cleanse the capital market by bidding to finance the brown firm before the other green lenders. Despite the absence of brown lenders, green investment can be deterred when the lenders hold the prior belief that the firm is likely to be brown type, who will choose the brown project even by paying a dirty premium charged by green lenders. However, a first-moving green lender, if exists, can facilitate green investment through the same dynamic information revelation as discussed in Section 4.1. Namely, with the belief that the brown firm borrows from the first-moving green lender, the remaining green lenders in the subsequent market believe that the holdout firm is likely to be green type, who will not choose the brown project when green lenders charge a dirty premium. Thus the subsequent green lenders must charge a large financial repayment that induces green investment and breaks the lenders even. Knowing that the brown firm will face an unfavorable funding condition in the subsequent market, the first-moving green lender offers the same hefty financial repayment as the subsequent lenders will offer. The brown firm then finds it (weakly) optimal to accept that offer and then choose the green project.

[16] We provide the formal proof in Proposition B.3 of Appendix.

4.3 Policy Implications

Theorem 4 and 5 suggest important policy implications to achieve ESG integration in the presence of adverse selection on the firm's inherent preference for ESG. First, our analysis suggests that policymakers should consider the value-add of the incumbent ESG-friendly lenders in inducing borrowers to integrate ESG. Our analytical result implies that incumbent ESG-friendly lenders can "cleanse" the ESG market by taking out the brown firms. Thus, imposing a comparative disadvantage on ESG-friendly lenders may deter borrowing firms' ESG integration.

Indeed, ESG-endorsing lenders contributed to establishing a new capital market for ESG (e.g., the PRI that has existed since 2006) and led the efforts engaging with companies on ESG integration (Ceccarelli et al., 2021).[17] Further, these established ESG-endorsing lenders are major players in the capital market.[18] For instance, the Japanese GPIF has allocated to asset managers and companies integrating ESG, and sought them to justify their ESG investment thesis. Moreover, the Korea National Pension Fund is legally bound to follow its Stewardship Code when making investment decisions.

Given this information, it is also conceivable that many corporate issuers have been borrowing from these incumbent large-sized institutional lenders to finance their ESG projects. Furthermore, when these firms seek capital to fund their new ESG projects, they are likely to engage the same lenders for financing the new projects again due to their existing relationship. If so, there is indeed a high likelihood that incumbent ESG-endorsing lenders would offer contracts to firms making new ESG investments earlier than other competing lenders that are new to the market.

Next, our paper also highlights the necessity for the regulators to consider ways in which asset allocators (e.g., pension funds and retail lenders) can evaluate the asset managers'

[17] For example, there are several asset owners that committed to ESG integration, such as the Japanese GPIF ($1.8 trillion), the Norwegian Sovereign Wealth Fund ($1.3 trillion), the Korea National Pension Fund ($766 billion), the California Public Employees' Retirement System (CalPERS) ($426 billion), and the California State Teachers Retirement System (CalSTRS) ($259 billion) (go to `https://www.pionline.com/interactive/worlds-largest-retirement-funds-2021` for more details). The total size of these funds is sizable compared to the entire US market capitalization that is estimated at $ 40 trillion in 2022 (go to `https://siblisresearch.com/data/us-stock-market-value/` for more details). These owners already require asset managers to integrate the ESG metrics into their investment process and engage with their portfolio companies on critical ESG issues of their choosing (Henderson et al., 2019). Confirming this notion, Kim and Yoon (2022) find that the Principles for Responsible Investment (PRI) signatories attracted significantly larger fund inflows from asset allocators after committing to incorporate ESG into their investment decisions.

[18] See `https://www.pionline.com/interactive/worlds-largest-retirement-funds-2021` for details.

willingness to genuinely integrate ESG. If such infrastructure is established, more capital will be effectively allocated to ESG-friendly managers, enhancing their market power in the ESG market and their ability to cleanse the ESG market. We view this implication as similar to (but a substantially developed version of) the SEC's recent policy proposal of the "naming rule" that permits asset managers to add the term "ESG" to the names of their mutual funds only when these managers are verified to have long committed to ESG.[19] Such regulation may be primarily designed to prevent asset managers from deceiving lenders in the ESG market. Nonetheless, ESG-friendly asset managers can also signal their ESG commitment by running mutual funds with names including the term "ESG" and play a role in "cleansing" the ESG market.

Lastly, our analysis provides an alternative explanation of the empirical observations deemed as an act of greenwashing by ESG-friendly lenders. For example, Kim and Yoon (2022) points out that the PRI signatories are not exhibiting ESG follow-through in the following 6 - 12 quarters after signing. Our main results of Theorem 4 and 5 suggest that these signatories (if they are truly willing to integrate ESG) are indeed cleansing the ESG market through two channels. First, the holdout firms who decide not to borrow from the PRI signatories can be perceived to have the willingness to integrate ESG by the other lenders, which addresses the adverse selection problem in the ESG market. Next, the firms that borrow from the PRI signatories are incentivized to integrate ESG after accepting a high borrowing rate, even though they may not be strongly willing to integrate ESG.

5 Related Literature

Extensive literature points out the discrepancy between firm ESG commitments and follow-through. For example, Kim and Yoon (2022) empirically analyzes active mutual fund managers in the US that signed the PRI initiative and finds that the signatories heavily advertise their ESG commitments to attract a significant increase in fund flows after signing but do not exhibit improvements in fund-level ESG performance or fund returns. Liang, Sun and Teo (2022) examines hedge funds that signed the PRI initiative and finds that these funds underperform other hedge funds after risk adjustments but attract greater flows, accumulate more assets, and harvest greater fee revenues. On the corporate issuer side, Raghunandan and Rajgopal (2022*b*) analyzes the member firms in the Business Roundtable (BRT) that

[19]See https://www.sec.gov/news/press-release/2022-91 for details.

pledged to serve the interests of broad stakeholders by signing the Statement on the Purpose of a Corporation. Their study finds no evidence that the signatories significantly engaged in stakeholder-centric practices.

On the other hand, some academic studies document significant follow-through ESG performance. Gibson Brandon et al. (2022) documents that PRI signatories outside of the US exhibit a moderate incorporation of ESG. Ceccarelli et al. (2021) finds that certain PRI signatories take leading roles in engaging companies to induce ESG follow-through. Furthermore, Dikolli et al. (2022) finds mutual funds identified as ESG funds by Morningstar are more likely than other funds to vote in support of shareholder proposals that relate to ESG issues. This positive effect is more pronounced in index funds than in active funds.

There are papers that analyze the nascent nature of ESG information, which naturally is related to difficulties in evaluating ESG activities and thus deterring greenwashing. Berg, Koelbel and Rigobon (2022) and Serafeim and Yoon (2022) find that ESG scores from different raters exhibit low correlation and disagree on outcome measures that capture ESG risk. This is not only because disclosing ESG information is largely voluntary but also because the information is not accurately verified (Gipper, Ross and Shi, 2022). The disagreement among the raters on measuring ESG outcomes generally leads to disentangling the actual ESG performance of companies (or even asset managers) from the information disclosed to outside lenders (Christensen, Serafeim and Sikochi, 2022).

Given the above informational frictions, an important policy issue is how much the government and/or companies should act to deter greenwashing. Some papers highlight the necessity of regulatory enforcement. For example, Choy et al. (2021) finds that public environmental enforcement has positive externalities in shaping borrowers' environmental activities. Specifically, they find that loan agreements are more likely to include environmental covenants in the presence of higher regulatory enforcement intensity. Others highlight the importance of disclosure and examine the potential benefits of mandatory disclosure. Fiechter, Hitz and Lehmann (2022) examines the impacts of the Corporate Social Responsibility (CSR) directive passed in the EU. They find that firms within the scope of the CSR directive respond by increasing their CSR activities and that the firms even start doing so before the directive takes effect. Grewal, Riedl and Serafeim (2019) finds that the market reacts positively to the passage of this directive. Krueger et al. (2021) finds that mandatory ESG disclosure increases the availability and quality of ESG reporting: analysts' earnings forecasts become more accurate and less dispersed after ESG disclosure becomes mandatory. Christensen et al. (2017) finds that mining-related injuries decrease after safety records in the mining industry are required to be included in financial reports. Aghamolla and An (2023) and Xue (2023) argue that firms may inefficiently under-invest in ESG project *ex ante* when the disclosure is mandatory or exceptionally precise due to the fear of being penalized for their poor ESG performance by outside lenders *ex post*.

There are also papers that hint at the potential of market-driven solutions for the greenwashing problem, largely through voluntary disclosure. For example, Rouen, Sachdeva and Yoon (2022) provides evidence that the content within ESG reports converges to material information after the release of Sustainability Accounting Standards Board (SASB) standards (i.e., even in the absence of regulation). Bochkay, Choi and Hales (2022) examines the adoption of sustainability standards developed by the SASB and finds improvements in the sustainability outcomes (e.g., negative sustainability-related incidents and violations). These papers highlight that improvements in monitoring follow-through ESG performance can be obtained by market forces and voluntary guidance on ESG disclosure.

There is a growing literature that theoretically analyzes how the changes in lenders' attitudes to ESG can influence socially responsible investments in asset markets. Pástor, Stambaugh and Taylor (2021) finds that dispersion in lenders' concern with ESG is a key necessary condition for the investment in ESG projects; green firms can enjoy a substantively low cost of capital only when the lenders' desire to pursue ESG even by sacrificing financial returns is not fully adjusted in financial markets. On the other hand, Gupta, Kopytov and Starmans (2022) argues that firm managers may strategically delay their ESG integration decision until they meet an unexpected surge of lenders' demand for ESG and thus finance their ESG projects cheaply.

Another strand of literature focuses on crowd-out effects on socially responsible investments in asset markets. Green and Roth (2021) argues that it may be suboptimal for each individual ESG-friendly lender to maximize ESG values in her own portfolio instead of the aggregate social surplus. Regarding non-ESG lenders pursuing financial returns only, such an investment strategy crowds out firms that are not highly financially profitable but could generate positive (but relatively small) social returns, resulting in low aggregate social surplus. In addition, Bisceglia, Piccolo and Schneemeier (2023) suggests that ESG-friendly lenders should concentrate their resources on a selected group of firms to maximize the social impacts each targeted firm can generate. However, the concentration of capital also creates negative crowd-out effects: the excluded firms will be deprived of capital for ESG integration; only the selected firms will survive and thus obtain strong market power in a real economy, incurring an additional aggregate welfare loss.

Furthermore, a growing number of papers analyze how ESG-friendly lenders can incentivize borrowing firms to integrate ESG into their business. Heinkel, Kraus and Zechner (2001) argues that ESG-friendly lenders can influence borrowing firms' behavior by playing an "exit" strategy: penalizing the borrowing firms that break their ESG promises by divesting the stocks of these firms. Hart and Zingales (2017) argues that the exit strategy will leave divested non-ESG firms unchanged, resulting in welfare losses. They instead suggest an alternative "voice" strategy: ESG-friendly lenders should become major shareholders and thus directly influence firm managers' behavior by voting for ESG-endorsing corporate policies in shareholders' meetings. Other papers further analyze the effectiveness of the "voice" strategy in various firm ownership structures. Broccardo, Hart and Zingales (2022) argues that the firm ownership must be sufficiently diversified among shareholders, which substantially lowers the cost of ESG integration each individual shareholder shoulders. Edmans, Levit and Schneemeier (2022) argues that an ESG-friendly lender can reward a firm integrating ESG by purchasing a large number of shares, which increases market capitalization. They also find that such a practice can be more effective if firm managers are short-termistic because the managers will be instantly compensated for raising the market value of shares. These papers assume that lenders, armed with rewarding or penalizing schemes, can control borrowers' ex-post actions on ESG.

Lasty, some recent papers focus on the optimal design of measuring and disclosing corporate borrowers' ESG activities in the presence of asymmetric information. Friedman, Heinle and Luneva (2021) shows that the optimal design of ESG reporting standards to tackle the greenwashing problem depends on the outside lenders' aggregate preferences for ESG. Bonham and Riggs-Cragun (2022) compares the impacts of different regulatory schemes on ESG, such as executive compensation based on ESG outcome, tax benefits for ESG activities, and regulations on disclosing firms' ESG activities. They identify the respective institution and market conditions for each of those schemes to effectively motivate regulated firms to integrate ESG.

Our research is most closely related to Oehmke and Opp (2024), which shows that ESG-friendly lenders can achieve ESG investments by attaching an ESG investment covenant to the terms of lending but sacrificing their financial payoffs. However, given the institutional frictions (e.g., the hard-to-verify-and-assure nature of firm ESG efforts), borrowers can deviate from their promises on ESG integration, which is the main focus of our current research. Our paper complements and extends the aforementioned literature by discovering the competition policies in ESG credit markets as a key solution for greenwashing problems before the establishment of a precise standard of monitoring corporate borrowers' ESG efforts and performances. Particularly, competitive advantages held by ESG-friendly lenders improve rather than hamper ESG integration, which has no analog in any other studies.

6 Conclusion

This paper presents a model of ESG integration where borrowers' promises on ESG are not contractible. Competing with non-ESG lenders considering financial payouts only, ESG-friendly lenders face difficulties ensuring that the borrowing firm integrates ESG. A key constraint on ESG integration is that it is practically impossible to prevent borrowers from deviating from their ESG promises and engaging in greenwashing. Before suggesting a relevant solution for ESG integration, the first essential work should be to understand the impact of the lack of contractual enforcement on the borrowers' incentive for ESG integration.

Our main findings are summarized as follows. Corporate issuers have the incentive to integrate ESG only when the cost of borrowing is high. Indeed, a high borrowing cost lowers private net financial gains of corporate issuers from not following through on their ESG promises and pursuing short-run financial returns. However, ESG-friendly lenders alone cannot achieve ESG integration due to the competition with non-ESG lenders — who only appreciate financial payoffs and thus are willing to finance cheaply once the borrowers undertake any financial project with a high financial return. Nevertheless, ESG-friendly lenders play a crucial role in achieving ESG integration in the presence of adverse selection on the corporate issuers' innate preferences for ESG. Particularly, ESG-friendly lenders with a first-mover advantage can finance and thus take out the firms with weak preferences for ESG early on from the financial market, creating the following positive effects. First, the firms not funded by the first-moving ESG-friendly lenders are perceived as those with strong preferences for ESG. Hence, the subsequent lenders require a high borrowing rate because of a low financial return from integrating ESG. Knowing this, the first-moving ESG-friendly lenders also charge a high borrowing rate to firms with weak preferences for ESG. These non-ESG firms then have no other option but to borrow at a high borrowing rate that incentivizes ESG integration.

Our research further suggests an important policy implication: promoting competition between lenders may not always facilitate ESG integration because corporate leaders can have a twofold incentive to deviate from ESG promises. First, a competitive lending market lowers the cost of borrowing, which incentivizes firm managers to pursue short-run financial income instead of long-run social value. Second, the incumbent ESG-friendly lenders cannot "cleanse" the ESG market by taking out the firms that are not genuine about integrating ESG.

The central lesson from our research is that, with the lack of commitment, the impacts of funding conditions for borrowers and competition structures for lenders on ESG integration are completely different from the model allowing contractual enforcement. To the best of our knowledge, our work's motivations, insights, and policy implications are novel and have not been studied in the previous literature. We believe our research will open a new avenue for important policy debates and inform empirical works on greenwashing.

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Appendix

A Proofs

We introduce additional notations and terminologies for exposition. First, let $n_G, n_B \in \mathbb{N}\backslash\{1\}$ denote the respective numbers of green and brown lenders. Moreover, let $\underline{D}_B$ and $\underline{D}_G$ denote the lowest repayment term that brown lenders and green lenders offer, respectively. Also, define $\underline{D} := \min\{\underline{D}_B, \underline{D}_G\}$. We throughout denote the lenders who offer $\underline{D}$ by *winning lenders*. Furthermore, we will coin the brown lenders who offer $\underline{D}_B$ as *winning brown lenders* and any green lenders who offer $\underline{D}_G$ as *winning green lenders*. Lastly, let the first stage ($t = 1$) refer to the stage in which all green lenders simultaneously make offers to the firm, and let the second stage ($t = 2$) refer to the stage in which all brown lenders simultaneously make offers. Recall that the firm reaches the second stage only if it rejects all offers from the green lenders.

A.1 Proof of Theorem 1

Step 1: the second-stage subgame. We first characterize the equilibrium in the second-stage subgame. In this subgame, brown lenders necessarily earn zero equilibrium profit by the standard argument *à la* Bertrand competition. Thus, there are two possible equilibrium outcomes in the second-stage subgame:

(a) $\underline{D}_B = \frac{1}{p_G}$, and then, the firm chooses the green project.

(b) $\underline{D}_B = \frac{1}{p_B}$, and then, the firm chooses the brown project.

In what follows, we check how the equilibrium is characterized by $\overline{D}(\lambda)$ defined as (1).

First, consider the case $\overline{D}(\lambda) < \frac{1}{p_B} < \frac{1}{p_G}$. By Lemma 1, the firm will always choose the green project whether $\underline{D}_B = \frac{1}{p_B}$ or $\frac{1}{p_G}$, so the winning brown lenders earn zero profit only if $\underline{D}_B = \frac{1}{p_G}$. Thus, (a) is the only possible equilibrium outcome. Furthermore, given that the winning brown lenders offer $\underline{D}_B = \frac{1}{p_G}$, each brown lender cannot be better off by deviating to offer $D' \neq \underline{D}_B$: the firm will reject any deviating offer $D' > \underline{D}_B$; if $D' \in (\overline{D}(\lambda), \underline{D}_B)$, the firm will accept the deviating offer and choose the green project, but the deviating brown lender gets a negative payoff $p_G D' - 1 < 0$; if $D' \leq \overline{D}(\lambda)$, the firm will accept the deviating offer and choose the brown project, but the deviating brown lender will get a negative payoff since

$\overline{D}(\lambda) < \frac{1}{p_B}$. Lastly, when receiving the offer $\underline{D}_B = \frac{1}{p_G}$, it is optimal for the firm to choose the green project: rejecting this offer will yield zero payoff, while accepting the offer yields $p_G(R - \underline{D}_B) = p_G R - 1 \geq 0$. Hence, (a) is the unique equilibrium.

Second, consider $\overline{D}(\lambda) \geq \frac{1}{p_G} > \frac{1}{p_B}$. In this case, the firm will always choose the brown project whether $\underline{D}_B = \frac{1}{p_B}$ or $\frac{1}{p_G}$, so the winning brown lenders earn zero profit only if $\underline{D}_B = \frac{1}{p_B}$. Thus, (b) is the only possible equilibrium outcome. Furthermore, given that the winning brown lenders offer $\underline{D}_B = \frac{1}{p_B}$, each brown lender cannot be better off by deviating to offer $D' \neq \underline{D}_B$: the firm will reject any deviating offer $D' > \underline{D}_B$; if $D' < \underline{D}_B$, the firm will accept the deviating offer and choose the brown project since $D' < \underline{D}_B = \frac{1}{p_B} < \overline{D}(\lambda)$, but the deviating brown lender will get a negative payoff $p_B D' - 1 < 0$. Lastly, when receiving the offer $\underline{D}_B = \frac{1}{p_B}$, it is optimal for the firm to choose the brown project: rejecting this offer will yield zero payoff, while accepting the offer yields $p_B(R - \underline{D}_B) = p_B R - 1 > 0$. Hence, (b) is the unique equilibrium.

Third, consider $\frac{1}{p_B} < \overline{D}(\lambda) < \frac{1}{p_G}$. In this case, the outcome (a) cannot be an equilibrium: if a brown lender deviates by offering $D' \in (\frac{1}{p_B}, \overline{D}(\lambda)]$, the firm will accept such a deviating offer and choose the brown project by Lemma 1, which gives the deviating lender a positive payoff $p_B D' - 1 > 0$. Thus, (b) is the only possible equilibrium outcome. Furthermore, given that the winning brown lenders offer $\underline{D}_B = \frac{1}{p_B}$, it is optimal for each brown lender to offer the same repayment term: if a brown lender offers $D' < \underline{D}_B = \frac{1}{p_B}$, the firm will accept such a deviating offer and then choose the brown project, but the deviating lender will get a strictly negative payoff $p_B D' - 1 < 0$; the firm will reject any offer $D' > \underline{D}_B = \frac{1}{p_B}$. Lastly, for $\underline{D}_B = \frac{1}{p_B}$, it is optimal for the firm to accept the offer from brown lenders and choose the brown project, which yields the payoff $p_B(R - \underline{D}_B) = p_B R - 1 > 0$. Therefore, (b) is the unique equilibrium.

Finally, consider the case $\overline{D}(\lambda) = \frac{1}{p_B} < \frac{1}{p_G}$. We show that (b) is the only possible equilibrium outcome. Suppose to the contrary that there is an equilibrium with the outcome (a). Then a brown lender can increase the probability of funding by deviating to offering the repayment term $D' = \frac{1}{p_B} = \overline{D}(\lambda)$. Then the firm will surely accept the deviating offer $D' = \frac{1}{p_B}$ and choose the brown project, which yields the deviating lender the same zero profit but a strictly higher probability of funding than playing the prescribed equilibrium strategy, a contradiction. Furthermore, given that the winning brown lenders offer $\underline{D}_B = \overline{D}(\lambda) = \frac{1}{p_B}$, it is optimal for each brown lender to offer the same repayment term: the firm will surely reject any offer $D' > \frac{1}{p_B}$; if a brown lender offers $D' < \frac{1}{p_B}$, the firm will accept such a deviating offer and choose the brown project since $D' \leq \overline{D}(\lambda)$, which yields a negative payoff

$p_B D' - 1 < 0$ to the deviating brown lender. Lastly, after receiving the offer $\underline{D}_B = \frac{1}{p_B}$, it is optimal for the firm to accept the offer and choose the brown project, which yields the payoff $p_B(R - \underline{D}_B) = p_B R - 1 > 0$ to the firm. Therefore, (b) is the unique equilibrium.

In sum, there is an essentially unique equilibrium in the second-stage subgame (i.e., the firm accepts the same equilibrium repayment term and chooses the same project in all equilibria): if $\overline{D}(\lambda) < \frac{1}{p_B}$, $\underline{D}_B = \frac{1}{p_G}$ and the firm chooses the green project; if $\overline{D}(\lambda) \geq \frac{1}{p_B}$, $\underline{D}_B = \frac{1}{p_B}$ and the firm chooses the brown project.

Step 2: the first-stage subgame. We next characterize the equilibrium strategies in the first stage by backward induction. Knowing that brown lenders will offer $\underline{D}_B$ in the second stage, the firm surely rejects any offer with a repayment term $D > \underline{D}_B$ in the first stage. Thus, a green lender can influence the firm's project selection by directly financing the firm only if she offers a repayment term $D < \underline{D}_B$: the firm will choose the same project even if any green lender offers $D = \underline{D}_B$ and the firm accepts it.

There are two possible cases. First, consider $\overline{D}(\lambda) \geq \frac{1}{p_B}$. Recall from Lemma 1 that the firm will accept $\underline{D}_B = \frac{1}{p_B}$ and then choose the brown project if the firm reaches the second stage, which yields the zero payoff to green lenders. Suppose a green lender offers $D < \underline{D}_B = \frac{1}{p_B} \leq \overline{D}(\lambda)$. Then the firm will accept the green lender's offer but make the same project selection since $D < \overline{D}(\lambda)$. Since $D < \frac{1}{p_B}$, such an offer will yield $p_B D - 1 < 0$ to the green lender, which implies that every green lender has no incentive to offer a repayment term strictly lower than $\underline{D}_B$. Therefore, it is optimal for every green lender to offer $D \geq \frac{1}{p_B}$. Lastly, the firm, whether it borrows in the first stage or in the second stage, optimally chooses the brown project since $\overline{D}(\lambda) \geq \frac{1}{p_B} = \underline{D} = \underline{D}_B$, which constitutes the equilibrium.

Next, consider $\overline{D}(\lambda) < \frac{1}{p_B}$ where we have $\underline{D}_B = \frac{1}{p_G}(> \frac{1}{p_B})$. In this case, the firm will choose the green project if the firm goes to the second stage, which yields $\phi > 0$ to green lenders. The firm makes the same project selection if any green lender offers any repayment term $D \in (\overline{D}(\lambda), \underline{D}_B)$, whereas such an offer yields a strictly lower payoff to the green lender than making no offer since $p_G D - 1 + \phi < \phi$. If a green lender offers $D \leq \overline{D}(\lambda) < \frac{1}{p_B}$, the firm will accept such an offer and choose the brown project. However, the green lender will get a strictly negative payoff $p_B D - 1 < 0$. Since every green lender can get either ϕ or 0 by making no offer, every green lender has no incentive to offer $D \leq \overline{D}(\lambda)$. Combining all these observations, the only possible equilibrium strategy of green lenders is to offer $D \geq \underline{D}_B = \frac{1}{p_G}$. By applying the same logic, it is optimal for every green lender to offer $\underline{D}_G$, given that all winning green lenders play the same strategy. Lastly, since $\overline{D}(\lambda) < \frac{1}{p_G} = \underline{D} = \underline{D}_B$, it is optimal for the firm to borrow from either green or brown lender and choose the green project, which constitutes the equilibrium.

A.2 Proof of Theorem 2

We first state and prove the following lemma, which will be used in the main proof.

Lemma A.1.

(i) Suppose that all lenders make offers simultaneously. In any equilibrium, the winning lenders earn zero financial payoff.

(ii) Suppose that all brown lenders simultaneously offer in the first stage, and then all green lenders simultaneously offer in the second stage. Then, in any equilibrium in the second-stage subgame, all green lenders earn zero financial payoff.

Proof. We throughout focus on the case that there is only one winning lender. The proof for the case of multiple winning lenders is essentially identical and thus omitted.

We prove part (i) first. Suppose to the contrary that the winning lender earns a positive financial payoff in equilibrium by offering a repayment term D. If $D > \overline{D}(\lambda)$, the firm will choose the green project, and hence, the winning lender earns the financial payoff $p_G D - 1 > 0$. However, any brown lender can profitably deviate by offering $D' = D - \varepsilon$ for some $\varepsilon > 0$ such that $\varepsilon < (\frac{p_G D - 1}{p_G}) \wedge (D - \overline{D}(\lambda))$. Similarly, if $D \leq \overline{D}(\lambda)$, the firm will choose the brown project, and hence, the winning lender's financial payoff is $p_B D - 1 > 0$. However, a brown lender can profitably deviate by offering $D' = D - \varepsilon$ such that $\varepsilon < (\frac{p_B D - 1}{p_B})$. Hence, the winning lender cannot earn a strictly positive financial payoff in equilibrium.

Next, suppose that the winning lender earns a negative financial payoff in equilibrium. This can happen only in an equilibrium where the firm chooses the green project (otherwise, the winning lender, regardless of her type, earns a strictly negative equilibrium payoff), which can be supported only if $\overline{D}(\lambda) < \underline{D}$. Furthermore, the negative financial payoff of the winning lender means that $\underline{D} < \frac{1}{p_G}$. Then, the winning lender can profitably deviate by slightly increasing the repayment term to $D' = D + \varepsilon$, where $\varepsilon > 0$ is small enough for D' to be lower than the second-lowest repayment term offered by the other lenders. D' would be accepted by the firm for sure, and then, the firm will still choose the green project because $D' > \underline{D} > \overline{D}(\lambda)$.

Since $\varepsilon > 0$, the winning lender will get a strictly higher total payoff than she would by offering D, a contradiction.

To prove part (ii), consider green lenders in the second stage. Suppose $\underline{D}_G$ yields a strictly positive financial payoff to the winning green lender. If $\underline{D}_G > \overline{D}(\lambda)$, the firm will choose the green project after it accepts $\underline{D}_G$. Hence, we must have $\underline{D}_G > \frac{1}{p_G}$. However, a green lender (other than the winning green lender) can profitably deviate by offering $D' = \underline{D}_G - \varepsilon$ for some $0 < \varepsilon < (\underline{D}_G - \overline{D}(\lambda)) \wedge \left(\frac{p_G \underline{D}_G - 1}{p_G}\right)$: such a deviation is profitable as it generates a positive financial payoff without altering the firm's project selection. Similarly, if $\underline{D}_G \leq \overline{D}(\lambda)$, a green lender can profitably deviate by offering $D' = \underline{D}_G - \varepsilon$ for some $0 < \varepsilon < (\overline{D}(\lambda) - \underline{D}_G) \wedge \left(\frac{p_B \underline{D}_G - 1}{p_B}\right)$. Suppose $\underline{D}_G$ yields a strictly negative financial payoff to the winning green lender. For such a repayment to support an equilibrium, we must have $\underline{D}_G > \overline{D}(\lambda)$: if not, the winning green lender will get the negative total payoff and thus withdraw her offer. Then, the winning green lender can increase her payoff by raising the repayment term to $D' = \underline{D}_G + \varepsilon$ for an arbitrarily small $\varepsilon > 0$ such that D' remains to be the lowest repayment offer; such a deviation is profitable because it increases the lender's financial payoff without changing the firm's project selection. *Q.E.D.*

We are ready to prove Theorem 2.

Case (i): all lenders make offers simultaneously. We first consider the case in which all lenders make offers simultaneously. First, suppose $\overline{D}(\lambda) < \frac{1}{p_B}$. By Lemma 1 and Lemma A.1, we must have $\overline{D}(\lambda) < \frac{1}{p_B} < \underline{D} = \frac{1}{p_G}$ and the firm must choose the green project. We first show that, given that $\underline{D} = \frac{1}{p_G}$, it is indeed optimal for each green lender to offer the same repayment term. Suppose a green lender deviates by offering $D' \neq \underline{D}$. If $D' > \underline{D}$, the firm will reject a deviating offer. If $\overline{D}(\lambda) < D' < \underline{D}$, the firm will accept the deviating offer and choose the same green project, which will yield the deviating green lender to suffer a financial loss but the same externality. If $D' \leq \overline{D}(\lambda)$, the firm will accept the deviating offer and choose the brown project, which will yield the deviating green lender to suffer both a financial loss and zero externality. Similarly, it is also optimal for each brown lender to offer the same repayment term $\underline{D}$. Lastly, since $\underline{D} > \overline{D}(\lambda)$, it is optimal for the firm to borrow at the repayment term $\underline{D}$ and choose the green project.

Second, suppose $\frac{1}{p_B} \leq \overline{D}(\lambda)$. By Lemma 1 and Lemma A.1, we must have either $\frac{1}{p_B} \leq \overline{D}(\lambda) < \underline{D} = \frac{1}{p_G}$ or $\underline{D} = \frac{1}{p_B} \leq \overline{D}(\lambda)$ in equilibrium. We first show that the former outcome cannot be an equilibrium. In any equilibrium such that $\frac{1}{p_B} \leq \overline{D}(\lambda) < \underline{D} = \frac{1}{p_G}$ (if any), a brown lender could get a non-negative payoff and a strictly higher probability of funding by deviating to $D' = \frac{1}{p_B} < \underline{D}$. By the tie-breaking rule in the lenders' bidding, every brown lender will prefer offering D' to $\underline{D}$, which should never happen in equilibrium. Therefore, we must have $\underline{D} = \frac{1}{p_B} \leq \overline{D}(\lambda)$ in any equilibrium. Next, given that the lowest repayment term offer is $\underline{D} = \frac{1}{p_B} \leq \overline{D}(\lambda)$, it is indeed optimal for each green lender to offer the same repayment term: any repayment $D' > \underline{D}$ would be rejected by the firm, while any repayment $D' < \underline{D}$ would yield a negative payoff to the deviating green lender. Similarly, it is also optimal for each brown lender to offer the same repayment term $\underline{D}$. Lastly, since $\underline{D} > \overline{D}(\lambda)$, it is optimal for the firm to borrow at the repayment term $\underline{D}$ and choose the brown project.

Case (ii): brown lenders make offers prior to green lenders. Next, suppose that brown lenders make offers prior to green lenders. By Lemma A.1, the green lenders necessarily earn zero financial payoff in the second stage. First, suppose $\overline{D}(\lambda) < \frac{1}{p_B}$. Note that $\underline{D}_G = \frac{1}{p_G}$: if $\underline{D}_G = \frac{1}{p_B}$, a winning green lender will get a strictly negative financial payoff since $p_G < p_B$. We first show that $\underline{D} = \underline{D}_G = \frac{1}{p_G}$, and thus, the firm chooses the green project in any equilibrium. Suppose for contradiction that there is an equilibrium such that $\underline{D} < \underline{D}_G = \frac{1}{p_G}$, which could be the case only if $\underline{D}_B < \underline{D}_G = \frac{1}{p_G}$. If $\underline{D}_B > \overline{D}(\lambda)$, the firm will choose the green project after it accepts $\underline{D}_B$. If $\underline{D}_B \leq \overline{D}(\lambda)$, the firm will choose the brown project after it accepts $\underline{D}_B$. In all possible cases, the winning brown lenders end up with negative payoff upon financing the firm:

$$\begin{cases} p_G \underline{D}_B - 1 < 0 & \text{if} \quad \overline{D}(\lambda) < \underline{D}_B < \underline{D}_G = \frac{1}{p_G}, \\ p_B \underline{D}_B - 1 < 0 & \text{if} \quad \underline{D}_B \leq \overline{D}(\lambda) < \frac{1}{p_B}. \end{cases}$$

However, the winning brown lenders can always avoid such negative payoff by offering a sufficiently high repayment term that the firm would reject for sure. Contradiction.

We next show that all lenders have no incentive to deviate from $\underline{D} = \frac{1}{p_G}$, given that the winning lenders offer the same repayment term. First, consider green lenders. If a green lender deviates and offers $D' > \underline{D}_G$, the firm would reject D' for sure. If a green lender deviates by offering $D' \in (\overline{D}(\lambda), \underline{D}_G)$, she will surely fund the firm but get a strict net loss since $p_G D' - 1 + \phi < \phi$. Finally, if a green lender offers $D' \leq \overline{D}(\lambda)$, the firm will accept the offer and choose the brown project. However, such an offer will gives the negative net payoff $p_B D' - 1 < 0$ since $\overline{D}(\lambda) < \frac{1}{p_B}$. Similarly, all brown lenders also have no incentive to deviate from $\underline{D}$. Finally, after receiving the offer $\underline{D} = \frac{1}{p_G}$, it is optimal for the firm to choose the green project whether it borrows from a brown lender or a green lender.

Next, suppose $\overline{D}(\lambda) \geq \frac{1}{p_B}$. We first show that $\underline{D} = \frac{1}{p_B}$, and thus, the firm chooses the brown project in any equilibrium. First of all, we can exclude the possibility $\underline{D} < \frac{1}{p_B} \leq \overline{D}(\lambda)$, in which case the winning lenders would obtain negative payoff. Furthermore, if the winning lenders earn a positive financial payoff, a brown lender could benefit from undercutting $\underline{D}$; hence, we necessarily have either $\underline{D} = \frac{1}{p_B} \leq \overline{D}(\lambda)$ or $\underline{D} = \frac{1}{p_G} > \overline{D}(\lambda)$ in any equilibrium. Finally, we can further eliminate the possibility of $\underline{D} = \frac{1}{p_G} > \overline{D}(\lambda)$ because such equilibrium would violate the tie-breaking rule for lenders: by deviating to $D' = \frac{1}{p_B} \leq \overline{D}(\lambda)$, a brown lender could maximize her chance to finance the firm without making any financial loss. In sum, we must have $\underline{D} = \frac{1}{p_B}$ in any equilibrium.

Furthermore, lenders have no incentive to deviate from $\underline{D} = \frac{1}{p_B}$, given that all other lenders offer the same repayment term. Indeed, any deviation to $D' > \frac{1}{p_B}$ would be rejected by the firm for sure, while any deviation to $D' < \frac{1}{p_B} \leq \overline{D}(\lambda)$ results in a negative financial payoff without changing the firm's projection choice. Finally, after receiving the offer $\underline{D} = \frac{1}{p_B}$, it is optimal for the firm to choose the brown project whether it borrows from a brown lender or a green lender.

A.3 Proof of Theorem 3

Case (i): $\frac{1}{p_B} \leq \overline{D}(\lambda) < \left(\frac{1+\phi}{p_B}\right) \wedge \frac{1}{p_G}$. In this case, we construct two equilibria. First, we establish an equilibrium where all (green) lenders offer $\underline{D} = \frac{1}{p_G}$, and the firm chooses the green project for sure. In this equilibrium, every lender gets the payoff $u^* := p_G\underline{D} - 1 + \phi = \phi > 0$. To see that there is no profitable deviation, suppose a deviation offer $D' > \overline{D}(\lambda)$ first. Such deviation will never increase the deviating lender's financial payoff (D' only results in a negative financial payoff if $D' \in (\overline{D}(\lambda), \underline{D})$; D' will be rejected for sure by the firm if $D' > \underline{D}$) without changing the firm's project decision. Therefore, any deviation $D' > \overline{D}(\lambda)$ cannot strictly better off the deviating lender. Next, suppose a deviation offer $D' \leq \overline{D}(\lambda)$. The firm will then accept D' and then choose the brown project. Thus, the deviating lender would obtain $p_B D' - 1$ as final payoff, which is strictly less than u^* since

$$p_B D' - 1 \leq p_B \overline{D}(\lambda) - 1 < p_B \times \frac{1+\phi}{p_B} - 1 = \phi = u^*.$$

In sum, no lender has any incentive to deviate from $\underline{D} = \frac{1}{p_G}$. Furthermore, it is optimal for the firm to accept the offer $\underline{D} = \frac{1}{p_G}$ and choose the green project: undertaking the green project yields a strictly higher payoff than rejecting the offer $\underline{D}$ (i.e., $p_G(R - \underline{D}) + \lambda\phi > 0$);

the firm chooses the green project under the repayment term $\underline{D} = \frac{1}{p_G}$ by Lemma 1.

Next, we establish another equilibrium in which the firm chooses the brown project. To see this, suppose that all lenders offer $\underline{D} = \frac{1}{p_B}$. By Lemma 1, it is straightforward that the firm chooses the brown project. Furthermore, all lenders earn zero payoffs since $\underline{D}$ breaks the lenders even, and the brown project creates no externality. It is also straightforward that no lender has any profitable deviation; any deviation to $D' > \underline{D}$ will be rejected by the firm for sure, while any deviation to $D' < \underline{D}$ only results in a strictly negative payoff. Lastly, it is optimal for the firm to accept the offer $\underline{D}$ since undertaking the brown project under $\underline{D}$ yields a strictly higher payoff than rejecting the offer (i.e., $p_B(R - \underline{D}) > 0$).

Case (ii): $\overline{D}(\lambda) < \frac{1}{p_B} < \left(\frac{1+\phi}{p_B}\right) \wedge \frac{1}{p_G}$. By applying the same logic used in the previous case for the establishment of the first type of equilibrium, it is straightforward that there is an equilibrium where the firm chooses the green project. In the remainder of this proof, we will show that the firm chooses the green project in any equilibrium. Suppose to the contrary that there is an equilibrium in which the firm chooses the brown project. In this equilibrium, we must have $\underline{D} \leq \overline{D}(\lambda)$ (Lemma 1). Furthermore, since all lenders compete in Bertrand fashion, all lenders must earn zero payoffs in any equilibrium in which the firm chooses the brown project (the proof is essentially identical to the proof of Lemma A.1), which is the case only if $\underline{D} = \frac{1}{p_B}$. However, we have $\frac{1}{p_B} > \overline{D}(\lambda)$, which implies $\underline{D} > \overline{D}(\lambda)$, a contradiction.

Case (iii): $\left(\frac{1+\phi}{p_B}\right) \wedge \frac{1}{p_G} \leq \overline{D}(\lambda)$. The condition $\left(\frac{1+\phi}{p_B}\right) \wedge \frac{1}{p_G} \leq \overline{D}(\lambda)$ can be rewritten as $\frac{1}{p_B} < \left(\frac{1+\phi}{p_B}\right) \wedge \frac{1}{p_G} \leq \overline{D}(\lambda)$. By applying the same logic in part (i) for the establishment of the second type of equilibrium, there is an equilibrium in which the firm chooses the brown project. In the remainder of this proof, we will show that the firm chooses the brown project in any equilibrium. Suppose to the contrary that there is an equilibrium where the firm chooses the green project. Since all lenders compete in Bertrand fashion, all lenders must earn zero financial payoffs in any equilibrium (the proof is essentially identical to the proof of Lemma A.1), which implies $\underline{D} = \frac{1}{p_G} \leq \overline{D}(\lambda)$. However, by Lemma 1, the firm must prefer the green project only if $\underline{D} = \frac{1}{p_G} > \overline{D}(\lambda)$, a contradiction.

A.4 Proof of Theorem 4

Proof of Theorem 4-(i). We first construct a strategy profile such that both green and brown firms choose the green project. Later on, we verify that this strategy profile constitutes an equilibrium. Choose two real numbers $t_G \in [0,1]$ and $t_B \in [0,1]$ such that

$$\frac{qt_G}{qt_G + (1-q)t_B} > \frac{p_B\overline{D}(\lambda_B) - 1}{(p_B - p_G)\overline{D}(\lambda_B)} \tag{A.1}$$

Note that the right hand side of (A.1) lies in $[0,1)$ by the assumption $\frac{1}{p_B} \leq \overline{D}(\lambda_B) < \frac{1}{p_G}$ and thus there always exist t_G and t_B that satisfy (A.1). Indeed, $t_G = 1$ and $t_B = 0$ always satisfy (A.3). We can also rewrite (A.1) as

$$\frac{qt_G + (1-q)t_B}{qt_G p_G + (1-q)t_B p_B} > \overline{D}(\lambda_B). \tag{A.2}$$

For any given pair (t_G, t_B) that satisfies (A.2), consider the following strategy profile:

- All lenders (both green and brown lenders) offer $\underline{D} = \underline{D}_G = \underline{D}_B = \frac{1}{p_G}$.
- Let $\underline{D}_1$ denote the lowest repayment term the firm receives in the first stage:
  (a) If $\underline{D}_1 > \frac{1}{p_G}$, both green and brown firms reject $\underline{D}_1$;
  (b) If $\underline{D}_1 < \frac{1}{p_G}$, both green and brown firms accept $\underline{D}_1$. For each $\lambda \in \{\lambda_B, \lambda_G\}$, the firm with type λ chooses the green project if and only if $\underline{D}_1 > \overline{D}(\lambda)$;
  (c) For each $i \in \{G, B\}$, if $\underline{D}_1 = \frac{1}{p_G}$, then the firm with type λ_i accepts $\underline{D}_1$ with probability $1 - t_i$ and then chooses in the green project.
- Let $\underline{D}_2$ the lowest repayment term that the firm receives in the second stage:
  - For each $\lambda \in \{\lambda_B, \lambda_G\}$, the firm with type λ accepts $\underline{D}_2$ if and only if $\max\{p_B(R - \underline{D}_2), p_G(R - \underline{D}_2) + \lambda\phi\} \geq 0$;
  - If the firm accepts $\underline{D}_2$, the firm chooses the green project if and only if $\underline{D}_2 > \overline{D}(\lambda)$.
- In the second stage, brown lenders believe that the firm is of λ_G type with the following posterior probability:[20]

$$q_2^* := \frac{qt_G}{qt_G + (1-q)t_B}.$$

In what follows, we will show that the above strategy profile constitutes an equilibrium. In the light of Lemma 1 and 2, it is straightforward that the firm's strategy is (weakly) optimal

[20]We choose t_B strictly larger than zero, and hence, the second stage is reached with a positive probability. As a result, all brown lenders hold a well-defined common posterior belief q_2^*.

for both types. In addition, the posterior belief q_2^* is consistent with the actions taken by green and brown firms. Thus, it remains to check whether it is optimal for both brown and green lenders to play the prescribed strategies.

Brown lenders: We first prove that it is optimal for brown lenders to play the prescribed strategy. Note that all brown lenders earn zero payoff if they play the prescribed strategy by offering $\underline{D}_B = \frac{1}{p_G}$. Thus, it suffices to show that a brown lender cannot get a strictly higher payoff by offering $D' \neq \underline{D}_B$ given that all the other brown lenders offer $\underline{D}_B$. The firm, whether its type is green or brown, will reject any offer with a repayment term $D' > \frac{1}{p_G} = \underline{D}_B$. Hence, we throughout focus on deviating offers $D' < \frac{1}{p_G}$.

First, suppose that a brown lender deviates by offering $D' \in (\overline{D}(\lambda_B), \frac{1}{p_G})$. Since $\overline{D}(\lambda_G) < \overline{D}(\lambda_B) < D' < \underline{D}_B$, both green and brown firms will accept D' and choose the green project. The deviating brown lender will then get the payoff $p_G D' - 1 < 0$. Therefore, no brown lender has an incentive to offer $D' \in (\overline{D}(\lambda_B), \frac{1}{p_G})$.

Next, suppose that a brown lender deviates to $D' \leq \overline{D}(\lambda_G)$. Since $D' \leq \overline{D}(\lambda_G) < \overline{D}(\lambda_B) < \frac{1}{p_G}$, both green and brown firms will accept the deviation offer and choose the brown project. However, the deviating brown lender will suffer a financial loss

$$p_B D - 1 \leq p_B \overline{D}(\lambda_G) - 1 < 0,$$

where the last inequality follows from Assumption 3.

Lastly, suppose that a brown lender deviates to $D' \in (\overline{D}(\lambda_G), \overline{D}(\lambda_B)]$. Again, since $D' < \underline{D}_B$, both green and brown firms will accept the deviation offer, while the green firm will choose the green project and the brown firm chooses the brown project, respectively. Hence, the deviating brown lender will get the expected payoff $[q_2^* p_G + (1 - q_2^*) p_B] D - 1$, which is strictly negative since

$$\begin{aligned}[q_2^* p_G + (1 - q_2^*) p_B] D' - 1 &\leq [q_2^* p_G + (1 - q_2^*) p_B] \overline{D}(\lambda_B) - 1 \\ &= \frac{p_G q t_G + p_B (1 - q) t_B}{q t_G + (1 - q) t_B} \overline{D}(\lambda_B) - 1 < 0,\end{aligned}$$

where the weak inequality follows from $D' \leq \overline{D}(\lambda_B)$ and the strict inequality follows from (A.2), respectively. Consequently, any brown lender does not have an incentive to deviate from offering $\underline{D}_B$, given that all else brown lenders offer $\underline{D}_B$.

Green lenders: Consider the green lenders next. Note that if all green lenders, brown lenders, and brown and green firms play the prescribed equilibrium strategies, each green lender will get zero financial payoff and the extra payoff ϕ from the externality generated by the firm's green project.

In what follows, we prove that it is optimal for each green lender to offer $\underline{D}_G = \frac{1}{p_G}$ given that all else green lenders offer the same repayment term. First, suppose that a green lender deviates to $D' \in (\overline{D}(\lambda_G), \overline{D}(\lambda_B)]$. Then, both green and brown firms will accept D' because $D' \leq \overline{D}(\lambda_B) < \frac{1}{p_G} = \underline{D}$ by Assumption 3. Under the repayment term D', the green firm will choose the green project, while the brown firm will choose the brown project, which gives the deviating lender $[qp_G + (1-q)p_B]D' - 1 + \phi q$ as the final payoff. However, we have

$$[qp_G + (1-q)p_B]D' - 1 + \phi q < [qp_G + (1-q)p_B]\frac{1}{p_G} - 1 + \phi q = (1-q)\frac{p_B - p_G}{p_G} + \phi q \leq \phi$$

where the first inequality follows from $D \leq \overline{D}(\lambda_B) < \frac{1}{p_G}$ by Assumption 3, and the second inequality follows from $\phi \geq \frac{p_B - p_G}{p_G}$ by Assumption 1 and 2.[21] Hence, the deviation will yield a payoff strictly lower than the equilibrium payoff ϕ.

Next, suppose that a green lender deviates to $D' \in [0, \overline{D}(\lambda_G)] \cup (\overline{D}(\lambda_B), \infty)$. Given that both types of the firm already choose the green project on the equilibrium path, it suffices to show that D' never yields a strictly positive financial payoff to the deviating green lender. Neither the green nor brown firm would accept $D' > \underline{D} = \frac{1}{p_G}$, and thus, we can focus on the case $D' \in [0, \overline{D}(\lambda_G)] \cup (\overline{D}(\lambda_B), \frac{1}{p_G})$. Note that any D' lower than $\underline{D} = \frac{1}{p_G}$ will be accepted by both types of the firm for sure. However, if $D' \leq \overline{D}(\lambda_G)$, both types of the firm will choose the brown project, and thus, the deviating lender will earn the financial payoff $p_B D' - 1 \leq p_B \overline{D}(\lambda_G) - 1 < 0$. On the other hand, if $D' \in (\overline{D}(\lambda_B), \frac{1}{p_G})$, both types of the firm will choose the green project, and thus, the deviating lender will earn the financial payoff $p_G D' - 1 < p_G \frac{1}{p_G} - 1 = 0$.

Proof of Theorem 4-(ii). We throughout focus on the cast that brown lenders and green lenders bid simultaneously; the proof Theorem 4-(ii) for The case that brown lenders bid first is essentially identical and thus omitted.

Note first that there is always an equilibrium such that all lenders simultaneously offer $\underline{D} = \frac{1}{qp_G + (1-q)p_B}$, and then, the brown firm and the green firm respectively the brown project and the green project. Suppose to the contrary of Theorem 4-(ii) that there is an

[21] By Assumption 1-(ii), we have $R \geq \frac{1}{p_G}$. In addition, we have $\phi > (p_B - p_G)R$ by Assumption 2. Combining these two inequalities, we obtain $\phi > \frac{p_B - p_G}{p_G}$.

equilibrium in which both green and brown firms choose the green project. Let $\tilde{D}$ denote the equilibrium repayment term that both firms accept. Since both firms choose the green project and $\overline{D}(\lambda_G) < \overline{D}(\lambda_B)$, we must have $\overline{D}(\lambda_B) < \tilde{D}$ by Lemma 1. Furthermore, by the standard argument in Bertrand competition, all brown lenders must earn zero payoff in equilibrium: if a brown lender suffers a negative payoff, she can increase her payoff to zero by withdrawing her offer; if a brown lender earns a positive payoff by financing the firm with a positive probability, another brown lender can profitably deviate by offering a repayment term slightly lower than the winning brown lender(s).

Suppose that a brown lender deviates and offers $D' = \overline{D}(\lambda_B) < \tilde{D}$. Both green and brown firms will accept D', so the deviating brown lender can strictly increase her probability of financing.[22] Since $\overline{D}(\lambda_G) < \overline{D}(\lambda_B)$, the green firm will choose the green project, and the brown firm will choose the brown project. Thus, the deviating lender gets the payoff $[qp_G + (1-q)p_B]\overline{D}(\lambda_B) - 1$, where

$$[qp_G + (1-q)p_B]\overline{D}(\lambda_B) - 1 \geq 0.$$

Since brown lenders get zero payoff from offering $\tilde{D}$, the deviating lender has the incentive to deviate by offering $D' = \overline{D}(\lambda_B)$, a contradiction.

A.5 Proof of Theorem 5

In this section, we introduce a new notation $\underline{D}_2$, which denote the lowest repayment term offered in equilibrium in the second stage. Similarly, a notation $\underline{D}_1$ denotes the lowest repayment term offered in equilibrium in the first stage. Finally, let $\underline{D} = \min\{\underline{D}_1, \underline{D}_2\}$.

Proof of Theorem 5-(i). We first show that there always exists an equilibrium such that the brown firm chooses the brown project. If $\frac{1}{p_B} \leq \overline{D}(\lambda_B)$, it is straightforward that the following strategy profile constitutes an equilibrium: all lenders offer $D = \frac{1}{p_B}$, and then, both green and brown firms choose the brown project. If $\frac{1}{p_B} > \overline{D}(\lambda_B)$, Assumption 4-(ii) implies

$$\overline{D}(\lambda_G) < \frac{1}{p_B} < \frac{1}{qp_G + (1-q)p_B} \leq \frac{1 + (1-q)\phi}{qp_G + (1-q)p_B} \leq \overline{D}(\lambda_B).$$

Thus, the following strategy profile constitutes an equilibrium: all lenders offer the repayment

[22] There are multiple brown lenders in the model, and hence, the equilibrium funding probability is strictly less than one for at least one brown lender.

term $D = \frac{1}{qp_B + (1-q)p_B}$, and then, the firm chooses the brown project if and only if $\lambda = \lambda_B$.

Suppose to the contrary of Theorem 5-(i) that there is an equilibrium in which both brown and green firms choose the green project. Let $\tilde{D}$ denote the equilibrium repayment term that both brown and green firms accept. Since both firms choose the green project and $\overline{D}(\lambda_G) < \overline{D}(\lambda_B)$, we must have $\overline{D}(\lambda_B) < \tilde{D}$ by Lemma 1. Furthermore, by the standard argument in Bertrand competition (Lemma A.1), all green lenders must earn zero financial payoff in equilibrium and thus obtain the equilibrium payoff ϕ.

Suppose that a green lender deviates and offers $D' = \overline{D}(\lambda_B) < \tilde{D}$. Then both green and brown firms will accept D', so the deviating green lender can strictly increase her probability of funding.[23] Since $\overline{D}(\lambda_G) < \overline{D}(\lambda_B) = D'$, the green firm will still choose the green project, and the brown firm will choose the brown project under D', respectively. Thus, the payoff of the deviating green lender is

$$[qp_G + (1-q)p_B]\overline{D}(\lambda_B) - 1 + q\phi \geq 1 + (1-q)\phi - 1 + q\phi \geq \phi$$

Hence, the deviating green lender has the incentive to deviate by offering $D' = \overline{D}(\lambda_B)$, a contradiction.

Proof of Theorem 5-(ii). We construct a strategy profile that both green and brown firms choose the green project for the case that multiple (more than two) green lenders simultaneously bid in the second stage.[24] Specifically, choose two real numbers $t_G \in [0, 1]$ and $t_B \in [0, 1]$ such that

$$\frac{qt_G}{qt_G + (1-q)t_B} > \frac{p_B\overline{D}(\lambda_B) - 1}{(p_B - p_G)\overline{D}(\lambda_B)} \tag{A.3}$$

Note that the right hand side of (A.3) lies in $[0, 1)$ by the assumption $\frac{1}{p_B} < \frac{1+\phi}{p_B} \leq \overline{D}(\lambda_B) < \frac{1}{p_G}$ and thus there always exist t_G and t_B that satisfy (A.3). Indeed, $t_G = 1$ and $t_B = 0$ always satisfy (A.3). We can also rewrite (A.3) as

$$\frac{qt_G + (1-q)t_B}{qt_Gp_G + (1-q)t_Bp_B} > \overline{D}(\lambda_B). \tag{A.4}$$

For any given pair (t_G, t_B) that satisfies (A.4), consider the following strategy profile:

- All green lenders offer $D = \underline{D} = \frac{1}{p_G}$.

[23] There are multiple lenders in the model, and hence, the equilibrium funding probability is strictly less than one for at least one lender.

[24] See Proposition B.4 for the proof of the cases in which only one green lender bids in the second stage.

- Let $\underline{D}_1$ denote the lowest repayment term the firm receives in the first stage:
  (a) If $\underline{D}_1 > \frac{1}{p_G}$, both green and brown firms reject $\underline{D}_1$;
  (b) If $\underline{D}_1 < \frac{1}{p_G}$, both green and brown firms accept $\underline{D}_1$. For each $\lambda \in \{\lambda_B, \lambda_G\}$, the firm with type λ chooses the green project if and only if $\underline{D}_1 > \overline{D}(\lambda)$;
  (c) For each $i \in \{G, B\}$, if $\underline{D}_1 = \frac{1}{p_G}$, then the firm with type λ_i accepts $\underline{D}_1$ with probability $1 - t_i$ and then chooses in the green project.
- Let $\underline{D}_2$ the lowest repayment term that the firm receives in the second stage:
  - For each $\lambda \in \{\lambda_B, \lambda_G\}$, the firm with type λ accepts $\underline{D}_2$ if and only if $\max\{p_B(R - \underline{D}_2), p_G(R - \underline{D}_2) + \lambda\phi\} \geq 0$;
  - If the firm accepts D_2, the firm chooses the green project if and only if $\underline{D}_2 > \overline{D}(\lambda)$.
- In the second stage, all lenders believe that the firm is of λ_G type with the following posterior probability:
$$q_2^* := \frac{qt_G}{qt_G + (1-q)t_B}.$$

Verifying that the strategy profile described above constitutes an equilibrium is essentially identical to the proof of Theorem 4-(i), so we omit the formal proof.

Internet Appendix

B Supplementary Analysis

In this section, we provide supplementary analysis of the model with adverse selection presented in Section 4.

B.1 The Capital Market with Both Brown and Green lenders

First, consider the case that there are both brown and green lenders in the capital market (Section 4.1). We index brown lenders by $j = 1, 2, \ldots, n_B$, and let q^j denote the probability (belief) that the j-th brown lender assigns to the firm's private type $\lambda = \lambda_G$ in equilibrium, *conditional on* the event that the firm reaches to the second stage after rejecting all offers of green lenders. Lastly, we define $F(D; q')$ as follows:

$$F(D; q') := \begin{cases} [q' p_G + (1 - q') p_B] D - 1 & \text{if } \overline{D}(\lambda_G) < D \leq D(\lambda_B), \\ p_G D - 1 & \text{if } D > D(\lambda_B), \\ p_B D - 1 & \text{if } D \leq D(\lambda_G). \end{cases}$$

Indeed, $F(D; q')$ is the net financial gain of a brown lender with a repayment term D and belief that $\lambda = \lambda_G$ with probability q'.

We first present two preliminary observations. We throughout call any brown lender who offers a repayment term strictly higher than $\underline{D}_B$ a *"losing brown lender."*

Lemma B.1. *Suppose that Assumption 3-(i) holds, then we have the following:*

(i) In equilibrium, $q^j \leq q^i$ for any winning brown lender j and any losing brown lender i;

(ii) In any equilibrium such that the second stage is reached with a positive probability, $F(\underline{D}_B; q^j) = 0$ for any winning brown lender j.

Proof. To prove (i), suppose to the contrary that there is a winning brown lender j and a losing brown lender i such that $q^j > q^i$. Since the winning brown lender j must earn non-negative financial payoff in equilibrium, we necessarily have $F(\underline{D}_B; q^j) \geq 0$. Then there are two possible cases. First, if $\overline{D}(\lambda_G) < \underline{D}_B \leq \overline{D}(\lambda_B)$, we have

$$0 \leq F(\underline{D}_B; q^j) = [q^j p_G + (1-q^j)p_B]\underline{D}_B - 1 < [q^i p_G + (1-q^i)p_B]\underline{D}_B - 1 = F(\underline{D}_B; q^i).$$

Hence, the brown lender i has the incentive to deviate by undercutting the winning brown lender's offer $\underline{D}_B$. Second, if $\underline{D}_B \in (0, \overline{D}(\lambda_G)]$, we have $F(\underline{D}_B; q^i) = F(\underline{D}_B; q^j) = p_B\underline{D}_B - 1 \geq 0$. Similarly, if $\underline{D}_B \in (\overline{D}(\lambda_B), \infty)$, we have $F(\underline{D}_B; q^i) = F(\underline{D}_B; q^j) = p_G\underline{D}_B - 1 \geq 0$. Hence the losing brown lender i can increase her funding probability by offering $\underline{D}_B$ without making any financial loss, which violates the tie-breaking rule for the lenders, a contradiction.

We next prove part (ii). Since all brown lenders have a common prior belief about the firm's private type, commonly observe the firm's action taken in the first stage, and rationally believe how each type of the firm behaves, all brown lenders must have the same posterior belief (i.e., $q^i = q^j$ for any i and j) in any equilibrium where the second stage is reached with a positive probability. Furthermore, recall from the proof of part (i) that $F(\underline{D}_B; q^j) \geq 0$ for any winning brown lender j. If $F(\underline{D}_B; q^j) > 0$ for some winning brown lender j, any brown lender i can profitably deviate by offering a repayment term $D < \underline{D}_B$ such that $F(D; q^i) > 0$. Therefore, we must have $F(\underline{D}_B; q^j) = 0$ for every winning brown lender j. *Q.E.D.*

Lemma B.2. *Suppose that Assumption 3-(i) holds. Then $\underline{D}_B > \overline{D}(\lambda_G)$ and the green firm surely chooses the green project in any equilibrium.*

Proof. Suppose to the contrary that there is an equilibrium in which $\underline{D}_B \leq \overline{D}(\lambda_G)$. Suppose further that a winning brown lender expects the firm to choose the green project with probability $x \in [0,1]$ in response to the offer $\underline{D}_B$. In this equilibrium, any winning brown lender will get the payoff

$$[xp_G + (1-x)p_B]\underline{D}_B - 1 \leq [xp_G + (1-x)p_B]\overline{D}(\lambda_G) - 1 < 0,$$

where the weak inequality follows from $\underline{D}_B \leq \overline{D}(\lambda_G)$ and the strict inequality follows from $\overline{D}(\lambda_G) < \frac{1}{p_B} < \frac{1}{p_G}$ in Assumption 3-(i). Thus any winning brown lender can profitably deviate by withdrawing her offer, a contradiction.

To prove the second part, suppose to the contrary that there is an equilibrium in which the green firm chooses the brown project with a positive probability. By Lemma 1, such an equilibrium can be supported only if $\underline{D} \leq \overline{D}(\lambda_G)$. Since we prove $\underline{D}_B > \overline{D}(\lambda_G)$ in the previous part and $\underline{D} = \min\{\underline{D}_B, \underline{D}_G\}$ by definition of $\underline{D}$, we must have

$$\underline{D} = \underline{D}_G \leq \overline{D}(\lambda_G) < \underline{D}_B.$$

Hence, both green and brown firms will accept $\underline{D}_G$ by Lemma 2. Furthermore, both firms will surely choose the brown project since $\overline{D}(\lambda_B) > \overline{D}(\lambda_G) \geq \underline{D}_G$. This implies that the winning green lender(s) will get the payoff

$$p_B \underline{D}_G - 1 \leq p_B \overline{D}(\lambda_G) - 1 < 0,$$

where the last strict inequality is due to Assumption 3-(i). However, the winning green lender can get a strictly higher (zero) payoff by withdrawing her offer, a contradiction. *Q.E.D.*

The following proposition clarifies the role of Assumption 3-(ii) in our analysis.

Proposition B.1. *Suppose Assumption 3-(i) holds true and*

$$\overline{D}(\lambda_B) < \frac{1}{qp_G + (1-q)p_B}. \tag{B.1}$$

Then, both green and brown firms choose the green project in any equilibrium.

Proof. First of all, it is straightforward that the equilibrium stated by Theorem 4-(i) also exists if the condition (B.1) holds true. In this proof, we will show that both green and brown firms also choose the green project in all other equilibria (if exists). Recall from Lemma B.2 that the green firm chooses the green project in any equilibrium. Therefore, we must have $\overline{D}(\lambda_G) < \underline{D}$. Suppose to the contrary that there is an equilibrium in which the brown firm chooses the brown project. By Lemma 1, the brown firm chooses the brown project only if

$$\underline{D} \leq \overline{D}(\lambda_B). \tag{B.2}$$

Combining these conditions with (B.1), we must have

$$\overline{D}(\lambda_G) < \underline{D} = \min\{\underline{D}_G, \underline{D}_B\} \leq \overline{D}(\lambda_B) < \frac{1}{qp_G + (1-q)p_B}. \tag{B.3}$$

Step 1. We first claim that all lenders (regardless of their types) must earn a non-negative financial payoff in equilibrium. By Lemma B.1, brown lenders always get non-negative payoffs, so it suffices to show that winning green lenders get non-negative payoffs. Suppose to the contrary that a green lender earns a negative financial payoff in equilibrium. We first make some preliminary observations. First, a green lender makes a negative financial payoff only if the firm accepts her repayment term; hence, we may assume this green lender is one of the winning lenders. Second, this lender enjoys non-financial externalities $q\phi$; thus, her equilibrium payoff is strictly less than $q\phi$. Lastly, let $\underline{D}'$ denote the lowest repayment term offer among all other lenders.[25] We must have $\underline{D} \leq \underline{D}'$, and hence $\overline{D}(\lambda_G) < \underline{D}'$.

Now, we claim that this green lender could improve her payoff by deviating from $\underline{D}_G$ and offering $D' > \underline{D}'$. Since the firm chooses the offer with the lowest repayment term (Lemma 2), such a deviating offer D' will give zero financial payoff to the deviating lender. Furthermore, since $\overline{D}(\lambda_G) < \underline{D}'$, the green firm continues choosing the green project. Hence, the deviation to D' yields the lender at least $q\phi$ as a final payoff. In sum, the green lender could strictly improve her payoff by deviating from the equilibrium strategy, a contradiction.

Step 2. We next show that it is impossible for all lenders to have non-negative financial payoffs simultaneously in any equilibrium. Let $y(\lambda) \in [0, 1]$ denote the probability that the firm of type $\lambda \in \{\lambda_G, \lambda_B\}$ finances its project in the first stage. There are three possible cases. First, consider the case $y(\lambda_G) = y(\lambda_B) = 1$. From the observation at the beginning of this proof, the green firm chooses the green project and the brown firm chooses the brown project in equilibrium, respectively. Hence, the green lender who finances the firm in the first stage must get the following financial payoff

$$[qp_G + (1-q)p_B]\underline{D} - 1 \leq [qp_G + (1-q)p_B]\overline{D}(\lambda_B) - 1 < 0,$$

where the first inequality follows from (B.3) and the second inequality follows from (B.1). Similarly, if $y(\lambda_B) = y(\lambda_G) = 0$, any winning brown lender must earn a negative financial payoff.

Finally, suppose $y(\lambda) \in (0, 1)$ for some $\lambda \in \{\lambda_B, \lambda_G\}$. Such randomization is justified only if $\underline{D}_G = \underline{D}_B = \underline{D}$. Then the financial payoff of a winning green lender is

$$[p_G q_1^* + p_B(1 - q_1^*)]\underline{D} - 1, \tag{B.4}$$

where

$$q_1^* = \frac{qy(\lambda_G)}{qy(\lambda_G) + (1-q)y(\lambda_B)}$$

[25] $\underline{D}' = \underline{D}$ if there are multiple winning lenders. $\underline{D}' > \underline{D}$ if the green lender is the only winning lender.

is the probability that the firm borrowing from a green lender is of type λ_G. On the other hand, a winning brown lender gets the following financial payoff

$$[p_G q_2^* + p_B(1 - q_2^*)]\underline{D} - 1, \tag{B.5}$$

where

$$q_2^* = \frac{q(1 - y(\lambda_G))}{q(1 - y(\lambda_G)) + (1 - q)(1 - y(\lambda_B))},$$

is the probability that the firm borrowing from a brown lender is of type λ_G. Since the brown lender's financial payoff (B.5) must be zero by Lemma B.1, (B.5) must be equal to zero, which implies

$$\underline{D} = \frac{1}{p_G q_2^* + p_B(1 - q_2^*)}. \tag{B.6}$$

Substituting $\underline{D}$ in (B.3) with (B.6), we have

$$\underline{D} = \frac{1}{p_G q_2^* + p_B(1 - q_2^*)} \leq \overline{D}(\lambda_B) < \frac{1}{q p_G + (1 - q) p_B} \quad \Longleftrightarrow \quad q > q_2^*. \tag{B.7}$$

In addition, substituting $\underline{D}$ in (B.4) with (B.6), the green lender's financial payoff (B.4) is non-negative if and only if

$$\frac{p_G q_1^* + p_B(1 - q_1^*)}{p_G q_2^* + p_B(1 - q_2^*)} \geq 1 \quad \Longleftrightarrow \quad q_1^* \leq q_2^* \quad \Longleftrightarrow \quad y(\lambda_G) \leq y(\lambda_B).$$

But the inequality $y(\lambda_G) \leq y(\lambda_B)$ implies

$$q_2^* = \frac{q(1 - y(\lambda_G))}{q(1 - y(\lambda_G)) + (1 - q)(1 - y(\lambda_B))} \geq q,$$

which contradicts the earlier observation in (B.7). Since Step 1 and 2 cannot jointly hold true, there cannot exist any equilibrium where the brown firm chooses the brown project, a contradiction. *Q.E.D.*

The next proposition shows that, in any equilibrium where both green and brown firms choose the green project, any winning brown lender must hold a posterior belief that necessarily assigns a probability to the firm's type $\lambda = \lambda_G$ strictly higher than the prior probability q.

Proposition B.2. *Suppose that Assumption 3-(i) and (ii) hold true. In any equilibrium where both green and brown firms choose the green project, any brown lender's posterior belief* *assigns a probability to the firm's type $\lambda = \lambda_G$ strictly higher than q (i.e., $q^j > q$ for all $j = 1, 2, \ldots, n_B$).*

Proof. Recall from Lemma B.1 that, in any equilibrium, any winning brown lender must assign a lower posterior belief to the firm's type $\lambda = \lambda_G$ than any other brown lender. Let $\underline{q}_2$ denote the posterior belief held by the winning brown lenders in equilibrium where both green and brown firms choose the green project.

We first show that we necessarily have $\underline{D}_B \geq \underline{D}_G$. Suppose to the contrary $\underline{D}_B < \underline{D}_G$. Then both green and brown firms will surely reject $\underline{D}_G$ (Lemma 2), which yields $\underline{q}_2 = q$ and $\underline{D}_B p_G - 1 = 0$ (Lemma B.1). Now suppose that one of the winning brown lenders deviates to a repayment offer $D = \overline{D}(\lambda_B)$. Since $\overline{D}(\lambda_B) < \underline{D} = \underline{D}_B = \frac{1}{p_G}$, both green and brown firms will accept the deviating offer. After accepting the repayment term D, the brown firm will choose the brown project and the green firm will choose the green project, respectively (Lemma 1). Hence, the deviating lender will get the following payoff

$$[qp_G + (1-q)p_B]D - 1 = [qp_G + (1-q)p_B]\overline{D}(\lambda_B) - 1 \geq 0,$$

where the last inequality follows from Assumption 3. In sum, the deviating brown lender can weakly increase her payoff and strictly increase her probability of funding. However, this should not be the case in equilibrium, a contradiction.

Next, consider any equilibrium where $\underline{D} = \underline{D}_G \leq \underline{D}_B$ and both green and brown firms choose the green project. By Lemma 1, we must have $\overline{D}(\lambda_B) < \underline{D} \leq \underline{D}_B$ to support this equilibrium. Furthermore, to prevent the possibility of undercutting $\underline{D}_B$ in the second stage, we must have $\underline{D}_B = \frac{1}{p_G}$, and thus, all brown lenders earn zero payoff in the second stage. Suppose that one of the winning brown lenders deviates to $D' = \overline{D}(\lambda_B)$. Such deviation induces the brown firm to choose the brown project and the green firm to choose the green project, which gives the deviating brown lender $[\underline{q}_2 p_G + (1-\underline{q}_2)p_B]\overline{D}(\lambda_B) - 1$. For this deviation not to be profitable, the following condition must hold:[26]

$$[\underline{q}_2 p_G + (1-\underline{q}_2)p_B]\overline{D}(\lambda_B) - 1 < 0 \quad \Longleftrightarrow \quad \overline{D}(\lambda_B) < \frac{1}{\underline{q}_2 p_G + (1-\underline{q}_2)p_B}.$$

Since $\overline{D}(\lambda_B) \geq \frac{1}{qp_G + (1-q)p_B}$ by Assumption 3, the last inequality holds only if $q < \underline{q}_2$, which is the desired result. *Q.E.D.*

[26]If $[\underline{q}_2 p_G + (1-\underline{q}_2)p_B]\overline{D}(\lambda_B) - 1 = 0$, the deviating lender cannot strictly improve her final payoff but can strictly increase her probability of funding.

B.2 The Capital Market with Green lenders Only

Next, consider the case as in Section 4.2 where only green lenders are in the capital market.

Proposition B.3. *Suppose all green lenders simultaneously compete in the capital market. Suppose further Assumption 4-(i) and the following inequality hold:*

$$\overline{D}(\lambda_B) < \frac{1 + (1-q)\phi}{qp_G + (1-q)p_B}. \tag{B.8}$$

Then, there exists an equilibrium in which both brown and green firms choose the green project. The same outcome is supported as an equilibrium when at least one green lender can bid for funding in the first stage, and multiple green lenders simultaneously bid in the second stage.

Proof. We first prove for the case where all green lenders simultaneously compete in the capital market. Suppose that all green lenders offer $\tilde{D} = \frac{1}{p_G} > \overline{D}(\lambda_B) > \overline{D}(\lambda_G)$. Then, both green and brown firms accept $\tilde{D}$ and then choose the green project. Thus, if no lender deviates from $\tilde{D}$, all green lenders obtain the payoff

$$\frac{1}{n_G}\left(p_G\tilde{D} - 1\right) + \phi = \phi.$$

To show that no lender has the incentive to deviate from the symmetric offer strategy $\tilde{D}$, suppose to the contrary that one of the lenders deviates to $D' \neq \tilde{D}$. Since any $D' > \tilde{D}$ will be surely rejected by both brown and green, we focus on the deviating offers $D' < \tilde{D}$ without loss of generality. First, if $D' \in (\overline{D}(\lambda_B), \tilde{D})$, both brown and green firms will accept D' and then choose the green project, yielding the following payoff to the deviating lender:

$$p_G D' - 1 + \phi < p_G\tilde{D} - 1 + \phi = \phi.$$

Next, if $D' \in (\overline{D}(\lambda_G), \overline{D}(\lambda_B)]$, the brown firm and the green firm will respectively choose the brown and green projects in response to D', yielding the following payoff to the deviating lender:

$$\begin{aligned}[qp_G + (1-q)p_B]D' - 1 + q\phi &\leq [qp_G + (1-q)p_B]\overline{D}(\lambda_B) - 1 + q\phi \\ &< 1 + (1-q)\phi - 1 + q\phi = \phi,\end{aligned}$$

where the strict inequality follows (B.8). Finally, if $D' \leq \overline{D}(\lambda_G)$, both brown and green firms would accept D' and then choose the brown project, yielding the following payoff to the deviating lender:

$$p_B D' - 1 \le p_B \overline{D}(\lambda_G) - 1 < 1 + \phi - 1 = \phi,$$

where the strict inequality holds because $\overline{D}(\lambda_G) < \frac{1+\phi}{p_B}$ by Assumption 4-(i). Combining the results, any $D' < \tilde{D}$ yields a payoff strictly less than ϕ. Therefore, it is optimal for every green lender to offer $\tilde{D}$.

Next, the same outcome that both green and brown firms choose the green project also sustains as an equilibrium if at least one green lender can bid for funding first. Suppose that all green lenders offer $\tilde{D} = \frac{1}{p_G}$ in both the first and second stages. On the equilibrium path, both brown and green firms accept such $\tilde{D}$ and then choose the green project. Furthermore, we assign an out-of-equilibrium belief to the firm that deviates and approaches the lenders in the second stage as the firm with green type with probability q (same as the prior belief). Then, by applying the similar logic used in the case of simultaneous competition, it is straightforward that no lender has the incentive to deviate from $\tilde{D} = \frac{1}{p_G}$ given that all other lenders make the same offer $\tilde{D}$. *Q.E.D.*

Proposition B.4. *Suppose there is only one green lender bidding in the second stage. Then there exists an equilibrium in which the firm, regardless of its type, chooses the green project.*

Proof. For exposition, let $\underline{D}_t$ denote the lowest repayment term offered in stage t for each $t = 1$ and 2.

First, suppose that there is only one green lender in both the first and the second stages, respectively. Consider the following strategy profile.

- In the first stage, both green and brown firms accept $\underline{D}_1$ with probability 1 if $\underline{D}_1 < R$. For the case $\underline{D}_1 = R$, both green and brown firms accept $\underline{D}_1 = R$ with probability $\frac{1}{2}$. In all cases, the firm chooses the green (brown) project if it accepts $\underline{D}_1$ in the first stage and $\underline{D}_1 > \overline{D}(\lambda)$ ($D \le \overline{D}(\lambda)$).
- In the second stage, the firm, regardless of its type, accepts D if and only if $D \le R$. Furthermore, the firm with type $\lambda \in \{\lambda_B, \lambda_G\}$ chooses the green (brown) project if $D > \overline{D}(\lambda)$ ($D \le \overline{D}(\lambda)$).
- The green lender in the first stage offers $D = R$. The green lender in the second stage offers $D = R$ with the posterior belief that $\lambda = \lambda_G$ with probability q.

This strategy profile induces both brown and green firms to invest in the green project in the first stage. It is straightforward that this strategy profile constitutes an equilibrium, and hence we omit the formal proof.

Next, suppose that multiple green lenders simultaneously bid in the first stage, while there is only one green lender bidding in the second stage. Let $\underline{D}_t$ denote the lowest repayment term offered in stage $t = 1, 2$. Consider the following strategy profile.

- In the first stage, both green and brown firms accept $\underline{D}_1$ with probability 1 if $\underline{D}_1 < R$. For the case $\underline{D}_1 = R$, both green and brown firms accept $\underline{D}_1 = R$ with probability $\frac{1}{2}$. In all cases, the firm chooses the green (brown) project if it accepts $\underline{D}_1$ in the first stage and $\underline{D}_1 > \overline{D}(\lambda)$ ($D \leq \overline{D}(\lambda)$).

- In the second stage, the firm accepts D if and only if $D \leq R$. Furthermore, the firm with type $\lambda \in \{\lambda_B, \lambda_G\}$ chooses the green (brown) project if $D > \overline{D}(\lambda)$ ($D \leq \overline{D}(\lambda)$).

- All green lenders in the first stage offer $D = \frac{1}{p_G}$. The green lender in the second stage offers $D = R$ with the posterior belief that $\lambda = \lambda_G$ with probability q.

This strategy profile induces both brown and green firms to invest in the green project in the first stage. To show that all green lenders in the first stage have no incentive to deviate, suppose first that a green lender in the first stage deviates to $D' \in (\overline{D}(\lambda_G), \overline{D}(\lambda_B)]$. Then, both green and brown firms will accept D', and then, the green firm will choose the green project, while the brown firm will choose the brown project, which gives the deviating lender $[qp_G + (1-q)p_B]D' - 1 + \phi q$ as the final payoff. However, we have

$$[qp_G + (1-q)p_B]D' - 1 + \phi q < [qp_G + (1-q)p_B]\frac{1}{p_G} - 1 + \phi q = (1-q)\frac{p_B - p_G}{p_G} + \phi q \leq \phi,$$

where the first inequality follows from $D \leq \overline{D}(\lambda_B) < \frac{1}{p_G}$ by Assumption 4, and the second inequality follows from $\phi \geq \frac{p_B - p_G}{p_G}$ by Assumption 1 and 2.[27] Hence, the deviation will yield a payoff strictly lower than the equilibrium payoff ϕ.

Next, suppose that a green lender in the first stage deviates to $D' \in [0, \overline{D}(\lambda_G)] \cup (\overline{D}(\lambda_B), \infty)$. This green deviating lender will earn ϕ if she follows the equilibrium strategy. Thus, it suffices to show that such a deviation gives the deviating green lender a payoff lower

[27] By Assumption 1-(ii), we have $R \geq \frac{1}{p_G}$. In addition, we have $\phi > (p_B - p_G)R$ by Assumption 2. Combining these two inequalities, we obtain $\phi > \frac{p_B - p_G}{p_G}$.

than ϕ. Neither the green nor brown firm will accept $D' > \underline{D} = \frac{1}{p_G}$, so we focus on the case $D' \in [0, \overline{D}(\lambda_G)] \cup (\overline{D}(\lambda_B), \frac{1}{p_G})$. Note that any D' lower than $\underline{D} = \frac{1}{p_G}$ will be accepted by both types of the firm for sure. However, if $D' \leq \overline{D}(\lambda_G)$, both types of the firm will choose the brown project. Hence, the deviating lender will earn the total payoff $p_B D' - 1$. However, this payoff is strictly lower than ϕ since

$$p_B D' - 1 \leq p_B \overline{D}(\lambda_G) - 1 < p_B \times \frac{1+\phi}{p_B} - 1 = \phi,$$

where the first inequality follows from the supposition $D' \leq \overline{D}(\lambda_G)$ and the second inequality follows from Assumption 4. On the other hand, if $D' \in (\overline{D}(\lambda_B), \frac{1}{p_G})$, both types of the firm will choose the green project. The deviating lender will then earn the payoff $p_G D' - 1$, which is strictly lower than ϕ since $p_G D' - 1 < p_G + \phi \frac{1}{p_G} - 1 + \phi = \phi$. In sum, there is no profitable deviation for the green lender in the first stage. Lastly, the optimality of the other players' strategies is straightforward, so we omit the formal proof. *Q.E.D.*