A Theory of ESG Monitoring in Financial Contracts

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Abstract

We develop a model of ESG investing where firms have private information about their ESG commitment: some value non-pecuniary payoffs from green investment, while others opportunistically greenwash. Lenders choose whether to include an ESG-monitoring covenant that imperfectly detects greenwashing. Monitoring disciplines opportunistic borrowers, but sustaining it requires a lending discount that partly becomes an informational rent for intrinsically ESG-oriented firms. Therefore, monitoring adoption is non-monotonic in verification capability and occurs only at intermediate levels. Furthermore, lender competition yields state-dependent effects: it discourages monitoring when the lender's best alternative is pooled lending, but can encourage monitoring against selective lending to green firms. Particularly, in the latter case, competition may increase the prevalence of ESG discipline while shifting the market toward lower-intensity monitoring regimes.

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1 Introduction

Over the past decade, environmental, social, and governance (ESG) considerations have become an increasingly important dimension of capital allocation (Pástor, Stambaugh and Taylor, 2021; Chen, Dong and Lin, 2020). As capital flows toward firms claiming strong ESG performance, concerns have also grown about the credibility of these commitments, increasing demand for mechanisms that verify firms' ESG behavior. In response, the market infrastructure for ESG monitoring has expanded through specialized verification technologies, sustainability ratings, and broader regulatory disclosure mandates (Christensen, Hail and Leuz, 2021; Simnett, Vanstraelen and Chua, 2009; Gipper, Sequeira and Shi, 2025). These developments improve the availability of ESG information, but they do not by themselves explain when such information is embedded in financial contracts that discipline firms' behavior.

Despite this proliferation of ESG information, how capital markets can effectively induce firms to follow through on their commitments remains relatively unexplored. A fundamental friction is that firms retain substantial discretion over the ESG policies they adopt *ex post*, after financing has been secured. Consequently, even when advanced verification and monitoring tools are available, it remains unclear whether and how investors can embed them in financial contracts in ways that meaningfully constrain opportunistic greenwashing. This paper addresses that question by studying the economic trade-offs of monitoring borrowers' ESG performance. Specifically, we ask: What are the costs and benefits for pro-ESG lenders of monitoring borrowers' ESG follow-through? Under what conditions does an improvement in verification capability encourage the inclusion of ESG covenants in lending contracts? More broadly, what market conditions induce lenders to discipline borrowers' ESG activities, and at what cost to equilibrium lending terms?

To address these questions, this paper develops a simple model of ESG investing in which a "green" lender—who places substantial weight on a non-pecuniary "social" payoff—chooses whether to include in the lending contract a covenant that grants her the right to monitor the borrower's use of funds earmarked for ESG-related projects. The model features two informational frictions. First, the firm privately knows its intrinsic ESG commitment, giving rise to adverse selection: a green firm values the social consequences of its investment, whereas a brown firm cares exclusively about financial payoffs. Second, the firm's ex-post project choice is subject to moral hazard: after obtaining financing, it chooses between a *green* project that generates the non-pecuniary social payoff but lower financial returns and a *brown* project that yields higher financial returns but no such non-pecuniary payoff. To

mitigate these frictions, the green lender can employ an imperfect verification technology that detects and redirects non-compliance with probability $m < 1$. The green lender also faces competitive pressure from "brown" lenders, who care only about financial returns and arrive in the market with probability β. In this setting, competition shapes the borrower's outside option of alternative non-ESG funding.

We first show that adopting an ESG-monitoring covenant requires a lending discount. Because a brown firm maximizes financial payoffs, it views monitoring as a binding constraint that rules out its privately optimal brown project. If the green lender were to insist on the same repayment terms as under a non-monitoring contract, the brown firm would instead seek cheaper and unconstrained financing from brown lenders, who price loans anticipating the more profitable brown project. To satisfy the brown firm's incentive compatibility and secure the right to monitor, the green lender must therefore offer more favorable financial terms, effectively conceding a larger share of the firm's cash flows to compensate the borrower for the expected financial loss from enforced green investment.

Crucially, the lending discount required to sustain monitored lending is increasing in monitoring capability. As the verification technology improves, the brown firm faces a higher probability of detection and redirection, which raises its expected financial loss from accepting the monitoring covenant. To keep the brown firm willing to borrow, the green lender must therefore offer even more favorable repayment terms. Because these borrower-friendly terms are designed to satisfy the brown firm's participation constraint, they are also available to the green firm. Since the green firm is intrinsically committed to green investment, it can capture the same lending discount without bearing any real compliance cost. Thus, an improvement in monitoring effectiveness paradoxically raises the real cost of ESG discipline by increasing the informational rents for intrinsically ESG-oriented borrowers.

Consequently, the rising cost of maintaining incentive compatibility makes the adoption of ESG monitoring non-monotonic in monitoring capability. When monitoring is too weak, the probability of detection is too low for the enforcement benefits to justify the associated costs and financial concessions. When monitoring is too strong, however, the contract becomes too costly to sustain: the brown firm must be heavily compensated for being redirected toward its privately inferior project, and that discount is passed through as a substantial informational rent to the green firm. If enforcement becomes sufficiently certain, these concessions dominate the green lender's social gains, rendering the monitoring covenant unattractive. Taken together, the ESG-monitoring covenant is adopted if and only if monitoring capability is intermediate—strong enough to meaningfully discipline the brown firm, but not so strong

that the required lending discount and associated informational rents become prohibitive.

However, the effect of lender competition—an increase in β—on monitoring adoption is state-dependent and hinges on the green lender's best non-monitoring alternative. Suppose this alternative is pooled lending, under which the green lender finances both firm types without monitoring their ex-post behavior. In this case, stronger competition improves the borrower's outside option and forces the green lender to concede more surplus. This effect is stronger under monitoring, because a monitored contract already requires substantial financial concessions to satisfy the brown firm's incentive compatibility and generates large informational rents for the green firm. As a result, the green lender has less room to absorb the additional competitive pressure under monitoring than under its non-monitoring alternatives.

When the optimal non-monitoring alternative is withdrawal, stronger competition further increases the appeal of staying out of the lending market: the green lender can avoid lending costs while still potentially enjoying the social payoff if the green firm obtains financing elsewhere and undertakes the green project. Taken together, stronger competition reduces the relative payoff from monitoring more than from withdrawal or pooled lending, causing the monitoring-adoption region to contract.

By contrast, when the green lender's best non-monitoring alternative is to lend selectively to the green firm, the effect of competition depends on the social return from green investment. In this environment, the green lender can extract a premium by offering guaranteed early funding to the green firm that values timely realization of the social payoff. When the social return is high, stronger competition erodes this separating premium more sharply than it reduces the payoff from monitored lending, thereby making monitoring relatively more attractive. When the social return is low, however, the separating premium is limited, so stronger competition primarily discourages monitoring.

For intermediate values of the social return, competition shifts market-driven ESG discipline toward lower-intensity monitoring. At relatively low levels of verification capability, monitored lending requires only modest concessions, so its payoff is less sensitive to competition than the selective lending alternative. At high levels of verification capability, by contrast, the substantial concessions required to sustain monitored lending make it more vulnerable to competitive pressure. As a result, stronger competition can broaden the adoption of lower-intensity monitoring while making high-intensity monitoring less sustainable.

Our analysis yields several important implications for the institutions shaping ESG discipline in capital markets. First, for regulators and policymakers, the results suggest that

the main challenge is not simply a lack of ESG information, but the difficulty of using that information to discipline borrowers through financial contracts. While reporting standards and verification regimes are essential, their effectiveness depends on lenders' willingness to adopt monitoring, which is constrained by the incentive compatibility of the lending contract. Without accounting for these contractual frictions, policies designed to improve disclosure may not only fail to change firm behavior, but may also discourage monitoring adoption by making monitored lending prohibitively costly.

Furthermore, these findings speak to ESG raters, assurance providers, and other intermediaries whose services are intended to mitigate information asymmetry. Our model shows that superior measurement and assessment technologies do not automatically translate into stronger discipline. Instead, market demand for these services depends on how the competitive environment reshapes surplus division and informational rents between lenders and borrowers. The value of ESG information is therefore context-dependent: whether a pro-ESG lender ultimately uses high-quality ESG data depends on whether the competitive landscape allows that information to be incorporated into incentive-compatible contractual arrangements.

The rest of the paper proceeds as follows. Section 2 discusses the related literature and distinguishes our results from prior work. Section 3 presents the model and key assumptions. Section 4 provides preliminary analysis. Section 5 analyzes the equilibrium and discusses policy and empirical implications. Section 6 concludes. All proofs are relegated to the appendix.

2 Related Literature

A growing empirical literature examines ESG monitoring and assurance as mechanisms for enhancing the credibility of sustainability disclosures. A central finding is that ESG assurance is increasingly widespread but highly heterogeneous in scope and rigor. Gipper, Ross and Shi (2025) document a sharp rise in third-party assurance of ESG metrics among large U.S. firms, alongside substantial variation in the choice of assured metrics, assurance levels, and providers. Rather than firm fundamentals, assurance adoption appears to be driven primarily by reporting framework choices and peer effects. Earlier international evidence in Simnett, Vanstraelen and Chua (2009) similarly shows that firms are more likely to obtain voluntary assurance when reputational and credibility concerns are salient, and that institutional features shape both the decision to obtain assurance and the choice of assurance provider.

Subsequent work studies how ESG assurance affects reported outcomes, highlighting

both its disciplining role and limitations. Berg, Oliver Huidobro and Rigobon (2024) find that firms obtaining assurance for carbon accounting initially report higher emissions, consistent with assurance correcting under-reporting, and that only assured firms subsequently reduce emissions. This evidence suggests that assurance can influence both reporting behavior and real environmental outcomes. At the same time, assurance does not uniformly eliminate misreporting. Gipper, Sampson and Shi (2025) document strategic under-reporting of carbon emissions following climate controversies and show that firms increase their use of third-party assurance in response, although manipulation persists unless accompanied by stronger governance mechanisms. Related evidence in Aobdia et al. (2024) shows that firms substantially increased restatements of Scope 1 emissions following regulatory scrutiny, with assured emissions data exhibiting fewer upward restatements.

These studies show that ESG monitoring and assurance can improve disclosure credibility and affect real outcomes, while remaining imperfect and strategically adopted. This evidence motivates our focus on the contractual adoption of ESG monitoring technologies. In particular, we study when pro-ESG lenders choose to embed such technologies in financial contracts and how those incentives depend on monitoring effectiveness and surrounding market structure.

Our paper is closely related to a growing theoretical literature studying ESG investing and the role of investor incentives in shaping firms' ESG behavior. A central theme in this literature is that the effectiveness of ESG capital depends on investors' ability to discipline firms' ESG commitments. Oehmke and Opp (2025) show that when investors can enforce firms' ESG follow-through, competition among investors with heterogeneous ESG preferences improves the allocation of ESG capital. Likewise, Wong and Yu (2024) emphasize that firms value ESG-oriented investors because active engagement can mitigate ESG-related agency problems and thereby attract additional capital. By contrast, Chowdhry, Davies and Waters (2019) and Chang, Rhee and Yoon (2024) show that when such enforcement is ineffective or unavailable, competition among investors can instead undermine firms' ESG integration. Our analysis complements this literature by endogenizing investors' adoption of ESG monitoring technology. Rather than taking enforcement capacity as given, we study when pro-ESG lenders optimally choose to monitor borrowers' ESG follow-through and how monitoring adoption interacts with lender competition.

Another theoretical literature studies the incentive effects of ESG disclosure and the measurement of sustainability performance. Aghamolla and An (2023) and Chen and Oldrini (2024) compare voluntary and mandatory ESG disclosure regimes and show that disclosure de-

sign can distort firms' project-selection incentives, albeit through different mechanisms. Laux and Mahieux (2026) show that mandatory disclosure of ESG-related information can also distort firms' investment incentives when disclosure is imprecise. Chen and Schneemeier (2026) show that strong demand for green assets from responsible investors can induce managers to overstate firms' environmental performance in order to improve stock-price feedback. Likewise, Xue (2025) shows that more precise green disclosure can increase the emissions cost firms internalize through stock prices, potentially inducing excessive green investment. More broadly, a growing literature emphasizes that ESG performance is inherently multi-dimensional and often measured with error across environmental, social, and governance dimensions (Friedman, Heinle and Luneva, 2021; Friedman and Ormazabal, 2024; Azarmsa and Shapiro, 2025; Chaigneau and Sahuguet, 2025).

While the existing literature studies the design, precision, and strategic use of ESG disclosure, our focus is on the contractual margin through which such information acquires real disciplinary force in capital markets. In this sense, we do not study disclosure choice *per se*. Instead, we examine when ESG-related information becomes sufficiently contractible and valuable for lenders to embed it into monitoring arrangements. To do so, we characterize the incentive structure behind ESG-monitoring adoption and show that it depends jointly on *(i)* investors' overall ESG monitoring capacity—which governs the size of the informational rents that ESG-oriented borrowers can extract—and *(ii)* how competition among investors with heterogeneous ESG preferences reallocates surplus and informational rents across alternative lending contracts. This perspective also distinguishes our analysis from existing work that emphasizes improving the accuracy of ESG-related information: we show instead that excessively effective ESG monitoring can hinder, rather than promote, its adoption by lenders.

3 Model

3.1 Basic Setup

We first lay out the basic setup of the model. Consider a two-period economy ($t = 1, 2$) consisting of a firm and multiple investors. We assume that all agents in the model are risk-neutral and do not discount future payoffs.

The firm can undertake an investment project that yields a financial return and an ESG-consistent non-pecuniary payoff. Both projects require an upfront investment of one

monetary unit of capital. The firm can choose between a *green* project (denoted by G) and a *brown* project (denoted by B).[1] Project G yields a financial return $R > 0$ with probability $p_G \in (0, 1)$ and zero otherwise. It also generates a payoff $\phi > 0$, which captures a non-pecuniary payoff associated with green investment. While such a payoff may have a broader societal interpretation, we treat ϕ as a payoff valued only by pro-ESG agents and not by non-ESG agents. For expositional convenience, we refer to this non-pecuniary payoff as the "social" return throughout. By contrast, project B yields the same financial return R with probability $p_B \in (0, 1)$ and zero otherwise, but it produces no social return. For a non-trivial equilibrium analysis, we impose the following regularity condition.

Assumption 1. *(i)* $p_G R - 1 + \phi > p_B R - 1 > p_G R - 1 > 0$*; (ii)* $\phi \leq 1$.

In Assumption 1-(i), the first inequality indicates that project G generates a higher total surplus—defined as the sum of financial and social returns net of the investment cost—than project B. This condition justifies interpreting project G as the optimal choice for pro-ESG agents who highly value the non-pecuniary social payoff ϕ. The second inequality implies that project B has a higher net present value (NPV), i.e., a larger expected financial payoff, than project G. Hence, a profit-maximizing firm may prefer project B when it focuses solely on financial returns. The last inequality ensures that both projects G and B yield at least non-negative NPVs, thereby ruling out trivial equilibria in which the firm would never select project G due to its financial loss. Lastly, Assumption 1-(ii) rules out a trivial case in which the non-pecuniary social return is so large that a pro-ESG lender would be willing to finance project G even without claiming any share of the project's financial return.

The firm is assumed to have no initial wealth, so it must obtain external financing from an outside lender. The firm faces two sequential opportunities for external financing in the capital market over two periods, $t = 1, 2$. At $t = 1$, a single lender offers a contract that specifies repayment contingent on the firm's project yielding a high financial return $R > 0$. We restrict attention to the case in which the firm has limited liability, in the sense that a repayment obligation cannot exceed the realized financial return. Thus, an offer suffices to specify the repayment obligation, denoted by $D \in [0, R]$, in the event that the high financial return R is realized. The firm then decides whether to accept this offer. If it accepts, it borrows from the $t = 1$ lender and exits the market to undertake its project. If it declines, the $t = 1$ lender leaves the market and the firm waits until the market reopens at $t = 2$.

[1] Our analysis focuses on potential incentive misalignments between the firm investing in ESG and external lenders. For simplicity, we abstract from any internal agency problem within the firm.

At $t = 2$, multiple lenders compete in Bertrand fashion by offering financing contracts that also specify state-contingent repayments. The firm borrows from the lender offering the most favorable contract. If two or more lenders make offers with the same repayment term that is most favorable to the firm, we assume that the firm randomly selects one of them with equal probability.[2]

We next describe how the firm and lenders value the financial and non-pecuniary components of project payoffs. We begin with the firm by defining its payoff-relevant types. The firm can be either *green* or *brown*, depending on how it values the non-pecuniary social payoff generated by project G. If the firm's type is green, it values the social return generated by project G equally to the financial payoff from undertaking the project. Specifically, the green firm's payoff function, given a repayment obligation $D \in [0, R]$ contingent on the high financial return R, is

$$p_i(R - D) + \mathbb{I}(i)\phi \;\; \forall \; i \in \{G, B\} \;\text{ and } D \in [0, R], \tag{1}$$

where $\mathbb{I} : \{G, B\} \to \{0, 1\}$ is an indicator function such that $\mathbb{I}(G) = 1$ and $\mathbb{I}(B) = 0$. The first term $p_i(R - D)$ captures the net financial return accrued to the firm; the second term $\mathbb{I}(i)\phi$ captures the firm's valuation of the social return.

In contrast, if the firm's type is brown, its utility equals only the expected financial payoff from investment:

$$p_i(R - D) \;\; \forall \; i \in \{G, B\} \;\text{ and } D \in [0, R]. \tag{2}$$

We now turn to lenders' preferences. Lenders at $t = 1$ and $t = 2$ differ in how they value the financial return and the non-pecuniary social payoff from the firm's project. First, the $t = 1$ lender is "green" such that, like the green-typed firm, she values the social return of the firm's investment equally to her financial gains.[3] Specifically, if she funds the firm directly,

[2] We interpret this randomization as the act of a chance node rather than the firm's deliberate randomization. This assumption is intended to exclude the possibility that the firm discriminates between indistinguishable offers based on the lenders' identities.

[3] A number of large institutional investors that actively endorse ESG integration have historically played a central role in opening and shaping this market, giving them a natural incumbency advantage over traditional lenders. Major asset owners—such as GPIF, Norges Bank Investment Management, the Korean National Pension Fund, CalPERS, and CalSTRS—collectively manage trillions of dollars and have long required asset managers to incorporate ESG metrics and to engage with portfolio firms on sustainability issues. Empirically, Kim and Yoon (2023) show that signatories of the Principles for Responsible Investment subsequently experience substantial inflows from asset allocators, further strengthening the influence of early ESG adopters.

the green lender's payoff function given her claim D on the firm's financial return is

$$p_i D - 1 + \mathbb{I}(i)\phi \ \forall\, i \in \{G, B\} \text{ and } D \in [0, R] \tag{3}$$

If the green lender does not directly finance the firm's project, her payoff is

$$\mathbb{I}(i)\phi \ \forall\, i \in \{G, B\}\,, \tag{4}$$

This preference reflects the "warm-glow" utility that any pro-ESG lender values the realization of the social return of project G, no matter who finances and undertakes it (Wong and Yu, 2024; Chaigneau and Sahuguet, 2025; Oehmke and Opp, 2025).[4,5]

In contrast, the lenders at $t = 2$ are "brown" to the extent that they only value the financial gains from their investment in the firm's project. Specifically, each brown lender's payoff function given his claim D on the firm's financial return is

$$p_i D - 1 \ \forall\, i \in \{G, B\} \text{ and } D \in [0, R]. \tag{5}$$

Note that the green firm's preference is aligned with the green lender, whereas the brown firm's preference is aligned with the brown lenders.[6] Building on this basic preference structure, the next subsection introduces the key market frictions that generate the incentive misalignments central to our analysis.

3.2 Information Environment and Contractual Assumptions

We now turn to the assumptions that adapt the model to the institutional features of ESG investing. Our first key friction is adverse selection regarding the firm's intrinsic ESG commit-

These observations justify modeling green lenders as first movers with a competitive advantage in offering contracts ahead of brown lenders.

[4] Abis, Buffa and Sadasivam (2024) provide empirical evidence of ESG preference heterogeneity that parallels our green and brown firm types. They distinguish *impact funds*, which value ESG outcomes intrinsically and exhibit little greenwashing or window dressing, from *opportunity funds*, which use ESG information primarily for financial performance and are more prone to strategic ESG exposure management.

[5] The green lender can be instead a *non-consequentialist* in the sense that her non-pecuniary payoff is tied only to directly financing the green project (Dangl et al., 2025). In this case, the green lender derives no benefit from the green project being financed by brown lenders in the subsequent market, which simplifies the set of relevant non-monitoring alternatives. Our baseline warm-glow specification is therefore more general, nesting the non-consequentialist formulation as a simpler case.

[6] All qualitative results continue to hold so long as the green (brown, respectively) firm values a sufficiently large (small, respectively) fraction of the non-pecuniary social payoff.

ment. Before the game begins, nature draws the firm's type, which is green with probability $\lambda \in (0,1)$. The firm privately observes its own type, while lenders only share a common prior over green and brown types. This setting reflects the inherent limitations of current financial reporting in capturing a borrower's non-pecuniary preferences and long-term social objectives. In the absence of standardized ESG accounting metrics, outsiders face a significant hurdle in verifying whether a firm's stated sustainability goals reflect its true underlying type or a strategic posture to attract capital.[7]

Second, we introduce a hidden-action problem by assuming that the firm's ex-post project choice is non-contractible, capturing the greenwashing risk central to our analysis. Because lenders cannot credibly earmark loan proceeds for specific projects without a verification mechanism, firms may opportunistically choose the financially superior brown project even after securing funding on ESG-related grounds. This friction highlights the contractual gap that arises when reported ESG commitments are not backed by enforceable verification technologies.

Third, to capture ESG-oriented lenders' attempts to mitigate greenwashing, we assume that the green lender can imperfectly monitor the borrower's use of funds. Specifically, she decides whether to include a monitoring covenant in the contract, denoted by $\mu \in \{M, N\}$. If $\mu = M$, the lender acquires a contractual right to intervene in project choice at a fixed monitoring cost $c > 0$, which represents the economic resources required for ESG verification, such as third-party assurance fees or the costs of auditing sustainability-linked performance targets. Under this covenant, if the firm opportunistically chooses project B, the green lender detects this deviation and imposes compliance with project G with probability $m \in (0,1)$. If $\mu = N$, no such monitoring right is in place. For simplicity, we assume that switching from B to G imposes no additional cost on the firm; any positive switching cost would only strengthen the firm's ex-ante incentive to commit to project G without altering our qualitative results.

In our framework, the detection probability m serves as a reduced-form representation of the borrower's ESG information environment and the rigor of verification; hereafter, we refer to m as the green lender's ESG monitoring capability. In an accounting context, a higher m corresponds to more stringent auditing standards, higher-quality assurance, or more granular disclosure requirements that improve the lender's ability to verify the borrower's

[7]For example, Kim and Yoon (2023) find that asset managers claiming to pursue ESG integration attracted greater fund inflows but did not subsequently improve their ESG performance. Similarly, Cappucci (2018) and Kotsantonis and Serafeim (2019) emphasize that the lack of standardized metrics impedes effective monitoring of ESG integration. Collectively, this evidence suggests that adverse selection remains an important friction in ESG investing.

ex-post actions. At the same time, ESG monitoring often relies on external assurance—such as third-party verification of sustainability-linked covenants—that is inherently costly and imperfect. Verification remains subject to informational and incentive frictions, since monitoring providers are often paid by borrowers and their effort or stringency is not fully observable (Lizzeri, 1999; Beyer et al., 2010). Motivated by these features, we model ESG monitoring as a costly and imperfect technology that detects borrowers' non-compliance with probability $m < 1$.[8]

These considerations also motivate our focus on contractual monitoring covenants rather than on borrowers' disclosure design in isolation. While disclosure provides the informational foundation for ESG discipline, it affects firms' behavior only when it can be embedded in enforceable contractual arrangements. Our objective is therefore to study the contractual margin through which ESG-related information becomes economically consequential in capital markets. By modeling the green lender's decision to adopt an ESG-monitoring covenant, we speak directly to when and how ESG information is actually used to discipline borrowers' ex-post actions.

Fourth, we allow for potentially imperfect competition among lenders by modeling the arrival of brown lenders at $t = 2$ with probability $\beta \in (0, 1)$. A higher β captures stronger competitive pressure by making alternative financing from traditional lenders more accessible to borrowers. We use this reduced-form approach because, in our setting, competition operates through the borrower's outside option of unconstrained funding.

Together with the green lender's monitoring technology, this market structure also provides a realistic interpretation of the green lender's first-mover advantage. Rather than being purely abstract, that advantage can be understood as reflecting lender-specific ESG expertise, reputational capital, and relationship-based screening capacity. In practice, lenders that enter ESG-linked finance earlier may be better able to design KPI-based contracts, evaluate borrowers' transition plans, coordinate third-party verification, and identify borrowers for whom monitored ESG lending is especially valuable. The model thus captures the idea

[8] A growing body of empirical evidence supports this assumption. Kim et al. (2025) show that borrowers under low-transparency sustainability-linked loans (SLLs) may worsen their ESG performance after loan initiation, suggesting frictions in verifying and enforcing ESG integration. Likewise, Du, Harford and Shin (2023) and Auzepy, Bannier and Martin (2023) find that many SLLs rely on soft or non-ambitious ESG targets that are not systematically associated with meaningful environmental or social improvements. Evidence from the green bond market similarly shows that the credibility of "use-of-proceeds" restrictions depends critically on the strength of external verification and certification (Flammer, 2021). More broadly, the lack of standardized and comparable sustainability disclosure can limit investors' and lenders' ability to monitor firms' ESG performance (Krueger et al., 2024).

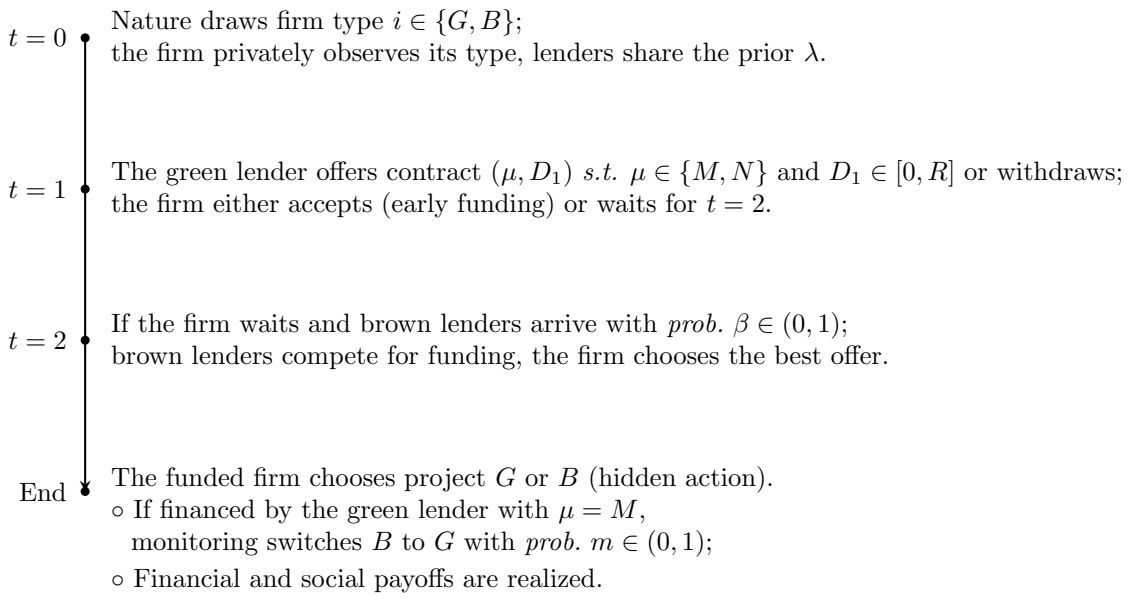


Figure 1 – Timeline of actions

that market-led ESG discipline depends not only on the availability of better information, but also on the presence of specialized lenders capable of turning that information into credible and enforceable contractual arrangements. In this sense, the green lender's incumbency allows her to transform soft ESG information into hard, contractually enforceable targets through specialized monitoring.

Lastly, for analytical convenience, we assume that the green lender's contract offer at $t = 1$ is unobservable to brown lenders at $t = 2$, so brown lenders observe only that the firm has declined the green lender's early offer. This assumption simplifies belief updating (Hörner and Vieille, 2009; Fuchs, Öry and Skrzypacz, 2016); allowing full observability would mainly add off-path contingencies and belief assignments without sharpening the main economic forces in the model. It is also realistic because the specific terms of lending contracts are often not publicly disclosed. For ease of reference, Figure 1 summarizes the timing and information structure of the game.

3.3 Equilibrium

We analyze the perfect Bayesian equilibrium (henceforth called "equilibrium"). Let the 6-tuple $(\mu^*, D_1^*, D_2^*, \lambda_2^*, s_G^*, s_B^*)$ generically denote a pure-strategy equilibrium strategy profile and posterior belief system, where:

- $(\mu^*, D_1^*) \in (\{M, N\} \times [0, R]) \cup \{\varnothing\}$ denotes the equilibrium contractual offer made by the green lender in the first period, where $(\mu^*, D_1^*) = \varnothing$ denotes the case in which the green lender withdraws from the capital market without making an offer.

- s_G^* and s_B^* denote the equilibrium acceptance strategies of the green and brown firms in the first period, where, for each $i \in \{G, B\}$ and each (μ, D), $s_i^*(\mu, D) = 1$ denotes acceptance and $s_i^*(\mu, D) = 0$ denotes waiting until $t = 2$ in response to the green lender's offer.[9]

- $\lambda_2^* \in [0, 1]$ and $D_2^* \in [0, R]$ denote the brown lenders' common equilibrium posterior belief and common offer, respectively, in the second period.[10]

Both the firm's optimal strategy at $t = 2$ and its optimal project selection rule in either period are straightforward (see Lemma 1 and 2 in Section 4); thus, we omit them from the description of an equilibrium strategy profile. We also restrict attention to the equilibria in which all brown lenders in the second period make the same contractual offer D_2^*. This restriction is without loss for our analysis, because the Bertrand nature of competition at $t = 2$ implies that the outcome in any equilibrium is equivalent to one in which all brown lenders offer the same repayment level.[11]

We further impose the two tie-breaking rules. First, regardless of its type, the firm breaks ties in favor of accepting the green lender's offer and initiating its project early. Second, if the green lender at $t = 1$ is indifferent between including and excluding the monitoring covenant, we assume that she breaks ties in favor of the non-monitoring contract.[12]

We focus on pure-strategy equilibria, though mixed-strategy equilibria will be considered when needed. The definition below is stated only for pure strategies; the extension to mixed strategies is straightforward and therefore omitted. Given the two tie-breaking rules imposed above and the earlier observation that, without loss, all brown lenders may be assumed to employ the same pure strategy, the only remaining strategy component that may be mixed is the green lender's offer strategy at $t = 1$.

[9] We impose the natural restriction that $s_B^*(\varnothing) = s_G^*(\varnothing) = 0$.

[10] It is standard to impose that players with the same information hold the same posterior belief both on and off the equilibrium path (Fudenberg and Tirole, 1991, Definition 8.2).

[11] Precisely, consider any equilibrium in which brown lenders possibly employ asymmetric mixed strategies at $t = 2$. Let $\underline{D}_2$ denote the lowest repayment that the firm may receive in equilibrium. Then there exists an outcome-equivalent equilibrium in which all brown lenders offer $D = \underline{D}_2$.

[12] These tie-breaking rules are imposed only to select a unique equilibrium when multiplicity arises. Such multiplicity occurs only at knife-edge parameter values (e.g., when $m = \overline{m}^*$ or $m = \underline{m}^*$ in Theorem 1-(i)), so the main insights of the paper do not depend on them.

Definition 1. *An (pure-strategy) equilibrium is an ordered 6-tuple* $(\mu^*, D_1^*, D_2^*, \lambda_2^*, s_G^*, s_B^*)$ *such that:*

(i) ***The green lender*** *(*$t = 1$*):* *Given* $(D_2^*, \lambda_2^*, s_G^*, s_B^*)$ *and the induced continuation outcome at* $t = 2$*, the green lender maximizes her payoff by offering* (μ^*, D_1^*)*, or withdraws from lending (with ties broken in favor of offering a contract without the monitoring covenant).*

(ii) ***Brown lenders*** *(*$t = 2$*):* *Brown lenders hold the same posterior belief* λ_2^* *in the second period. On the equilibrium path, beliefs are updated using Bayes' rule. Off the equilibrium path, beliefs are unrestricted. Given* λ_2^**, the firm and brown lenders play a symmetric pure-strategy equilibrium in the* $t = 2$ *continuation game, in which all brown lenders optimally offer the same repayment term* D_2^**.*

(iii) ***The firm*** *(*$t = 1, 2$*):* *Given* $(\mu^*, D_1^*, D_2^*, \lambda_2^*)$*, for each firm type* $i \in \{G, B\}$ *chooses* s_i^**, an acceptance strategy at* $t = 1$*, to maximize its expected payoff (with ties broken in favor of acceptance). Once the firm arrives at* $t = 2$*, it borrows from the brown lender offering the most favorable contract.*[13]

The equilibrium concept therefore requires that each player's strategy be optimal given beliefs and continuation play in the subsequent period. In particular, the green lender's contract offer at $t = 1$ anticipates the outcome of Bertrand competition among brown lenders at $t = 2$, while the firm's acceptance decision reflects the trade-off between early financing and the option to wait for the competitive market.

4 Preliminary Analysis

The equilibrium is obtained by backward induction. We first analyze how the firm's equilibrium project choice depends on its type. We then characterize the brown lenders' equilibrium offer strategies at $t = 2$, which in turn pin down the firm's reservation utility when deciding whether to accept an offer at $t = 1$.

[13] Given the assumption $p_B R - 1 > 0$ in Assumption 1, Bertrand competition among brown lenders yields a repayment term D_2^* that gives the firm a strictly positive financial payoff. Therefore, the firm never finds it optimal to reject the lenders' offers in the second period.

4.1 The Firm's Post-Borrowing Project Choice

The firm's project choice hinges on its preference for social value.

Lemma 1. *In any equilibrium, the green firm always chooses project G. The brown firm chooses project B under any accepted contract with repayment $D < R$.*

Fix any $D \in [0, R]$. The green firm's payoff from project G is $p_G(R - D) + \phi$, while its payoff from project B is $p_B(R - D)$. By Assumption 1, we have $p_G R + \phi > p_B R$, so the green firm strictly prefers project G when $D = 0$. Moreover, because $p_G < p_B$, introducing repayment D reduces the payoff from project B by more than it reduces the payoff from project G. Hence,

$$p_G(R - D) + \phi > p_B(R - D) \quad \forall D \in [0, R],$$

and therefore the green firm strictly prefers project G for any repayment level D.

For the brown firm, since $p_G < p_B$, we have

$$p_G(R - D) \leq p_B(R - D) \quad \forall D \in [0, R],$$

where the inequality is strict for every $D < R$. Because the brown firm cares only about the financial payoff from its project, it strictly prefers the financially superior project B whenever the repayment level is below R. Thus, except for the payoff-irrelevant boundary case in which the brown firm is left with zero residual financial payoff, the firm's project choice is pinned down by its type: the green firm chooses G, whereas the brown firm chooses B. As shown in Lemma 2 below, the equilibrium repayment in the second-period market satisfies $D_2^*(\lambda_2^*) < R$; hence, in the continuation market relevant for our equilibrium analysis, the brown firm strictly chooses project B.[14]

Lemma 1 simplifies the analysis considerably. Given a belief $\tilde{\lambda}$ that the borrowing firm is green, a lender assigns probability $\tilde{\lambda}$ to project G and probability $1 - \tilde{\lambda}$ to project B. If the brown firm borrows from the green lender under a contract with the monitoring covenant, it still chooses project B, although this choice is overturned with probability m. Hence, under monitoring, the overall probability that the firm implements project G is $\tilde{\lambda} + (1 - \tilde{\lambda})m$.

[14]Note that Lemma 1 holds not only in pure-strategy equilibria but also in mixed-strategy equilibria. Moreover, Lemma 1 does not depend on the tie-breaking rules introduced in Definition 1.

4.2 The Continuation Game at $t = 2$

We next analyze the market at $t = 2$, in which the firm seeks financing from brown lenders. Let $\lambda_2^* \in [0, 1]$ denote the brown lenders' posterior belief about the firm's type, conditional on the firm entering the lending market at $t = 2$. Bertrand competition among brown lenders yields the following result.

Lemma 2. *Suppose that brown lenders believe that the firm arriving at the $t = 2$ capital market is green with probability λ_2^*. Then the $t = 2$ Bertrand continuation game has a unique equilibrium outcome: the firm borrows from a brown lender under the repayment term*

$$D_2^*(\lambda_2^*) := \frac{1}{\lambda_2^* p_G + (1 - \lambda_2^*) p_B}. \tag{6}$$

Given the belief λ_2^*, each brown lender assigns a probability λ_2^* to the firm being green and a probability $1 - \lambda_2^*$ to the firm being brown. Thus, the expected financial payoff from funding the firm with repayment D_2 is

$$\big(\lambda_2^* p_G + (1 - \lambda_2^*) p_B\big) D_2 - 1.$$

Under Bertrand competition, each brown lender must earn zero expected financial payoff, which pins down D_2 as in (6). Accepting $D_2 = D_2^*(\lambda^*)$ yields both the brown and the green firms positive final payoffs, and thus they accept it in equilibrium.

The key implication of Lemma 2 is that the firm's overall funding conditions worsen as brown lenders assign a higher probability to the firm being green. From (6), we see that $D_2^*(\lambda_2^*)$, the repayment claimed by brown lenders, increases in λ_2^*, their belief that the firm is green. In other words, brown lenders, who care only about financial payoffs, demand a higher claim on the firm's future cash flows as they become more pessimistic about its financial performance. As a result, an increase in λ_2^* raises the firm's borrowing cost at $t = 2$ directly through a higher repayment obligation.

Moreover, a higher borrowing cost at $t = 2$ indirectly worsens the firm's funding conditions at $t = 1$. After receiving the green lender's offer (μ, D_1), the firm compares this early funding opportunity with its expected payoff from waiting until $t = 2$, which equals $\beta\big[p_G(R - D_2^*) + \phi\big]$ if the firm is green and $\beta\big[p_B(R - D_2^*)\big]$ if it is brown. The firm's expected payoff from declining the $t = 1$ offer is therefore decreasing in D_2^*, implying that the firm may optimally accept the green lender's contract even when D_1 is relatively large. Consequently,

the firm's bargaining power *vis-à-vis* the green lender is weaker when brown lenders assign a high probability to the firm being green. In the next section, we study how the green lender at $t = 1$ incorporates the firm's outside option, determined by its expected payoff from waiting until $t = 2$, into her lending-contract design strategy.

4.3 The Green Lender's Lending Constraints at $t = 1$

We next analyze the green lender's offer strategy at $t = 1$. Broadly, the green lender has three possible strategies at this stage: *(i)* offering a contract (N, D_1) without a monitoring covenant; *(ii)* offering a contract (M, D_1) with a monitoring covenant, which allows her to imperfectly intervene in the firm's project choice; or *(iii)* choosing not to fund the firm directly by making no offer.

At $t = 1$, the firm accepts the green lender's contract (μ, D_1) only if it yields an expected payoff at least as high as the firm's reservation utility from waiting until $t = 2$. This reservation utility is determined by three factors. First, the firm encounters brown lenders at $t = 2$ with probability β. Second, the firm accepts the brown lenders' break-even contract $D_2^*(\lambda_2^*)$ at $t = 2$ (Lemma 2). Third, after accepting $D_2^*(\lambda_2)$, the firm's optimal project choice is G if it is green and B if it is brown (Lemma 1). Hence, given the brown lenders' posterior belief λ_2^*, the green firm's expected payoff from waiting is

$$\beta\big[p_G(R - D_2^*(\lambda_2^*)) + \phi\big],$$

and the brown firm's corresponding payoff is

$$\beta\big[p_B(R - D_2^*(\lambda_2^*))\big].$$

We now characterize the maximum repayment the green lender can claim, which depends on the type of lending contract.

Contracts without Monitoring. First, suppose that the green lender offers a contract (N, D_1) without a monitoring covenant. The brown firm's payoff from borrowing at $t = 1$ is $p_B(R - D_1)$, so it accepts the green lender's offer if and only if

$$p_B(R - D_1) \geq \beta p_B(R - D_2^*(\lambda_2^*)),$$

or equivalently,

$$D_1 \leq D_B^N(\lambda_2^*) := R - \beta\big(R - D_2^*(\lambda_2^*)\big). \tag{7}$$

The term $D_B^N(\lambda_2^*)$ represents the maximum repayment that the green lender can extract under a contract without monitoring. This repayment can be decomposed into two components. First, because the green lender has the bargaining power to make a take-it-or-leave-it offer, she can appropriate the full return R from the brown project if the capital market at $t = 2$ is unavailable. Second, however, the capital market at $t = 2$ opens with probability β, in which case the firm can reduce its borrowing cost by $R - D_2^*(\lambda_2^*)$. Therefore, the green lender must reduce her repayment claim by $\beta(R - D_2^*(\lambda_2^*))$ to make the offer acceptable to the firm.

We next consider the green firm, which, by Lemma 1, chooses project G regardless of the identity of the lender. If the green firm accepts the $t = 1$ offer, its payoff is $p_G(R-D_1)+\phi$, whereas its expected payoff from declining the $t = 1$ offer and waiting until $t = 2$ is $\beta(p_G(R - D_2^*(\lambda_2^*)) + \phi)$. Therefore, the green firm prefers borrowing from the green lender at $t = 1$ if and only if

$$p_G(R - D_1) + \phi \geq \beta\big(p_G(R - D_2^*(\lambda_2^*)) + \phi\big),$$

or equivalently,

$$D_1 \leq D_G^N(\lambda_2^*) := R + \frac{\phi}{p_G} - \beta\left(R + \frac{\phi}{p_G} - D_2^*(\lambda_2^*)\right). \tag{8}$$

We can interpret $D_G^N(\lambda_2^*)$ in the same way as $D_B^N(\lambda_2^*)$ above, except that the full surplus the green lender can extract is now $R + \frac{\phi}{p_G}$, which adds the social return normalized by the probability of project success.

The expression in (8) indicates that $D_G^N(\lambda_2^*)$ may exceed the limited-liability bound R. Our main analysis focuses on the interior case in which $D_G^N(\lambda_2^*) < R$, so that the green lender's maximal separating repayment is not constrained by limited liability. If $D_G^N(\lambda_2^*) \geq R$, the feasible separating repayment must be capped at R; the separating alternative then becomes a boundary case, and comparisons involving $D_G^N(\lambda_2^*)$ should be interpreted weakly.[15]

[15]This boundary case changes only the payoff expression for the non-monitoring separating alternative and the local comparative statics in Theorem 2-(ii); see footnote 19. All other qualitative results in the main text and their proofs continue to hold when $D_G^N(\lambda_2^*) \geq R$, with the separating repayment capped at R.

Contracts with Monitoring. Next, suppose the green lender offers a lending contract (M, D_1) with a monitoring covenant. Since the brown firm chooses project B but is forced to switch to project G upon detection by the green lender, the brown firm's payoff from accepting the $t = 1$ offer is $(1 - m)p_B(R - D_1) + mp_G(R - D_1)$. The brown firm therefore prefers borrowing from the green lender at $t = 1$ if and only if

$$(1 - m)p_B(R - D_1) + mp_G(R - D_1) \geq \beta p_B(R - D_2^*(\lambda_2^*)), \tag{9}$$

or equivalently,

$$D_1 \leq D_B^M(\lambda_2^*) := R - \beta \frac{p_B}{mp_G + (1 - m)p_B}(R - D_2^*(\lambda_2^*)). \tag{10}$$

The term $D_B^M(\lambda_2^*)$ represents the maximum repayment acceptable to the brown firm under a monitoring contract. As with $D_B^N(\lambda_2^*)$ and $D_G^N(\lambda_2^*)$, it can be decomposed into two components: if the green lender acts as a monopolistic lender, she can extract the full financial return from the brown firm; however, her repayment claim must be reduced to account for the firm's outside option at $t = 2$. A key distinction from $D_B^N(\lambda_2^*)$ and $D_G^N(\lambda_2^*)$ is that the discount associated with the $t = 2$ market is weighted more heavily under monitoring. Instead of assigning weight β to the arrival of brown lenders and the resulting discount, the green lender places the strictly larger weight

$$\beta \frac{p_B}{mp_G + (1 - m)p_B}$$

on this term. Intuitively, for the monitoring contract to be acceptable to the brown firm, the green lender must compensate the firm for being forced to choose project G with probability m. This additional compensation is reflected in the larger weight on the discount $R - D_2^*(\lambda_2^*)$ in (10). Note that Assumption 1 ensures that $D_B^M(\lambda_2^*)$ remains non-negative. In fact, its infimum is approached as $\beta \to 1$, $m \to 1$, and $\lambda_2^* \to 0$, yielding $D_B^M(\lambda_2^*) \to [1 - (p_B - p_G)R]/p_G > 0$, where the last inequality follows from $\phi > (p_B - p_G)R$ and $\phi \leq 1$. This rules out the boundary case in which the financial loss imposed on the brown firm by monitoring is so large that inducing acceptance would require a direct subsidy, i.e., $D_B^M(\lambda_2^*) < 0$.[16]

Another important feature of $D_B^M(\lambda_2^*)$ is that it is strictly concave in m. In other words,

[16] Relaxing Assumption 1-(ii) may require imposing an additional repayment-feasibility constraint $D_B^M(\lambda_2^*) \geq 0$, which can narrow the green lender's adoption of the monitoring contract in equilibrium. This constraint does not qualitatively alter the main results of Theorem 2 in Section 5.3.

as m increases, the green lender must offer the brown firm an increasingly large discount. To see this, note that we can rewrite the left-hand side of (9) as $((1-m)p_B + mp_G)(R - D_1)$. Hence, $D_B^M(\lambda_2^*)$ is characterized by

$$\underbrace{((1-m)p_B + mp_G)}_{\text{success probability}} \underbrace{(R - D_B^M(\lambda_2^*))}_{\text{payoff conditional on success}} = \underbrace{\beta p_B (R - D_2^*(\lambda_2^*))}_{\text{payoff from rejection}}. \tag{11}$$

Differentiating both sides with respect to m and rearranging yields

$$\frac{\partial D_B^M(\lambda_2^*)}{\partial m} = -\frac{(p_B - p_G)\big(R - D_B^M(\lambda_2^*)\big)}{(1-m)p_B + mp_G}, \tag{12}$$

which is negative and strictly decreasing in m. Intuitively, when m is already high, the expected success probability $(1-m)p_B + mp_G$ is already low, so preserving the brown firm's expected payoff requires a disproportionately larger increase in its payoff conditional on success, that is, a larger cut in repayment. Hence, $D_B^M(\lambda_2^*)$ falls at an increasing rate in m.

By contrast, the green firm always chooses project G, even when the green lender engages in external monitoring. In particular, the green firm's payoff from accepting the $t = 1$ contract with a monitoring covenant remains

$$p_G(R - D_1) + \phi,$$

and is therefore unaffected by the presence of monitoring. Consequently, the green firm accepts the green lender's contract (M, D_1) if and only if

$$p_G(R - D_1) + \phi \geq \beta\big[p_G(R - D_2^*(\lambda_2^*)) + \phi\big] \iff D_1 \leq D_G^N(\lambda_2^*),$$

where $D_G^N(\lambda_2^*)$ is defined in (8). Hence, the green firm's preference for early financing at $t = 1$ is independent of whether the green lender includes a monitoring covenant in her contract offer.

The upper thresholds $D_B^N(\lambda_2^*)$, $D_G^N(\lambda_2^*)$, and $D_B^M(\lambda_2^*)$ in (7)–(10) capture the green lender's bargaining power in the capital market under different lending arrangements. Higher values of these thresholds allow the green lender to claim a larger share of the firm's financial return as repayment. Thus, these objects should be interpreted as acceptance thresholds. The following lemma summarizes how the green lender's market power varies with the presence of a monitoring covenant, her monitoring ability, and the degree of competition in the capital

market.

Lemma 3.

(i) $D_B^M(\lambda_2^*) < D_B^N(\lambda_2^*) < D_G^N(\lambda_2^*)$ *for every* $\lambda_2^* \in [0,1]$, $m \in (0,1)$, *and* $\beta \in (0,1)$.

(ii) $D_B^M(\lambda_2^*)$ *is decreasing in* m;

(iii) $D_B^M(\lambda_2^*), D_B^N(\lambda_2^*)$, *and* $D_G^N(\lambda_2^*)$ *are decreasing in* β;

(iv) $D_B^M(\lambda_2^*), D_B^N(\lambda_2^*)$, *and* $D_G^N(\lambda_2^*)$ *are increasing in* λ_2^*.

Lemma 3 exhibits several features that characterize the green lender's optimal lending strategy. First, part (i) implies that $D_G^N(\lambda_2^*) > \max\{D_B^M(\lambda_2^*), D_B^N(\lambda_2^*)\}$, implying that the green lender can maximize her expected financial payoff per unit of capital by selectively lending to the green firm. Delaying financing until $t = 2$ is costly for both firm types because funding then arrives only with probability $\beta < 1$. However, this delay is more costly for the green firm, since the probability of realizing the social return ϕ is also reduced to β. This asymmetry strengthens the green lender's bargaining position *vis-à-vis* the green firm, and allows her to claim a larger share of the firm's financial return as repayment.

Furthermore, part (i) can equivalently be written as $D_B^M(\lambda_2^*) < \min\{D_B^N(\lambda_2^*), D_G^N(\lambda_2^*)\}$, implying that the green lender must offer the brown firm a discount in order to include a monitoring covenant. The reason is that, by Lemma 1, the brown firm strictly prefers project B and can always wait until $t = 2$ to borrow from a brown lender and choose B. A monitoring contract is therefore acceptable only if it sufficiently compensates the brown firm for being forced to choose project G with probability m. Part (ii) further shows that this required discount increases with m: as monitoring becomes more effective, stronger financial incentives are needed to induce acceptance. In the extreme, the green lender may optimally forgo the monitoring covenant when the required discount makes the contract excessively unprofitable.

This finding resonates with Oehmke and Opp (2025), who argue that green lenders must offer monetary discounts in exchange for enforcing green investment by brown firms. Our model differs from theirs in two important respects. First, we consider a more general environment in which the green lender cannot perfectly enforce green investment by the brown firm. Second, the green lender in our model can endogenously choose whether to adopt external monitoring when designing her contract offer at $t = 1$. These features allow us to analyze how the green lender's incentive to include a monitoring covenant depends on her ability to detect the borrowing firm's deviation toward brown investment.

Interestingly, the green lender's use of monitoring does not merely subsidize the enforcement of green investment by brown firms; it also benefits green firms through cheaper borrowing. Because $\max\{D_B^M(\lambda_2^*), D_B^N(\lambda_2^*)\} < D_G^N(\lambda_2^*)$, the green firm is willing to accept any borrowing term that the brown firm is willing to accept. As a result, a discount designed to satisfy the brown firm's participation constraint leaves the green firm with a strictly positive informational rent. In particular, since $D_B^M(\lambda_2^*) < D_B^N(\lambda_2^*)$, the discount is especially large under a monitoring covenant, allowing the green firm to obtain a substantial informational rent by mimicking the brown firm.

Lastly, parts (iii) and (iv) characterize how the green lender's repayment claim on the borrowing firm's financial return varies with the structure of the capital market. Part (iii) shows that the green lender must accept a lower repayment as β increases—that is, as competition among lenders becomes more intense. Part (iv) further shows that the green lender can raise her repayment claim as λ_2^* increases—that is, as brown lenders in the subsequent capital market become more pessimistic about the profitability of the firm arriving at $t = 2$. In the following section, we combine these forces to characterize how the green lender's market power shapes the full equilibrium outcome.

5 Equilibrium Analysis

5.1 The Green Lender's Problem at $t = 1$

We now return to the $t = 1$ market and characterize the equilibrium by solving the green lender's problem by backward induction. At this stage, the green lender has four options: (i) offering a contract with a monitoring covenant (monitoring); (ii) offering a contract without a monitoring covenant that is acceptable to both firm types (pooling); (iii) offering a contract without a monitoring covenant that is acceptable only to the green firm (separating); or (iv) not lending to either firm type (withdrawal). We first take the posterior belief λ_2^* as given and then examine the green lender's expected payoff under each of these four options; the green lender chooses the one that maximizes her expected payoff. Later, we will discuss how the equilibrium posterior belief λ_2^* will be endogenized.

Monitoring Contract (M). We first examine the case in which the green lender includes a monitoring covenant in her contract offer. Under this *monitoring* contract, the maximum

repayment she can credibly claim is $D_B^M(\lambda_2^*)$, so she offers the contract $(M, D_B^M(\lambda_2^*))$.

By construction of $D_B^M(\lambda_2^*)$ in (10), the brown firm accepts this offer. The green firm also accepts the same contract, since it obtains a strictly higher payoff given that $D_B^M(\lambda_2^*) < D_G^N(\lambda_2^*)$ and the monitoring covenant does not affect the green firm's project choice. The green lender's expected payoff from offering the monitoring (hereafter denoted by "M") contract, $(M, D_B^M(\lambda_2^*))$, is therefore

$$\begin{aligned} U_M(\lambda_2^*) :=& \lambda\big[p_G D_B^M(\lambda_2^*) + \phi\big] + (1-\lambda)\big[m\big(p_G D_B^M(\lambda_2^*) + \phi\big) + (1-m)p_B D_B^M(\lambda_2^*)\big] - c - 1 \\ =& (\lambda + (1-\lambda)m)(p_G D_B^M(\lambda_2^*) + \phi) + (1-\lambda)(1-m)p_B D_B^M(\lambda_2^*) - c - 1. \end{aligned} \tag{13}$$

To understand (13), note first that given the prior belief λ, the green lender funds the green firm with probability λ and the brown firm with probability $1-\lambda$. By Lemma 1, the green firm chooses project G after obtaining external financing, regardless of whether monitoring is in place. By contrast, the brown firm strictly prefers project B, although this choice is overturned and redirected to project G with probability m when the monitoring covenant is active. Taken together, the green lender will fund project G with probability $\lambda + (1-\lambda)m$. Finally, the green lender incurs the monitoring cost $c > 0$ and pays the upfront investment cost of 1. If the green lender offers this monitoring contract in equilibrium, any outcome in which the firm delays financing until $t = 2$ lies off the equilibrium path, so the posterior belief λ_2^* at $t = 2$ is unrestricted.

Non-Monitoring Pooling Contract (NP). Next, the green lender may choose to forgo her monitoring right. In this case, two subcases arise. First, the green lender can fund both green and brown firms by offering a sufficiently low repayment $D_1 \leq D_B^N(\lambda_2^*) < D_G^N(\lambda_2^*)$. Under this "pooling" strategy, the maximum repayment she can credibly claim is $D_B^N(\lambda_2^*)$, so she offers the non-monitoring and pooling (hereafter denoted by "NP") contract $(N, D_B^N(\lambda_2^*))$, which yields the expected payoff

$$U_{NP}(\lambda_2^*) := \lambda\big[p_G D_B^N(\lambda_2^*) + \phi\big] + (1-\lambda)p_B D_B^N(\lambda_2^*) - 1. \tag{14}$$

To understand (14), note that after obtaining financing from the green lender, the green firm chooses project G, while the brown firm chooses project B, as characterized in Lemma 1. Since both firm types accept the green lender's offer at $t = 1$, no firm proceeds to the $t = 2$ market on the equilibrium path. Therefore, if the non-monitoring pooling contract

is offered in equilibrium, the posterior belief λ_2^* at $t = 2$ is off path and unrestricted.

Non-Monitoring Separating Contract (NS). Alternatively, the green lender may increase her repayment claim to $D_1 \in (D_B^N(\lambda_2^*), D_G^N(\lambda_2^*)]$ and thereby fund only the green firm's project. Under this "separating" strategy, the highest repayment she can credibly demand is $D_G^N(\lambda_2^*)$, so she offers the non-monitoring and separating (hereafter denoted by "NS") contract $(N, D_G^N(\lambda_2^*))$, which yields the expected payoff

$$U_{NS}(\lambda_2^*) := \lambda\big[p_G D_G^N(\lambda_2^*) + \phi - 1\big]. \tag{15}$$

To understand (15), note that only the green firm accepts the contract. Hence, the green lender finances the green firm's project with probability λ, while the contract is rejected with probability $1 - \lambda$. Moreover, since only the brown firm rejects the green lender's offer and instead seeks financing at $t = 2$, the posterior belief at $t = 2$ must satisfy $\lambda_2^* = 0$ if the non-monitoring separating contract is offered in equilibrium.

Withdrawal ($\varnothing$). Lastly, the green lender may choose not to lend to either firm type (hereafter denoted by "$\varnothing$"). In this case, both the green and brown firms must go to the $t = 2$ market for financing. Since the green firm, if it obtains financing from a brown lender with probability β, chooses project G and thereby generates the social return ϕ, the green lender obtains the expected payoff

$$U_\varnothing := \beta\lambda\phi. \tag{16}$$

That is, the green lender can free-ride on the brown lenders' financing of project G in the subsequent period. If the green lender withdraws, the firm, regardless of its type, goes to the $t = 2$ market.[17] The brown and green firms then obtain expected payoffs $\beta p_B(R - D_2^*(\lambda_2^*))$ and $\beta\big[p_G(R - D_2^*(\lambda_2^*)) + \phi\big]$, respectively. Although these continuation payoffs depend on λ_2^*, the green lender's payoff under withdrawal, $U_\varnothing$, does not.

In sum, the green lender chooses among four strategies: a monitoring contract, a non-monitoring pooling contract, a non-monitoring separating contract, and withdrawal. These

[17] If withdrawal occurs in equilibrium, then $\lambda_2^* = \lambda$. If instead the green lender withdraws as a deviation from another equilibrium, λ_2^* need not coincide with λ. In either case, however, the green lender's payoff under withdrawal does not depend on λ_2^*. We therefore define $U_\varnothing$ in (16) independently of λ_2^*.

strategies are associated with expected payoffs $U_M(\lambda_2^*)$, $U_{NP}(\lambda_2^*)$, $U_{NS}(\lambda_2^*)$, and $U_\varnothing$, respectively. Depending on parameter values and beliefs, equilibrium behavior may involve selecting one of these options or, when a pure-strategy equilibrium does not exist, randomizing among them. The equilibrium strategy is therefore determined by comparing these four payoffs, taking into account how the posterior belief λ_2^* shapes the firm's continuation payoff from entering the $t = 2$ market and thereby the green lender's feasible repayment claims $D_B^M(\lambda_2^*)$, $D_B^N(\lambda_2^*)$, and $D_G^N(\lambda_2^*)$. In the next section, we use the structure of these four payoffs to characterize when the green lender optimally includes the monitoring covenant and to derive the monitoring-adoption region as a function of market competitiveness and informational frictions.

5.2 Optimality of ESG Monitoring

Our primary interest is in when the green lender chooses to offer a monitoring contract. We begin by examining how this incentive varies with her monitoring ability $m \in (0, 1)$, that is, under what conditions the monitoring contract $(M, D_B^M(\lambda_2^*))$ arises in equilibrium. Because the monitoring contract is accepted by both the green and brown firms, it imposes no restriction on the off-the-equilibrium-path belief $\lambda_2^* \in [0, 1]$. In the next theorem, we fix λ_2^* at an arbitrary level and study how the lender's incentive varies with m.

Theorem 1. *Fix $\beta \in (0, 1)$, $\lambda \in (0, 1)$, and $c > 0$.*

(i) For each $\lambda_2^* \in [0, 1]$, there exist threshold values $0 \le \underline{m}^* \le \overline{m}^* \le 1$ such that

$$U_M(\lambda_2^*) > \max\{U_{NP}(\lambda_2^*), U_{NS}(\lambda_2^*), U_\varnothing\}$$

if and only if $m \in (\underline{m}^*, \overline{m}^*)$. Equivalently, there is an equilibrium where the green lender offers $(M, D_B^M(\lambda_2^*))$ if and only if $m \in (\underline{m}^*, \overline{m}^*)$.

(ii) The interval $(\underline{m}^*, \overline{m}^*)$ expands as λ_2^* increases in the sense of set inclusion: if $\lambda_2' < \lambda_2''$, then

$$(\underline{m}^*(\lambda_2'), \overline{m}^*(\lambda_2')) \subseteq (\underline{m}^*(\lambda_2''), \overline{m}^*(\lambda_2'')).$$

Figure 2 graphically illustrates the *ESG-monitoring region* $(\underline{m}^*, \overline{m}^*)$—that is, the range of the green lender's monitoring ability m for which her equilibrium strategy is to offer the

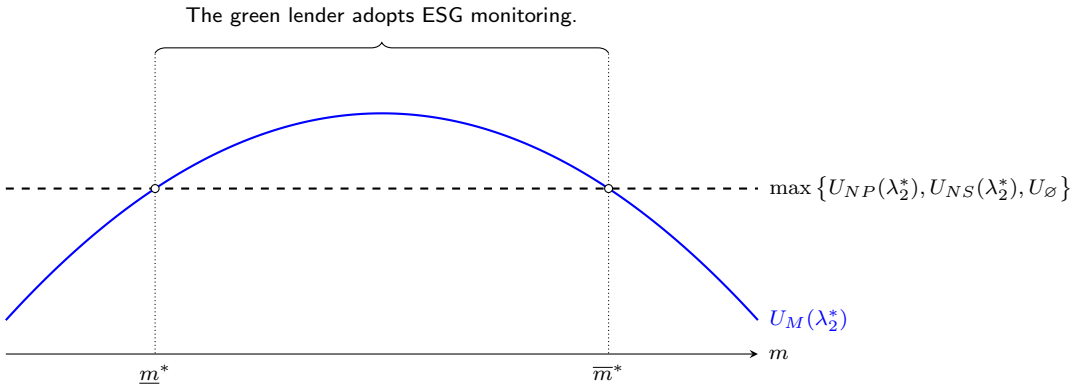


Figure 2 – Characterization of the ESG-monitoring region $m \in (\underline{m}^*, \overline{m}^*)$

monitoring contract $(M, D_B^M(\lambda_2^*))$.[18]

An increase in the green lender's monitoring ability m affects her incentive to include a monitoring covenant through three channels. On the one hand, under the monitoring contract, the firm chooses project G with probability $\lambda+(1-\lambda)m$, so the green lender's expected payoff from the social return, $(\lambda+(1-\lambda)m)\phi$, increases linearly with m. On the other hand, stronger monitoring lowers the green lender's financial payoff through two channels. First, it makes the brown firm more likely to be redirected from project B to project G, even though project G yields the financial return with a lower probability. Second, to keep the brown firm willing to accept the monitoring contract, the green lender's repayment under monitoring, $D_B^M(\lambda_2^*)$, decreases in m.

These countervailing effects imply that the green lender's payoff under the monitoring contract, $U_M(\lambda_2^*)$, is non-monotonic in m. When m is low, monitoring generates little additional compliance by the brown firm, so the enforcement benefit remains small relative to its cost. When m is high, however, the repayment $D_B^M(\lambda_2^*)$ must decline at an increasing rate to keep the brown firm willing to accept the monitoring contract (see (12) and the surrounding discussion). This sharper repayment cut is dictated by the brown firm's acceptance condition, but the resulting discount is also enjoyed by the green firm, which would have accepted the contract anyway. Hence, as monitoring becomes stronger, the informational rent left to the green firm rises more rapidly, making the monitoring contract less attractive. Taken together, these forces imply that the green lender adopts ESG monitoring only when her monitoring

[18] Theorem 1-(i) also covers the case in which $\underline{m}^* = \overline{m}^*$, so the range $(\underline{m}^*, \overline{m}^*)$ is empty. This occurs when the monitoring cost c is sufficiently large relative to the green lender's payoff from the social return. Note that $U_M(\lambda_2^*)$ is strictly decreasing in c, whereas the other payoffs, $U_{NP}(\lambda_2^*)$, $U_{NS}(\lambda_2^*)$, and $U_\varnothing$, are independent of c.

ability lies in an intermediate range, as stated and illustrated in Theorem 1-(i) and Figure 2.

The analysis yields an important policy implication. Tighter ESG disclosure or verification standards—including ESG-linked performance metrics, periodic reporting, external review, and assurance—aimed at strengthening lenders' monitoring capabilities do not always translate into stronger market-driven ESG discipline. Although such reforms can improve the observability and enforceability of borrowers' ESG behavior, they can also force lenders to leave borrowers a substantially large share of financial returns in order to induce them to accept monitored lending, thereby increasing the rents left to them. If these rents are too large, tighter ESG disclosure or verification may discourage, rather than encourage, pro-ESG lenders from adopting monitoring covenants. The effectiveness of ESG-related regulation therefore depends not only on improving ESG information, but also on how this information interacts with contract design and the competitive structure of capital markets.

The model also yields a testable empirical hypothesis about ESG-monitoring adoption by pro-ESG lenders: the use of ESG-monitoring covenants should be highest at intermediate levels of monitoring effectiveness. This prediction follows directly from the non-monotonicity of the green lender's payoff under the monitoring contract in Theorem 1-(i). Empirically, the analysis implies an inverted-U relationship between the incidence of ESG-monitoring covenants and proxies for monitoring effectiveness, such as the precision of ESG metrics, the strength of external verification standards, or the stringency of ESG-related disclosure regulation.

Theorem 1-(ii) further concerns how the ESG-monitoring region $(\underline{m}^*, \overline{m}^*)$ varies with the off-the-equilibrium-path belief λ_2^*. A higher λ_2^* means that brown lenders at $t = 2$ view a firm arriving there as more likely to be green and therefore less financially attractive. By Lemma 2, this raises the repayment demanded at $t = 2$ and worsens the firm's outside option from waiting. Consequently, whenever the green lender sets her repayment so that the relevant firm type is just indifferent between borrowing at $t = 1$ and waiting until $t = 2$, a higher λ_2^* allows her to raise that repayment. See (7)–(10).

The comparison with the non-monitoring separating contract is relatively straightforward. A higher λ_2^* also improves the green lender's payoff under the non-monitoring separating contract by weakening the green firm's outside option at $t = 2$. But that gain is limited because only the green firm accepts the separating contract. Under monitoring, by contrast, both firm types accept, so the lender benefits more broadly from the higher repayment that a weaker outside option makes possible. This is why a rise in λ_2^* makes monitoring relatively more attractive than the non-monitoring separating contract.

However, the comparison with the non-monitoring pooling contract is subtler, because both the monitoring contract and the non-monitoring pooling contract are accepted by both firm types. The key difference is that, under monitoring, the brown firm is redirected toward the green project with positive probability, and that project succeeds less often than the brown project. Since repayment is collected only when the project succeeds, a given increase in repayment bites less often under monitoring than under the non-monitoring pooling contract. Therefore, when a higher λ_2^* worsens the firm's outside option at $t = 2$, the green lender can raise repayment by more under the monitoring contract while still keeping the brown firm willing to accept. This is why a rise in λ_2^* also makes monitoring relatively more attractive than the non-monitoring pooling contract.

Taken together, these observations explain why a higher λ_2^* always expands the ESG-monitoring region. A rise in λ_2^* worsens the firm's outside option at $t = 2$ and thereby allows the green lender to demand higher repayment at $t = 1$. This strengthens the monitoring contract relative to both non-monitoring alternatives: relative to the non-monitoring separating contract because the gain from higher repayment is realized under monitoring for both firm types, and relative to the non-monitoring pooling contract because an increase in repayment bites less often under monitoring. Hence, as λ_2^* increases, the range of monitoring ability for which the green lender optimally adopts ESG monitoring becomes larger.

This result suggests a broader policy implication: the effectiveness of policies designed to promote ESG monitoring may depend crucially on the matching structure between pro-ESG lenders and ESG-oriented borrowers in capital markets. When firms turning to non-ESG lenders are unlikely to be perceived as inherently ESG-oriented, their outside option of alternative funding remains strong, forcing pro-ESG lenders to make larger contractual concessions to induce acceptance of monitored lending. In such environments, stronger monitoring may further increase the rents left to borrowers and thus discourage monitoring adoption. More broadly, policies aimed at strengthening market-led ESG discipline are unlikely to be effective without accounting for how readily pro-ESG lenders and ESG-oriented borrowers form financial relationships in capital markets.

5.3 ESG-Monitoring Adoption and Competition

A central remaining question is how competition in the lending market affects the green lender's incentive to adopt ESG monitoring. This question is important because competition changes the borrower's outside option and thereby reshapes the surplus and informational

rents associated with alternative contracts. We therefore turn to how the intensity of lender competition—captured by $\beta \in (0,1)$ in our model—affects the green lender's willingness to include a monitoring covenant in her contract offer. Continuing to fix λ_2^* at an arbitrary level, we study how the interval

$$(\underline{m}^*, \overline{m}^*) = \{m \in (0,1) : U_M(\lambda_2^*) > \max\{U_{NP}(\lambda_2^*), U_{NS}(\lambda_2^*), U_\varnothing\}\}$$

varies with β.

Theorem 2. *Fix $\lambda_2^* \in [0,1]$ such that the range $(\underline{m}^*, \overline{m}^*)$ is non-empty. Then the following results hold:*

(i) Suppose that the green lender's best non-monitoring alternative is withdrawal or the non-monitoring pooling contract:

$$U_\varnothing = \max\{U_{NP}(\lambda_2^*), U_{NS}(\lambda_2^*), U_\varnothing\} \text{ or } U_{NP}(\lambda_2^*) = \max\{U_{NP}(\lambda_2^*), U_{NS}(\lambda_2^*), U_\varnothing\}.$$

Then $(\underline{m}^*, \overline{m}^*)$ shrinks as β increases marginally.

(ii) Suppose that the green lender's unique best non-monitoring alternative is the non-monitoring separating contract and that the separating repayment is interior:

$$U_{NS}(\lambda_2^*) > \max\{U_{NP}(\lambda_2^*), U_\varnothing\} \quad \text{and} \quad D_G^N(\lambda_2^*) < R.$$

Then there exist two cutoffs $0 < \underline{\phi}^* < \overline{\phi}^*$ that govern the effect of β on the monitoring adoption as follows: a marginal increase in β shrinks $(\underline{m}^*, \overline{m}^*)$ if $\phi \leq \underline{\phi}^*$; a marginal increase in β expands $(\underline{m}^*, \overline{m}^*)$ if $\phi \geq \overline{\phi}^*$; a marginal increase in β leads to a decrease in both $\underline{m}^*$ and $\overline{m}^*$ otherwise.[19]

Theorem 2 studies how competitive funding access, captured by β, reshapes the green lender's best non-monitoring alternative and thereby the contractual viability of ESG monitoring. As β increases, brown lenders arrive at $t = 2$ with higher probability, which strengthens the firm's outside option of waiting and weakens the green lender's bargaining position at

[19] If $D_G^N(\lambda_2^*) \geq R$, the separating repayment is capped at R and is locally independent of β. In this boundary case, the effect of β does not depend on ϕ: $U_{NS}(\lambda_2^*)$ is locally unchanged, while $U_M(\lambda_2^*)$ decreases with a marginal increase in β, so the range $(\underline{m}^*, \overline{m}^*)$ shrinks. See the last part of the proof of Theorem 2 in the appendix.

$t = 1$. As a result, the green lender must reduce her repayment claim under any lending contract, lowering her financial payoff from direct lending (Lemma 3-(iii)). This effect alone does not determine whether competition discourages or encourages ESG monitoring, because what matters is how the monitoring contract compares with the green lender's best non-monitoring alternative.

First, suppose the green lender's best non-monitoring alternative is to withdraw from lending, so that her payoff is $U_{\varnothing} = \beta\lambda\phi$. In this case, stronger lender competition raises the value of withdrawal, because a higher β makes it more likely that brown lenders arrive at $t = 2$ and finance the green firm, thereby generating the social return ϕ that the green lender values even when she does not lend directly. By contrast, if the green lender offers the monitoring contract, greater competition weakens her bargaining position and reduces her financial payoff from lending. Hence, as competition intensifies, the monitoring contract becomes less attractive relative to withdrawal, and the ESG-monitoring region contracts.

Next, suppose the green lender's best non-monitoring alternative is the non-monitoring pooling contract, under which she lends to both firm types without monitoring. As β increases, the brown firm's outside option improves, so the green lender must lower repayment under both contracts to keep the brown firm willing to accept. This repayment adjustment is larger under monitoring, because repayment bites less often when the brown firm is redirected toward the lower-success-probability green project. As discussed after Theorem 1, the resulting extra repayment concession primarily enlarges the green firm's informational rent, since the green firm also enjoys the lower repayment even though it would have accepted anyway. Hence, stronger competition lowers the green lender's payoff more under the monitoring contract than under the non-monitoring pooling contract, so the ESG-monitoring region contracts.

Lastly, suppose that the green lender's best non-monitoring alternative is the non-monitoring separating contract, under which only the green firm accepts. In this case, the effect of lender competition depends on the size of the social return ϕ. Under the separating contract, the green lender sets repayment so that the green firm is just willing to borrow at $t = 1$ rather than wait until $t = 2$. The key difference is that borrowing early allows the green firm to secure the full social return ϕ, whereas waiting until $t = 2$ yields only the expected social return $\beta\phi$. Thus, the green lender can extract an early-financing premium of size $(1 - \beta)\phi$ under the separating contract. When ϕ is small, this premium is small, so a higher β does not weaken the separating contract by much. When ϕ is large, however, the premium is large, and stronger competition erodes it sharply by making delay less costly to the green firm. Hence, as competition intensifies, monitoring becomes relatively less attractive

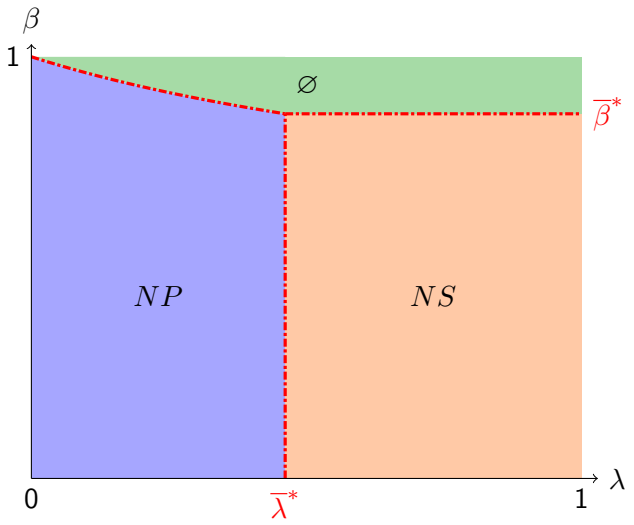


Figure 3 – The green lender's best deviation strategy when ESG monitoring is not adopted. NP refers to lending both types of the firm without monitoring by offering $(N, D_B^N(\lambda_2^*))$, NS refers to lending to the green firm separately without monitoring by offering $(N, D_G^N(\lambda_2^*))$, and $\varnothing$ refers to the withdrawal from lending.

when ϕ is small ($\phi < \underline{\phi}^*$), but relatively more attractive when ϕ is large ($\phi > \overline{\phi}^*$).

When ϕ is in an intermediate range, stronger competition shifts the ESG-monitoring region to the left by lowering both thresholds $\underline{m}^*$ and $\overline{m}^*$. The reason is that, in this case, stronger competition weakens the non-monitoring separating contract enough to make low-intensity monitoring more attractive, but not enough to offset the large repayment concessions required under high-intensity monitoring. Near $\underline{m}^*$, monitoring is still weak, so the green lender does not need to leave much informational rents to sustain it; the erosion of the separating alternative therefore dominates, which lowers $\underline{m}^*$. Near $\overline{m}^*$, by contrast, monitoring is already strong, so sustaining it requires a large repayment discount; stronger competition then hurts the monitoring contract more than the separating contract, which lowers $\overline{m}^*$. Thus, competition shifts adoption toward lower-intensity monitoring and away from high-intensity ESG discipline.

Interestingly, this mixed pattern arises only when ϕ is intermediate. If ϕ were smaller, stronger competition would not weaken the non-monitoring separating contract by much, so the monitoring region would shrink throughout. If ϕ were larger, stronger competition would weaken the separating contract so strongly that the monitoring region would expand throughout. When ϕ lies between these two cases, however, the effect of competition depends on the level of monitoring intensity m.

The remaining question is which non-monitoring option becomes the green lender's best alternative, that is, her optimal deviation from the equilibrium monitoring contract $(M, D_B^M(\lambda_2^*))$. This question matters because it determines which part of Theorem 2 applies in different market environments. To illustrate this, we focus on the benchmark out-of-equilibrium belief $\lambda_2^* = 0$, under which any firm arriving at the $t = 2$ market off the equilibrium path is believed to be brown with probability one.[20] Figure 3 maps the green lender's optimal non-monitoring alternative as a function of β and λ.

Two broad patterns emerge from Figure 3. When lending-market competition is sufficiently intense, the green lender's best deviation is to withdraw from lending ($\varnothing$). When competition is weaker and the firm is sufficiently unlikely to be green, her best deviation is instead pooled non-monitoring lending to both firm types (NP). In both regions, stronger competition makes monitoring less attractive to the green lender, consistent with Theorem 2-(i). The most interesting region arises when competition is weak but the firm is sufficiently likely to be green. In that case, the green lender's best non-monitoring alternative is to finance the green firm separately (NS) and extract a large repayment in exchange for guaranteed early funding. This is precisely the region in which the effect of competition becomes more nuanced: stronger competition may either encourage or discourage ESG-monitoring adoption, depending on the magnitude of the social return generated by green investment (Theorem 2-(ii)). Moreover, competitive pressure can also reshape the relative attractiveness of low- and high-intensity monitoring technologies.

Our analysis yields a nuanced implication for market-led ESG discipline: lender competition does not uniformly undermine monitoring incentives. For example, when the market comprises a sufficiently large share of ESG-oriented borrowers ($\lambda \geq \overline{\lambda}^*$) and social returns are substantial ($\phi > \overline{\phi}^*$), intensified competition can actually encourage monitoring adoption. By contrast, even when ESG-oriented borrowers constitute a large share of the borrower pool, stronger competition discourages monitoring when social returns are small ($\phi \leq \underline{\phi}^*$) and shifts the market toward lower-intensity ESG discipline when social returns are intermediate ($\phi \in (\underline{\phi}^*, \overline{\phi}^*)$). Thus, market developments that intensify competition do not necessarily weaken discipline; rather, they may encourage lenders to formalize ESG follow-through only when borrowers place sufficiently high value on mission-consistent capital.

Our analysis also yields an important implication for the design of ESG disclosure, assurance, and verification regimes. Improving the observability and enforceability of borrowers'

[20] We use $\lambda_2^* = 0$ as a benchmark because it is naturally selected by standard refinements such as the D1 criterion. The qualitative analysis is unchanged for $\lambda_2^* \neq 0$.

ESG behavior is valuable only insofar as it supports the contractual adoption of monitoring by pro-ESG lenders. Specifically, stronger verification can be counterproductive when it narrows the range of monitoring intensities that lenders are willing to adopt: if more rigorous monitoring substantially increases the informational rents and repayment concessions required to keep borrowers willing to accept monitored lending, pro-ESG lenders may respond by reducing, rather than expanding, monitoring adoption. Better ESG information therefore does not automatically translate into stronger market-driven discipline. Its effectiveness depends on whether the surrounding market environment allows that information to be embedded into lending arrangements on incentive-compatible terms.

The analysis further suggests that competition policy in ESG capital markets should be explicitly state-contingent. When intrinsically ESG-oriented borrowers are scarce, stronger competition raises the effective cost of incentive compatibility and can make ESG-monitoring covenants prohibitively costly, thereby discouraging monitoring adoption. By contrast, when the borrower pool is more ESG-oriented and the non-pecuniary social return from ESG investing is sufficiently large, stronger competition can weaken the lender's non-monitoring separating alternative and thereby encourage monitoring. When the non-pecuniary return is more modest, however, competition may instead shift adoption toward lower-intensity monitoring while rendering high-intensity monitoring less sustainable. Consequently, regulatory interventions affecting the competitive structure of ESG capital markets must be calibrated to borrower composition and the magnitude of the non-pecuniary return generated by green investment.

We conclude this section by noting that the analysis above does not yet deliver a full equilibrium characterization. Instead, taking the out-of-equilibrium belief λ_2^* as given, we have identified the conditions on m—the green lender's monitoring capability—under which an equilibrium with ESG-monitoring adoption can be sustained, and we have characterized how the associated adoption region varies across economic environments. Completing equilibrium analysis requires determining which contract (or mixture of contracts) is sustained once all incentive and belief restrictions are jointly imposed. This step is non-trivial because, under pooled finance at $t = 1$, no firm reaches the $t = 2$ market on the equilibrium path, so the out-of-equilibrium belief λ_2^* is not uniquely pinned down, naturally leading to multiple equilibria. In the Online Appendix, we provide a complete characterization of equilibrium as a function of the key parameters λ, β, and m.

6 Conclusion

This paper studies a central tension in market-led ESG discipline: although capital markets now have greater access to ESG disclosure, assurance, ratings, and other verification tools, these informational advances do not automatically translate into credible enforcement of firms' ESG commitments. We develop a model in which a pro-ESG lender decides whether to include an ESG-monitoring covenant in a financial contract when borrowers differ in their intrinsic ESG orientation and retain discretion over project choice after financing is obtained. Monitoring can discipline opportunistic borrowers, but it also tightens incentive constraints and requires the lender to offer financial concessions to make monitored contracts acceptable. Because intrinsically ESG-oriented borrowers benefit from the same concessions, monitoring also generates informational rents. The central implication is that the private adoption of ESG monitoring need not increase monotonically with monitoring effectiveness. Better monitoring strengthens enforcement, but it can also make monitoring more expensive to sustain in equilibrium.

The analysis further shows that competition has a state-dependent effect on ESG monitoring. Greater competition can weaken monitoring when it erodes lenders' ability to recover the costs of enforcement, especially when monitoring mainly serves as a pooling device against greenwashing. But competition can also make monitoring relatively more attractive when the relevant non-monitoring alternative is selective lending to already ESG-oriented borrowers. The broader message is that the equilibrium use of ESG monitoring depends not only on the quality of ESG information, but also on how that information interacts with contract design, borrower composition, and the structure of the lending market.

These results have implications for the institutions that increasingly shape ESG discipline in practice. In particular, for regulators and policymakers, the model suggests that tighter disclosure, assurance, and verification standards may have weaker effects than intended if they improve observability without also improving the contractual feasibility of enforcement. More broadly, the paper suggests that the challenge in ESG capital markets is not simply informational but fundamentally contractual: whether ESG commitments translate into real changes in firm behavior depends on whether financial markets can convert improved information into economically viable and incentive-compatible contracts.

Several avenues for future research remain. One natural extension is to incorporate richer lender heterogeneity, including differences in monitoring costs, reputational motives, or the extent to which lenders internalize social returns. Another is to explore dynamic settings

where borrowers build ESG reputations over time, potentially shifting screening and monitoring incentives through repeated interactions. It would also be useful to extend the framework to environments with multiple competing ESG metrics or misaligned assurance providers, where measurement itself becomes strategic. More broadly, understanding when ESG information becomes contractually consequential—versus largely symbolic—appears central to future research on sustainable finance.

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Appendix

A Proofs

A.1 Proof of Lemma 1

First consider the green firm. Under Assumption 1, we have

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

Hence, for any $D \in [0, R]$, we have

$$p_G(R - D) + \phi - p_B(R - D) = (p_G R + \phi - p_B R) + (p_B - p_G)D > 0.$$

Thus, under a non-monitoring contract (N, D), the green firm strictly prefers project G to project B.

Now consider a monitoring contract (M, D). If the green firm chooses project B, the covenant detects this choice with probability m and redirects the firm to project G; otherwise, the firm implements project B. Hence, the payoff from choosing B under (M, D) is

$$(1 - m)p_B(R - D) + m[p_G(R - D) + \phi].$$

However, choosing G yields $p_G(R - D) + \phi$. The payoff difference is therefore equal to

$$p_G(R-D)+\phi-\{(1-m)p_B(R-D)+m[p_G(R-D)+\phi]\} = (1-m)\{p_G(R-D)+\phi-p_B(R-D)\}.$$

Since $m \in (0, 1)$ and the term $p_G(R - D) + \phi - p_B(R - D) > 0$ for any $D \in [0, R]$, the green firm strictly prefers project G under a monitoring contract as well.

Next consider the brown firm. Under a non-monitoring contract (N, D), the payoff from choosing project B is $p_B(R-D)$, while the payoff from choosing project G is $p_G(R-D)$. Since $p_B > p_G$, the brown firm strictly prefers project B whenever $D < R$.

Finally, consider a monitoring contract (M, D). If the brown firm chooses project B, it is redirected to project G with probability m and otherwise implements project B, so its expected payoff is

$$(1 - m)p_B(R - D) + mp_G(R - D).$$

Choosing project G yields $p_G(R-D)$. Therefore,

$$(1-m)p_B(R-D)+mp_G(R-D)-p_G(R-D)=(1-m)(p_B-p_G)(R-D).$$

Because $m \in (0,1)$ and $p_B > p_G$, this is strictly positive whenever $D < R$. Hence, under any accepted contract with repayment $D < R$, the brown firm strictly prefers project B. Therefore, the green firm always chooses project G, while the brown firm chooses project B whenever its repayment obligation satisfies $D < R$. *Q.E.D.*

A.2 Proof of Lemma 2

Because the Bertrand continuation game has a unique equilibrium outcome and any such outcome is payoff-equivalent to a symmetric pure-strategy equilibrium, it suffices to characterize the symmetric equilibrium outcome.

Fix a $t = 2$ posterior belief $\lambda_2^* \in [0,1]$ and let

$$p(\lambda_2^*) := \lambda_2^* p_G + (1-\lambda_2^*)p_B.$$

Suppose there are $n \geq 2$ brown lenders. We show that in any symmetric equilibrium of the $t = 2$ market, the repayment offered by brown lenders must equal

$$D_2^*(\lambda_2^*) := \frac{1}{p(\lambda_2^*)}.$$

Step 1: Necessity. Suppose, to the contrary, that all brown lenders offer some repayment $D' \neq D_2^*(\lambda_2^*)$.

If $D' > D_2^*(\lambda_2^*)$, then each brown lender earns

$$\frac{1}{n}\left[p(\lambda_2^*)D' - 1\right] > 0$$

in the symmetric profile. A lender can profitably deviate by slightly undercutting, offering $\widetilde{D} = D' - \varepsilon$ for sufficiently small $\varepsilon > 0$. The firm strictly prefers the lower repayment, so the deviating lender wins the market and obtains

$$p(\lambda_2^*)\widetilde{D} - 1 = p(\lambda_2^*)(D' - \varepsilon) - 1.$$

For sufficiently small ε close to zero, this payoff is strictly larger than $\frac{1}{n}\left[p(\lambda_2^*)D' - 1\right]$. Hence $D' > D_2^*(\lambda_2^*)$ cannot be sustained in equilibrium.

If $D' < D_2^*(\lambda_2^*)$, then any lender who finances the firm at repayment D' earns

$$p(\lambda_2^*)D' - 1 < 0.$$

Such an offer cannot be optimal, since the lender can instead avoid funding the firm, or equivalently make an offer that is not accepted, and obtain zero. Hence $D' < D_2^*(\lambda_2^*)$ cannot be sustained either. Therefore, any symmetric equilibrium offer must satisfy $D_2 = D_2^*(\lambda_2^*)$.

Step 2: Sufficiency. Consider the symmetric strategy profile in which every brown lender offers $D_2^*(\lambda_2^*)$. Each lender obtains zero expected profit:

$$p(\lambda_2^*)D_2^*(\lambda_2^*) - 1 = 0.$$

Given that all other lenders offer $D_2^*(\lambda_2^*)$, any deviation to $D' > D_2^*(\lambda_2^*)$ is rejected because the firm strictly prefers the lower repayment offered by competitors, so the deviating lender obtains zero. Any deviation to $D' < D_2^*(\lambda_2^*)$ wins the market but yields strictly negative expected profit. Thus no lender has a profitable deviation, and the symmetric profile in which all brown lenders offer $D_2^*(\lambda_2^*)$ is an equilibrium.

Finally, since $p(\lambda_2^*) \geq p_G$ and Assumption 1 implies $p_G R > 1$, we have

$$D_2^*(\lambda_2^*) = \frac{1}{p(\lambda_2^*)} \leq \frac{1}{p_G} < R.$$

Thus the repayment is feasible under limited liability, and the firm strictly benefits from accepting the brown lenders' break-even offer. *Q.E.D.*

A.3 Proof of Lemma 3

Proof of part (i). Fix $\lambda_2^* \in [0,1]$. Within this proof, slightly abusing notation, let

$$p(m) := mp_G + (1-m)p_B.$$

By Assumption 1 and Lemma 2, we have

$$D_2^*(\lambda_2^*) = \frac{1}{\lambda_2^* p_G + (1-\lambda_2^*)p_B} \leq \frac{1}{p_G} < R,$$

implying $R - D_2^*(\lambda_2^*) > 0$.

We first compare $D_B^M(\lambda_2^*)$ and $D_B^N(\lambda_2^*)$. Using (7) and (10), we have

$$\begin{aligned} D_B^N(\lambda_2^*) - D_B^M(\lambda_2^*) &= \Big[(1-\beta)R + \beta D_2^*(\lambda_2^*)\Big] - \left[\Big(1 - \beta\frac{p_B}{p(m)}\Big)R + \beta\frac{p_B}{p(m)} D_2^*(\lambda_2^*)\right] \\ &= \beta\big(R - D_2^*(\lambda_2^*)\big)\left(\frac{p_B}{p(m)} - 1\right). \end{aligned}$$

Since $p_G < p_B$, we have $p(m) < p_B$ for every $m \in (0,1)$. Hence we have $D_B^N(\lambda_2^*) \geq D_B^M(\lambda_2^*)$, where the inequality is strict whenever $\beta > 0$.

Next, we compare $D_G^N(\lambda_2^*)$ and $D_B^N(\lambda_2^*)$. Using (7) and (8),

$$\begin{aligned} D_G^N(\lambda_2^*) - D_B^N(\lambda_2^*) &= \left[(1-\beta)\Big(R + \frac{\phi}{p_G}\Big) + \beta D_2^*(\lambda_2^*)\right] - \Big[(1-\beta)R + \beta D_2^*(\lambda_2^*)\Big] \\ &= (1-\beta)\frac{\phi}{p_G}. \end{aligned}$$

Hence we have $D_G^N(\lambda_2^*) \geq D_B^N(\lambda_2^*)$, with strict inequality whenever $\beta < 1$.

Combining the two comparisons gives

$$D_B^M(\lambda_2^*) \leq D_B^N(\lambda_2^*) \leq D_G^N(\lambda_2^*).$$

In the interior case $\beta \in (0,1)$, both inequalities are strict:

$$D_B^M(\lambda_2^*) < D_B^N(\lambda_2^*) < D_G^N(\lambda_2^*).$$

At the boundary cases $\beta = 0$ and $\beta = 1$, the corresponding inequalities may hold weakly.

Q.E.D.

Proof of part (ii). Fix $\lambda_2^* \in [0,1]$. Let $p(m) := mp_G + (1-m)p_B$. Recall from (10) that

$$D_B^M(\lambda_2^*) = R - \beta\frac{p_B}{p(m)}\big(R - D_2^*(\lambda_2^*)\big).$$

By Assumption 1, we have $p_G R > 1$. Moreover, recall from the previous proof of part (i) that $D_2^*(\lambda_2^*) < R$. Since $D_2^*(\lambda_2^*)$ is independent of m, differentiating $D_B^M(\lambda_2^*)$ with respect to m yields

$$\frac{\partial D_B^M(\lambda_2^*)}{\partial m} = -\beta p_B\big(R - D_2^*(\lambda_2^*)\big)\frac{\partial}{\partial m}\left(\frac{1}{p(m)}\right),$$

where

$$\frac{\partial}{\partial m}\left(\frac{1}{p(m)}\right) = \frac{p_B - p_G}{p(m)^2} > 0.$$

Therefore, we have

$$\frac{\partial D_B^M(\lambda_2^*)}{\partial m} = -\beta p_B\big(R - D_2^*(\lambda_2^*)\big)\frac{p_B - p_G}{p(m)^2} \leq 0.$$

The inequality is strict whenever $\beta > 0$. Hence $D_B^M(\lambda_2^*)$ is weakly decreasing in m, and strictly decreasing in the interior case $\beta \in (0,1)$. *Q.E.D.*

Proof of part (iii). We show that $D_B^M(\lambda_2^*)$, $D_B^N(\lambda_2^*)$, and $D_G^N(\lambda_2^*)$ are decreasing in β. As established in the proofs of parts (i) and (ii), Assumption 1 implies $D_2^*(\lambda_2^*) < R$.

First, differentiating $D_B^M(\lambda_2^*)$ with respect to β gives

$$\frac{\partial D_B^M(\lambda_2^*)}{\partial \beta} = -\frac{p_B}{p(m)}\big(R - D_2^*(\lambda_2^*)\big) < 0,$$

where the strict inequality follows from $p_B/p(m) > 0$ for every $m \in (0,1)$ and $R - D_2^*(\lambda_2^*) > 0$.

Next, using (7), we obtain

$$\frac{\partial D_B^N(\lambda_2^*)}{\partial \beta} = -\big(R - D_2^*(\lambda_2^*)\big) < 0.$$

Finally, using (8), we have

$$\frac{\partial D_G^N(\lambda_2^*)}{\partial \beta} = -\left(R + \frac{\phi}{p_G} - D_2^*(\lambda_2^*)\right) < 0,$$

where the strict inequality follows from $D_2^*(\lambda_2^*) < R$ and $\phi > 0$. Taken together, $D_B^M(\lambda_2^*)$, $D_B^N(\lambda_2^*)$ and $D_G^N(\lambda_2^*)$ are all strictly decreasing in β for any $\beta \in [0,1]$. *Q.E.D.*

Proof of part (iv). We first show that $D_B^M(\lambda_2^*)$ is increasing in λ_2^*. Differentiating $D_B^M(\lambda_2^*)$

with respect to λ_2^* gives

$$\frac{\partial D_B^M(\lambda_2^*)}{\partial \lambda_2^*} = \beta \frac{p_B}{p(m)} \frac{\partial D_2^*}{\partial \lambda_2^*} = \beta \frac{p_B}{p(m)} \frac{p_B - p_G}{\left(\lambda_2^* p_G + (1-\lambda_2^*) p_B\right)^2} \geq 0,$$

where the inequality is strict whenever $\beta > 0$.

The arguments for $D_B^N(\lambda_2^*)$ and $D_G^N(\lambda_2^*)$ are analogous. In particular, from (7) and (8), we have

$$\frac{\partial D_B^N(\lambda_2^*)}{\partial \lambda_2^*} = \frac{\partial D_G^N(\lambda_2^*)}{\partial \lambda_2^*} = \beta \frac{p_B - p_G}{\left(\lambda_2^* p_G + (1-\lambda_2^*) p_B\right)^2} \geq 0,$$

where the inequality is strict whenever $\beta > 0$. Therefore, $D_B^M(\lambda_2^*)$, $D_B^N(\lambda_2^*)$, and $D_G^N(\lambda_2^*)$ are all (weakly) increasing in λ_2^*, while they are strictly increasing in λ_2^* whenever $\beta > 0$. *Q.E.D.*

A.4 Proof of Theorem 1

We first prove a mathematical property of U_M, U_{NP}, and U_{NS} used in the proof.

Lemma A.1. *For any $\lambda_2^* \in [0,1]$,*

$$\frac{\partial U_M}{\partial \lambda_2^*} \geq \frac{\partial U_{NP}}{\partial \lambda_2^*} \geq \frac{\partial U_{NS}}{\partial \lambda_2^*} \geq \frac{\partial U_\varnothing}{\partial \lambda_2^*} = 0.$$

The first two inequalities are strict whenever $\beta > 0$. The third inequality is strict whenever $\beta > 0$ and $D_G^N(\lambda_2^*) < R$.

Proof. Define $p(x) := xp_G + (1-x)p_B$ throughout this proof. We focus on the interior case in which $D_G^N(\lambda_2^*) < R$. If the limited-liability cap binds under the separating contract, then U_{NS} is locally independent of λ_2^*, so the inequality chain below continues to hold weakly.

Since $U_\varnothing = \beta\lambda\phi$ from (16), we have $\frac{\partial U_\varnothing}{\partial \lambda_2^*} = 0$. Furthermore, from (13)–(15), differentiating U_M, U_{NP}, and U_{NS} with respect to λ_2^* gives

$$\begin{aligned}
\frac{\partial U_{NP}}{\partial \lambda_2^*} &= \beta p(\lambda) \frac{\partial D_2^*}{\partial \lambda_2^*}, \\
\frac{\partial U_{NS}}{\partial \lambda_2^*} &= \lambda \beta p_G \frac{\partial D_2^*}{\partial \lambda_2^*}, \\
\frac{\partial U_M}{\partial \lambda_2^*} &= \beta[\lambda p_G + (1-\lambda) p(m)] \frac{p_B}{p(m)} \frac{\partial D_2^*}{\partial \lambda_2^*}.
\end{aligned}$$

Moreover, we have $\frac{\partial D_2^*}{\partial \lambda_2^*} = \frac{p_B - p_G}{p(\lambda_2^*)^2} > 0$.

We first compare U_{NP} and U_{NS}. Since $p(\lambda) - \lambda p_G = (1-\lambda)p_B > 0$, we have

$$\frac{\partial U_{NP}}{\partial \lambda_2^*} - \frac{\partial U_{NS}}{\partial \lambda_2^*} = \beta(1-\lambda)p_B \frac{\partial D_2^*}{\partial \lambda_2^*} \geq 0,$$

with strict inequality whenever $\beta > 0$. Next, compare U_M and U_{NP}. We have

$$\begin{aligned}\frac{\partial U_M}{\partial \lambda_2^*} - \frac{\partial U_{NP}}{\partial \lambda_2^*} &= \beta \left\{ [\lambda p_G + (1-\lambda)p(m)] \frac{p_B}{p(m)} - p(\lambda) \right\} \frac{\partial D_2^*}{\partial \lambda_2^*} \\ &= \beta \lambda p_G \left(\frac{p_B}{p(m)} - 1 \right) \frac{\partial D_2^*}{\partial \lambda_2^*} \geq 0,\end{aligned}$$

where the last inequality follows from $p(m) = mp_G + (1-m)p_B < p_B$ for every $m \in (0,1)$ and $\frac{\partial D_2^*}{\partial \lambda_2^*} > 0$. In particular, the inequality is strict whenever $\beta > 0$. Finally, we have

$$\frac{\partial U_{NS}}{\partial \lambda_2^*} = \lambda \beta p_G \frac{\partial D_2^*}{\partial \lambda_2^*} \geq 0,$$

with strict inequality whenever $\beta > 0$. Combining these inequalities yields the desired result.

Q.E.D.

Proof of Part (i). Fix $\lambda_2^* \in [0,1]$. We first characterize the set of monitoring abilities for which the monitoring payoff dominates all non-monitoring alternatives. Viewing $U_M(\lambda_2^*)$ as a function of m, differentiating twice with respect to m yields

$$\frac{\partial^2 U_M}{\partial m^2} = -\frac{2\lambda\beta p_G p_B \big(R - D_2^*(\lambda_2^*)\big)(p_B - p_G)^2}{\big(mp_G + (1-m)p_B\big)^3} < 0,$$

where the strict inequality follows from $\lambda \in (0,1)$, $\beta \in (0,1)$, $p_B > p_G$, and $D_2^*(\lambda_2^*) < R$ by Lemma 2. By contrast, $U_{NP}(\lambda_2^*)$, $U_{NS}(\lambda_2^*)$, and $U_\varnothing$ do not depend on m. Hence,

$$U_M(\lambda_2^*) - \max\{U_{NP}(\lambda_2^*), U_{NS}(\lambda_2^*), U_\varnothing\}$$

is concave in m. Therefore, the set of $m \in (0,1)$ such that

$$U_M(\lambda_2^*) > \max\{U_{NP}(\lambda_2^*), U_{NS}(\lambda_2^*), U_\varnothing\}$$

is an interval, possibly empty. Indeed, the payoff-dominance set is an interval by concavity.

Denote the endpoints of this interval by

$$0 \leq \underline{m}^*(\lambda_2^*) \leq \overline{m}^*(\lambda_2^*) \leq 1,$$

with $\underline{m}^*(\lambda_2^*) = \overline{m}^*(\lambda_2^*)$ when the interval is empty. Then

$$U_M(\lambda_2^*) > \max\{U_{NP}(\lambda_2^*), U_{NS}(\lambda_2^*), U_\varnothing\} \quad \Longleftrightarrow \quad m \in (\underline{m}^*(\lambda_2^*), \overline{m}^*(\lambda_2^*)).$$

It remains to verify that this payoff condition is equivalent to the existence of an equilibrium in which the green lender offers the monitoring contract $(M, D_B^M(\lambda_2^*))$. Suppose first that such an equilibrium exists. Since the green lender breaks ties in favor of a non-monitoring contract, offering the monitoring contract must yield a strictly higher payoff than every non-monitoring alternative:

$$U_M(\lambda_2^*) > \max\{U_{NP}(\lambda_2^*), U_{NS}(\lambda_2^*), U_\varnothing\}.$$

By the interval characterization above, this implies $m \in (\underline{m}^*(\lambda_2^*), \overline{m}^*(\lambda_2^*))$.

Conversely, suppose $m \in (\underline{m}^*(\lambda_2^*), \overline{m}^*(\lambda_2^*))$. Then the monitoring payoff strictly dominates all non-monitoring alternatives. Moreover, by Assumption 1, $D_B^M(\lambda_2^*) > 0$. Assign λ_2^* as brown lenders' posterior belief upon observing that the firm arrives at the $t = 2$ market. Since both firm types accept the monitoring contract constructed below, arrival at $t = 2$ is off the equilibrium path, so this posterior belief is unrestricted. If the $t = 2$ market is reached, the continuation game is played as characterized in Lemma 2.

Given this belief, the green lender compares the monitoring payoff $U_M(\lambda_2^*)$ with the best alternative among $U_{NP}(\lambda_2^*)$, $U_{NS}(\lambda_2^*)$, and $U_\varnothing$. Since

$$U_M(\lambda_2^*) > \max\{U_{NP}(\lambda_2^*), U_{NS}(\lambda_2^*), U_\varnothing\},$$

it is optimal for the green lender to offer $(M, D_B^M(\lambda_2^*))$ at $t = 1$.

Finally, both firm types accept this offer. By construction of $D_B^M(\lambda_2^*)$ in (10), the brown firm weakly prefers accepting $(M, D_B^M(\lambda_2^*))$ to waiting until $t = 2$; by the tie-breaking rule, it accepts. Furthermore, the green firm also accepts the offer $(M, D_B^M(\lambda_2^*))$ since $D_B^M(\lambda_2^*) \leq D_G^N(\lambda_2^*)$ (Lemma 3-(i)) and the monitoring covenant does not affect its project choice (Lemma 1). Thus, the proposed strategy profile and belief system constitute an equilibrium with monitoring. *Q.E.D.*

Proof of Part (ii). By Lemma A.1, we have

$$\frac{\partial U_M}{\partial \lambda_2^*} \geq \frac{\partial U_{NP}}{\partial \lambda_2^*} \geq \frac{\partial U_{NS}}{\partial \lambda_2^*} \geq \frac{\partial U_{\varnothing}}{\partial \lambda_2^*} = 0$$

for any fixed $m \in (0,1)$. Hence, for any $V \in \{U_{NP}, U_{NS}, U_{\varnothing}\}$, we have

$$\frac{\partial}{\partial \lambda_2^*}\big(U_M - V\big) \geq 0.$$

Thus, for each fixed m, increasing λ_2^* weakly increases the payoff gain from monitoring relative to each non-monitoring alternative.

Now take any $\lambda_2' < \lambda_2''$ and suppose that monitoring is optimal at λ_2' for some $m \in (0,1)$. To emphasize the dependence of the monitoring payoff on m, write it as $U_M(\lambda_2^*; m)$. Then

$$U_M(\lambda_2'; m) > \max\{U_{NP}(\lambda_2'), U_{NS}(\lambda_2'), U_{\varnothing}\}.$$

Equivalently, $U_M(\lambda_2'; m) - V(\lambda_2') > 0$ for all $V \in \{U_{NP}, U_{NS}, U_{\varnothing}\}$. Since each difference $U_M - V$ is weakly increasing in λ_2^*, it follows that

$$U_M(\lambda_2''; m) - V(\lambda_2'') > 0 \ \forall\, V \in \{U_{NP}, U_{NS}, U_{\varnothing}\}.$$

Therefore,

$$U_M(\lambda_2''; m) > \max\{U_{NP}(\lambda_2''), U_{NS}(\lambda_2''), U_{\varnothing}\},$$

implying that the monitoring-adoption set at λ_2' is contained in the monitoring-adoption set at λ_2''. Hence,

$$(\underline{m}^*(\lambda_2'), \overline{m}^*(\lambda_2')) \subseteq (\underline{m}^*(\lambda_2''), \overline{m}^*(\lambda_2'')). \qquad \textit{Q.E.D.}$$

A.5 Proof of Theorem 2

For exposition, define $p(x) = xp_G + (1-x)p_B$ for each $x \in [0,1]$. Fix the green lender's monitoring capability $m \in (\underline{m}^*, \overline{m}^*)$ and a $t = 2$ out-of-equilibrium belief $\lambda_2^* \in [0,1]$ that supports the equilibrium in which the green lender optimally offers the monitoring contract $(M, D_B^M(\lambda_2^*))$. Because brown lenders at $t = 2$ cannot observe what the green lender played at $t = 1$, any deviation by the green lender that leads the firm to enter the $t = 2$ market does not trigger any belief updating at $t = 2$.

Proof of Part (i). First, suppose that

$$U_{\varnothing} = \max\{U_{NP}(\lambda_2^*),\, U_{NS}(\lambda_2^*),\, U_{\varnothing}\},$$

so that the green lender's best deviation from offering $(M, D_B^M(\lambda_2^*))$ is to withdraw from lending. In this case, the green lender's net gain from adopting the monitoring contract is $U_M(\lambda_2^*) - U_{\varnothing}$. For every $m \in [0,1]$, this gain is strictly decreasing in β:

$$\frac{\partial}{\partial \beta}\big[U_M(\lambda_2^*) - U_{\varnothing}\big] = -\big(\lambda p_G + (1-\lambda)p(m)\big)\frac{p_B}{p(m)}\big(R - D_2^*(\lambda_2^*)\big) - \lambda\phi < 0.$$

Since $U_M(\lambda_2^*;\, m)$ is strictly concave in m and $U_{\varnothing}$ does not depend on m, an increase in β shifts $U_M(\lambda_2^*;\, m) - U_{\varnothing}$ downward pointwise in m. Consequently, the ESG-monitoring region $(\underline{m}^*, \overline{m}^*)$—i.e., the set of m for which $U_M(\lambda_2^*) \geq U_{\varnothing}$—shrinks as β increases. That is, $\frac{d\underline{m}^*}{d\beta} \geq 0$ and $\frac{d\overline{m}^*}{d\beta} \leq 0$, where the inequalities strictly hold for interior cases $\underline{m}^* > 0$ and $\overline{m}^* < 1$.

Next, suppose $U_{NP}(\lambda_2^*) = \max\{U_{NP}(\lambda_2^*), U_{NS}(\lambda_2^*), U_{\varnothing}\}$, that is, the green lender's best deviation is to offer the non-monitoring and pooling contract $(N, D_B^N(\lambda_2^*))$. Since the out-of-equilibrium belief remains unaltered at λ_2^* even after the green lender's deviation, the green lender's maximum payoff from this deviation strategy is realized by offering $(N, D_B^N(\lambda_2^*))$, which yields $U_{NP}(\lambda_2^*)$. In this case, the green lender's net gain from adopting the monitoring contract is $U_M(\lambda_2^*) - U_{NP}(\lambda_2^*)$. For every $m \in (0,1]$, this gain is strictly decreasing in β:

$$\begin{aligned}\frac{\partial}{\partial \beta}\big[U_M(\lambda_2^*) - U_{NP}(\lambda_2^*)\big] &= -\big(R - D_2^*(\lambda_2^*)\big)\left[\left(\lambda p_G \frac{p_B}{p(m)} + (1-\lambda)p_B\right) - \big(\lambda p_G + (1-\lambda)p_B\big)\right] \\ &< 0,\end{aligned}$$

where the inequality follows from $R - D_2^*(\lambda_2^*) > 0$ and $\frac{p_B}{p(m)} > 1$. Since $U_M(\lambda_2^*;\, m)$ is strictly concave in m and $U_{NP}(\lambda_2^*)$ does not depend on m, the difference $U_M(\lambda_2^*; m) - U_{NP}(\lambda_2^*)$ is strictly concave in m. Hence, the set of m for which $U_M(\lambda_2^*; m) - U_{NP}(\lambda_2^*) > 0$ is an interval. Moreover, because this payoff difference is strictly decreasing in β for every fixed $m \in (0,1]$, that interval shrinks when β increases. That is, $\frac{d\underline{m}^*}{d\beta} \geq 0$ and $\frac{d\overline{m}^*}{d\beta} \leq 0$, where the inequalities strictly hold for interior cases, i.e., when $\underline{m}^* > 0$ and $\overline{m}^* < 1$. *Q.E.D.*

Proof of Part (ii). We first consider the interior case $D_G^N(\lambda_2^*) < R$; the boundary case $D_G^N(\lambda_2^*) \geq R$ is discussed after the proof. Suppose $U_{NS}(\lambda_2^*) > \max\{U_{NP}(\lambda_2^*), U_{\varnothing}\}$, such that the lender's optimal deviation is the non-monitoring separating contract. Given that out-of-equilibrium be-

liefs remain invariant at λ_2^* upon deviation, the lender's maximum deviation payoff is uniquely determined by $U_{NS}(\lambda_2^*)$. The incentive to adopt monitoring is thus captured by the net gain $U_M(\lambda_2^*) - U_{NS}(\lambda_2^*)$. Since U_{NS} is independent of m and U_M is strictly concave in m, the net gain inherits strict concavity. This property ensures that the monitoring-adoption region, defined by the set $\{m : U_M(\lambda_2^*) - U_{NS}(\lambda_2^*) > 0\}$, is a single interval characterized by the thresholds $(\underline{m}^*, \overline{m}^*)$, provided the set is non-empty.

The derivative of the net gain with respect to β is given by

$$\frac{\partial}{\partial \beta}\big[U_M(\lambda_2^*) - U_{NS}(\lambda_2^*)\big] = \lambda\phi - \big(R - D_2^*(\lambda_2^*)\big)\left[(1-\lambda)p_B + \lambda\frac{mp_G(p_B - p_G)}{mp_G + (1-m)p_B}\right],$$

which is non-negative if and only if

$$\phi \geq \frac{1}{\lambda}\left[(1-\lambda)p_B + \frac{\lambda m p_G(p_B - p_G)}{mp_G + (1-m)p_B}\right](R - D_2^*(\lambda_2^*)).$$

Since $R \geq D_2^*(\lambda_2^*)$ and the term in the brackets is strictly increasing in m, there exists a unique cutoff $\hat{m}^* \in [0,1]$ such that the derivative is non-negative for $m \leq \hat{m}^*$ and negative otherwise. Formally, we define

$$\hat{m}^* := \inf\left\{m \in (0,1) : \phi \leq \frac{1}{\lambda}\left[(1-\lambda)p_B + \frac{\lambda m p_G(p_B - p_G)}{mp_G + (1-m)p_B}\right](R - D_2^*(\lambda_2^*))\right\}.$$

With the convention that $\hat{m}^* = 0$ when the derivative is negative for all $m \in (0,1)$ and $\hat{m}^* = 1$ when it is nonnegative for all $m \in (0,1)$, there exists a cutoff $\hat{m}^* \in [0,1]$ such that the derivative is nonnegative for $m \leq \hat{m}^*$ and negative for $m > \hat{m}^*$. Because $\hat{m}^*$ is monotonically increasing in ϕ, we can identify two thresholds $\underline{\phi}(\underline{m}^*, \overline{m}^*) < \overline{\phi}(\underline{m}^*, \overline{m}^*)$ that categorize the position of $\hat{m}^*$ relative to the adoption region. Specifically, $\hat{m}^* \leq \underline{m}^*$ if $\phi \leq \underline{\phi}$ and $\hat{m}^* \geq \overline{m}^*$ if $\phi \geq \overline{\phi}$.

We now examine the comparative statics of the monitoring region $(\underline{m}^*, \overline{m}^*)$ with respect to β. Based on the position of $\hat{m}^*$ relative to the adoption region, the impact of lender competition can be categorized into three exhaustive cases: *(i)* $\hat{m}^* \leq \underline{m}^*$, *(ii)* $\hat{m}^* \geq \overline{m}^*$, and *(iii)* $\hat{m}^* \in (\underline{m}^*, \overline{m}^*)$.

Case 1. Suppose $\hat{m}^* \leq \underline{m}^*$, which is equivalent to $\phi \leq \underline{\phi}(\underline{m}^*, \overline{m}^*)$. In this regime, the

derivative $\frac{\partial}{\partial\beta}[U_M(\lambda_2^*) - U_{NS}(\lambda_2^*)]$ is non-positive for all $m \geq \hat{m}^*$, implying

$$\frac{\partial}{\partial\beta}\big[U_M(\lambda_2^*) - U_{NS}(\lambda_2^*)\big]\big|_{m=\underline{m}^*} \leq 0 \quad \text{and} \quad \frac{\partial}{\partial\beta}\big[U_M(\lambda_2^*) - U_{NS}(\lambda_2^*)\big]\big|_{m=\overline{m}^*} < 0.$$

At the thresholds, the implicit function theorem dictates that

$$\frac{dm^*}{d\beta} = -\frac{\partial(U_M - U_{NS})/\partial\beta}{\partial(U_M - U_{NS})/\partial m}\bigg|_{m=m^*} \quad \forall\, m^* \in \{\underline{m}^*, \overline{m}^*\}.$$

By the strict concavity and the definition of the adoption region, the denominator $\frac{\partial(U_M - U_{NS})}{\partial m}$ is strictly positive at $\underline{m}^*$ and strictly negative at $\overline{m}^*$. It follows that $\frac{d\underline{m}^*}{d\beta} \geq 0$ and $\frac{d\overline{m}^*}{d\beta} < 0$; thus, the monitoring region $(\underline{m}^*, \overline{m}^*)$ shrinks as β increases.

Case 2. Suppose $\hat{m}^* \geq \overline{m}^*$, which is equivalent to $\phi \geq \overline{\phi}(\underline{m}^*, \overline{m}^*)$. In this regime, the derivative $\frac{\partial}{\partial\beta}[U_M(\lambda_2^*) - U_{NS}(\lambda_2^*)]$ is non-negative for all $m \leq \hat{m}^*$, implying

$$\frac{\partial}{\partial\beta}\big[U_M(\lambda_2^*) - U_{NS}(\lambda_2^*)\big]\big|_{m=\underline{m}^*} > 0 \quad \text{and} \quad \frac{\partial}{\partial\beta}\big[U_M(\lambda_2^*) - U_{NS}(\lambda_2^*)\big]\big|_{m=\overline{m}^*} \geq 0.$$

As in *Case 1*, the implicit function theorem dictates that the sign of $\frac{dm^*}{d\beta}$ for each $m^* \in \{\underline{m}^*, \overline{m}^*\}$ is determined by $-\frac{\partial(U_M - U_{NS})/\partial\beta}{\partial(U_M - U_{NS})/\partial m}$. Given that the denominator $\frac{\partial(U_M - U_{NS})}{\partial m}$ is strictly positive at $\underline{m}^*$ and strictly negative at $\overline{m}^*$, it follows that $\frac{d\underline{m}^*}{d\beta} < 0$ and $\frac{d\overline{m}^*}{d\beta} \geq 0$. Consequently, the monitoring region $(\underline{m}^*, \overline{m}^*)$ expands as β increases.

Case 3. Suppose $\hat{m}^* \in (\underline{m}^*, \overline{m}^*)$, which is equivalent to $\phi \in (\underline{\phi}(\underline{m}^*, \overline{m}^*), \overline{\phi}(\underline{m}^*, \overline{m}^*))$. In this intermediate regime, the derivative $\frac{\partial}{\partial\beta}[U_M(\lambda_2^*) - U_{NS}(\lambda_2^*)]$ is strictly positive for $m < \hat{m}^*$ and strictly negative for $m > \hat{m}^*$. It follows that

$$\frac{\partial}{\partial\beta}\big[U_M(\lambda_2^*) - U_{NS}(\lambda_2^*)\big]\big|_{m=\underline{m}^*} > 0 \quad \text{and} \quad \frac{\partial}{\partial\beta}\big[U_M(\lambda_2^*) - U_{NS}(\lambda_2^*)\big]\big|_{m=\overline{m}^*} < 0.$$

Applying the implicit function theorem as in the previous cases, the sign of $\frac{dm^*}{d\beta}$ for each $m^* \in \{\underline{m}^*, \overline{m}^*\}$ is determined by the ratio of the derivatives $\partial(U_M - U_{NS})/\partial\beta$ and $\partial(U_M - U_{NS})/\partial m$. At the lower threshold $\underline{m}^*$, the numerator is positive and the denominator $\frac{\partial(U_M - U_{NS})}{\partial m}$ is positive, yielding $\frac{d\underline{m}^*}{d\beta} < 0$. Conversely, at the upper threshold $\overline{m}^*$, both the numerator and the denominator are negative, which also yields $\frac{d\overline{m}^*}{d\beta} < 0$. Consequently, an increase in β induces a uniform leftward shift of the monitoring region $(\underline{m}^*, \overline{m}^*)$. *Q.E.D.*

Boundary case for $D_G^N(\lambda_2^*)$. The proof of part (ii) focuses on the interior case $D_G^N(\lambda_2^*) < R$. If

instead $D_G^N(\lambda_2^*) \geq R$, limited liability caps the separating repayment at R. The green lender's payoff from the non-monitoring separating contract is then

$$U_{NS}^{cap}(\lambda_2^*) = \lambda[p_G R + \phi - 1],$$

which is locally independent of β as long as the cap binds. Since $D_B^M(\lambda_2^*)$ is decreasing in β, $U_M(\lambda_2^*)$ decreases with a marginal increase in β. Thus, when the separating contract is the relevant non-monitoring alternative and the cap binds, a marginal increase in β shrinks the monitoring-adoption region.