Review of Economic Studies (2024) **00**, 1–33 doi:10.1093/restud/rdae048

Advance access publication 22 April 2024

# A Theory of Socially Responsible Investment

Martin Oehmke

*London School of Economics, UK and CEPR, UK*

and

Marcus M. Opp

*Stockholm School of Economics, Sweden and CEPR, UK*

*First version received November* 2020*; Editorial decision February* 2024*; Accepted April* 2024 *(Eds.)*

We characterize the conditions under which a socially responsible (SR) fund induces firms to reduce externalities, even when profit-seeking capital is in perfectly elastic supply. Such impact requires that the SR fund's mandate permits the fund to trade off financial performance against reductions in social costs—relative to the counterfactual in which the fund does not invest in a given firm. Based on such an impact mandate, we derive the social profitability index, an investment criterion that characterizes the optimal ranking of impact investments when SR capital is scarce. If firms face binding financial constraints, the optimal way to achieve impact is by enabling a scale increase for clean production. In this case, SR and profit-seeking capital are complementary: Surplus is higher when both investor types are present.

*Key words*: Socially responsible investing, Sustainable investing, ESG, Social profitability index, Fiduciary duty

*JEL codes*: G31, G23, D62, Q52

## 1. INTRODUCTION

In recent years, the question of the social responsibility of business, famously raised by Friedman (1970), has re-emerged in the context of the spectacular rise of socially responsible (SR) investment. Assets under management in SR funds have grown manifold,[1] and many investors seek to augment their asset allocation with environmental, social, and governance (ESG) scores (Pastor *et al.*, 2021; Pedersen *et al.*, 2021). While the financial performance of such investments has been explored (see, *e.g.* Hong and Kacperczyk, 2009; Chava, 2014; Barber *et al.*, 2021), it is less clear whether the presence of SR funds has any real consequences for firm behaviour. After

1. For example, the Global Sustainable Investment Alliance (2018) reports sustainable investing assets of $30.7tn at the beginning of 2018, an increase of 34% relative to two years prior.

*The editor in charge of this paper was Veronica Guerrieri.*

all, firms have access to an (approximately) abundant supply of purely profit-seeking capital willing to finance activities irrespective of the associated externalities (Welch, 2014).

Understanding the real effects of SR investments requires taking a corporate finance view. To this end, we incorporate an SR fund and the choice between clean and dirty production into a standard model of corporate financing with abundant profit-seeking financial capital, building on Holmström and Tirole (1997). The model's main results are driven by the interaction of negative production externalities (which can lead to overinvestment in socially undesirable dirty production) and financing constraints (leading to underinvestment in socially desirable clean production). Such financing frictions are not only empirically relevant for young firms (an important source of clean innovation), but they also matter for mature firms that seek to replace profitable dirty production with more expensive clean production technologies.

We find that whether an SR fund can achieve impact crucially depends on the fund's mandate. If an SR fund is only concerned about the social costs generated by firms in its portfolio (*e.g.* the portfolio carbon footprint), the fund finds it optimal to invest only in clean firms. Under such a *narrow mandate*, the SR fund does not need to sacrifice financial returns. However, the fund also has no impact, because the firms in its portfolio would have been clean anyway.

Impact requires that the SR fund accounts for social costs more broadly, including the costs that arise in the counterfactual case when the SR fund does not invest in a particular firm. Under this broader *impact mandate*, the SR fund can affect firm production decisions but must then sacrifice financial returns. Therefore, rather than following a traditional notion of fiduciary duty, an SR fund with an impact mandate must explicitly specify its desired trade-off between impact and financial performance. Given this desired trade-off, we derive the social profitability index (SPI), an investment criterion determining the optimal allocation of scarce SR capital across heterogeneous firms. Because impact is about avoided pollution as opposed to its level, investments in high-pollution industries can rank highly according to the SPI. When financial constraints are binding, impact is optimally achieved by raising a firm's financing capacity under clean production beyond the amount that purely profit-motivated investors would provide. The increase in clean production (and, hence, total surplus) is larger when both investor types are present, reflecting a complementarity between profit-seeking and SR capital.

We develop these results in a parsimonious model, initially focusing on the investment decision of a single firm. The firm is owned by an entrepreneur with limited wealth who has access to two production technologies, dirty and clean, both with constant returns to scale up to a threshold and zero returns thereafter (yielding a particularly simple form of decreasing returns to scale). Dirty production has a higher per-unit financial return, but clean production is socially preferable because it generates lower social costs. Production under either technology requires the entrepreneur to exert unobservable effort, so that not all cash flows are pledgeable to outside investors. The firm can raise funding from (up to) two types of outside investors, financial investors and an SR fund. Financial investors have abundant capital and behave competitively. As their name suggests, they care exclusively about financial returns. In addition to financial returns, the SR fund's mandate accounts for the social costs generated by firms.

We first present two benchmark cases. In the first, we consider a setting in which only financial investors are present. Because financial investors care about monetary payoffs only, the entrepreneur is more likely to be financially constrained under clean production and, conditional on being financially constrained, the maximum scale that the entrepreneur can obtain is larger under dirty production. As a result, the entrepreneur may adopt the socially inefficient dirty production technology, even if she internalizes the associated externalities to an extent that she would choose the clean technology under self-financing. The second benchmark characterizes the planner's solution. When the firm is not financially constrained, the planner can implement the first-best allocation via a Pigouvian tax. In contrast, if the firm is financially constrained, a Pigouvian tax alone does not achieve first best and must be complemented with an investment subsidy. This result reflects that regulation targeting only one source of inefficiency (externalities) without addressing the other (financing constraints) has limited effectiveness.

In practice, informational frictions and political economy constraints make it difficult for governments to implement the planner's solution (see Tirole, 2012). This motivates the main part of our analysis, which investigates whether and how an SR fund addresses these inefficiencies. Our model demonstrates that the SR fund has impact (*i.e.* changes the firm's technology choice) if and only if the fund's mandate places sufficient weight on the *reduction in social costs resulting from the fund's investment*. Under such an impact mandate, the SR fund internalizes the counterfactual social cost that would arise if the firm chose dirty production when seeking financing from financial investors only. This implies that the SR fund is willing to make a financial loss on its investment, which is necessary to achieve impact. In contrast, if the SR fund were to follow a narrow mandate that only incorporates the *level of social costs generated by firms in its portfolio*, it would simply invest in firms that are clean anyway. In this case, dirty firms remain dirty and obtain financing from financial investors, so that the equilibrium allocation is unchanged relative to the benchmark case in which only financial investors are present.

The optimal financing agreement in the presence of the SR fund with an impact mandate can be implemented by issuing two bonds: a green bond purchased by the SR fund and a regular bond purchased by financial investors. In this implementation, the green bond is issued at a premium in the primary market, consistent with evidence in Baker *et al.* (2022) and Zerbib (2019). Alternatively, the optimal financing arrangement can be implemented with two share classes. In this case, the share class controlling the technology choice is issued at a premium. In both cases, the presence of the fairly priced security allows financial investors to break even, economizing on the capital contribution the SR fund needs to make.

If the firm is financially constrained under the clean technology and the SR fund has an impact mandate, the optimal way for the SR fund to achieve impact is to facilitate an increase in the scale of clean production. In this case, there is a complementarity between financial and SR capital: total surplus (which, in our model, is determined by the total scale of clean production) is generally higher if both investor types are present. The complementarity arises because of financial investors' disregard for externalities, which allows dirty production at a larger scale than the entrepreneur could achieve under self-financing. The resulting threat of dirty production relaxes the participation constraint for the SR fund, thereby generating additional financing capacity. This enables a surplus-enhancing increase in the scale of (socially valuable) clean production, since binding financial constraints imply that clean production is below the social optimum.

While SR capital has seen substantial growth over the last few years, it is likely that such capital remains scarce relative to capital that only chases financial returns. This raises the question of how scarce SR capital is invested most efficiently. A multi-firm extension of our model yields a micro-founded investment criterion from the perspective of an SR impact fund, the *Social Profitability Index* (SPI). Similar to the standard profitability index, the SPI measures "bang for buck"—in this case, the payoff the SR fund generates under its mandate per unit of SR capital. Unlike the conventional profitability index, the SPI not only reflects the social return of the project that is being funded, but also the counterfactual social costs that a firm would have generated in the absence of investment by the SR fund. Therefore, investment criteria for SR funds should include estimates of carbon emissions that are avoided if the firm adopts a cleaner production technology. Because avoided externalities matter, it can be efficient for the SR fund to invest in firms that generate substantial social costs, as long as the SR fund's investment generates a sufficient reduction in those costs. Conversely, it is inefficient for the SR fund to invest in firms that are clean anyway because such investments would use up scarce SR capital while generating no impact.

Given that impact requires a sacrifice of financial returns, an important question is whether an SR fund with an impact mandate can attract funding. When individual investors are small and have textbook "homo oeconomicus" preferences, a classic free-rider problem arises: Even though all investors are affected by the externalities caused by firms, they rely on each other to sacrifice financial returns. As a result, the SR impact fund cannot attract resources (at least as long as coordination among individual investors is difficult, as is likely for global externalities such as climate change). In this case, our analysis rationalizes the existence of state-owned funds that invest on behalf of their citizens, thereby mitigating the free-rider problem.

However, recent empirical research (see, *e.g.* Bonnefon *et al.*, 2019; Heeb *et al.*, 2023) has documented that demand for sustainable investments is unlikely to be driven by the calculations of a self-interested "homo oeconomicus." Instead, this line of research suggests that warm-glow preferences play a major role. Warm-glow investors receive a utility boost from "having done their part" and are therefore willing to sacrifice financial returns for impact (see Riedl and Smeets, 2017). As more investors act according to such preferences, it will be easier for an SR fund with an impact mandate to attract funding from individual investors.

*Related literature.* The theoretical literature on socially responsible investing consists of two main strands: *exclusion* and *impact investing*. Following the pioneering paper by Heinkel *et al.* (2001), the literature on *exclusion* studies the effects of investor boycotts, divestment, and portfolio tilting away from dirty firms. Whether the threat of exclusion impacts a firm's production decisions depends on the cost imposed on the firm by not being able to (fully) access capital from SR investors. In most of this literature, exclusion increases the firm's cost of capital because the remaining investors demand higher risk premia to absorb the divested shares.[2] Edmans *et al.* (2022) highlight that unconditional divestment (to shrink the scale of dirty firms) can be dominated by a conditional threat of divestment (which incentivizes dirty firms to change their production technology).[3] Landier and Lovo (2020) consider a risk-neutral environment, in which divestment does not affect risk premia. Instead, the threat of divestment raises the firm's effective cost of capital because of a matching friction between firms and investors. In this setting, they analyse how to optimally achieve impact via the threat of divestment, including accounting for the emissions of suppliers.

Our model shuts down the exclusion channel by considering a risk-neutral environment with a perfectly elastic supply of profit-motivated capital. This setting captures that the impact of divestment on the cost of capital is likely to be small in competitive financial markets (see, *e.g.* Heinkel *et al.*, 2001; Welch, 2014; Broccardo *et al.*, 2022; Berk and van Binsbergen, 2021). Our paper, therefore, belongs to the second strand of the literature, which studies how *impact investors* can change firm behaviour. Like most of this literature (see, *e.g.* Gollier and Pouget, 2014; Chowdhry *et al.*, 2018; Biais and Landier, 2022), we study the ability of a large SR fund to impact firm behaviour and reduce externalities.[4] Rather than imposing costs on dirty firms via the threat of divestment (a "stick"), the SR fund in our model effectively subsidizes firms to adopt clean technologies (a "carrot"). One attractive feature of our framework is that it does not restrict attention to ad-hoc tools but instead takes an optimal contracting approach to solve for optimal engagement. When financing constraints are binding for clean firms, optimal engagement by the

2. See, *e.g.* Pastor *et al.* (2021), Pedersen *et al.* (2021), Broccardo *et al.* (2022), Zerbib (2022), and De Angelis *et al.* (2023).

3. Davies and Van Wesep (2018) point out that blanket divestment can have other unintended consequences, such as inducing firms to prioritize short-term profit at the expense of long-term value.

4. In contrast, Broccardo *et al.* (2022) study a setting in which being infinitesimal is of advantage. In particular, if the median investor in a firm has pro-social preferences and firm policies are governed by majority voting, small shareholders can achieve first best via voting.

SR fund enables the firm to expand clean production relative to what profit-motivated investors would fund, a key ingredient for the complementarity between profit-motivated investors and the SR fund.[5]

In addition to highlighting the role of financial constraints, our paper makes several broader contributions that hold independent of whether financial constraints are binding. First, we show that, when profit-seeking capital is abundant, impact requires that investors in an SR fund make financial sacrifices. Because impact does not come for free, it is essential that the objective of achieving impact and the desired trade-off between impact and financial performance are incorporated explicitly in the fund's mandate. Second, given an explicit impact mandate, our framework provides a micro-founded decision metric for the optimal allocation of scarce SR capital across firms (the SPI). Absent an explicit impact mandate, the SR fund will simply invest in firms that would have been clean regardless of the SR fund's investment. The result that investors without an explicit impact mandate may end up simply replacing profit-driven investors is robust beyond our specific modelling framework. Green and Roth (2021) confirm this prediction using an assignment matching model. While our model does not consider competition between SR funds, Green and Roth (2021) show that funds without an explicit impact mandate end up competing for investments with impact-driven funds, further reducing impact and profitability.[6]

## 2. MODEL

We study the role of socially responsible investing in a setting in which *production externalities* interact with *financing constraints*. Our analysis builds on the canonical model of corporate financing in the presence of agency frictions laid out in Holmström and Tirole (1997) and Tirole (2006). One key innovation of our framework is that it endogenizes the choice of production technologies, one of them "clean" (*i.e.* associated with low social costs), the other "dirty" (*i.e.* associated with higher social costs).

*The entrepreneur, production, and moral hazard.* We consider a risk-neutral entrepreneur who is protected by limited liability and endowed with initial liquid assets of $A$. The entrepreneur has access to two mutually exclusive production technologies $\tau \in \{C, D\}$. The technologies generate identical cash flows. Denoting firm scale by $K$, the firm generates positive cash flow of $R \cdot \min(K, \bar{K})$ with probability $p$ (conditional on effort by the entrepreneur, as discussed below) and zero otherwise. Both technologies therefore exhibit constant returns to scale up to $\bar{K}$ and no returns thereafter. This formulation captures decreasing returns to scale in the simplest possible fashion, while still maintaining the tractability of the Holmström and Tirole (1997) framework.[7]

While cash flows are identical, the technologies differ with respect to the required investment and the social costs they generate. Per unit of scale, the dirty technology $D$ generates a negative (non-pecuniary) externality $\phi_D > 0$ and requires an upfront investment of $k_D$ (also per unit). The

5. Chowdhry *et al.* (2018) show that subsidies optimally take the form of investment by socially-minded activists if firms cannot credibly commit to pursuing social goals. There is no such commitment problem in our setting. Roth (2019) compares impact investing with grants, highlighting the ability of investors to withdraw capital as an advantage of investment over grants.

6. Gupta *et al.* (2022) demonstrate that, in a dynamic setting, competition among SR investors can lead to a delay of abatement investments by polluting firms.

7. In Appendix B, we discuss standard specifications of decreasing-returns-to-scale production functions and demonstrate robustness of our results when there are $N > 2$ production technologies.

clean technology results in a lower per-unit social cost $0 \leq \phi_C < \phi_D$, but requires a higher per-unit upfront investment $k_C > k_D$.[8] The entrepreneur internalizes a fraction $\gamma^E \in [0, 1)$ of social costs, capturing potential intrinsic motives not to cause social harm. In the special case $\gamma^E = 0$, the entrepreneur is motivated purely by financial payoffs.

To generate a meaningful trade-off in the choice of technologies, we assume that the ranking of the two technologies differs depending on whether it is based on financial or social value. In the relevant region with positive returns ($K \leq \bar{K}$), the per-unit financial value of technology $\tau$ is given by $\pi_\tau := pR - k_\tau$, while the per-unit social value (or surplus) is $\upsilon_\tau := \pi_\tau - \phi_\tau$. We assume that the dirty technology creates higher financial value, $\pi_D > \pi_C$, but that clean production generates higher (and strictly positive) social value, $\upsilon_C > \max\{\upsilon_D, 0\}$. These assumptions capture the idea that there exists a technology, here technology *D*, that increases profits relative to the socially optimal choice (here technology *C*) at the expense of higher social costs.[9]

As in Holmström and Tirole (1997), the entrepreneur is subject to an agency problem. Whereas the choice of production technology is assumed to be observable (and, hence, contractible), effort is assumed to be unobservable (and, therefore, not contractible). Under each technology, the investment pays off with probability $p$ only if the entrepreneur exerts effort ($a = 1$). The payoff probability is reduced to $p - \Delta p$ if the entrepreneur shirks ($a = 0$), where $p > \Delta p > 0$. Shirking yields a per-unit non-pecuniary benefit of $B$ to the entrepreneur, for a total private benefit of $BK$. A standard result (which we will show below) is that this agency friction reduces the firm's unit pledgeable income by $\xi := p\frac{B}{\Delta p}$, the per-unit agency cost. A high value of $\xi$ can be interpreted as an indicator of poor governance, such as large private benefits or weak performance measurement. We make the following assumption on the per-unit agency cost:

**Assumption 1 (Agency Cost).** *For each technology $\tau$, the agency cost per unit of capital $\xi := p\frac{B}{\Delta p}$ satisfies*

$$\pi_\tau < \xi < pR - \frac{p}{\Delta p}\pi_\tau. \tag{1}$$

This assumption states that the moral hazard problem, as characterized by the agency cost per unit of capital $\xi$, is neither too weak nor too severe. The first inequality implies that the moral hazard problem alone ensures a finite production scale (even in the limit of constant returns to scale, *i.e.* $\bar{K} \to \infty$). The second inequality is a sufficient condition that rules out equilibrium shirking and ensures feasibility of outside financing. To streamline notation, $\pi$ and $v$ are defined assuming that the entrepreneur exerts effort (as usual, shirking is an off-equilibrium action).

*Outside investors and securities.* We assume that the entrepreneur's assets are not sufficient to fund the scale $\bar{K}$ under either technology, *i.e.* $A < \bar{K}k_D$, generating demand for outside financing. The entrepreneur can raise financing from (up to) two types of risk-neutral outside investors $i \in \{F, SR\}$, where $F$ denotes a mass of competitive *financial investors* and *SR* denotes a *socially responsible fund*. As their name suggests, financial investors care exclusively about financial returns. In contrast, the SR fund's mandate also accounts for the social costs generated by firms, $\phi_\tau K$, with intensity $\gamma^{SR}$. We normalize $\gamma^{SR} + \gamma^E \leq 1$, so that jointly the SR fund and the entrepreneur do not internalize more than 100% of social costs.

8. The assumption that $0 \leq \phi_C < \phi_D$ reflects that our analysis focuses on the mitigation of negative production externalities by an SR fund. We discuss the case of positive production externalities in Appendix B.

9. Once we allow for $N$ technologies (see Appendix B), the dirtiest technology may no longer be the profit-maximizing technology. In this case, technology $D$ corresponds to the profit-maximizing technology. The case where the profit-maximizing technology is also the cleanest technology is uninteresting for our analysis of SR investment, since even purely profit-motivated capital would ensure clean production in this case.

Our analysis distinguishes between two types of objective functions (mandates) for the SR fund.

**Definition 1 (The SR Fund's Mandate).** *A SR fund has a* ***narrow mandate*** *if it accounts for the absolute level of social costs produced by firms in its portfolio. An SR fund has an* ***impact mandate*** *if it accounts for social costs relative to a counterfactual scenario in which the SR fund does not invest in a given firm. Under both mandates, we refer to the weight given to social costs,* $\gamma^{SR}$*, as the* ***social responsibility parameter****.*

The SR fund's mandate can be linked to distinct moral criteria. The impact mandate is essentially consequentialist with respect to social costs. In contrast, the narrow mandate is closer to a notion of direct responsibility, under which the fund internalizes social costs only if it has invested in the firm that produces the social cost.[10]

Regardless of the entrepreneur's source of financing, it is without loss of generality to restrict attention to financing arrangements in which the entrepreneur issues securities that pay a total amount of $X := X^F + X^{SR}$ upon project success and 0 otherwise, where $X^F$ and $X^{SR}$ denote the payments promised to financial investors and the SR fund, respectively. Given that the firm has no resources in the low state, this security can be interpreted as debt or equity. The entrepreneur's utility can then be written as a function of the investment scale $K \le \bar{K}$,[11] the total promised repayment $X$, the effort decision $a$, upfront consumption by the entrepreneur $c$, and the technology choice $\tau \in \{C, D\}$,

$$\begin{aligned} U^E(K, X, \tau, c, a) = p(RK - X) - (A - c) - \gamma^E \phi_\tau K \\ + \mathbb{1}_{a=0}\left[BK - \Delta p(RK - X)\right]. \end{aligned} \tag{$U^E$}$$

The first two terms of this expression, $p(RK - X) - (A - c)$, represent the project's net financial payoff to the entrepreneur under high effort, where $A - c$ can be interpreted as the upfront co-investment made by the entrepreneur. The third term, $\gamma^E \phi_\tau K$, measures the social cost internalized by the entrepreneur. The final term, $BK - \Delta p(RK - X)$, captures the incremental payoff conditional on shirking ($a = 0$). Exerting effort is incentive compatible if and only if $U^E(K, X, \tau, c, 1) \ge U^E(K, X, \tau, c, 0)$, which limits the total amount $X$ that the entrepreneur can promise to repay to outside investors to

$$X \le \left(R - \frac{B}{\Delta p}\right) K. \tag{IC}$$

Per unit of scale, the entrepreneur's pledgeable income is therefore given by $pR - \xi$. The resource constraint at date 0 implies that capital expenditures, $Kk_\tau$, must equal the total investments made by the entrepreneur and outside investors,

$$Kk_\tau = A - c + I^F + I^{SR}, \tag{2}$$

where $I^F$ and $I^{SR}$ represent the amounts invested by financial investors and the SR fund, respectively.

10. For a more detailed analysis of how different moral criteria affect social preferences and outcomes, see Moisson (2020) and Dangl *et al.* (2023).

11. It is without loss of generality to restrict the equilibrium scale to $K \le \bar{K}$. Given zero returns above $\bar{K}$, it is never optimal to pick a scale $K > \bar{K}$.

## 3. BENCHMARK ANALYSIS

Our benchmark analysis consists of two parts. In Section 3.1, we show that if investors care exclusively about financial returns, the dirty technology may be chosen even if the entrepreneur has some concern for the higher social cost generated by dirty production (*i.e.* $\gamma^E > 0$). In Section 3.2, we analyse how a benevolent planner would address this inefficiency.

### 3.1. *Financing from financial investors only*

The setting in which the entrepreneur can borrow exclusively from competitive financial investors corresponds to the special case $I^{SR} = X^{SR} = 0$. The entrepreneur's objective is then to choose a financing arrangement (consisting of scale $K \in [0, \bar{K}]$, promised repayment $X^F \in [0, R]$, upfront consumption $c \geq 0$, and technology choice $\tau \in \{C, D\}$) that maximizes the entrepreneur's utility $U^E$ subject to the entrepreneur's IC constraint and financial investors' IR constraint

$$U^F := pX^F - I^F \geq 0 \tag{IR}$$

As a preliminary step, it is useful analyse the financing arrangement that maximizes scale for a given technology $\tau$ absent technological limits (*i.e.* $\bar{K} \to \infty$). Following standard arguments (see Tirole, 2006), this agreement requires the entrepreneur to co-invest all her wealth (*i.e.* $c = 0$) and that the entrepreneur's IC constraint as well as the financial investors' IR constraint bind. The binding IC constraint ensures that the firm optimally leverages its initial resources $A$, whereas the binding IR constraint is a consequence of competition among financial investors. When all outside financing is raised from financial investors, the maximum firm scale under production technology $\tau$ is then given by $\frac{A}{\xi - \pi_\tau}$. This expression shows that the entrepreneur can scale her initial assets $A$ by a factor that depends on the agency cost per unit of investment, $\xi := p\frac{B}{\Delta p}$, and the per-unit financial value under technology $\tau$, $\pi_\tau$. Because $\xi > \pi_D$ (see Assumption 1), the moral hazard problem alone ensures a finite scale of $\frac{A}{\xi - \pi_\tau}$ under either technology.

The comparison between this agency-induced scale limit $\frac{A}{\xi - \pi_\tau}$ and the technological limit $\bar{K}$ then determines whether a firm is financially constrained.

**Definition 2 (Financing Constraints).** *A firm is financially constrained for technology $\tau$ if and only if the entrepreneur's assets A are sufficiently low, $A < \bar{K}(\xi - \pi_\tau)$.*

The amount of liquid assets $A$ required to eliminate financing constraints is higher for technology $C$, which is financially less profitable ($\pi_D > \pi_C$). Moreover, conditional on being financially constrained, $A < \bar{K}(\xi - \pi_C)$, the maximum scale that the entrepreneur can obtain from financial investors is larger under dirty production. In our continuous-scale framework, financing constraints therefore manifest themselves via a reduction in scale. We note that the loss of value due to suboptimal scale is economically equivalent to the complete rationing of capital that would arise in a fixed-scale model with a binary investment decision.

The following lemma highlights that the entrepreneur's technology choice $\tau_F$ is then driven by a tradeoff between achieving larger production scale and her concern for externalities. Of course, if the entrepreneur completely disregards externalities ($\gamma^E = 0$), no trade-off arises and the entrepreneur always chooses the more profitable dirty production technology.

**Lemma 1 (Benchmark: Financial Investors Only).** *If only financial investors are present, the entrepreneur chooses technology $\tau$ that maximizes her utility*

$$\underline{U}^E = \max_\tau (\pi_\tau - \gamma^E \phi_\tau) K^F_\tau. \tag{3}$$

*where*

$$K_\tau^F := \min\left\{\frac{A}{\xi - \pi_\tau}, \bar{K}\right\}. \tag{4}$$

According to Lemma 1, if financing is raised from financial investors only, the entrepreneur chooses the technology $\tau_F$ that maximizes her payoff, which is given by the product of the per-unit payoff to the entrepreneur (financial NPV net off internalized social costs) and the maximum scale under technology $\tau$, $K_\tau^F$. Maximum scale (up to $\bar{K}$) is optimal because, under the equilibrium technology $\tau_F$, the project generates positive surplus for the entrepreneur and financial investors. It follows that the entrepreneur adopts the dirty technology whenever

$$(\pi_D - \gamma^E \phi_D) K_D^F > (\pi_C - \gamma^E \phi_C) K_C^F. \tag{5}$$

Given that the dirty technology is financially more profitable, $\pi_D > \pi_C$, and the scale is larger under the dirty technology, $K_D^F \geq K_C^F$, this condition is satisfied whenever the entrepreneur's concern for externalities $\gamma^E$ lies below a strictly positive cutoff $\bar{\gamma}^E$.

**Corollary 1 (Benchmark: Conditions for Dirty Production).** *If only financial investors are present, the entrepreneur adopts the dirty production technology if and only if* $\gamma^E < \bar{\gamma}^E := \frac{\pi_D K_D^F - \pi_C K_C^F}{\phi_D K_D^F - \phi_C K_C^F}$.

Corollary 1 implies that the entrepreneur may choose the dirty technology when financing from financial investors is available, even if she would choose the clean technology under self-financing.[12]

### 3.2. *The planner's problem*

As a second benchmark, we characterize the solution to the planner's problem. In our setting, welfare is defined as the total surplus created by production (including social costs),

$$\Omega := \min\left\{K, \bar{K}\right\} \cdot \upsilon_\tau. \tag{6}$$

First-best welfare is achieved by choosing the socially optimal technology $C$ and producing at the socially optimal scale $K = \bar{K}$ (given that $\upsilon_C > 0$).

Going forward, we focus on the interesting case in which the laissez-faire equilibrium with financial investors only (see Lemma 1) does not achieve first-best welfare. For ease of exposition, we also set $\phi_C = 0$ for the remainder of this section.

**Proposition 1 (Planner's Solution).** *The solution to the planner's problem is as follows.*

1. *If the firm is financially unconstrained under the clean technology,* $A \geq \bar{K}(\xi - \pi_C)$*, first-best welfare can be achieved by a Pigouvian tax of* $\phi_\tau$ *per unit of scale.*
2. *Otherwise, a Pigouvian tax alone cannot achieve first best, but needs to be complemented with an investment subsidy of* $\bar{K}(\xi - \pi_C) - A$.

If financial constraints do not bind, the planner's only concern is to ensure the correct technology choice. A Pigouvian tax is then sufficient to render dirty production less profitable than

12. Because the entrepreneur is constrained under self-financing, $A < k_D \bar{K}$, she prefers the clean technology if and only if $\frac{A}{k_C}(\pi_C - \gamma^E \phi_C) \geq \frac{A}{k_D}(\pi_D - \gamma^E \phi_D)$. Hence, the entrepreneur is "corrupted" by financial markets when $\gamma^E \in (\tilde{\gamma}^E, \bar{\gamma}^E)$ where $\tilde{\gamma}^E := \frac{k_C \pi_D - k_D \pi_C}{k_C \phi_D - k_D \phi_C}$.

clean production. The entrepreneur responds by adopting the clean technology and, because financial constraints do not bind, can raise sufficient funds from capital markets to achieve the socially efficient scale $\bar{K}$.

If, instead, financial constraints are binding for the clean technology, a Pigouvian tax of $\phi_\tau$ (or, equivalently, banning technology $D$) would achieve the correct technology choice, but would fail to address the underinvestment problem that arises due to financial constraints.[13] To achieve first best, the planner now needs to additionally subsidize clean production by an amount of $\bar{K}(\xi - \pi_C) - A$. This investment subsidy could be provided through an equity injection (which the firm uses to raise additional funds from financial investors) or via a subsidized loan.

For simplicity, we have ignored the potential social costs of subsidies, which could arise, for example, from the deadweight costs of taxes required to finance the subsidy. In the presence of such costs, it would be necessary to trade off the costs of the subsidy against the social benefits of increased clean production. Even in our simple setting, the information required to calibrate such a subsidy would demand expertise that is typically associated with private investors, such as understanding of agency rents, profitability, and efficient production scales.[14]

## 4. INVESTMENT BY A SOCIALLY RESPONSIBLE FUND

We now turn to our main question: whether and how an SR fund impacts the firm's investment decision (in the absence of optimal government policies). Section 4.1 develops our main results in a single-firm setting, assuming that SR capital is abundant relative to the funding needs of the firm. In Section 4.2, we consider a multi-firm setting to investigate how scarce SR capital should be allocated across firms.

### 4.1. *Single-firm analysis*

In contrast to financial investors, the SR fund's mandate incorporates not only financial payoffs $X^{SR}$ but also social costs $\phi_\tau K$. The extent to which social costs are incorporated depends on the fund's mandate $M \in \{narrow, impact\}$ (see Definition 1) and the associated social responsibility parameter $\gamma^{SR}$,

$$U^{SR}_{impact} = pX^{SR} - I^{SR} - \gamma^{SR}\phi_\tau K, \qquad (U^{SR}_{impact})$$

$$U^{SR}_{narrow} = pX^{SR} - I^{SR} - \gamma^{SR}\phi_\tau K \cdot \mathbb{1}_{I^{SR}>0}. \qquad (U^{SR}_{narrow})$$

Accordingly, an SR fund with an impact mandate internalizes social costs independent of whether the fund has invested in the company. As a result, the fund accounts for incremental social costs relative to the counterfactual scenario of not investing in the firm. In contrast, under a narrow mandate, the fund internalizes the absolute level of social costs, but only if it has invested in the firm. It is useful to note that even under an impact mandate with full internalization of social costs ($\gamma^E + \gamma^{SR} = 1$), the SR fund's objective does not coincide with the planner's objective. The reason is that the SR fund does not internalize rents that accrue to the

13. If $\phi_C > 0$, a Pigouvian tax is no longer equivalent to banning the dirty technology because, in addition to reducing the profitability of the dirty technology, the tax would also tighten financial constraints (see proof of Proposition 1).

14. These informational requirements make it difficult to implement the optimal policy, even if there is no lack of political willpower (see, *e.g.* Tirole, 2012).

entrepreneur. We view this as a realistic restriction on the SR fund's objective, consistent with plausible preferences for the fund's investors (see Section 5).[15]

**4.1.1. Optimal financing arrangement with an SR fund.** We now analyse whether and how the financing arrangement and the resultant technology choice are altered when an SR fund is present. Because the entrepreneur could still raise financing exclusively from financial investors, the utility she receives under the financing arrangement with financial investors only, $\underline{U}^E$ given in equation (6), now becomes the entrepreneur's outside option. If the SR fund remains passive, $I^{SR} = 0$, its payoff under an impact mandate is given by

$$\underline{U}^{SR}_{impact} = -\gamma^{SR}\phi_{\tau_F} K^F_{\tau_F} < 0. \tag{7}$$

This expression, which acts as the SR fund's reservation utility under an impact mandate, accounts for the social costs generated when the entrepreneur raises financing exclusively from financial investors and chooses technology $\tau_F$ and scale $K^F_{\tau_F}$ (see Lemma 1). In contrast, under a narrow mandate, the SR fund's reservation payoff is unaffected by the social costs generated if the SR fund does not invest, so that

$$\underline{U}^{SR}_{narrow} = 0. \tag{8}$$

The dependence of the SR fund's outside option on its mandate, as highlighted by equations (7) and (8), plays a key role for our results.

To generate Pareto improvements relative to their respective outside options $\underline{U}^{SR}_M$ and $\underline{U}^E$, the SR fund can engage with the entrepreneur and agree on a financing contract that specifies the technology $\tau$, scale $K$, as well as the required financial investments and cash flow rights for all investors and the entrepreneur. For ease of exposition, we give all the bargaining power to the SR fund, so that the optimal bilateral agreement maximizes the payoff to the socially responsible fund subject to the entrepreneur's outside option. In Appendix A, we show that all of our main results are unaffected by the specific assumption regarding who has the bargaining power.

**Problem 1 (Optimal Bilateral Agreements).** *Given a mandate M, the SR fund's objective is*

$$\max_{I^F, I^{SR}, X^{SR}, X^F, K, c, \tau} U^{SR}_M \tag{9}$$

*subject to the entrepreneur's IR constraint:*

$$U^E\left(K, X^{SR} + X^F, \tau, c, 1\right) \geq \underline{U}^E, \tag{IR$^E$}$$

*as well as the entrepreneur's IC constraint, the resource constraint (2), the financial investors' IR constraint, and non-negativity constraints* $K \geq 0, c \geq 0, X^{SR} \geq, X^F \geq 0$.

Constraint IR$^E$ ensures that the entrepreneur receives at least as much as she would under her outside option of raising financing exclusively from financial investors, $\underline{U}^E$. Note that the above formulation permits the possibility of compensating the entrepreneur with sufficiently high upfront consumption ($c > 0$) in return for smaller scale $K$, possibly even shutting down production completely (as suggested by Harstad, 2012).

15. If the SR fund's mandate accounted for those rents, its objective would be equivalent to the planner's problem discussed in Section 3.2.

**Proposition 2 (Technology and Scale with an SR Fund).** *The equilibrium technology choice and scale depend on the SR fund's mandate:*

1. *If the SR fund has a narrow mandate, the equilibrium technology choice and scale are identical to the benchmark equilibrium described in Lemma 1.*
2. *Let* $\hat{\upsilon}_\tau := \pi_\tau - (\gamma^E + \gamma^{SR})\phi_\tau \geq \upsilon_\tau := \pi_\tau - \phi_\tau$ *denote bilateral surplus (per unit of scale) for the SR fund and the entrepreneur. If the SR fund has an impact mandate, the equilibrium technology choice is given by*

$$\hat{\tau} = \arg\max_{\tau} \hat{\upsilon}_\tau \hat{K}_\tau, \tag{10}$$

*where the scale given technology* $\tau$ *satisfies*

$$\hat{K}_\tau = \min\left\{ \frac{A + \underline{U}^E}{\xi - \gamma^E \phi_\tau}, \bar{K} \right\}. \tag{11}$$

Proposition 2 contains the main theoretical result of the paper. First, it shows that an SR fund with a narrow mandate has no impact. The reason is that, under a narrow mandate, the SR fund can avoid "responsibility for pollution" simply by not investing. Moreover, since financial investors provide financing at competitive terms under both technologies, there is no way for the SR fund to extract financial rents. Hence, under a narrow mandate, it is strictly optimal for the SR fund not to invest in firms that generate social costs ($\phi > 0$). As a result, the firm obtains the same financing terms as in the benchmark case in which the SR fund is not present.

Because the outcome under a narrow mandate is the same as under the benchmark model without an SR fund, in what follows we focus on an SR fund with an impact mandate. Under an impact mandate, the equilibrium technology choice $\hat{\tau}$ maximizes total bilateral surplus accruing to the SR fund and the entrepreneur, which is given by the product of the per-unit surplus $\hat{\upsilon}_\tau$ and the production scale $\hat{K}_\tau$. As long as the entrepreneur is financially constrained under the financing arrangement with an SR fund, the offered scale, $\frac{A+\underline{U}^E}{\xi-\gamma^E\phi_\tau}$, ensures that the entrepreneur earns the same utility as her outside option $\underline{U}^E$. In the special case $\gamma^E = 0$, the clean scale under the optimal arrangement simply matches the scale that the entrepreneur would have obtained from financial investors under the dirty production technology, *i.e.* $\hat{K}_C = K_D^F$.[16] (In the absence of binding financial constraints, the equilibrium scale is equal to the unconstrained scale $\bar{K}$.)

While the optimal financing arrangement uniquely pins down the production side (*i.e.* technology choice and scale), there exists a continuum of co-investment arrangements between financial investors and the SR fund that solve Problem 1. This indifference arises because any increase in cash flows accruing to financial investors, $\hat{X}^F$, translates at competitive terms into higher upfront investment by financial investors, $\hat{I}^F$.

**Corollary 2 (Optimal Co-investment Arrangements).** *For any total payout to investors* $\hat{X}$, *the set of optimal co-investment arrangements between financial investors and the SR fund can be obtained by tracing out the cash-flow share accruing to the SR fund* $\lambda \in [0, 1]$ *and setting* $\hat{X}^{SR} = \lambda\hat{X}$, $\hat{X}^F = (1-\lambda)\hat{X}$, $\hat{I}^F = p\hat{X}^F$, *and* $\hat{I}^{SR} = \hat{I} - \hat{I}^F$. *It is (at least) weakly optimal to set* $\hat{c} = 0$, *so that pledged income is given by:*

$$p\hat{X} = \left(pR - \gamma^E \phi_{\hat{\tau}}\right)\hat{K}_{\hat{\tau}} - \left(A + \underline{U}^E\right). \tag{12}$$

16. For $\gamma^E > 0$, the offered scale is lower ($\hat{K}_C < K_D^F$) because the entrepreneur internalizes some of the benefits of adopting the clean technology.

If the firm is financially constrained, so that $\hat{K}_{\hat{\tau}} = \frac{A+U^E}{\xi - \gamma^E \phi_{\hat{\tau}}}$, it is strictly optimal for the entrepreneur co-invest all her wealth, which implies that $\hat{c} = 0$. Accordingly, the financing arrangement fully exhausts the entrepreneur's pledgeable income, $p\hat{X} = (pR - \xi)\hat{K}_{\hat{\tau}}$, and the only indeterminacy in the financing arrangement is the cash-flow share accruing to the SR fund and financial investors, respectively. If the firm is not financially constrained, $\hat{K}_{\hat{\tau}} = \bar{K}$, the entrepreneur could raise more financing than needed to finance scale $\bar{K}$. Because pledgeable income is no longer a constraining factor, either the income pledged to investors $p\hat{X}$ lies below the incentive-compatible maximum or the entrepreneur consumes upfront. In equation (12), we assume that the entrepreneur co-invests all her assets, so that $\hat{c} = 0$. However, in the financially unconstrained region there are also co-investment arrangements that feature positive upfront consumption and a higher repayment to investors, with identical payoffs for investors and the entrepreneur.

There are two particularly intuitive ways in which the optimal financing arrangement characterized in Proposition 2 and Corollary 2 can be implemented.

**Corollary 3 (Implementation).** *The following securities implement the optimal financing agreement under an impact mandate:*

1. ***Green bond and regular bond:*** *The entrepreneur issues two bonds with respective face values* $\hat{X}^F$ *and* $\hat{X}^{SR}$ *at prices* $\hat{I}^F$ *and* $\hat{I}^{SR}$*. The green bond contains a technology-choice covenant specifying technology* $\hat{\tau}$*.*
2. ***Dual-class share structure:*** *The entrepreneur issues voting and non-voting shares, where shares with voting rights yield an issuance amount of* $\hat{I}^{SR}$ *in return for control rights and a fraction* $\lambda$ *of dividends. The remaining proceeds* $\hat{I}^F$ *are obtained in return for non-voting shares with a claim on a fraction* $1 - \lambda$ *of dividends.*

Under both implementations, the security targeted at the SR fund is issued at a premium in the primary market (see Corollary 5), ensuring that only the SR fund has an incentive to purchase this security.[17]

**4.1.2. Impact.** To shed light on the economic mechanism behind Proposition 2, this section provides a more detailed investigation of the case in which the SR fund has impact, which we define as an induced change in the firm's production decision, through a switch in technology from $\tau_F = D$ to $\hat{\tau} = C$ and/or a change in production scale.[18] Based on Proposition 2, the following corollary summarizes the conditions for impact.

**Corollary 4 (Impact).** *Suppose* $\gamma^E < \bar{\gamma}^E$*, so that the firm chooses the dirty technology when raising financing from financial investors only. Then, the SR fund has impact if and only if it follows an impact mandate with a sufficiently high social responsibility parameter,* $\gamma^{SR} \geq \bar{\gamma}^{SR}$*, where the threshold* $\bar{\gamma}^{SR}$ *is decreasing in* $\gamma^E$*.*

Impact therefore requires that the SR fund follows an explicit impact mandate and places sufficient weight on the reduction in social costs that arises from the fund's investment ($\gamma^{SR} \geq \bar{\gamma}^{SR}$).

17. If a technology-choice covenant is not feasible (*e.g.* due to incomplete contracts), the dual-class share implementation fund dominates.

18. If investment by the SR fund does not result in a change in production technology compared to the benchmark case (*i.e.* $\hat{\tau} = \tau_F$), there is no impact. In this case, we obtain the same scale, $\hat{K}_{\hat{\tau}} = K^F_{\tau_F}$, and utility for all agents in the economy as in the benchmark case. This less interesting situation occurs if the entrepreneur adopts the clean production technology even in the absence of investment by the SR fund, or if the entrepreneur adopts the dirty technology irrespective of whether the SR fund provides funding.

If the SR fund internalizes all externalities, $\gamma^{SR} = 1$, production will always be clean because $\hat{\upsilon}_C = \upsilon_C > \upsilon_D = \hat{\upsilon}_D$ and $\hat{K}_C = K_F^D$.

*Complementarity between financial and SR capital.* If the conditions for impact are satisfied, our model features a complementarity between financial investors and the SR fund. This complementarity results not from co-investment by both types of investors but by the presence of both types of capital.

**Proposition 3 (Complementarity).** *Suppose the conditions for impact are satisfied:*

1. *If the entrepreneur's assets A are below a cutoff so that both $K_C^F$ and $K_C^{SR}$ are less than $\bar{K}$, financial and SR capital act as complements: The equilibrium clean scale with both investor types, $\hat{K}_C$, is larger than the clean scale that can be financed in an economy with only one of the two investor types,*

$$\hat{K}_C > \max\left\{K_C^F, K_C^{SR}\right\}. \tag{13}$$

2. *Otherwise, there is no complementarity and $\hat{K}_C = \bar{K} = \max\{K_C^F, K_C^{SR}\}$.*

Intuitively, if the clean technology is not subject to financial constraints, the only relevant inefficiency is the wrong technology choice. Impact is then achieved via a Coasian transfer (*e.g.* upfront consumption) to induce the entrepreneur to switch the technology. Equilibrium scale is not affected and there is no complementarity. In contrast, if the clean technology is subject to financial constraints, the presence of the SR fund leads to both a change in the production technology and an increase in scale. In this case, the equilibrium clean scale in the presence of both investor types strictly exceeds the scale that is attainable with only one investor type.

Consider first why the equilibrium clean scale with both investors exceeds the maximum clean scale that can be funded by financial investors, $\hat{K}_C > K_C^F$. If $\gamma^E < \bar{\gamma}^E$, a clean scale of $K_C^F$ is not large enough to induce clean production if only financial investors are present. As shown in Corollary 1, in this case the entrepreneur prefers dirty production at scale $K_D^F$. Therefore, to induce the entrepreneur to switch to the clean production technology, the SR fund needs to inject additional resources into the firm. Due to the moral hazard friction and the resultant underinvestment problem, this capital injection is optimally used to increase the scale of clean production above and beyond what financial investors are willing to offer, so that $\hat{K}_C > K_C^F$.

Perhaps more surprisingly, $\hat{K}_C$ also exceeds the scale that could be financed if only the SR fund were present. The reason is that financial investors' disregard for externalities allows dirty production at a larger scale than the entrepreneur could achieve under self-financing. The resulting pollution threat relaxes the participation constraint for the SR fund, through its effect on its reservation utility, $\underline{U}_{impact}^{SR} = -\gamma^{SR}\phi_D K_D^F$. This unlocks additional financing capacity, so that $\hat{K}_C > K_C^{SR}$. Because clean production is socially valuable, Proposition 3 implies that total surplus, $\upsilon_C \hat{K}_C$, is strictly higher if both financial investors and the SR fund deploy capital, relative to the case in which all capital is allocated one investor type.

Abstracting from the specific modelling details, *two basic ingredients* are necessary for the complementarity between the two investor types to arise. First, there must be underinvestment in the clean technology. Second, the SR fund needs to internalize social costs relative to the counterfactual of not investing in the firm (the impact mandate). Because the SR fund internalizes this counterfactual, the threat of dirty production (enabled by financial investors) acts as a *quasi asset* to the firm, generating additional financing capacity from the SR fund. Because of underinvestment (the first ingredient), the additional financing from the SR fund results in an increase in clean scale, which is socially valuable.

Whether this complementarity is present matters for (additional) government intervention. In particular, when the complementarity arises—binding financing constraints and an SR fund with an impact mandate—the introduction of a Pigouvian tax would strictly reduce welfare.[19] By eliminating the threat of dirty production, the key ingredient for additional clean financing capacity from the SR fund would be lost. Of course, if the planner were to choose the optimal policy in the presence of financial constraints (a Pigouvian tax accompanied with an investment subsidy) first-best could be achieved regardless of whether an SR fund is present (see Proposition 1).

*The cost of impact.* Even though the SR fund only invests if doing so increases its utility relative to the case in which it remains passive,

$$\Delta U^{SR} := \hat{v}_C \hat{K}_C - \hat{v}_D K_D^F > 0, \tag{14}$$

the SR fund does not break even in financial terms.

**Corollary 5 (Impact Requires a Financial Loss).** *Impact (a switch from $\tau_F = D$ to $\hat{\tau} = C$) requires that the SR fund makes a financial loss. That is, in any optimal financing arrangement as characterized in Proposition 2,*

$$p\hat{X}^{SR} - \hat{I}^{SR} = \left(\pi_C - \gamma^E \phi_C\right) \hat{K}_C - \left(\pi_D - \gamma^E \phi_D\right) K_D^F < 0. \tag{15}$$

*An SR fund with a narrow mandate breaks even financially but has no impact.*

Intuitively, to induce a change from dirty to clean production, the SR fund must offer an agreement consisting of scale for the clean technology and upfront consumption that would not be offered by competitive financial investors. Because financial investors just break even, the SR fund must make a financial loss. The financial loss to the SR fund reflects the reduction of bilateral surplus for financial investors and the entrepreneur relative to their preferred agreement, which yields a joint payoff of $(\pi_D - \gamma^E \phi_D) K_D^F$. If the entrepreneur is purely profit-motivated, she simply needs to be compensated for the reduction in profits arising from the switch to the clean technology, $(\pi_C - \pi_D) K_D^F$, where we use the fact that $\hat{K}_C = K_D^F$ if $\gamma^E = 0$.

Empirically, Corollary 5 predicts that SR funds with impact must have a negative alpha and, conversely, that SR funds that generate weakly positive alpha do not generate impact. Our model also predicts that the financial loss for the SR fund, $p\hat{X}^{SR} - \hat{I}^{SR}$, occurs at the time when the firm seeks financing in the primary market, consistent with evidence on the at-issue pricing of green bonds in Baker *et al.* (2022) and Zerbib (2019). However, if the SR fund were to sell its cash flow stake $\hat{X}^{SR}$ after the firm has financed the clean technology, our model does not predict a price premium for the green security in the secondary market (*i.e.* in the secondary market, the security would be fairly priced at $p\hat{X}^{SR}$).[20]

19. The result that Pigouvian taxes generally do not achieve first best in the presence of financial constraints echoes the findings of Hoffmann *et al.* (2017) and Inderst and Heider (2022). Most closely related, Inderst and Heider (2022) show that in an industry equilibrium building on Holmström and Tirole (1997), optimal regulation depends on whether financial constraints bind in aggregate.

20. In our static model, control (or a technology covenant) matters, and is therefore priced, only once, at the time of the initial investment. In a dynamic setting, control could matter multiple times (whenever investment technologies are chosen).

### 4.2. *The social profitability index*

We now derive a micro-founded investment criterion for allocation of scarce SR capital from the perspective of an SR fund with an impact mandate. To do so, we extend the single-firm analysis presented in Section 4 to a multi-firm setting with limited SR capital, denoted by $\kappa^{SR}$. We endogenize the capitalization of the SR fund in Section 5. We continue to assume that financial capital is abundant.

The economy consists of a continuum of infinitesimal firms grouped into distinct firm types.[21] Firms that belong to the same type $j$ are identical in terms of all relevant parameters of the model, whereas firms belonging to distinct types differ according to at least one dimension (with Assumption 1 satisfied for all types). Let $\mu(j)$ denote the distribution function of firm types, then the aggregate social cost in the absence of the SR fund is given by

$$\int_{\gamma_j^E<\bar{\gamma}_j^E} \phi_{D,j} K_{D,j}^F d\mu(j) + \int_{\gamma_j^E\geq\bar{\gamma}_j^E} \phi_{C,j} K_{C,j}^F d\mu(j). \tag{16}$$

The first term of this expression captures the social cost generated by firms that, in the absence of the SR fund, choose the dirty technology ($\gamma_j^E < \bar{\gamma}_j^E$), whereas the second term captures firm types run by entrepreneurs that have enough concern for social costs that they choose the clean technology even in the absence of the SR fund ($\gamma_j^E \geq \bar{\gamma}_j^E$).

Given this aggregate social cost, how should an SR fund with an impact mandate allocate its limited capital? One direct implication of Proposition 2 is that any investment in firm types with $\gamma_j^E \geq \bar{\gamma}_j^E$ cannot be optimal for the SR fund. These firms adopt the clean technology even when raising financing exclusively from competitive financial investors, and the SR fund would make a financial loss without being able to reduce social costs.

For the remaining firm types, an impact mandate with social responsibility parameter $\gamma^{SR}$ implies that the SR fund receives the following payoff from reforming a firm of type $j$:

$$\begin{aligned}\Delta U_j^{SR} = &\left(\pi_{C,j} - \gamma_j^E \phi_{C,j}\right) \hat{K}_{C,j} - \left(\pi_{D,j} - \gamma_j^E \phi_{D,j}\right) K_{D,j}^F \\ &+ \gamma^{SR} \left(\phi_{D,j} K_{D,j}^F - \phi_{C,j} \hat{K}_{C,j}\right).\end{aligned} \tag{17}$$

Here, $(\pi_{C,j} - \gamma_j^E \phi_{C,j})\hat{K}_{C,j} - (\pi_{D,j} - \gamma_j^E \phi_{D,j}) K_{D,j}^F < 0$ captures the financial loss required to induce a firm of type $j$ to adopt the clean production technology. The remaining term, $\gamma^{SR}(\phi_{D,j} K_{D,j}^F - \phi_{C,j}\hat{K}_{C,j}) > 0$, captures the mandate-implied benefit associated with the resulting reduction in social costs.

Due to limited capital $\kappa^{SR}$, the SR fund is generally not able to reform all firms. To optimally fulfil its mandate, it should therefore prioritize investments in firm types that maximize the mandate-implied payoff per dollar invested. This is achieved by ranking firms according to a variation on the classic profitability index, the *social profitability index* (SPI).[22] The SPI is the ratio of the mandate-implied incremental payoff the SR fund generates by reforming firm $j$ and

21. The assumption that firms are infinitesimally small rules out well-known difficulties that arise when ranking investment opportunities of discrete size.

22. The profitability index yields a consistent ranking of investments if there is a single resource constraint and if the scarce resource is completely exhausted (see Berk and DeMarzo, 2019). In our setting, the single resource constraint is the total amount of SR capital $\kappa^{SR}$. SR capital is fully exhausted because firms are of infinitesimal size.

the amount of capital the SR fund needs to invest to reform the firm,[23]

$$\mathrm{SPI}_j = \mathbb{1}_{\gamma_j^E < \bar{\gamma}_j^E} \frac{\Delta U_j^{SR}}{I_j^{SR}}. \tag{18}$$

**Proposition 4 (The Social Profitability Index (SPI)).** *A SR fund with an impact mandate ranks firms according to the social profitability index, $SPI_j$. There exists a threshold $\mathrm{SPI}^*(\kappa^{SR}) \geq 0$ such that an SR fund with scarce capital $\kappa^{SR}$ invests in all firms for which $\mathrm{SPI}_j \geq \mathrm{SPI}^*(\kappa^{SR})$.*

According to Proposition 4, it is optimal to invest in firms with the highest SPI until no funds are left, which happens at the cutoff $\mathrm{SPI}^*(\kappa^{SR})$. SR capital is scarce if and only if the amount $\kappa^{SR}$ is not sufficient to reform all firm types with $\mathrm{SPI}_j > 0$.

The SPI links the attractiveness of an investment for the SR fund to the underlying model parameters, thereby shedding light on the types of investments that the SR fund should prioritize.

**Proposition 5 (SPI Comparative Statics).** *As long as $\gamma_j^E < \bar{\gamma}_j^E$, the SPI is increasing in the avoided social cost, $\Delta\phi_j := \phi_{D_j} - \phi_{C_j}$, and the entrepreneur's concern for social cost, $\gamma_j^E$, and is decreasing in the financial cost associated with switching to the clean technology, $\Delta\pi_j := k_{C,j} - k_{D,j}$.*

Proposition 5 states that an SR fund with an impact mandate should prioritize firms for which avoided social cost $\Delta\phi_j$ is high. Note that, because the SPI reflects difference in social costs, it can be optimal for the SR fund to invest in firms that generate significant social costs, provided that these firms would have caused even larger social costs in the absence of engagement by the SR fund. The avoided social cost $\Delta\phi_j$ has to be traded off against the associated financial costs, as measured by the reduction in financial profits $\Delta\pi_j$.

The ranking of investments implied by SPI also has implications for the assortative matching between the social-mindedness of entrepreneurs and SR capital (see also Green and Roth, 2021).[24] As long as the SR fund is needed to generate impact, $\gamma_j^E < \bar{\gamma}_j^E$, there is a form of positive assortative matching: The SR fund optimally prioritizes firms with more socially-minded entrepreneurs because they generate larger bilateral surplus and require a smaller investment from the SR fund to become clean. However, as soon as the entrepreneur internalizes social costs to an extent that she chooses the clean technology even if financed by financial investors (*i.e.* $\gamma_j^E \geq \bar{\gamma}_j^E$), the SPI drops discontinuously to zero. It is inefficient for the SR fund to invest in these firms.

To obtain a closed-form expression for the SPI, it is useful to consider the special case $\gamma^E = 0$ and $\gamma^{SR} = 1$. Moreover, while strictly speaking it is optimal to minimize the SR fund's investment by assigning all cash-flow rights to financial investors, suppose that the SR fund requires

23. The change in the payoff to the SR fund $\Delta U_j^{SR}$ is the same across all financing agreements characterized in Proposition 2. Absent other constraints, it is therefore optimal for the SR fund to choose the minimum co-investment that implements clean production.

24. Our analysis assumes that the entrepreneur's social preference is observable (*e.g.* inferred from past decisions). In future work, it could be interesting to analyse the effects of unobservable social preferences on the optimal financing agreement, so as to ensure truth-telling.

a fraction $\lambda_j$ of a firm's cash flow rights. This minimum cash-flow stake then pins down $I_j^{SR}$.[25] Given these assumptions, the SPI is given by

$$\text{SPI}_j = \frac{\Delta\phi_j - \Delta\pi_j}{\Delta\pi_j + \lambda_j \min\left\{p_j R_j - \xi_j, k_{D,j} - \frac{A_j}{\bar{K}_j}\right\}}. \tag{19}$$

This expression reveals the intuitive tradeoff between the two main ingredients of the SPI, avoided pollution $\Delta\phi_j$ and foregone profits $\Delta\pi_j$. If financial constraints bind, then $\text{SPI}_j = \frac{\Delta\phi_j - \Delta\pi_j}{\Delta\pi_j + \lambda_j(p_j R_j - \xi_j)}$. In this case, the SPI implies that firms with tighter financial constraints should be prioritized (where, following Tirole, 2006, financial constraints are measured by lower unit-pledgeable income $p_j R_j - \xi_j$). If firms are not financially constrained, $\text{SPI}_j = \frac{\Delta\phi_j - \Delta\pi_j}{\Delta\pi_j + \lambda_j(k_{D,j} - A_j/\bar{K}_j)}$. In this case, firms with more liquid assets (higher $A$) should be prioritized. This happens because these firms can contribute more of their own resources, whereas their pollution threat is capped at $\phi_D \bar{K}$ (and therefore independent of $A$).

An interesting question in this multi-firm setting is whether increasing the amount of capital deployed by the SR fund necessarily raises welfare. As shown in Appendix C, welfare always increases when SR capital is in addition to abundant financial capital. In contrast, when aggregate capital is fixed, welfare may be maximized when the fraction of SR capital is strictly below one, essentially a multi-firm version of the complementarity result in Proposition 3.

## 5. DELEGATION TO A SOCIALLY RESPONSIBLE FUND

So far we have focused on the decisions of a large SR fund with a given capital endowment, highlighting the importance of the fund's mandate for generating impact (Corollary 4). However, because achieving impact requires a financial sacrifice (Corollary 5), the question arises whether an SR fund with an impact mandate can obtain capital in the first place.

In this section, we provide formal conditions under which an SR impact fund can attract capital from small individual investors. The key result is that establishing an SR impact fund requires overcoming a free-rider problem. When individual investors are self-interested, this requires that they are able to coordinate their actions or that some investors are particularly exposed to the externality, so that it becomes rational for them to invest in the SR impact fund. Alternatively (or in addition), warm-glow investor preferences facilitate investment in the SR impact fund.

For ease of exposition, we focus on a special case of the setting considered in Section 4.2, with a continuum of identical firms of mass 1, owned by profit-motivated entrepreneurs (*i.e.* $\gamma^E = 0$). There are many investors who only care about firm cash flows, so that, as before, financial capital is abundant. Given $\gamma^E = 0$, all firms adopt the socially inefficient dirty technology in the absence of an SR fund with an impact mandate.

Rather than taking the endowment of the SR impact fund with social responsibility parameter $\gamma^{SR}$ as given, we now assume that there are $n$ investors. We initially consider self-interested investors that only care about the externality to the extent that it affects them personally, *i.e.* the textbook "homo oeconomicus." We assume that each investor bears a fraction $\gamma^i$ of the aggregate

25. The assumption of a required cash-flow stake for the SR fund can be justified on two grounds. First, it is natural that investors in the SR fund cannot rely purely on utility derived from the non-pecuniary benefits of reducing social costs, but require a certain amount of financial payoffs alongside non-pecuniary payoffs. Second, the minimum cash flow share $\lambda_j$ can be interpreted as a reduced form representation of the control rights that are necessary to ensure that firm $j$ implements the clean technology.

externality, implying that

$$\sum_{i=1}^{n} \gamma^i = 1. \tag{20}$$

Each investor $i$ has total funds $\kappa_i$, which can be allocated to (i) an SR fund with an impact mandate and social responsibility parameter $\gamma^{SR} \geq \bar{\gamma}^{SR}$, (ii) competitive profit-maximizing funds, and (iii) a storage technology offering zero net return. Given $\gamma^{SR} \geq \bar{\gamma}^{SR}$, Corollary 4 implies that the SR fund wants to reform all firms provided that it has sufficient capital. Because $\gamma^E = 0$, the SR fund needs to offer the entrepreneur a scale of $\hat{K}_C = K_D^F$ to induce entrepreneurs to switch to the clean technology.

Let $\kappa_i^{SR} \in [0, \kappa_i]$ denote the total amount that investor $i$ contributes to the SR fund. The total endowment of the SR fund is then given by $\kappa^{SR} = \sum_{i=1}^{n} \kappa_i^{SR}$. If the SR fund reforms a fraction $\omega$ of firms, the aggregate externality is given by $[\omega\phi_C + (1-\omega)\phi_D]K_D^F$. If $\kappa^{SR} \geq \Delta\pi K_D^F$, (see equation (15) with $\gamma^E = 0$), the SR fund has sufficient capital to reform all firms, so that $\omega = 1$. Otherwise, only a fraction $\omega = \frac{\kappa^{SR}}{\Delta\pi K_D^F}$ of firms can be reformed. The fraction of reformed firms is, therefore, given by

$$\omega = \min\left\{\frac{\kappa^{SR}}{\Delta\pi K_D^F}, 1\right\}. \tag{21}$$

Given that both the storage technology and profit-maximizing funds offer zero net return in equilibrium, investor $i$'s payoff is

$$U^i = -\frac{\kappa_i^{SR}}{\kappa^{SR}}\omega\Delta\pi K_D^F - \gamma^i(\phi_D - \omega\Delta\phi)K_D^F. \tag{22}$$

The first term captures investor $i$'s share of the loss incurred by the SR fund to reform a fraction $\omega$ of firms. The second term captures the effect of the aggregate externality on investor $i$'s utility given that a fraction $\omega$ of firms is reformed.

We now determine investor $i$'s privately optimal contribution to the SR fund, $\hat{\kappa}_i^{SR}$, given a total contribution by other investors of $\kappa_{-i}^{SR}$. It follows from (21) and (22) that, if $\kappa_{-i}^{SR} \geq \Delta\pi K_D^F$, the SR fund is sufficiently capitalized to reform all firms ($\omega = 1$), regardless of whether investor $i$ contributes. In this case, it is optimal for investor $i$ not to invest in the SR fund ($\hat{\kappa}_i^{SR} = 0$) because she would participate in the SR fund's financial loss without generating any additional reduction in the aggregate externality.

In contrast, when $\omega < 1$, investor $i$'s contribution to the SR fund generates a reduction in the aggregate externality. Investor $i$ then trades off the loss from contributing to the SR fund against the additional reduction in the externality, resulting in a total payoff of

$$U^i = -\kappa_i^{SR} - \gamma^i\phi_D K_D^F + \gamma^i\frac{\Delta\phi}{\Delta\pi}\left(\kappa_i^{SR} + \kappa_{-i}^{SR}\right), \tag{23}$$

where $-\kappa_i^{SR}$ represents the financial loss from investing in the SR fund and $\gamma^i\phi_D K_D^F$ the aggregate externality absent reform. In the third term, $\gamma^i\frac{\Delta\phi}{\Delta\pi}\kappa_i^{SR}$ captures the reduction in the externality due to investor $i$'s investment, whereas $\gamma^i\frac{\Delta\phi}{\Delta\pi}\kappa_{-i}^{SR}$ captures that investor $i$ benefits from the reduction in the externality resulting from the contribution of other agents to the SR fund.

We first provide a negative benchmark result for the non-cooperative allocation of capital to the SR fund, which builds on the large literature on the private provision of public goods (see, *e.g.* Samuelson, 1954; Olson, 1971; Bergstrom *et al.*, 1986).

**Proposition 6 (Free-rider Problem).** *Suppose investors are symmetric, $\gamma^i = \frac{1}{n}$. For n sufficiently large, no investor contributes to the SR impact fund, i.e. $\kappa^{SR} = 0$.*

This classic free-rider result arises because the reduction in externalities brought about by investment in the SR fund is non-rival and non-excludable. Therefore, each individual investor only partially internalizes the resulting social benefits. If this internalization is sufficiently small, $\gamma^i = \frac{1}{n} < \frac{\Delta\pi}{\Delta\phi}$, no individual investor contributes to the SR fund. Note that this condition is more likely to be satisfied for diffuse externalities that affect a large number of individuals.

Turned on its head, Proposition 6 also characterizes settings in which individual investors will provide capital to the SR fund. One such situation is when exposure to the externality is asymmetric.

**Corollary 6 (Asymmetric Exposure).** *Suppose there is at least one agent who internalizes the externality to a sufficient degree, $\gamma^i \geq \frac{\Delta\pi}{\Delta\phi}$. Then the SR impact fund has a positive equilibrium endowment $\kappa^{SR} > 0$.*

Following a similar logic, suppose that a subset of agents $n_1 \leq n$ is able to coordinate. Even when individual investors are small, such coordination can ensure that (at least) part of the social cost is internalized via the SR impact fund.

**Corollary 7 (Coordination).** *Suppose a subset $n_1$ of agents coordinate and that $\sum_{i=1}^{n_1} \gamma^i \geq \frac{\Delta\pi}{\Delta\phi}$. Then the SR impact fund has a positive equilibrium endowment $\kappa^{SR} > 0$.*

Corollaries 6 and 7 show that when individual investors are consequentialist (*i.e.* their utility depends on aggregate impact via $\kappa^{SR}$), effective size (either via asymmetry or coordination) is a necessary condition for an SR fund with an impact mandate to emerge.

When externalities are global in nature and affect many individuals, Corollaries 6 and 7 imply that individual investors are unlikely to overcome the free-rider problem. In this case, our model rationalizes the existence of state-owned funds that invest on behalf of their citizens (like the Norwegian sovereign wealth fund). Direct investment by a sovereign fund circumvents the free-rider problem that would arise if governments paid out their resource income and left investment decisions to individual citizens.[26] In fact, under some circumstances, even self-interested "homo oeconomicus" citizens would vote for the establishment of an SR sovereign fund with an impact mandate, because doing so provides a commitment device not to free-ride on externality-reducing investments (see Broccardo *et al.*, 2022 for a related idea).[27]

However, recent empirical evidence suggests that individual investors' preferences for sustainable investing are not driven mainly by consequentialist considerations (see *e.g.* Bonnefon *et al.*, 2019; Heeb *et al.*, 2023). Instead, this line of research documents that investor behaviour

26. This idea is related to Morgan and Tumlinson (2019) who provide a model in which shareholders value public goods but are subject to free-rider problems. This free-rider problem can be overcome if a company invests on behalf of shareholders instead of paying dividends.

27. Governments could also help reduce the free-rider problem by taxing the returns of SR funds with an impact mandate at a lower rate (see Nguyen *et al.*, 2024). Advantageous tax treatment would partially offset the lower pre-tax returns generated by impact funds.

is more consistent with warm-glow preferences. Consistent with Broccardo *et al.* (2022) and Inderst and Opp (2022), we assume that this warm-glow utility component reflects "decisional utility" that affects individual decisions but does not enter welfare. We now show that, if individual investors receive an additional warm-glow utility boost from "having done their part," (see, *e.g.* Andreoni, 1990), then, even in the absence of coordination, small investors may choose to invest in the SR impact fund.

**Corollary 8 (Warm Glow).** *Suppose investors experience an additional warm-glow utility boost of $w^i \kappa_i^{SR}$ from their own investment in an SR impact fund. Then an investor contributes to the fund if and only if $w^i \geq 1 - \gamma^i \frac{\Delta\phi}{\Delta\pi}$.*

Corollary 8 states that the free-rider problem is mitigated if, in addition to the impact generated, individual investors care directly about how much they have contributed to the SR impact fund. Naturally, the effect of warm-glow preferences is particularly relevant if the investor(s) whose utility is subject to warm glow (high $w^i$) are wealthy (high $\kappa_i$). One example is the Breakthrough Energy Catalyst (BEC) fund by the Gates Foundation, which invests in climate-friendly technologies that would otherwise not be financially viable (see Financial Times, 2022).

In conjunction with Corollaries 4, 8 highlights the interplay of consequentialist and warm-glow preferences in addressing externalities via an SR fund. Whereas the SR impact fund is consequentialist when inducing firms to reduce social costs, sufficient capitalization of the fund is easier if individual investors are non-consequentialist. This finding is consistent with results obtained by Landier and Lovo (2020).

## 6. CONCLUSION

A key question in today's investment environment is whether and how socially responsible investors can achieve impact. To shed light on this question, this paper develops a parsimonious theoretical framework based on the interaction of production externalities and corporate financing constraints.

Our analysis uncovers the importance of an explicit *impact mandate* for SR funds. Given an abundant supply of profit-motivated capital, it is not enough for SR funds to simply invest in firms that generate low absolute levels of social costs. Rather, social costs must be accounted for relative to the counterfactual social costs that would arise when not investing in a given firm. The necessity of an impact mandate generates positive and normative implications. From a positive perspective, our model implies that, in their current form, most ESG funds are unlikely to have impact because they lack a broad mandate. From a normative perspective, it states that, if society wants SR funds to have impact, then their mandate needs to violate a traditional notion of fiduciary duty, because achieving impact requires sacrificing financial returns. Building on the idea of "what gets measured gets managed," our results further suggest that SR funds need to be evaluated according to broader measures, explicitly accounting for real impact rather than focusing solely on financial metrics.

From a practical investment perspective, our model yields a micro-founded investment criterion for scarce SR capital, the *social profitability index* (SPI). In line with the impact mandate, the SPI accounts for social costs that would have occurred in the absence of engagement by an SR fund. Accordingly, it can be optimal to invest in firms that generate relatively low social returns (*e.g.* a firm with significant carbon emissions), provided that the potential increase in social costs, if only financially-driven investors were to invest, is sufficiently large. This contrasts with many common ESG metrics that focus on firms' social status quo. While conceptually intuitive, the implementation of the SPI requires relatively detailed knowledge of the production process within a given industry, in order to be able to estimate avoided social costs as well as the associated financial sacrifice. Estimating the SPI using increasingly detailed data available on emissions and production technologies is a potentially fruitful avenue for future research.

To highlight the key ideas in a transparent fashion, our model abstracts from a number of realistic features that could be investigated in future work. First, the model is static. In a dynamic setting, a number of additional interesting questions would arise: How to account for dirty legacy assets? How to ensure the timely adoption of novel (and cleaner) production technologies as they arrive over time? Because the adoption of future green technologies may be hard to contract *ex ante*, a dynamic theory might yield interesting implications on the issue of control. Second, our model considers the natural benchmark case in which individual investors have the same directional social preferences (*e.g.* to lower carbon emissions). More challenging is the case in which SR investors' objectives conflict or are multi-dimensional (*e.g.* there is agreement on the goal of lowering carbon emissions, but disagreement on the social costs imposed by nuclear energy). Finally, we excluded the possibility that firms interact as part of a supply chain or as competitors (as in Dewatripont and Tirole, 2020). For example, when the adoption of the clean technology by one firm crowds out dirty production by other firms, this generates additional benefits from the perspective of the SR fund, which, in turn, would increase the fund's willingness to finance clean production. It would be interesting to study such spillovers in future work.

APPENDIX

## A. Proofs

*Proof of Lemma 1.* We present this proof as a special case of the proof of Proposition 2 given below. Set $\gamma^{SR}=0$, so that the SR fund has the same preferences as financial investors and $\hat{v}_\tau=\pi_\tau-\gamma^E\phi_\tau$. To obtain the competitive financing arrangement (*i.e.* the agreement that maximizes the entrepreneur's utility $u$ subject to the investors' participation constraint), set $u$ such that $\hat{v}_\tau K^*_\tau(u)-u=0$, using equation (A.15) in Proposition 2. ■

*Proof of Corollary 1.* The result follows directly from a comparison of the net payoff to the entrepreneur, $\underline{U}^E$, in the presence of financial investors only under the clean and dirty technology, based on equation (3) in Lemma 1. ■

*Proof of Proposition 1.* The proof of this proposition covers the general case $\phi_C\geq 0$. Therefore, the proof also applies to the special case $\phi_C=0$ considered in the benchmark section. Consider a Pigouvian tax that is equal to the marginal social cost generated by technology $\tau$ per unit of capital, $\phi_\tau$. Given this tax, the after-tax profit for the dirty technology (per unit of capital) is strictly smaller than that of the clean technology (*i.e.* $\pi_D-\phi_D<\pi_C-\phi_C$) so that the dirty technology will not be adopted by the firm. We now distinguish two cases.

Case 1: If $A\geq\bar{K}(\xi-\pi_C+\phi_C)$, the firm can finance the efficient scale $\bar{K}$ for the clean technology by raising financing from financial investors, taking in to account the associated tax $\phi_C\bar{K}$. This follows from equation (4) adjusted for "after-tax" assets $\tilde{A}=A-\bar{K}\phi_C$. This proves the first statement of Proposition 1.

Case 2: If $A<\bar{K}(\xi-\pi_C+\phi_C)$, equation (4) implies that the efficient scale cannot be achieved when raising financing from financial investors. A subsidy of (at least) $s=\bar{K}(\xi-\pi_C+\phi_C)-A>0$ is required for the entrepreneur to finance a scale of $\bar{K}$. This proves the second statement of Proposition 1. ■

*Proof of Proposition 2.* The proof of Proposition 2 proceeds separately for the two mandates $M\in\{N,I\}$ of the SR fund.

**Narrow Mandate:** If $M=N$, the objective function of the SR fund is given by

$$U^{SR}_{narrow}=pX^{SR}-I^{SR}-\gamma^{SR}\phi_\tau K\cdot\mathbb{1}_{I^{SR}>0}\leq 0. \tag{A.1}$$

The inequality follows from two ingredients. First, due to competitive pricing by financial investors, the net financial payoff for the SR fund, $pX^{SR}-I^{SR}\leq 0$ is bounded above by zero (for any technology $\tau$). Second, the externality term satisfies $-\gamma^{SR}\phi_\tau K\cdot\mathbb{1}_{I^{SR}>0}\leq 0$, with equality if $I^{SR}=0$ or $\phi_\tau=0$ (or both). The maximum total payoff of $U^{SR}_{narrow}=0$ is then achieved by setting $I^{SR}=0$. Non-investment is strictly optimal for the SR fund if $\tau_F=D$ (in which case the entrepreneur needs to be subsidized financially to switch to the clean technology) or if the clean technology has a positive social cost, $\phi_C > 0$. If $\tau_F = C$ and $\phi_C = 0$, then the SR fund may co-invest at competitive terms and would get the same total payoff (zero) as under non-investment. In either case, the equilibrium scale and production technology is the same as in the benchmark equilibrium with financial investors only.

**Impact Mandate:** The proof makes use of Lemmas A.1 to A.5. As discussed in the main text, we prove our statements for a general bargaining procedure: With probability $\eta$, the entrepreneur gets to make a take-it-or-leave-it offer, giving her the maximum payoff, denoted by $\overline{U}^E$, while the SR fund remains at its reservation utility $\underline{U}^{SR}$. With probability $1-\eta$, the SR fund gets to make a take-it-or-leave-it offer, leading to the analogous respective payoffs of $\overline{U}^{SR}_{impact}$ and $\underline{U}^E$ (these payoffs are derived in equations (A.19) and (A.20), respectively.) The analysis in the main text considers the special case $\eta = 0$. Following Hart and Moore (1998), we augment this bargaining game by allowing the SR fund to make an offer before the above bargaining game starts. Then, for a given surplus division parameter $\eta$, we obtain

**Problem 1*.** *Under an impact mandate, the SR fund's problem is*

$$\max_{I^F, I^{SR}, X^{SR}, X^F, K, c, \tau} pX^{SR} - I^{SR} - \gamma^{SR}\phi_\tau K, \tag{A.2}$$

*subject to the entrepreneur's IR constraint given bargaining power $\eta$,*

$$U^E\left(K, X^{SR} + X^F, \tau, c, 1\right) \geq (1-\eta)\,\underline{U}^E + \eta \bar{U}^E, \tag{A.3}$$

*as well as the entrepreneur's IC constraint, the resource constraint (2), the financial investors' IR constraint, the non-negativity constraints $K \geq 0, c \geq 0$, and the technological constraint $K \leq \bar{K}$.*

**Lemma A.1.** *In any solution to Problem 1*, the financial investors' IR constraint must bind,*

$$pX^F - I^F = 0. \tag{A.4}$$

*Proof.* The proof is by contradiction. Suppose there were an optimal contract for which $pX^F - I^F > 0$. Then one could increase $X^{SR}$ while lowering $X^F$ by the same amount (until equation (A.4) holds). This perturbation strictly increases the SR fund's objective function under an impact mandate (A.2) and satisfies (by construction) the financial investors' IR constraint. All other constraints are unaffected because $X = X^{SR} + X^F$ is unchanged. Hence, we have found a feasible contract that increases the utility of the SR fund, contradicting that the original contract was optimal. ■

**Lemma A.2.** *There exists an optimal financing arrangement without participation of financial investors, i.e. $I^F = X^F = 0$.*

*Proof.* Take an optimal contract $(I^F, I^{SR}, X^{SR}, X^F, K, c, \tau)$ with $I^F \neq 0$. Now consider the following perturbation of the contract (leaving $K$, $c$, and $\tau$ unchanged). Set $\tilde{X}^F$ and $\tilde{I}^F$ to 0 and set $\tilde{I}^{SR} = I^{SR} + I^F$ and $\tilde{X}^{SR} = X^{SR} + X^F$. The SR fund's objective (A.2) is unaffected since

$$p\tilde{X}^{SR} - \tilde{I}^{SR} - \gamma^{SR}\phi_\tau K = pX^{SR} - I^{SR} + \underbrace{pX^F - I^F}_{0} - \gamma^{SR}\phi_\tau K \tag{A.5}$$

$$= pX^{SR} - I^{SR} - \gamma^{SR}\phi_\tau K, \tag{A.6}$$

where the second line follows from Lemma A.1. All other constraints are unaffected since $\tilde{X}^F + \tilde{X}^{SR} = X^F + X^{SR}$ and $\tilde{I}^F + \tilde{I}^{SR} = I^F + I^{SR}$ ■

Lemma A.2 implies that we can express Problem 1* in terms of total investment $I$ and the total promised repayment to investors $X$ in order to determine the optimal consumption $c$, technology choice $\tau$, and scale $K$. To make the proof instructive, it is useful to replace $X$ and $I$ as control variables by the expected repayment to investors $\Xi$ and the expected utility provided to the entrepreneur $u$, which satisfy

$$\Xi := pX, \tag{A.7}$$

$$u := \left(\pi_\tau - \gamma^E\phi_\tau\right)K + I - pX. \tag{A.8}$$

Then, using the definition $\hat{v}_\tau := \pi_\tau - (\gamma^E + \gamma^{SR})\phi_\tau \geq v_\tau$, we can write Problem 1* as a sequential maximization problem:

**Problem 1**.**

$$\max_{\tau} \max_{u\geq\eta\bar{U}^{E}+(1-\eta)\underline{U}^{E}} \max_{K,\Xi} \hat{\upsilon}_{\tau}K-u \tag{A.9}$$

*subject to*

$$K \geq 0 \tag{A.10}$$
$$K \leq \bar{K} \tag{A.11}$$
$$\Xi \geq -(A+u)+\left(pR-\gamma^{E}\phi_{\tau}\right)K \tag{A.12}$$
$$\Xi \leq (pR-\xi)K \tag{IC}$$
$$\Xi \geq 0 \tag{LL}$$

Constraint (A.12) ensures that upfront consumption is weakly greater than zero, $c \geq 0$, using the definition of $u$ in (A.8) and the aggregate resource constraint (2). Constraint (LL) ensures that the security offers limited liability to investors by guaranteeing a weakly positive expected payoff (this constraint will be irrelevant for the determination of equilibrium scale and technology). As the problem formulation suggests, it is useful to sequentially solve the optimization in three steps to exploit that $\Xi$ only enters the linear program via the constraints (A.12), (LL), and (IC) but not the objective (A.9).

It is clear from Problem 1** that only a technology that delivers positive surplus to investors and the entrepreneur (*i.e.* $\hat{\upsilon}_{\tau}>0$) is a relevant candidate for the equilibrium technology. (Note that $\hat{\upsilon}_{C}$ is unambiguously positive, whereas $\hat{\upsilon}_{D}$ could be positive or negative.) We now consider the inner problem: For a fixed technology $\tau$ with $\hat{\upsilon}_{\tau}>0$ and a fixed utility $u\geq\eta\bar{U}^{E}+(1-\eta)\underline{U}^{E}$, we solve for the optimal vector $(K,\Xi)$ as a function of $\tau$ and $u$.

**Lemma A.3.** *For any technology $\tau$ with $\hat{\upsilon}_{\tau}>0$and $u\geq\eta\bar{U}^{E}+(1-\eta)\underline{U}^{E}$, the solution to the inner problem, i.e.* $\max_{K,\Xi}\hat{\upsilon}_{\tau}K-u$ *subject to (A.10), (A.11), (A.12), (IC), and (LL) implies a maximum scale*

$$K_{\tau}^{*}(u)=\min\left\{\frac{A+u}{\xi-\gamma^{E}\phi_{\tau}},\bar{K}\right\}>0. \tag{A.13}$$

*The minimum expected repayment to investors is*

$$\Xi_{\tau}(u)=\max\left\{\left(pR-\gamma^{E}\phi_{\tau}\right)K_{\tau}^{*}(u)-(A+u),0\right\}. \tag{A.14}$$

*Proof.* The feasible set for $(K,\Xi)$ as implied by the five constraints (A.10), (A.11), (A.12), (IC), and (LL) forms a polygon (the orange region in Figure A.1). Choosing the maximal scale $K_{\tau}^{*}(u)$ is optimal, since, for any given $\tau$ with $\hat{\upsilon}_{\tau}>0$ and any fixed $u\geq\eta\bar{U}^{E}+(1-\eta)\underline{U}^{E}$, the objective function $\hat{\upsilon}_{\tau}K-u$ is strictly increasing in $K$ for $K\leq\bar{K}$ and independent of $\Xi$. The solution (indicated by the black dot) depends on whether financial constraints are binding (left panel) or not (right panel).

In both panels, the upper bound of $\Xi$ defined by (IC) is an increasing affine function of $K$ that runs through the origin, whereas the lower bound defined by equation (A.12) is an increasing affine function of $K$ with negative intercept $-(A+u)$. These bounds intersect at a positive value of $K$, since the slope coefficient in equation (A.12), $pR-\gamma^{E}\phi_{\tau}$, is strictly greater than the slope of equation (IC), $pR-\xi$:

$$\left(pR-\gamma^{E}\phi_{\tau}\right)-(pR-\xi)=\xi-\gamma^{E}\phi_{\tau}>\pi_{\tau}-\gamma^{E}\phi_{\tau}\geq\hat{\upsilon}_{\tau}>0,$$

where the first inequality follows from Assumption 1 (*i.e.* $\xi>\pi_{\tau}$).

*Financial constraints bind (left panel):* In the left panel, entrepreneurial assets are sufficiently low, $A=A_{L}$, so that the upper bound (IC) and the lower bound (A.12) intersect at scale $\frac{A+u}{\xi-\gamma^{E}\phi_{\tau}}<\bar{K}$, which implies that $\bar{K}$ is outside of the feasible region. Financial constraints bind. Given the optimal scale $K_{\tau}^{*}(u)=\frac{A+u}{\xi-\gamma^{E}\phi_{\tau}}$, the expected repayment (A.14) is uniquely determined by the binding IC constraint (*i.e.* $\Xi_{\tau}(u)=(pR-\xi)\frac{A+u}{\xi-\gamma^{E}\phi_{\tau}}$), as indicated by the black circle in Figure A.1.

*Financial constraints do not bind (right panel):* In the right panel, assets are sufficiently high, $A=A_{H}$, so that the intercept of constraint that defines the lower bound of $\Xi$ (*i.e.* constraint (A.12), which ensures $c\geq0$), shifts down by enough so that the efficient scale, $K_{\tau}^{*}(u)=\bar{K}$ can be achieved. In this case, there is a continuum of solutions for $\Xi$ to support scale $\bar{K}$, indicated graphically by the line segment connecting the black diamond and the black circle.

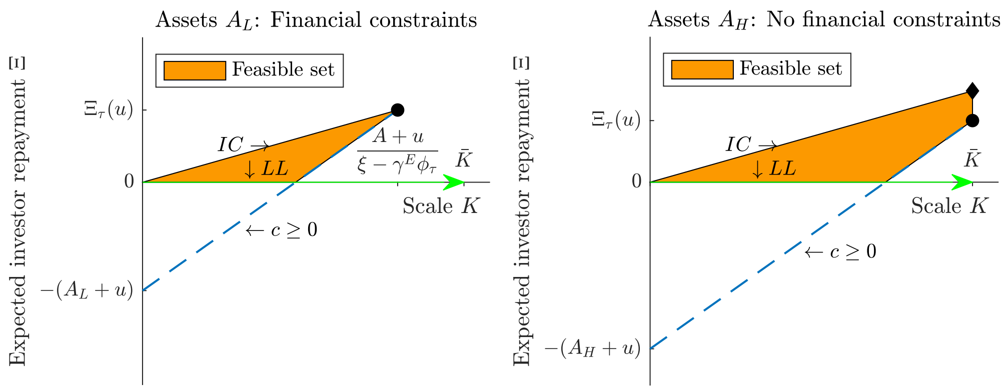


FIGURE A.1
Feasible set of the inner problem

*Notes:* The set of feasible solutions is depicted in orange and forms a polygon. The objective function is increasing in the direction of the green arrow (up to $\bar{K}$). The left panel plots the case of low entrepreneur assets $A_L$, so that financial constraints bind. The right panel plots the case of high entrepreneur assets $A_H$, so that the efficient scale $\bar{K}$ is achievable.

These solutions yield the same payoff to the SR fund, $\hat{v}_\tau \bar{K} - u$, and only differ in terms of the entrepreneur's upfront consumption $c$ and the associated income pledged to investors. By convention, we focus on the solution with the lowest upfront payment to the entrepreneur and, accordingly, the minimum expected repayment to investors (A.14), indicated by the black circle. ■

Given a solution to the inner problem, $(K_\tau^*(u), \Xi_\tau(u))$, we now turn to the optimal choice of $u$, which maximizes $\hat{v}_\tau K_\tau^*(u) - u$ subject to $u \geq \eta\bar{U}^E + (1-\eta)\underline{U}^E$.

**Lemma A.4.** *In any solution to Problem 1**, the entrepreneur obtains her reservation utility from the bargaining game* $u = \eta\bar{U}^E + (1-\eta)\underline{U}^E$.

*Proof.* It suffices to show that the objective in (A.9) is strictly decreasing in $u$. (As long as $K_\tau^*(u) = \bar{K}$, the objective $\hat{v}_\tau \bar{K} - u$ trivially decreasing in $u$). Now consider the case where $K_\tau^*(u) = \frac{A+u}{\xi-\gamma^E\phi_\tau}$. Then, using $\hat{v}_\tau = \pi_\tau - (\gamma^E + \gamma^{SR})\phi_\tau$, we obtain that:

$$\hat{v}_\tau K_\tau^*(u) - u = \frac{\hat{v}_\tau}{\xi - \gamma^E\phi_\tau} A - \frac{\xi + \gamma^{SR}\phi_\tau - \pi_\tau}{\xi - \gamma^E\phi_\tau} u \tag{A.15}$$

Since $\xi > \pi_\tau$ and $\xi > \gamma^E\phi_\tau$ (both by Assumption 1), both the numerator and the denominator of $\frac{\xi+\gamma^{SR}\phi_\tau-\pi_\tau}{\xi-\gamma^E\phi_\tau}$ are positive, so that equation (A.15) is strictly decreasing in $u$. ■

Given that the entrepreneur's utility is given by $u = \eta\bar{U}^E + (1-\eta)\underline{U}^E$, we can now define the (relevant) scale as a function of the bargaining power $\eta$, *i.e.*

$$\hat{K}_\tau(\eta) := K_\tau^*\left[\eta\bar{U}^E + (1-\eta)\underline{U}^E\right] \tag{A.16}$$

The payoff to the SR fund *for a given* $\tau$ (at the optimal scale) is then given by:

$$U_{impact}^{SR} = \hat{v}_\tau \hat{K}_\tau(\eta) - \left[\eta\bar{U}^E + (1-\eta)\underline{U}^E\right]. \tag{A.17}$$

We now turn to the final step, the optimal technology choice.

**Lemma A.5.** *The optimal technology choice is given by*

$$\hat{\tau} = \arg\max_\tau \hat{v}_\tau \hat{K}_\tau(\eta). \tag{A.18}$$

*Proof.* In the relevant case $\hat{\upsilon}_D > 0$, we need to compare payoffs (A.17) under the two technologies. The clean technology is chosen if and only if $\hat{\upsilon}_C \hat{K}_C(\eta) > \hat{\upsilon}_D \hat{K}_D(\eta)$, which simplifies to (A.18). If $\hat{\upsilon}_D \le 0$, then (A.18) trivially holds as only $\hat{\upsilon}_C > 0$. ■

Lemmas A.3 to A.5 jointly characterize the solution to Problem 1**, which solves the original Problem 1 and allows us to determine the respective maximum feasible utilities:

$$\bar{U}^E = \underline{U}^E + \hat{\upsilon}_{\hat{\tau}} \hat{K}_\tau \left(\bar{U}^E\right) - \hat{\upsilon}_{\tau_F} K^F_{\tau_F}, \tag{A.19}$$

$$\bar{U}^{SR}_{impact} = \underline{U}^{SR} + \hat{\upsilon}_{\hat{\tau}} \hat{K}_\tau \left(\underline{U}^E\right) - \hat{\upsilon}_{\tau_F} K^F_{\tau_F} \tag{A.20}$$

■

*Proof of Corollary 2.* Since the SR fund has all the bargaining power, we set $u = \underline{U}^E$. Then equation (A.14) implies that the expected repayment to investors satisfies $p\hat{X} = \Xi_{\hat{\tau}}(\underline{U}^E)$. Because any financing agreement must satisfy $X^F + X^{SR} = \hat{X}$ and $I^F + I^{SR} = \hat{I}$, we can trace out all possible agreements using the observation that financial investors break even (Lemma A.1), which implies that $pX^F - I^F = 0$ and $X^F \in [0, R]$.

Setting $\hat{c} = 0$ is strictly optimal as long as the scale $\hat{K}_{\hat{\tau}}$ is below $\bar{K}$ (as discussed in the main text). If $\hat{K}_{\hat{\tau}} = \bar{K}$, it is weakly optimal to set $\hat{c} = 0$ (and reduce the income pledged to investors below the maximum incentive-compatible value). Setting $\hat{c} = 0$, the income pledged to investors, $p\hat{X}$, satisfies (12), which follows from setting $U^E$ equal to $\underline{U}^E$. Finally, we need to verify that $p\hat{X} > 0$, which makes it feasible to set $\hat{c} = 0$. If $\hat{K}_{\hat{\tau}} = \bar{K}$ and, hence, $K^F_{\tau_F} = \bar{K}$, then the entrepreneur's outside option (3) satisfies $\underline{U}^E = (\pi_{\tau_F} - \gamma^E \phi_{\tau_F})\bar{K}$. Substituting this expression for $\underline{U}^E$ into equation (12) yields

$$p\hat{X} = k_{\tau_F}\bar{K} - A + \gamma^E \bar{K}(\phi_{\tau_F} - \phi_{\hat{\tau}}). \tag{A.21}$$

The term $k_{\tau_F}\bar{K} - A$ is strictly positive since we assume that the entrepreneur's assets satisfy $A < k_D \bar{K}$. The second term is weakly positive (strictly so whenever $\tau_F \neq \hat{\tau}$). Hence, $p\hat{X} > 0$, which means that it is indeed possible to set $\hat{c} = 0$. ■

*Proof of Corollary 3.* The result follows from the cash-flow rights described in Corollary 2 and the fact that equity and debt are identical in our setting (given that the cash flow of the firm's project is zero in the low state). ■

*Proof of Corollary 4.* The statements follow directly from the impact-mandate condition in Proposition 2 and the observation that the difference in joint surplus, $\hat{\upsilon}_D - \hat{\upsilon}_C$, is strictly decreasing in $\gamma^{SR} + \gamma^E$, with $\hat{\upsilon}_D - \hat{\upsilon}_C < 0$ for $\gamma^{SR} + \gamma^E = 1$. ■

*Proof of Proposition 3.* The proof of this proposition follows from Lemmas A.6 and A.7. ■

**Lemma A.6.** *The firm is financially constrained under the clean technology both in the benchmark equilibrium with financial investors only and in the equilibrium with the SR fund only,* $\max\{K^F_C, K^{SR}_C\} < \bar{K}$*, if and only if*

$$\frac{A}{\bar{K}} < \min\left\{\xi - \pi_C, k_D \frac{\xi - \gamma^E \phi_C}{pR - \gamma^E \phi_D}\right\}. \tag{A.22}$$

*Proof.* We first prove that $K^F_C < \bar{K}$ if and only if $\frac{A}{\bar{K}} < \xi - \pi_C$. This follows directly from the definition of $K^F_C = \min\{\frac{A}{\xi - \pi_C}, \bar{K}\}$ given in equation (4). Second, to see that $K^{SR}_C < \bar{K}$ if $\frac{A}{\bar{K}} < \min\{\xi - \pi_C, k_D \frac{\xi - \gamma^E \phi_C}{pR - \gamma^E \phi_D}\}$, note that analogous to equation (11), $K^{SR}_C$ can be expressed as

$$K^{SR}_C = \min\left\{\frac{A + \underline{U}^E_{SF}}{\xi - \gamma^E \phi_C}, \bar{K}\right\}. \tag{A.23}$$

In contrast to (11), $\underline{U}^E_{SF}$ now refers to the entrepreneur's outside option *under self-financing*, which yields scales $\frac{A}{k_D}$ and $\frac{A}{k_C}$ for the dirty and clean technology, respectively:

$$\underline{U}^E_{SF} := \max\left\{\frac{A}{k_D}(\pi_D - \gamma^E \phi_D), \frac{A}{k_C}(\pi_C - \gamma^E \phi_C)\right\}. \tag{A.24}$$

Equations (A.23) and (A.24) imply that $K_C^{SR} < \bar{K}$ if and only if

$$\frac{A}{\bar{K}} < \min\left\{k_D \frac{\xi - \gamma^E \phi_C}{pR - \gamma^E \phi_D}, k_C \frac{\xi - \gamma^E \phi_C}{pR - \gamma^E \phi_C}\right\}. \tag{A.25}$$

Therefore, if $\frac{A}{\bar{K}} < \min\{\xi - \pi_C, k_C \frac{\xi-\gamma^E\phi_C}{pR-\gamma^E\phi_C}, k_D \frac{\xi-\gamma^E\phi_C}{pR-\gamma^E\phi_D}\}$, we obtain that both $K_C^{SR} < \bar{K}$ and $K_C^F < \bar{K}$. Since $k_C \frac{\xi-\gamma^E\phi_C}{pR-\gamma^E\phi_C} > \xi - \pi_C$, this expression simplifies to (A.22).[28] This proves that $\max\{K_C^F, K_C^{SR}\} < \bar{K}$ if (A.22) holds. If (A.22) is not satisfied, $\frac{A}{\bar{K}} > \min\{\xi - \pi_C, k_D \frac{\xi-\gamma^E\phi_C}{pR-\gamma^E\phi_D}\}$, the above arguments imply that we obtain $K_C^F = \bar{K}$ or $K_C^{SR} = \bar{K}$ (or both). ■

**Lemma A.7.** *There is a strict complementarity,* $\hat{K}_C > \max\{K_C^F, K_C^{SR}\}$ *if and only if (A.22) holds. Else, there is no complementarity,* $\hat{K}_C = \max\{K_C^F, K_C^{SR}\} = \bar{K}$.

*Proof.* The proof consists of two parts. We first prove that $\hat{K}_C = \min\left\{\frac{A+\underline{U}^E}{\xi-\gamma^E\phi_C}, \bar{K}\right\} > K_C^{SR} = \min\left\{\frac{A+\underline{U}_{SF}^E}{\xi-\gamma^E\phi_C}, \bar{K}\right\}$ if and only if $K_C^{SR} < \bar{K}$ (see the condition in Lemma A.6). This follows directly from the fact that the outside option in the presence of financing from competitive financial investors exceeds the outside option under self-financing, *i.e.* $\underline{U}^E > \underline{U}_{SF}^E$.

Second, we show that $\hat{K}_C = \min\left\{\frac{A+\underline{U}^E}{\xi-\gamma^E\phi_C}, \bar{K}\right\} > K_C^F := \min\{\frac{A}{\xi-\pi_\tau}, \bar{K}\}$ if and only if $K_C^F < \bar{K}$. If $\hat{K}_C = \bar{K}$, the results follows immediately from $K_C^F < \bar{K}$. It remains to be shown that $\frac{A+\underline{U}^E}{\xi-\gamma^E\phi_C} > K_C^F$. We obtain

$$\frac{A + \underline{U}^E}{\xi - \gamma^E \phi_C} - K_C^F = \frac{A + (\pi_D - \gamma^E \phi_D) K_D^F - \left(\xi - \gamma^E \phi_C\right) K_C^F}{\xi - \gamma^E \phi_C} \tag{A.26}$$

$$\geq \frac{(\pi_D - \gamma^E \phi_D) K_D^F - \left(\pi_C - \gamma^E \phi_C\right) K_C^F}{\xi - \gamma^E \phi_C} > 0, \tag{A.27}$$

where the first equality uses the definition $\underline{U}^E = (\pi_D - \gamma^E\phi_D)K_D^F$. The weak inequality follows from $A \geq K_C^F(\xi - \pi_C)$, see (4). The final, strict inequality follows from the fact that the dirty technology was optimally chosen by the entrepreneur in the benchmark equilibrium with financial investors only, $(\pi_D - \gamma^E\phi_D)K_D^F > (\pi_C - \gamma^E\phi_C)K_C^F$, see (3).

Taken together, $\hat{K}_C > \max\{K_C^F, K_C^{SR}\}$ if and only if both $K_C^F < \bar{K}$ and $K_C^{SR} < \bar{K}$. This is satisfied if and only if Condition (A.22) holds (by Lemma A.6). ■

*Proof of Corollary 5.* Given that financial investors break even in expectation, see Lemma A.2, we can focus, without loss of generality, on the financing arrangement in which all external cash flow rights, $p\hat{X}$, are pledged to the SR fund. Case 1: The proof first considers the case $K_C^F < \bar{K}$. In this case, Lemma A.7 implies that the equilibrium scale offered by the SR fund is strictly greater than that offered by competitive financial investors, *i.e.* $\hat{K}_C > K_C^F$. Since $K_C^F$ is the largest possible clean scale that allows any investor to break even on financial terms, it must be the case that the SR fund makes a loss.

Case 2: We now consider the case $K_C^F = \bar{K}$. Recall that it is weakly optimal to set $\hat{c} = 0$, see Proof of Corollary 2. Then the financial resource constraint implies that the required investment by outside investors is:

$$\hat{I} = \bar{K} k_C - A. \tag{A.28}$$

Since the income pledged to investors $p\hat{X}$ satisfies equation (A.21), the net financial payoff can be written as

$$p\hat{X} - \hat{I} = \left(\pi_C - \gamma^E \phi_C\right) \bar{K} - (\pi_D - \gamma^E \phi_D) \bar{K} < 0, \tag{A.29}$$

28. Notice that $k_C \frac{\xi-\gamma^E\phi_C}{pR-\gamma^E\phi_C} - (\xi - \pi_C) = (\pi_C - \gamma^E\phi_C)\frac{pR-\xi}{pR-\gamma^E\phi_C} > 0$.

where the inequality follows from the fact that the entrepreneur prefers the dirty technology under the respective benchmark agreements offered by financial investors (with respective scales $K_D^F = \bar{K}$ and $K_C^F = \bar{K}$). ■

*Proof of Proposition 4*. Ranking investments based on the social profitability index is optimal under the same conditions as for the standard profitability index ranking (see, *e.g.* Berk and DeMarzo, 2019). First, there must be a single resource constraint, which is satisfied given that the SR fund faces a single capital constraint $\kappa$ in our setting. Second, the resource must be completely exhausted, which is satisfied because firms are of infinitesimal size in our setting. ■

*Proof of Proposition 5*. The social profitability index is defined as

$$\text{SPI:} = \frac{\Delta U^{SR}}{I^{SR}}. \tag{A.30}$$

The minimum investment that is sufficient to induce a change in production technology is given by pledging all cash flow rights to financial investors. Using the same steps as in the derivation of (A.29), we obtain that this minimum investment is given by

$$I_{\text{min}}^{SR} = \left(\pi_D - \gamma^E \phi_D\right) K_D^F - \left(\pi_C - \gamma^E \phi_C\right) \hat{K}_C. \tag{A.31}$$

Given the definition of $\Delta U^{SR}$, see equation (14), the corresponding (maximum) SPI is given by

$$\begin{aligned} \text{SPI}_{\text{max}} &= \frac{\hat{\upsilon}_C \hat{K}_C - \hat{\upsilon}_D K_D^F}{\left(\pi_D - \gamma^E \phi_D\right) K_D^F - \left(\pi_C - \gamma^E \phi_C\right) \hat{K}_C} \\ &= \gamma^{SR} \frac{\Delta\phi + \phi_C \left(1 - \frac{\hat{K}_C}{K_D^F}\right)}{\Delta\pi - \gamma^E \Delta\phi + \left(\pi_C - \gamma^E \phi_C\right) \left(1 - \frac{\hat{K}_C}{K_D^F}\right)} - 1. \end{aligned}$$

The ratio $\frac{\hat{K}_C}{K_D^F}$ depends on entrepreneurial assets $A$. It is easily verified that in all cases (constrained and unconstrained) $\text{SPI}_{\text{max}}$ is increasing in $\gamma^E$ and $\Delta\phi$ and decreasing in $\Delta\pi$ given that $\xi - \pi_\tau > 0$ (see Assumption 1).

Case 1: If assets $A$ are sufficiently high, so that $\hat{K}_C = K_D^F = \bar{K}$, we obtain:

$$\text{SPI}_{\text{max}} = \frac{\gamma^{SR}}{\frac{\Delta\pi}{\Delta\phi} - \gamma^E} - 1. \tag{A.32}$$

Case 2: If assets $A$ are intermediate, so that $K_D^F = \bar{K}$ and $\hat{K}_C = \frac{A + \bar{K}(\pi_D - \gamma^E \phi_D)}{\xi - \gamma^E \phi_C}$, we obtain:

$$\text{SPI}_{\text{max}} = \frac{\gamma^{SR}\left[\Delta\phi\xi + \phi_C\left(\xi - \pi_C - \Delta\pi - \frac{A}{\bar{K}}\right)\right]}{\Delta\pi\xi + \pi_C\left(\xi - \pi_C - \Delta\pi - \frac{A}{\bar{K}}\right) - \gamma^E\left[\phi_C\left(\xi - \pi_C - \frac{A}{\bar{K}}\right) + \Delta\phi\left(\xi - \pi_C\right)\right]} - 1. \tag{A.33}$$

To see that $\text{SPI}_{\text{max}}$ is increasing in $\gamma^E$ note that $\xi - \pi_C - \frac{A}{\bar{K}} > 0$ since $\bar{K} > K_C^F = \frac{A}{\xi - \pi_C}$. As a result, the denominator is strictly decreasing in $\gamma^E$.

Case 3: If assets $A$ are sufficiently low, so that $\hat{K}_C \le K_D^F < \bar{K}$, then

$$\text{SPI}_{\text{max}} = \frac{\gamma^{SR}}{\frac{\Delta\pi}{\Delta\phi} - \frac{\gamma^E}{\xi}\left[\xi - \pi_C + \frac{\Delta\pi}{\Delta\phi}\phi_C\right]} - 1. \tag{A.34}$$

■

*Proof of Proposition 6*. The investor's objective (23) is affine in $\kappa_i^{SR}$ with coefficient $\gamma^i \frac{\Delta\phi}{\Delta\pi} - 1$. If $\gamma^i = 1/n$, this coefficient is negative for sufficiently large $n$, so that the privately optimal contribution to the SR fund is $\kappa_i^{SR} = 0$ for all agents. ■

*Proof of Corollary 6*. The result follows immediately from the proof of Proposition 6. In particular, the SR has a positive endowment if $\gamma^i \frac{\Delta\phi}{\Delta\pi} - 1 > 0$ for at least one agent. ■

*Proof of Corollary 7.* See the proof of Corollary 6 and replace $\gamma^i$ with $\sum_{i=1}^{n_1} \gamma^i$. ■

*Proof of Corollary 8.* If there is an additional warm-glow benefit, the investor's objective is affine in $\kappa_i^{SR}$ with coefficient $w^i + \gamma^i \frac{\Delta\phi}{\Delta\pi} - 1$, which is positive if $w^i$ is sufficiently large. ■

## B. Production technology specification

### B.1. Many production technologies and social goods

In this section, we describe how Proposition 2 generalizes to more than two technologies and social goods. Suppose that the entrepreneur has access to $N \geq 2$ production technologies characterized by technology-specific cash flow, cost, and moral hazard parameters $R_\tau$, $\bar{K}_\tau$, $k_\tau$, $p_\tau$, $\Delta p_\tau$, and $B_\tau$. The differences in parameters could reflect features such as increased willingness to pay for goods produced by firms with clean production technologies, implying $R_C > R_D$ (for models with this feature, see Aghion *et al.*, 2023; Albuquerque *et al.*, 2019). Moreover, we allow for the technology-specific social cost parameter $\phi_\tau$ to be negative, in which case the technology generates a positive externality (a social good).

In analogy to the baseline model, we can then define, for each technology $\tau \in \{1, \ldots, N\}$, the financial value $\pi_\tau$, the agency rent $\xi_\tau$, and the maximum scale available from financial investors $K_\tau^F$, maintaining the assumption that $\xi_\tau > \pi_\tau$ for all $\tau$. A straightforward extension of Lemma 1 then implies that, in the absence of investment by the SR fund, the entrepreneur chooses technology

$$\tau_F = \arg\max_{\tau} \left(\pi_\tau - \gamma^E \phi_\tau\right) \min\left\{\frac{A}{\xi_\tau - \pi_\tau}, \bar{K}_\tau\right\}. \tag{B.1}$$

Equation (B.1) clarifies the entrepreneur's relevant outside option with $N$ technologies: Any production technology dirtier than $\tau_F$ is not a credible threat. Given the credible threat $\tau_F$, the induced technology choice in the presence of the SR fund $\hat{\tau}$ and the associated capital stock $\hat{K}$ are given by

$$\hat{\tau} = \arg\max_{\tau} \hat{v}_\tau \min\left\{\frac{A + \underline{U}^E}{\xi_\tau - \gamma^E \phi_\tau}, \bar{K}_\tau\right\}, \tag{B.2}$$

$$\hat{K} = \begin{cases} \min\{\frac{A+\underline{U}^E}{\xi_\tau - \gamma^E \phi_\tau}, \bar{K}_\tau\} & \text{if } \hat{v}_{\hat{\tau}} > 0 \\ 0 & \text{if } \hat{v}_{\hat{\tau}} \leq 0 \end{cases}, \tag{B.3}$$

which mirrors Proposition 2.

Whereas the formal expressions are unaffected by whether the externality is negative or positive, there is one important difference. If externalities are negative, an explicit impact mandate is necessary to ensure that the SR fund can affect the firm's choice of production technology. An impact mandate reduces the outside option for the SR fund (see equation (7)), thereby unlocking the required additional financing capacity. In contrast, if the externalities under technology $D$ are positive, $\phi_D < 0$, the outside option for the SR fund is higher under an impact mandate than under a narrow mandate (the outside option is positive under an impact mandate, whereas it is zero under a narrow mandate). Therefore, in the presence of positive externalities, impact is possible and, in fact, more likely to occur under a narrow mandate, revealing an interesting asymmetry between preventing social costs and encouraging social goods.

The more general technology specification additionally provides some insights about cases that we previously excluded. First, the entrepreneur's relevant outside option with $N$ technologies is the technology that maximizes bilateral surplus for financial investors and the entrepreneur. Any technology that does not maximize this bilateral surplus is not a credible threat. Note that for some industries the cleanest technology may also be profit-maximizing (*e.g.* because of demand from SR consumers). In this case, there is no trade-off between doing good and doing well and, hence, socially responsible investors play no role. Second, it is also possible that, for some industries, any feasible technology $\tau$ yields negative social surplus (*i.e.* $v_\tau < 0$ for all $\tau$). In this case, the socially optimal scale is zero and the entrepreneur is optimally rewarded with a transfer to shut down production.

### B.2. Decreasing returns to scale

In this section, we consider the case in which the two production technologies $\tau \in \{C, D\}$ exhibit standard decreasing returns to scale. In particular, suppose that the *marginal* financial value $\pi_\tau(K)$ is strictly decreasing in $K$. Then the first-best scale $K_C^{FB}$ under the (socially efficient) clean technology is characterized by the first-order condition

$$\pi_C\left(K_C^{FB}\right) = \phi_C. \tag{B.4}$$

Note that the first-best scale $K_C^{FB}$ corresponds to $\bar{K}$ in our baseline model.

Now consider the scenario in which technology $D$ is chosen in the absence of the SR fund, with an associated scale of $K_D^F$. Moreover, for ease of exposition, focus on the case $\gamma^E + \gamma^{SR} = 1$, so that the SR fund has incentives to implement the first-best scale. The optimal financing agreement that the SR fund offers to induce the entrepreneur to switch to the clean technology then comprises three cases.

1. If the financing constraints generated by the agency problem are severe, *i.e.* assets are below some cutoff $A < \tilde{A}$, the optimal agreement offered by the SR fund rewards the entrepreneur exclusively through an increase in scale (rather than upfront consumption). The resulting clean scale, $\hat{K}_C$, is smaller than first-best scale (*i.e.* $\hat{K}_C < K_C^{FB}$). In our baseline model, this case corresponds to $\hat{K}_C = \frac{A+\underline{U}^E}{\xi-\gamma^E\phi_\tau} < \bar{K}$
2. If the financing constraints generated by the agency problem are intermediate, *i.e.* $\tilde{A} < A < A^{FB}$, the optimal agreement specifies the first-best scale, $\hat{K}_C = K_C^{FB}$. In this case, it is efficient to increase clean scale up to the first-best level but no further, since scale above and beyond $K_C^{FB}$ would reduce joint surplus. Inducing the entrepreneur to switch technologies solely through an increase in scale would require a production scale exceeding the first-best level $K_C^{FB}$. It is therefore optimal to partially compensate the entrepreneur through a reduction in repayment (or an upfront consumption transfer, as in Corollary 2). In our baseline model, this refers to the case where $K_C^F < \bar{K}$ but $\hat{K}_C = \bar{K}$.
3. If financing constraints do not bind, $A > A^{FB}$, we essentially obtain a Coasian solution (*e.g.* a downstream fishery might pay an upstream factory to reduce pollution, as in Coase, 1960).[29] In this case, we distinguish between two sub-cases.
   - (a) If $\phi_C = 0$, financial investors would provide the first-best scale of the clean technology, *i.e.* $K_C^F = K_C^{FB}$. In our baseline model, this case corresponds $K_C^F = \hat{K}_C = \bar{K}$. The SR fund simply needs to provide a subsidy to induce a switch in the production technology, as in Corollary 2.
   - (b) If $\phi_C > 0$, financial investors would provide funding above and beyond the first-best scale of the clean production technology, *i.e.* $K_C^F > K_C^{FB}$. In our baseline model, this case cannot occur. The optimal financing agreement with the SR fund then ensures that the clean production technology is run at the first-best scale, $\hat{K}_C = K_C^{FB} < K_C^F$ via a lower repayment and/or upfront consumption, as in Corollary 2.

These results show that the insights from the reduced-form CRS specification of the baseline model extend to a standard specification with decreasing returns to scale.

## C. The composition of capital

In this section, we investigate how the composition of investor capital (and not simply its aggregate amount) matters for total surplus, motivated by the recent growth in ESG investing.

Increasing the amount of capital deployed by the SR fund does not mechanically translate into higher welfare. The reason is that the ranking of investments implied by the SPI does not necessarily coincide with the planner's ranking, even if $\gamma_j^E + \gamma^{SR} = 1$. Even though the SR fund's pay-off from reforming a firm, $\Delta U_j^{SR}$, coincides with the associated welfare change, $\upsilon_C \hat{K}_C - \upsilon_D K_D^F$, the planner would increase scale up to the efficient scale $\bar{K}$, which is strictly larger than the scale funded by the SR fund if the firm is financially constrained post reform, $\hat{K}_{C,j} < \bar{K}$. This wedge arises because the SR fund does not internalize rents that accrue to the entrepreneur. Therefore, the allocation implemented by the SR fund coincides with the planner's solution only if the firm is financially unconstrained post reform, $\hat{K}_C = \bar{K}$. Binding financial constraints introduce a wedge between the planner's solution and the allocation implemented by the SR fund. (A corollary of this statement is that, if all firms are financially unconstrained, the planner's ranking of investments coincides with the ranking implied by the SPI.)

29. Note that, in cases 2 and 3, the agreement needs to explicitly limit the amount of firm investment (and not simply specify the technology). Otherwise, the entrepreneur would find it privately optimal to convert upfront consumption into additional firm investment.

The change in total surplus relative to the case without the SR fund, $\Delta\Omega$, results from the set of reformed firms (*i.e.* firms with $\gamma_j^E < \bar{\gamma}_j^E$ and $\text{SPI}_j \geq \text{SPI}^*(\kappa^{SR})$). We can therefore write the change in total surplus as

$$\Delta\Omega = \int_{j:\gamma_j^E < \bar{\gamma}_j^E \ \& \ \text{SPI}_j \geq \text{SPI}^*(\kappa^{SR})} \left( \upsilon_{C,j} \hat{K}_{C,j} - \upsilon_{D,j} K_{D,j}^F \right) d\mu(j). \tag{C.5}$$

We then immediately obtain

**Proposition C.1 (Composition of Capital 1).** *Assume that financial capital is fixed and abundant. Aggregate welfare is increasing in the amount of SR capital $\kappa^{SR}$.*

*Proof of Proposition C.1.* Since financial capital is abundant relative to the financing needs of firms, an increase in $\kappa$ only operates through the set of reformed firms, *i.e.*

$$\Delta\Omega = \int_{j:\gamma_j^E < \bar{\gamma}_j^E \ \& \ \text{SPI}_j \geq \text{SPI}^*(\kappa)} \left( \upsilon_{C,j} \hat{K}_{C,j} - \upsilon_{D,j} K_{D,j}^F \right) d\mu(j). \tag{C.6}$$

An increase in $\kappa$ only affects the threshold $\text{SPI}^*(\kappa)$. Since $\upsilon_{\tau,j} = \hat{\upsilon}_{\tau,j} - (1 - \gamma_j^E - \gamma^{SR})\phi_{\tau,j}$, we obtain

$$\upsilon_{C,j} \hat{K}_{C,j} - \upsilon_{D,j} K_{D,j}^F \geq \hat{\upsilon}_{C,j} \hat{K}_{C,j} - \hat{\upsilon}_{D,j} K_{D,j}^F > 0, \tag{C.7}$$

where the first inequality is weak only in the case when the SR fund and the entrepreneur jointly internalize all externalities, $\gamma_j^E + \gamma^{SR} = 1$, and the second inequality follows from optimality of the SR fund's technology choice, see Proposition 2. Because the integrand in (C.6) is strictly positive, additional capital leads to strictly higher welfare. ■

Intuitively, increasing the level of SR capital has strictly positive welfare effects if it reduces externalities (that would have been financed by financial investors) and increases the scale of clean production for the set of reformed, financially constrained firms. Because financial capital is abundant, this positive effect is not driven by the (trivial) reason that there is more capital in the economy.

We now fix the total amount of capital in the economy and investigate the conjecture that increasing the *fraction* of SR capital, denoted by $x^{SR}$, is always welfare enhancing. Perhaps surprisingly, even if all externalities are accounted for (*i.e.* $\gamma^{SR} + \gamma^E = 1$) this conjecture is not generally true.

**Proposition C.2 (Composition of Capital 2).** *Assume that aggregate capital is fixed and abundant. If financial constraints are absent, $K_{C,j}^{SR} = K_{C,j}^F = \bar{K}_j$ for all firm types j, welfare is maximized for $x^{SR} = 1$. Otherwise, it may be optimal from a welfare perspective that a strictly positive fraction of capital is deployed by financial investors, $x^{SR} < 1$.*

*Proof of Proposition C.2.* The proof consists of two parts. We first consider the case in which financial constraints are absent, $K_{C,j}^{SR} = K_{C,j}^F = \bar{K}_j$. In this case, the SR fund will ensure that all firms in the economy choose the clean technology (since $\gamma^{SR} + \gamma^E = 1$ implies that $\hat{\upsilon}_{C,j} > \hat{\upsilon}_{D,j}$) and operate at the socially optimal scale $\bar{K}_j$. Therefore, first-best welfare is achieved for $x^{SR} = 1$ (see equation (6)). Moreover, as long as some firms would choose the dirty technology if only financial investors were present (*i.e.* $\gamma_j^E < \bar{\gamma}_j^E$), giving all capital to financial investors, $x^{SR} = 0$, would yield strictly lower welfare. This proves the first statement.

To prove that it may be strictly optimal to have $x^{SR} < 1$ consider the following case. Suppose that all firm types are financially constrained (*i.e.* $\max\{K_{C,j}^{SR}, K_{C,j}^F, K_{D,j}^F\} < \bar{K}_j$), that all dirty firms create negative social value, and that total investor capital is large enough such that the following two conditions are jointly met for some $\tilde{x}^{SR} \in (0, 1)$ :

1. Financial investors (with a fraction $1 - \tilde{x}^{SR}$ of total capital) could finance dirty production by all firms at scale $K_{D,j}^F$.
2. The SR fund (with a fraction $\tilde{x}^{SR}$ of total capital) could finance all firms at a clean scale of $\frac{A_j + \bar{U}_j^E}{\xi_j - \gamma_j^E \phi_{C,j}}$.

The first condition ensures that all firms have the outside option of dirty production at scale $K_{D,j}^F$ by raising financing from financial investors. The second condition ensures that, given this threat, the SR fund has sufficient capital to induce all firms to adopt the clean production technology by offering a (larger) clean scale of $\frac{A_j + \bar{U}_j^E}{\xi_j - \gamma_j^E \phi_{C,j}} > K_{C,j}^{SR}$ (see Proposition 3). This scale increase is socially valuable, implying that welfare is strictly higher for $\tilde{x}^{SR} < 1$ than for $x^{SR} = 1$. ■

Recall that first-best welfare requires that both the correct technology $C$ and the efficient scale $\bar{K}_j$ be chosen. If financial constraints do not bind, the only concern is whether the correct technology $C$ is chosen, which the SR fund will ensure for all firms when $x^{SR} = 1$ (since $\gamma^{SR} + \gamma^{E} = 1$). Because clean production is already at the efficient scale, the only effect of an increase in the fraction of financial capital is that, eventually, this will induce some firms to switch to dirty production. This happens once the fraction of socially responsible capital is too low to ensure that all firms adopt the clean technology.

In contrast, if a sufficient fraction of firms operates below the optimal scale $\bar{K}_j$ when all capital is held by the SR fund, we essentially obtain an aggregate version of the complementarity result given in Proposition 3. An increase in financial capital provides firms with the outside option of producing dirty at larger scale. This threat, in turn, unlocks additional financing capacity by the SR fund, enabling a welfare-improving scale increase of clean production. Thus, in the presence of binding financial constraints, the right balance between SR and financial capital is important.

*Acknowledgments.* For comments and suggestions, we thank Veronica Guerrieri (the editor), three anonymous referees, Franklin Allen, Ulf Axelson, Paul Beaumont, Roland Bénabou, Bruno Biais, Markus Brunnermeier, Patrick Bolton, Shaun Davies, Peter DeMarzo, Diego Garcia, Deeksha Gupta, Bengt Holmström, Ebba Jernmark-Burrows, Anastasia Kartasheva, Lukasz Pomorski, Ailsa Roëll, Joel Shapiro, Lin Shen, Jan Starmans, Paul Woolley, and seminar participants at ASU Sonoran, BIS, Bonn, Cambridge, Copenhagen Business School, CU Boulder, Deutsche Bundesbank, EFA, École Polytechnique, Erasmus University, EWFC, Frankfurt School of Finance, the FTZ Seminar, HEC, Humboldt Universität zu Berlin, IDC Financial Economics Conference, IMF Macro-Financial Research Conference, INSEAD Finance Symposium, LSE, MIT OrgEcon lunch, OxFIT, Princeton, Schroders, Stanford, Stockholm School of Economics, UCLA, USC, Warwick Business School, and WFA.

**Funding**

This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement 715467) as well as the Marianne and Marcus Wallenberg (MMW) foundation (grant agreement 2021.0122).

**Conflict of interest**

M.O. and M.M.O. have no conflicts of interest to disclose.

## REFERENCES

AGHION, P., BÉNABOU, R., MARTIN, R., *et al.* (2023), "Environmental Preferences and Technological Choices: Is Market Competition Clean or Dirty?", *American Economic Review: Insights*, **5**, 1–20.

ALBUQUERQUE, R., KOSKINEN, Y. and ZHANG, C. (2019), "Corporate Social Responsibility and Firm Risk: Theory and Empirical Evidence", *Management Science*, **65**, 4451–4469.

ANDREONI, J. (1990), "Impure Altruism and Donations to Public Goods: A Theory of Warm-Glow Giving", *The Economic Journal*, **100**, 464–477.

BAKER, M., BERGSTRESSER, D., SERAFEIM, G., *et al.* (2022), "The Pricing and Ownership of US Green Bonds", *Annual Review of Financial Economics*, **14**, 415–437.

BARBER, B. M., MORSE, A. and YASUDA, A. (2021), "Impact Investing", *Journal of Financial Economics*, **139**, 162–185.

BERGSTROM, T., BLUME, L. and VARIAN, H. (1986), "On the Private Provision of Public Goods", *Journal of Public Economics*, **29**, 25–49.

BERK, J. and DEMARZO, P. (2019), *Corporate Finance* (5th edn) (London: Pearson).

BERK, J. and VAN BINSBERGEN, J. H. (2021), "The Impact of Impact Investing" (Working Paper, Stanford University and Wharton).

BIAIS, B. and LANDIER, A. (2022), "Emission Caps and Investment in Green Technologies" (Working Paper, HEC Paris).

BONNEFON, J.-F., LANDIER, A., SASTRY, P., *et al.* (2019), "The Moral Preferences of Investors: Experimental Evidence" (Working Paper, TSE, MIT and HEC).

BROCCARDO, E., HART, O. and ZINGALES, L. (2022), "Exit versus Voice", *Journal of Political Economy*, **130**, 3101–3145.

CHAVA, S. (2014), "Environmental Externalities and Cost of Capital", *Management Science*, **60**, 2223–2247.

CHOWDHRY, B., DAVIES, S. W. and WATERS, B. (2018), "Investing for Impact", *The Review of Financial Studies*, **32**, 864–904.

COASE, R. H. (1960), "The Problem of Social Cost", *The Journal of Law and Economics*, **3**, 1–44.

DANGL, T., HALLING, M., YU, J., *et al.* (2023), "Social Preferences and Corporate Investment" (Working Paper, WU Vienna).

DAVIES, S. W. and VAN WESEP, E. D. (2018), "The Unintended Consequences of Divestment", *Journal of Financial Economics*, **128**, 558–575.

DE ANGELIS, T., TANKOV, P. and ZERBIB, O. D. (2023), "Climate Impact Investing", *Management Science*, **69**, 7669–7692.

DEWATRIPONT, M. and TIROLE, J. (2020), "The Morality of Markets and the Nature of Competition" (Working Paper, ULB and Toulouse School of Economics).

EDMANS, A., LEVIT, D. and SCHNEEMEIER, J. (2022), "Socially Responsible Divestment" (ECGI Working Paper).

Financial Times (2022), "Bill Gates-Backed Fund Aims to Invest $15bn in Clean Tech" (https://www.ft.com/content/f25fd95d-e2d8-43f8-b786-1552a1f0059e). Accessed March 28, 2022.

FRIEDMAN, M. (September 13, 1970), "A Friedman Doctrine: The Social Responsibility of Business is to Increase its Profits", *The New York Times Magazine*, 32-126.

GOLLIER, C. and POUGET, S. (2014), "The "Washing Machine": Investment Strategies and Corporate Behavior with Socially Responsible Investors" (Working Paper, Toulouse School of Economics).

GREEN, D. and ROTH, B. (2021), "The Allocation of Socially Responsible Capital" (Working Paper, Harvard Business School).

GUPTA, D., KOPYTOV, A. and STARMANS, J. (2022), "The Pace of Change: Socially Responsible Investing in Private Markets" (Working Paper, Stockholm School of Economics).

HARSTAD, B. (2012), "Buy Coal! A Case for Supply-Side Environmental Policy", *Journal of Political Economy*, **120**, 77–115.

HART, O. and MOORE, J. (1998), "Default and Renegotiation: A Dynamic Model of Debt", *The Quarterly Journal of Economics*, **113**, 1–41.

HEEB, F., KÖLBEL, J. F., PAETZOLD, F., *et al.* (2023), "Do Investors Care about Impact?", *The Review of Financial Studies*, **36**, 1737–1787.

HEINKEL, R., KRAUS, A. and ZECHNER, J. (2001), "The Effect of Green Investment on Corporate Behavior", *The Journal of Financial and Quantitative Analysis*, **36**, 431–449.

HOFFMANN, F., INDERST, R. and MOSLENER, U. (2017), "Taxing Externalities under Financing Constraints", *The Economic Journal*, **127**, 2478–2503.

HOLMSTRÖM, B. and TIROLE, J. (1997), "Financial Intermediation, Loanable Funds, and the Real Sector", *The Quarterly Journal of Economics*, **112**, 663–691.

HONG, H. and KACPERCZYK, M. (2009), "The Price of Sin: The Effects of Social Norms on Markets", *Journal of Financial Economics*, **93**, 15–36.

INDERST, R. and HEIDER, F. (2022), "A Corporate Finance Perspective on Environmental Policy" (Working Paper, Goethe University Frankfurt).

INDERST, R. and OPP, M. M. (2022), "Greenwashing and Retail Investors: The Case for a Taxonomy for ESG Investments?" (Working Paper, Stockholm School of Economics).

LANDIER, A. and LOVO, S. (2020), "ESG Investing: How to Optimize Impact" (Working Paper, HEC Paris).

MOISSON, P.-H. (2020), "Ethics and Impact Investment" (Working Paper, Toulouse School of Economics).

MORGAN, J. and TUMLINSON, J. (2019), "Corporate Provision of Public Goods", *Management Science*, **65**, 4489–4504.

NGUYEN, N., RIVERA, A. and ZHANG, H. H. (2024), "Incentivizing Investors for a Greener Economy", *The Journal of Financial and Quantitative Analysis*. https://doi.org/10.1017/S0022109024000267.

OLSON, M. (1971), *The Logic of Collective Action: Public Goods and the Theory of Groups* (Cambridge, MA: Harvard University Press).

PASTOR, L., STAMBAUGH, R. F. and TAYLOR, L. (2021), "Sustainable Investing in Equilibrium", *Journal of Financial Economics*, **142**, 550–571.

PEDERSEN, L. H., FITZGIBBONS, S. and POMORSKI, L. (2021), "Responsible Investing: The ESG-Efficient Frontier", *Journal of Financial Economics*, **142**, 572–597.

RIEDL, A. and SMEETS, P. (2017), "Why Do Investors Hold Socially Responsible Mutual Funds?", *The Journal of Finance*, **72**, 2505–2550.

ROTH, B. N. (2019), "Impact Investing: A Theory of Financing Social Enterprises" (Working Paper, Harvard Business School).

SAMUELSON, P. A. (1954), "The Pure Theory of Public Expenditure", *The Review of Economics and Statistics*, **36**, 387–389.

TIROLE, J. (2006), *The Theory of Corporate Finance* (Princeton, NJ: Princeton University Press).

TIROLE, J. (2012), "Some Political Economy of Global Warming", *Economics of Energy & Environmental Policy*, **1**, 121–132.

WELCH, I. (May 10, 2014), "Why Divestment Fails", *New York Times*, A23.

ZERBIB, O. D. (2019), "The Effect of Pro-Environmental Preferences on Bond Prices: Evidence from Green Bonds", *Journal of Banking and Finance*, **98**, 39–60.

ZERBIB, O. D. (2022), "A Sustainable Capital Asset Pricing Model (S-CAPM): Evidence from Green Investing and Sin Stock Exclusion", *Review of Finance*, **26**, 1345–1388.