Sustainable Investing and Market Governance*

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Abstract

This paper examines how sustainable investing affects the traditional governance role of financial markets. We show that stronger pro-social preferences among informed investors can reduce price informativeness about managerial effort toward improving financial performance, thereby increasing the cost of incentive provision. While this creates an agency cost, it can paradoxically generate positive real effects: because firms generating negative externalities face higher agency costs, purely financially motivated shareholders have incentives to reduce externalities to enhance price informativeness for governance purposes. Our results reveal an inherent link between firms' environmental and social (the "ES" of ESG) and governance (the "G" of ESG) outcomes. We also identify a novel complementarity between voice and exit in reducing firm externalities—pro-social investors' exit decisions prompt financial investors to exercise voice—in contrast to the conventional view of these strategies being substitutes.

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JEL Classifications: G30, G32, G34, G14, G23, M14, Q56

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1 Introduction

The rise of sustainable investing, which incorporates social and environmental factors into investment decisions, has significantly impacted financial markets. A growing literature examines how sustainable investors' impact on firms' market prices can have real environmental and social consequences by reducing corporate externalities (e.g., Heinkel et al., 2001; Pastor et al., 2021; Pedersen et al., 2021; Gupta et al., 2024). However, this literature has largely overlooked how changes in market prices due to sustainable investing affect the traditional governance role of financial markets (e.g., Holmström and Tirole, 1993).

In this paper, we examine how sustainable investing influences firm governance through its effects on price informativeness and market-based monitoring. Our analysis demonstrates that sustainable investing can weaken the governance role of financial markets by reducing the sensitivity of stock prices to information about firm fundamentals, particularly when firm externalities are significant. Specifically, a pro-social informed trader may choose not to invest in a firm with poor environmental or social outcomes, even when observing strong financial performance. This decision reduces informed trading based on firm fundamentals, thereby lowering the informational content of prices. Consequently, it becomes more costly for firms' shareholders to incentivize managers to improve financial performance. If these incentive costs become sufficiently high, shareholders may optimally reduce incentive provision, leading to lower managerial effort and ultimately diminishing firm financial performance. Thus, sustainable investing can increase the agency costs associated with the separation of ownership and control.

Building on this fundamental link between sustainable investing and market-based governance, we establish three key insights. First, our results reveal an inherent link between firms' environmental and social (the "ES" of ESG), and governance (the "G" of ESG) outcomes. This finding challenges arguments that these components are unrelated and should not be considered jointly in ESG ratings.[1] Specifically, we demonstrate that when an informed trader cares strongly about firm externalities, a positive correlation emerges between ES and G scores. This correlation arises endogenously because shareholders can more easily incentivize managerial effort to improve firm

[1] See, for example, "Is it time to separate 'E' from 'S' and 'G?," Financial Times, 14 March 2022 and "It's Time to Unbundle ESG," Harvard Business Review, 20 September 2024.

fundamentals (leading to higher G scores) when the firm is more likely to achieve good environmental and social outcomes (reflected in higher ES scores). Intuitively, lower externalities increase informed trading based on firm fundamentals, leading to more informative stock prices that enhance market-based governance.

Second, we demonstrate that purely financially motivated shareholders, who do not care about externalities, may rationally invest in reducing firm externalities. These shareholders can enhance price informativeness about firm fundamentals by reducing externalities, as this increases informed trading. This improvement in price informativeness benefits shareholders by reducing the cost of providing managerial incentives. Thus, the agency costs of sustainable investing can paradoxically generate positive real effects by incentivizing firms to reduce externalities.

Third, our model highlights a novel complementarity between voice and exit in reducing firm externalities. We show that the threat of a pro-social investor's exit from firms with negative externalities can incentivize financial shareholders to exercise voice in reducing these externalities. This complementarity between exit and voice introduces a new perspective, as academics and practitioners typically view the two as competing investment strategies (e.g., Broccardo et al., 2022). Specifically, in our model, pro-social investors' exit decisions prompt financial investors to exercise voice. This interaction across investor types differs from the existing literature in which the same investors choose between voice and exit.

The market-governance channel of sustainable investing in our paper differs from the traditional cost-of-capital (i.e., exit) and voice channels in the literature (e.g., Broccardo et al., 2022). In our framework, sustainable investors affect real outcomes by making incentive provision, rather than capital, more expensive. Firms invest in reducing externalities not to lower their cost of capital but to lower the cost of managerial incentive provision by improving the information content of their stock prices. Additionally, voice is exerted not by pro-social investors but rather by financial shareholders to prevent exit by an informed pro-social investor for non-fundamental reasons, which makes price less informative about managerial effort.

More specifically, we develop a model in which an informed investor who may have pro-social preferences interacts with noise traders in a Kyle-type market. All agents are risk-neutral. The firm generates both an uncertain financial payoff and an uncertain social cost, capturing negative externalities. We assume these two outcomes are uncorrelated to demonstrate the mechanism most transparently and abstract away from additional effects that may arise if investors could learn about a firm's financial performance based on its social outcomes (Pedersen et al., 2021, e.g.,).

The firm is initially owned by financial investors who value only financial payoffs. A manager operates the firm and can exert effort to increase the firm's financial performance. In the baseline model, we assume that the probability of the firm generating negative externalities is exogenous. The initial shareholders design the manager's compensation contract to maximize the firm's financial payoff minus compensation costs. The manager's pay can only be contingent on the firm's interim stock price.

The informed investor's valuation of firm shares depends on both the financial payoff and social cost, weighted by the intensity of her pro-social preferences. She privately observes both the financial payoff and social cost before trading and can either buy a share or abstain. Market makers set prices based on aggregate order flow to reflect the preferences of marginal financial investors who only care about financial performance. This setup allows us to examine how pro-social investors affect the information content of stock prices and, consequently, the effectiveness of market-based governance.

We show that as the informed investor's pro-social preferences intensify, she becomes less likely to acquire a share when observing high financial performance but a high social cost. This reduction in informed trading makes stock prices less informative about financial performance and, thus, about managerial effort toward improving financial performance. The decline in price informativeness about managerial effort increases the agency costs of separating ownership and control, as it becomes more costly to incentivize the manager when stock prices provide noisier signals of effort. If these costs become prohibitively high, shareholders may reduce incentive provision, leading to reduced effort and worse performance, highlighting an important real cost of sustainable investing.

Price informativeness about managerial effort crucially depends on the probability of the firm generating a high social cost. When the firm never generates a social cost, the informed investor always trades based on financial information, resulting in highly informative prices that enable low-cost managerial incentives. Conversely, when the firm frequently generates a high social cost, the informed investor regularly abstains from trading on financial information, reducing the information content of prices and making incentive provisions more costly. This mechanism generates a positive correlation between "ES" and "G": firms with good ES quality—reflected in low probabilities of negative externalities–are more likely to maintain good governance practices—reflected in high probabilities of strong financial performance through managerial effort.

In an extension of the baseline model, we allow the firm's initial financial shareholders to invest in reducing the probability of generating social costs. We find that shareholders may make such investments even if they do not intrinsically value these outcomes. A lower probability of a high social cost increases informed trading on financial information, making prices more informative about financial performance and lowering incentive costs. Thus, the threat of exit by pro-social investors can motivate financial shareholders to exercise voice in reducing negative externalities, generating real social benefits of sustainable investing.

Our framework highlights that sustainable investing can affect market prices and have real effects even without generating a "greenium." In our model, market makers rationally set prices to reflect only expected financial payoffs given public information. Consequently, firms with different ex-ante propensities to generate a high social cost have identical expected returns, even though the informed investor's trading behavior is affected by externalities. Thus, the absence of a greenium does not necessarily imply that sustainable investing fails to impact financial markets, firm performance, and externalities.

Our model also sheds light on the distinction between expected and average realized returns and the resulting challenge of measuring a greenium. While firms with different ex-ante propensities for high social costs have identical expected returns in our model, realized social costs influence informed trading: the informed investor is less likely to buy a share in a firm with high financial but poor social performance. This reduces the incorporation of positive financial information into interim prices of firms with high social costs, leading to lower prices and higher average realized returns. Thus, our framework predicts differences in average realized returns based on ex-post social outcomes, suggesting that empirical measurement of sustainability premiums depends critically on whether "green" firms are identified through ex-ante metrics or ex-post performance.

Beyond return levels, our model predicts that stock price volatility can vary with ex-ante propensities of firms to generate a high social cost even when expected returns remain constant. Prices become more informative and thus more volatile for firms with higher probabilities of good social outcomes as they attract more informed trading. This implies that the effects of sustainable investing may manifest in higher moments of return distributions even when expected returns remain unchanged.

We further explore how public news about firm externalities affects market monitoring in the presence of sustainable investing. We show that when firms receive news about the social cost being low, optimal contracts may include bonuses contingent on both prices and news about social costs. Consequently, managerial compensation tied to social outcomes may be optimal even when controlling shareholders do not care about the firm's social cost and when the manager cannot take actions to reduce externalities.

Additionally, we examine how the precision of the informed investor's private information about the firm's social cost affects price informativeness regarding effort. We find that increased precision can have ambiguous effects. A more precise signal increases the dispersion in the informed investor's posterior beliefs about the firm's social cost. When the investor anticipates a high social cost, increased precision reduces informed trading on financial information, decreasing effort informativeness. When anticipating a low social cost, the opposite occurs—increased precision encourages informed trading on financial information, increasing effort informativeness. Our analysis implies that greater disclosure about a firm's externalities can have ambiguous effects on firm governance.

The remainder of the paper proceeds as follows. We discuss the related literature in Section 2. Section 3 presents the model. Section 4 analyzes the benchmark case with only financial investors. Section 5 examines how pro-social investors affect agency costs and governance. Section 6 explores extensions, including firms' incentives to reduce social costs, the role of public news about social costs, and the precision of the informed investor's private information about social costs. Section 7 concludes.

2 Related Literature

Our paper contributes to the theoretical literature studying the real impact of pro-social investors on firm decisions (e.g., Heinkel et al., 2001; Hart and Zingales, 2017; Davies and Van Wesep, 2018; Chowdhry et al., 2019; Morgan and Tumlinson, 2019; Green and Roth, 2021; Matsusaka and Shu, 2021; Pastor et al., 2021; Roth, 2021; Barbalau and Zeni, 2022; Broccardo et al., 2022; Gollier and Pouget, 2022; Huang and Kopytov, 2022; Moisson, 2022; Allen et al., 2023; De Angelis et al., 2023; Döttling and Rola-Janicka, 2023; Edmans et al., 2023; Geelen et al., 2023; Jagannathan et al., 2023; Jin and Noe, 2023; Landier and Lovo, 2023; Levit et al., 2023; Oehmke and Opp, 2023; Piccolo et al., 2023; Malenko and Malenko, 2023; Döttling et al., 2024; Gupta et al., 2024; Gryglewicz et al., 2024).[2] A significant part of this literature examines how pro-social investors affect firm behavior through their impact on firms' cost of capital (e.g., Heinkel et al., 2001; Pastor et al., 2021; Pedersen et al., 2021; Berk and Van Binsbergen, 2022). Our paper demonstrates that pro-social investors can affect firm behavior through market prices beyond the cost-of-capital effect by undermining the traditional governance role of stock markets in disciplining management. We also highlight a complementarity between voice and exit in reducing firm externalities, in contrast to papers that view these as competing investment strategies (e.g., Berk and Van Binsbergen, 2022; Broccardo et al., 2022; Jagannathan et al., 2023; Gupta et al., 2024).

A small number of papers study optimal contracting based on stock prices when investors have pro-social preferences.[3] Chaigneau and Sahuguet (2024) study how a board optimally sets managerial compensation to balance financial and social goals. In their model, the stock price is exogenous, and there are no pro-social investors affecting price informativeness, which is our focus. The tilting strategy of pro-social investors in Edmans et al. (2023) can be interpreted as an incentive mechanism affecting managerial behavior through stock prices. In their framework, pro-social investors affect prices by changing the risk-bearing capacity of the market. In contrast, our framework shows how pro-social investors affect managerial behavior by altering the informa-

[2] Legal scholars have also recognized that sustainable investing practices affect the agency problem arising from the separation of ownership and control. For example, Christie (2021) discusses how sustainability concerns shape investor activism.

[3] A number of other papers study optimal contracting without stock price-based incentives (see, e.g., Baron, 2008; Bonham and Riggs-Cragun, 2022). There are also papers that study the effect of stock prices on managers' investment in public goods in the absence of agency problems in which managers maximize shareholder value (see, e.g., Pastor et al., 2021; Bucourt and Inostroza, 2023).

tiveness of the stock price. A related literature studies firm investment with sustainability concerns in the presence of feedback effects (see, e.g., Chen and Schneemeier, 2023; Xue, 2023). However, these papers do not study optimal contracting.

Our paper is closely related to Goldstein et al. (2022), who study how informed trading by pro-social investors affects the information contained in prices.[4] We contribute by introducing optimal contracting, which allows us to study how informed trading by pro-social investors affects the traditional governance role of stock markets. Our framework focuses on the real effects, highlighting a novel channel through which sustainable investing affects firm financial performance and externalities.

We also contribute to the literature studying how markets discipline management (e.g., Holmström and Tirole, 1993; Dow and Gorton, 1997; Maug, 1998; Admati and Pfleiderer, 2009; Edmans, 2009) by introducing public good provision and pro-social investors. Specifically, we examine how the pro-social preferences of an informed investor influence her trading behavior and the ability of shareholders to discipline managers using compensation contracts based on the stock price.

Our paper contributes to the literature examining multiple, potentially conflicting roles of stock prices (e.g., Bresnahan et al., 1992; Banerjee et al., 2022). Most closely related is Banerjee et al. (2022), who identify a fundamental trade-off between investment efficiency and effort efficiency when stock prices both guide investment decisions and incentivize effort. In contrast, our mechanism is driven by the interaction between public and private good provision, revealing a complementarity between social efficiency and effort efficiency when stock prices reflect both firm financial performance and externalities. Specifically, enhanced social efficiency—achieved through reducing negative externalities—improves effort efficiency by facilitating more informed trading based on financial information.

Our paper also relates to the literature studying the real effects of informed trading with multiple dimensions of firm investment decisions. For example, Piccolo (2022) show that coordination problems in information production can lead to multiple equilibria. Dow et al. (2024) show that competition for informed trading results in suboptimal short-termism, even when each firm's

[4]Yang et al. (2023) and Hitzemann et al. (2024) provide evidence consistent with pro-social investing affecting price informativeness.

managerial contract and project choice are individually optimal. In these papers, inefficiencies arise from general equilibrium effects with varying horizons of payoffs. Our mechanism differs as inefficiencies arise in partial equilibrium with identical payoff horizons. The insights therefore naturally differ. For example, interpreting the long-horizon projects in Dow et al. (2024) as sustainable choices and long-term investors as more pro-social implies that strengthening sustainable investing by increasing investor horizon would lead to more sustainable long-term investments, which increases efficiency. In contrast, strengthening pro-social preferences in our model leads to weaker governance and a deterioration in firm fundamentals, reducing efficiency.

3 Model

There are three dates, $t \in \{0,1,2\}$, and all agents are risk neutral. We consider a firm that is initially owned by financial investors.[5] At the final date $t = 2$, the firm generates a financial payoff for its owners and potentially imposes a negative externality on society. At $t = 0$, the firm's manager can increase the probability of a high financial payoff by exerting effort, and the initial shareholders can design an incentive contract to induce the manager's effort. At $t = 1$, an informed investor, who may care about the firm's externality, can acquire a stake in the firm.

The firm, financed entirely by equity with $N \gg 1$ shares outstanding, generates a financial payoff per share $F \in \{0,1\}$ and a total social cost $S \in \{0,\eta\}$ at the final date $t = 2$, where $\eta > 0$.[6] The social cost may represent, for instance, the social cost of carbon that captures the economic damages resulting from the firm's carbon emissions (e.g., Bolton and Kacperczyk, 2021, 2023) or the social cost of an opioid epidemic (e.g., Florence et al., 2021; Maclean et al., 2020; Case and Deaton, 2021). Managerial effort exerted at $t = 0$, $e_F \in \{0,1\}$, influences the probability of achieving the high financial payoff ($F = 1$). With effort ($e_F = 1$), this probability is given by $p_F \in (0,1)$; without effort ($e_F = 0$), it decreases to $p_F - \Delta_F$, where $0 < \Delta_F < p_F$. In the latter case, the manager enjoys a private benefit $B_F > 0$. The social cost S is equal to 0 with probability $p_S \in (0,1)$ and η with probability $1 - p_S$. In our baseline model, the probability p_S is exogenous. Section 6.1

[5] We make this assumption to abstract from the direct impact of sustainable investing through voice by pro-social shareholders. It would be sufficient to assume that financial investors own the majority of the firm's shares.

[6] The normalization of the low social cost to zero simplifies the analysis but is not required for our main results.

extends this to consider observable investments that can lower the probability of a high social cost. To most clearly demonstrate how sustainable investing affects the traditional monitoring role of financial markets, we assume that F and S are independent and abstract away from effects that can arise if investors update their expectations about a firm's financial performance based on its social outcomes (e.g., Pedersen et al., 2021). Furthermore, to focus on the case where market monitoring is desirable, we assume that exerting financial effort is socially efficient: $N\Delta_F > B_F$.

The firm's shares are traded at $t = 1$ in a discrete Kyle (1985)-type market. Noise traders' random demand $z \in \mathbb{N}_0 := \{0, 1, \ldots\}$ follows a geometric distribution with density function $(1 - \lambda)^z \lambda$, where $\lambda \in (0, 1)$.[7] For simplicity, we assume the informed investor learns the realized values of F and S before trading. We introduce noise into the informed investor's private information in Section 6.3. Trading frictions limit the informed investor to submitting an order $x \in \{0, 1\}$.[8] Our key departure from a standard Kyle (1985)-type framework is that the informed investor cares about the firm's social cost with intensity $\gamma \in [0, 1]$.[9] Specifically, the informed investor has warm-glow preferences, deriving utility $F - \gamma S$ when owning a share of the firm's equity ($x = 1$), and 0 otherwise.[10] The market makers' equilibrium pricing rule reflects the preferences of the marginal financial investor who is indifferent to the firm's social cost.[11] Consequently, the firm's stock price at $t = 1$ depends solely on the expected value of the firm's financial payoff F at $t = 2$.

[7]This distribution results in a constant likelihood ratio for larger order flows, simplifying the solution for the equilibrium pricing rule and optimal contract. Note that this specification implies that the expected demand from noise traders is $\frac{1}{\lambda} - 1 > 0$. However, we can shift the distribution so that the demand from noise traders is non-positive without affecting our main results.

[8]For instance, the informed investor may have convex opportunity costs to deploy capital or face short-selling restrictions (e.g., Edmans et al. (2015), Dow et al. (2017)). We can relax the restriction against short selling to allow for negative positions (e.g., $x \in \{-1, 0, 1\}$) without affecting our main results. The informed investor would fully trade on her negative information about the firm's financial performance, short selling ($x = -1$) upon observing $F = 0$. However, her trading intensity upon learning positive information ($F = 1$) would still decrease with stronger pro-social preferences.

[9]While not necessary for any of the results in our paper, requiring that $\gamma \leq 1$ ensures that the total disutility suffered by the informed investor does not exceed the social cost.

[10]The investor can either have deontological preferences, inherently valuing firms for being green (e.g., Heinkel et al. (2001), Pastor et al. (2021), and Pedersen et al. (2021)) or consequentialist broad-impact preferences, leading them to adopt an investment mandate reflecting those preferences (e.g., Gupta et al. (2024)). There is growing evidence that moral and ethical considerations influence investors' decision-making in a financial market context (e.g., Riedl and Smeets, 2017; Bauer et al., 2021; Humphrey et al., 2021; Zhang, 2021; Baker et al., 2022; Zhang, 2022; Bonnefon et al., 2023; Giglio et al., 2023; Heeb et al., 2023). See Kräussl et al. (2023) for a survey on the evidence for pro-social preferences in financial markets. For evidence on pro-social preferences in other non-financial contexts, see List (2009).

[11]The intuition is that the market makers must break even in expectation and anticipate selling any order imbalance to the marginal investor at $t = 2$, who we assume to be a financial investor valuing shares at F.

The firm's initial controlling shareholders—being financial investors—care only about the firm's financial payoff, F. At $t = 0$, they design the manager's compensation contract, denoted by W, to maximize the firm's expected financial payoff net of compensation costs. The manager is protected by limited liability, so the contract requires $W \geq 0$. To emphasize the monitoring role of the financial market, we assume that the manager's incentive pay can only be contingent on the firm's stock price P at $t = 1$.[12] The manager's outside option is normalized to zero. Following the literature, we assume that the firm's initial shareholders pay the manager's compensation (e.g., Holmström and Tirole, 1993; Admati and Pfleiderer, 2009; Edmans et al., 2009; Peng and Röell, 2014).[13] Figure 1 summarizes the model's timing.

$t = 0$	$t = 1$	$t = 2$
• Shareholders set compensation contract W • Manager chooses effort $e_F \in \{0,1\}$	• Informed investor trades $x \in \{0,1\}$ • Noise traders' demand z realizes • Market makers set stock price P • Manager compensated	• Financial payoff F realizes • Social cost S realizes

Figure 1: Model Timeline

4 Benchmark with Only Financial Investors

We first establish a benchmark case where the informed investor does not care about the firm's social cost (i.e., $\gamma = 0$). When the informed investor disregards social cost, our framework reduces to a standard market-monitoring model à la Holmström and Tirole (1993). We denote equilibrium

[12] Alternatively, we can adjust the information structure so that the stock price contains incremental information about the manager's effort beyond that in F. In this case, we can allow the contract to depend both on the price P and the financial performance F without qualitatively changing the model's main predictions.

[13] This assumption that the firm's stock price reflects its gross-of-wages financial payoff simplifies our analysis but is not crucial for our results. If the manager were instead paid from the firm's profits, then the firm's stock price would reflect the net-of-wages financial payoff of the firm. Because the manager's compensation is known at $t = 1$, the market-clearing price fully incorporates the compensation cost, and the informed investor would trade in the same way as in our main specification of the model.

objects in this benchmark case with a subscript 0. Under purely financial preferences, the informed investor's optimal strategy is straightforward: buy one share if and only if she observes $F = 1$.

Proposition 1. *Assume that the manager exerts effort ($e_F = 1$). Then, there exists a unique equilibrium in which the informed investor buys one share of the firm's stock ($x = 1$) if and only if she learns that its financial performance is high ($F = 1$). In this equilibrium, the pricing rule as a function of the aggregate order flow $q = x + z$ at $t = 1$ is given by*

$$P_0(q) = \begin{cases} 0, & \text{if } q = 0, \\ \frac{p_F}{p_F + (1-p_F)(1-\lambda)}, & \text{if } q > 0. \end{cases}$$

The equilibrium pricing rule reflects how trading reveals information. When aggregate order flow is low ($q = 0$), it reveals the absence of informed buying and, therefore, low financial performance ($F = 0$), resulting in $P_0(0) = 0$. In contrast, high aggregate order flow ($q > 0$) creates ambiguity—it could result from informed buying based on positive information about F (with probability p_F) or from noise trading (with probability $(1 - p_F)(1 - \lambda)$). The pricing rule captures this uncertainty. In equilibrium, the informed investor generates positive expected trading profits: when $F = 1$, each share's true value is 1, but the cost of buying a share is $P_0(q > 0) < 1$.

Anticipating the trading equilibrium at $t = 1$, the firm's initial shareholders design the manager's compensation contract W at $t = 0$. As is standard in risk-neutral contracting under limited liability, the optimal contract is determined by the likelihood ratio (e.g., Innes, 1990).[14] For ease of exposition, we consider the contracting problem as a function of the order flow rather than the price. As will become clear below, this is without loss of generality. The likelihood ratio as a function of the order flow q is defined as

$$\phi_0(k) = \frac{\Pr(q = k | e_F = 1)}{\Pr(q = k | e_F = 0)}, \ k \in \mathbb{N}_0.$$

The likelihood ratio $\phi_0(k)$ measures how informative the order flow q is about the manager's effort. It is optimal to compensate the manager in states where the likelihood ratio takes its maximum, as these states are most informative about effort.

[14] For papers considering risk-neutral contracting with a finite number of states, similar to this paper, see, e.g., Chaigneau et al. (2019) and Starmans (2023, 2024).

Lemma 1. *The likelihood ratio function is given by*

$$\phi_0(k) = \begin{cases} \frac{1-p_F}{1-p_F+\Delta_F}, & \text{if } k = 0, \\ \frac{p_F\lambda+(1-\lambda)}{(p_F-\Delta_F)\lambda+(1-\lambda)}, & \text{if } k > 0. \end{cases}$$

The likelihood ratio takes its maximum in states with $q > 0$ and equals

$$\phi_0^* = \max_{k\in\mathbb{N}} \phi_0(k) = \frac{p_F\lambda + (1-\lambda)}{(p_F - \Delta_F)\lambda + (1-\lambda)}.$$

We refer to the maximum likelihood ratio ϕ_0^* as the *effort informativeness* of the firm's stock price.[15] Since the maximum likelihood ratio occurs in all states $q > 0$, which corresponds to positive order flow and a high stock price, the manager optimally receives compensation only in these states. Hence, we consider a contract that pays the manager a constant bonus for $q > 0$ and zero otherwise.[16]

The manager's compensation for $q > 0$, denoted by $W_0^*(q > 0)$, is set to make the manager just indifferent between exerting effort and shirking:

$$\Pr(q > 0|e_F = 1)W_0^*(q > 0) = \Pr(q > 0|e_F = 0)W_0^*(q > 0) + B_F.$$

Corollary 1. *An optimal incentive-compatible contract is given by*

$$W_0^*(q) = \begin{cases} 0, & \text{if } q = 0, \\ \frac{B_F}{\Delta_F\lambda}, & \text{if } q > 0. \end{cases}$$

The optimal contract leverages the effort informativeness of stock prices by paying the manager more when the aggregate order flow—or, equivalently, the stock price—is high. A higher order flow indicates a higher likelihood of a good financial performance, which the manager can

[15]There is a positive link between the stock price's effort informativeness and its financial informativeness ψ_0, defined as the sensitivity of the order flow to the firm's financial payoff: $\psi_0 = \frac{Pr(q>0|F=1)}{Pr(q>0|F=0)} = \frac{1}{1-\lambda}$. In particular, effort informativeness (ϕ_0^*) can be expressed as a strictly increasing function of financial informativeness (ψ_0): $\phi_0^* = \frac{p_F\psi_0+(1-p_F)}{(p_F-\Delta_F)\psi_0+(1-p_F+\Delta_F)}$ and $\frac{\partial\phi_0^*}{\partial\psi_0} > 0$.

[16]Since the likelihood ratio is constant for $q > 0$, there also exist optimal contracts that compensate the manager for a subset of states with a positive order flow. Importantly, all optimal contracts generate the same cost for shareholders.

influence through effort.

The expected cost to shareholders of providing managerial incentives is

$$\Pr(q>0|e_F=1)W_0^*(q)=\frac{1-(1-p_F)\lambda}{\Delta_F\lambda}B_F=\frac{1}{1-\frac{1}{\phi_0^*}}B_F.$$

A higher private benefit from shirking, B_F, increases incentive costs by making the agency problem more severe. Higher effort informativeness, ϕ_0^*, reduces incentive costs. Specifically, a higher p_F reduces ϕ_0^* by making high financial payoffs more likely regardless of effort, while an increase in Δ_F raises ϕ_0^* by amplifying the manager's impact on financial payoffs. A higher λ increases ϕ_0^* by reducing noise trading.

The firm's initial controlling shareholders find it optimal to induce managerial effort if and only if

$$N\Delta_F\geq\frac{1}{1-\frac{1}{\phi_0^*}}B_F, \tag{1}$$

where the left-hand side (LHS) represents the increase in expected financial payoff from managerial effort, and the right-hand side (RHS) captures the cost of providing incentives. For the remainder of our analysis, we assume the parameters satisfy condition (1), ensuring that controlling shareholders prefer to induce managerial effort when the informed trader has no pro-social preferences. Without this assumption, shareholders would never induce effort, making changes in market-monitoring effectiveness irrelevant.

Assumption 1. *Condition* (1) *is satisfied.*

5 Agency Cost of Sustainable Investing

This section studies how the informed investor's pro-social preferences affect the governance role of financial markets. We denote equilibrium objects with a subscript γ to highlight their dependence on the intensity of these preferences. The benchmark case with $\gamma=0$ was analyzed in Section 4.

We first characterize how the informed investor's pro-social preferences affect equilibrium trading, pricing, and incentive costs in Section 5.1. Section 5.2 then examines the relationship between the firm's propensity to generate high social costs and managerial effort, showing that sustainable investing creates an endogenous link between these outcomes. Finally, Section 5.3 studies how sustainable investing affects expected returns and stock price volatility for firms with different propensities to generate social costs.

5.1 Equilibrium with Sustainable Investing

The presence of noise trading ensures that the expected market-clearing price remains strictly between 0 and 1. The informed investor values the firm's shares at $F - \gamma S$, reflecting both financial payoffs and social costs. The relative importance of social costs in her valuation is captured by the parameter γ. Given this valuation, her optimal trading strategy is straightforward in two states: she never submits a buy order when $F = 0$, as the expected market-clearing price would exceed her valuation, and she always buys when observing $F = 1$ and $S = 0$, as her valuation exceeds the expected market-clearing price. The remaining element of her trading strategy to determine is her behavior upon observing $F = 1$ and $S = \eta$. We denote by $a \in [0,1]$ the probability that she submits a buy order in this state. Figure 2 summarizes the informed investor's trading behavior across all possible states.

Proposition 2. *Assume that the manager exerts effort ($e_F = 1$). Then there exists a unique equilibrium in which the informed investor: (i) buys one share ($x = 1$) upon observing high financial and social performance ($F = 1$ and $S = 0$), (ii) abstains from buying ($x = 0$) upon observing low financial performance ($F = 0$), (iii) buys a share with probability a^* upon observing high financial but low social performance ($F = 1$ and $S = \eta$), where*

$$a^* = \begin{cases} 1, & \text{if } \gamma \leq \underline{\gamma}, \\ \frac{(1-p_F)(1-\lambda)-\gamma\eta(1-(1-p_F p_S)\lambda)}{\gamma\eta p_F \lambda(1-p_S)}, & \text{if } \gamma \in (\underline{\gamma}, \bar{\gamma}), \\ 0, & \text{if } \gamma \geq \bar{\gamma}. \end{cases}$$

The thresholds for pro-social preferences are given by

$$\underline{\gamma} = \frac{(1-p_F)(1-\lambda)}{\eta(1-(1-p_F)\lambda)} < \frac{(1-p_F)(1-\lambda)}{\eta(1-(1-p_F p_S)\lambda)} = \bar{\gamma}.$$

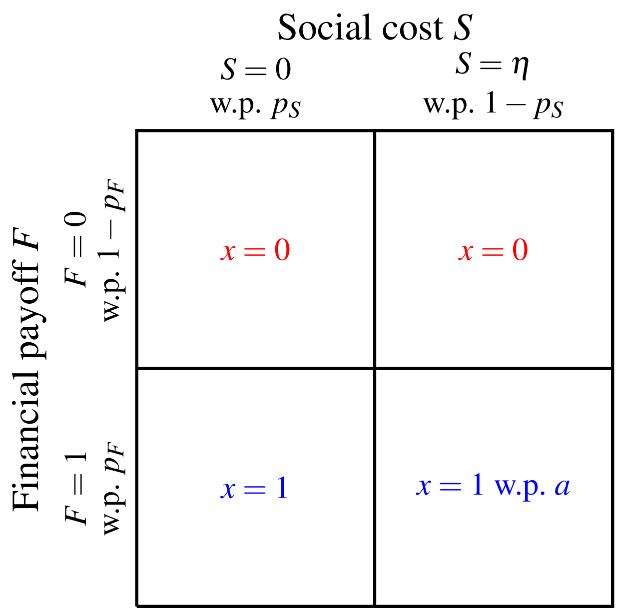

Figure 2: Informed Investor's Trading Strategy. This figure illustrates the informed investor's equilibrium trading behavior conditional on observing different combinations of the financial payoff (F) and social cost (S). The variable $a \in [0,1]$ denotes the probability that the informed investor submits a buy order upon observing $F = 1$ and $S = \eta$.

The equilibrium pricing rule as a function of the aggregate order flow $q = x + z$ at $t = 1$ is

$$P_\gamma(q) = \begin{cases} \frac{p_F(1-p_S)(1-a^*)}{p_F(1-p_S)(1-a^*)+(1-p_F)}, & \text{if } q = 0, \\ \frac{p_F(1-\lambda(1-p_S)(1-a^*))}{p_F(1-\lambda(1-p_S)(1-a^*))+(1-p_F)(1-\lambda)}, & \text{if } q > 0. \end{cases}$$

The informed investor's trading strategy can be characterized by two key quantities. The equilibrium level of informed trading, $\tau_\gamma^* = p_S + (1 - p_S)a^*$, captures the overall probability of buying given high financial performance, accounting for both social cost realizations. Figure 3 illustrates how the quantities a^* and τ_γ^* vary with the informed investor's pro-social preferences. For weak preferences ($\gamma \leq \underline{\gamma}$), social costs do not deter trading ($a^* = 1$), resulting in maximal informed trading ($\tau_\gamma^* = 1$). As preferences strengthen ($\gamma \in (\underline{\gamma}, \bar{\gamma})$), the informed investor becomes less willing to buy with a high social cost, and a^* declines linearly to zero. However, τ_γ^* declines more gradually since the informed investor still buys when observing a low social cost. For strong preferences ($\gamma \geq \bar{\gamma}$), the informed investor never buys with a high social cost ($a^* = 0$), and informed trading occurs only with a low social cost ($\tau_\gamma^* = p_S$).

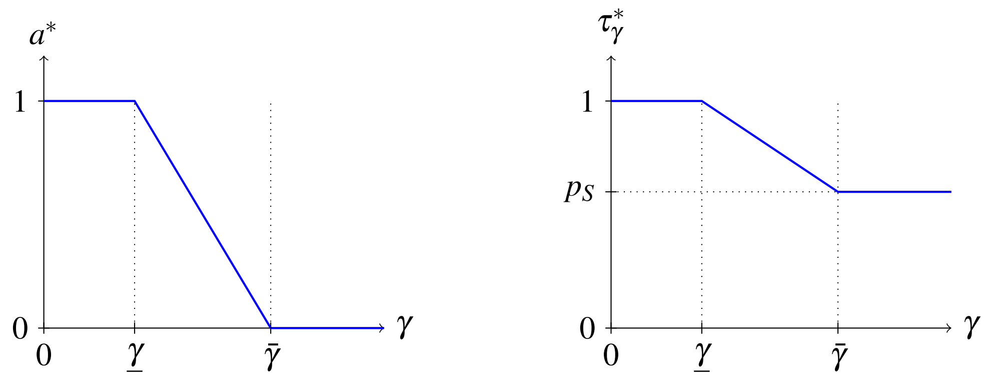

Figure 3: Equilibrium Trading Strategies. This figure shows how the informed investor's trading strategy varies with her pro-social preferences (γ). The left panel plots the probability of buying with a high social cost (a^*). For $\gamma \leq \underline{\gamma}$, the informed investor always buys ($a^* = 1$). For $\gamma \in (\underline{\gamma}, \bar{\gamma})$, a^* decreases linearly. For $\gamma \geq \bar{\gamma}$, the informed investor never buys with a high social cost ($a^* = 0$). The right panel plots the overall probability of informed buying given high financial performance (τ^*_γ). For $\gamma \leq \underline{\gamma}$, the informed investor always buys ($\tau^*_\gamma = 1$). For $\gamma \in (\underline{\gamma}, \bar{\gamma})$, τ^*_γ declines more gradually than a^* due to the possibility of a low social cost. For $\gamma \geq \bar{\gamma}$, informed buying occurs only with a low social cost ($\tau^*_\gamma = p_S$).

The equilibrium prices reflect how the informed investor's trading strategy varies with her pro-social preferences, shown in Figure 4. For weak pro-social preferences ($\gamma \leq \underline{\gamma}$), prices match the benchmark case: zero for low order flow and a constant positive value, which is less than 1, for high order flow. As pro-social preferences strengthen ($\gamma \in (\underline{\gamma}, \bar{\gamma})$), prices become less responsive to order flow—the price for high order flow decreases while the price for low order flow increases—reflecting reduced informativeness about financial performance. Specifically, when $\tau^*_\gamma < 1$, an order flow of $q = 0$ no longer provides a definitive signal of a low financial payoff. Similarly, a positive order flow ($q > 0$) no longer provides as strong a signal of a high financial payoff. For strong pro-social preferences ($\gamma \geq \bar{\gamma}$), the equilibrium level of informed trading declines further because the informed investor fully refrains from trading on positive financial information when social costs are high.

The informed investor's pro-social preferences affect the informativeness of prices about managerial effort through their impact on the likelihood ratio.

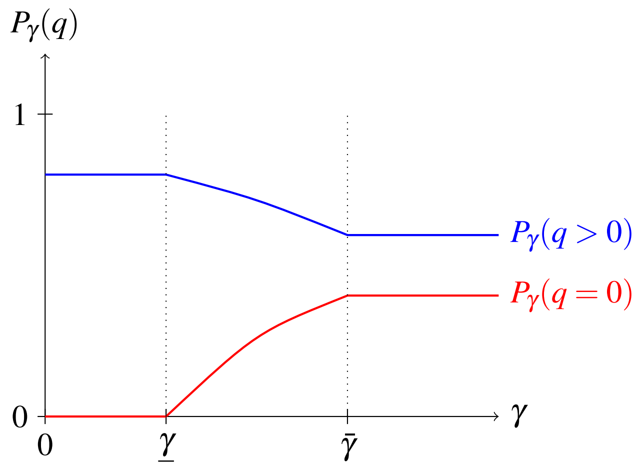

Figure 4: Equilibrium Prices. This figure shows how equilibrium prices vary with the informed investor's pro-social preferences (γ). The blue line represents the price when aggregate order flow is positive ($q > 0$), and the red line represents the price when order flow is zero ($q = 0$). Prices become less responsive to order flow as pro-social preferences strengthen, reflecting reduced informed trading on financial information.

Lemma 2. *The likelihood ratio is given by*

$$\phi_\gamma(k) = \begin{cases} \frac{1-a^* p_F - p_F p_S(1-a^*)}{1-(a^*+p_S(1-a^*))(p_F-\Delta_F)}, & \text{if } k = 0, \\ \frac{p_F(1-\lambda(1-p_S)(1-a^*))+(1-p_F)(1-\lambda)}{(p_F-\Delta_F)(1-\lambda(1-p_S)(1-a^*))+(1-p_F+\Delta_F)(1-\lambda)}, & \text{if } k > 0. \end{cases}$$

The maximum likelihood ratio occurs in states with positive order flow and equals

$$\phi_\gamma^* = \max_{k\in\mathbb{N}} \phi_\gamma(k) = \frac{p_F(1-\lambda(1-p_S)(1-a^*))+(1-p_F)(1-\lambda)}{(p_F-\Delta_F)(1-\lambda(1-p_S)(1-a^*))+(1-p_F+\Delta_F)(1-\lambda)}.$$

As in the benchmark case, the state achieving the maximum likelihood ratio is not unique. Writing ϕ_γ^* in terms of the equilibrium level of informed trading $\tau_\gamma^* = p_S + (1-p_S)a^*$ yields

$$\phi_\gamma^* = \frac{\lambda p_F \tau_\gamma^* + (1-\lambda)}{\lambda(p_F-\Delta_F)\tau_\gamma^* + (1-\lambda)}.$$

This expression highlights the direct relationship between effort informativeness (ϕ_γ^*) and informed trading intensity (τ_γ^*).[17]

[17] Using the notation from Footnote 15, we have $\psi_\gamma = \frac{(1-\lambda+\lambda\tau_\gamma^*)}{1-\lambda}$ where $\tau_\gamma^* = p_S + (1-p_S)a^*$ captures the equilibrium amount of informed trading when $F = 1$. The effort informativeness (ϕ_γ^*) can also be expressed in terms of

Corollary 2. *The effort informativeness of the firm's stock price decreases with the intensity of the informed investor's pro-social preferences:* $\frac{\partial \phi_\gamma^*}{\partial \gamma} \leq 0$ *for* $\gamma \geq \underline{\gamma}$*, strictly so when* $\gamma \in (\underline{\gamma}, \bar{\gamma})$.

Figure 5 illustrates how the maximum likelihood ratio varies with pro-social preferences. For $\gamma \leq \underline{\gamma}$, effort informativeness matches the benchmark case. As pro-social preferences strengthen beyond $\underline{\gamma}$, effort informativeness declines because the informed investor trades less aggressively on financial information.

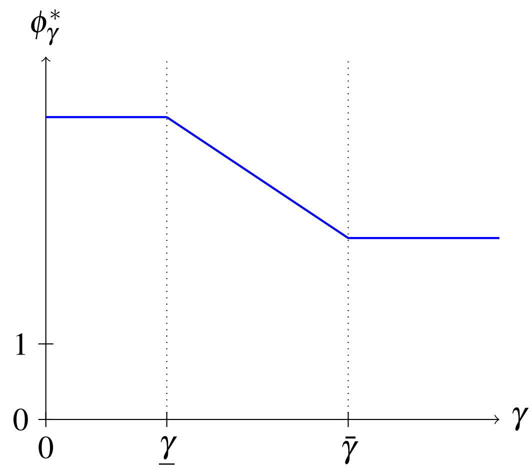

Figure 5: Maximum Likelihood Ratio. This figure shows how the maximum likelihood ratio ϕ_γ^* varies with pro-social preferences. The ratio remains constant at its benchmark level for $\gamma \leq \underline{\gamma}$. For stronger preferences, it decreases as the informed investor trades less aggressively on financial information, reducing price informativeness about managerial effort.

Given this decline in effort informativeness, the manager's optimal compensation contract also changes with pro-social preferences. The manager's compensation for positive order flow, $W_\gamma(q > 0)$, must make her indifferent between exerting effort and shirking.

Corollary 3. *An optimal incentive-compatible contract is given by*

$$W_\gamma^*(q) = \begin{cases} 0, & \text{if } q = 0, \\ \frac{B_F}{\Delta_F \lambda \tau_\gamma^*}, & \text{if } q > 0. \end{cases}$$

As γ increases and τ_γ^* decreases, the required bonus payment rises because effort becomes harder to infer from prices. When $\gamma = 0$, we recover the benchmark contract with $a^* = 1$.

financial performance informativeness (ψ_γ): $\phi_\gamma^* = \frac{p_F \psi_\gamma + (1-p_F)}{(p_F - \Delta_F)\psi_\gamma + (1 - p_F + \Delta_F)}$.

The expected cost of providing incentives under the optimal contract is

$$C_\gamma = \frac{1}{1-\frac{1}{\phi_\gamma^*}} B_F,$$

where ϕ_γ^* captures the effort informativeness of prices when the intensity of the informed investor's pro-social preferences is γ. As the informed investor's pro-social preferences strengthen, her trading strategy is increasingly affected by her private information about the firm's social cost rather than its financial performance. This shift makes governance through market monitoring less effective, increasing the cost of incentivizing managerial effort.

Corollary 4. *Sustainable investing increases the cost of providing managerial incentives. When $\gamma \in (\underline{\gamma}, \bar{\gamma})$, this cost strictly increases in the intensity of the informed investor's pro-social preferences. If $C_{\bar{\gamma}} > N\Delta_F$, then there exists a threshold $\gamma_e \in (\underline{\gamma}, \bar{\gamma})$ such that the firm's controlling shareholders optimally choose not to induce managerial effort whenever $\gamma > \gamma_e$, despite effort provision being socially efficient.*

Figure 6 illustrates how incentive costs (C_γ) vary with pro-social preferences. For weak preferences ($\gamma \leq \underline{\gamma}$), costs match the benchmark case. As preferences strengthen ($\gamma > \underline{\gamma}$), costs rise because the informed investor trades less aggressively on financial information. When these costs exceed the expected gain from effort ($N\Delta_F$), which occurs for $\gamma > \gamma_e$, shareholders optimally abandon managerial incentives. This reduction in effort represents a real efficiency loss from sustainable investing.

In our framework, sustainable investing influences corporate governance by altering the information content of stock prices, thereby affecting the cost effectiveness of market-based incentive schemes. This mechanism differs fundamentally from traditional cost-of-capital explanations for how sustainable investing affects firm behavior. For instance, Edmans et al. (2023) study a model featuring a market with limited risk-bearing capacity. The exit of sustainable investors due to the firm's negative externalities reduces the market's limited risk-bearing capacity and increases the firm's cost of capital. As a result, the firm invests less, resulting in poorer financial performance. In contrast, our model features a rational risk-neutral market, which implies that all firms have the same cost of capital. However, the exit of the informed investor due to the firm's negative

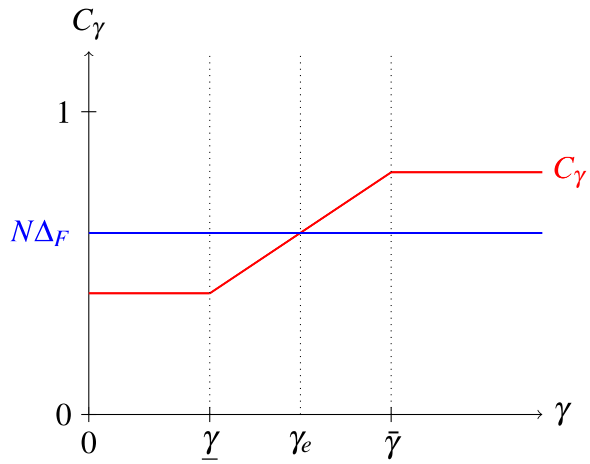

Figure 6: Cost of Incentive Provision. This figure plots the expected cost of providing incentives (C_γ) as a function of pro-social preferences (γ). For weak preferences ($\gamma \leq \underline{\gamma}$), costs equal the benchmark level. As preferences strengthen, costs increase because informed trading becomes less informative about firm fundamentals. When costs exceed the expected benefit from effort ($N\Delta_F$), shareholders optimally forgo incentive provision. The threshold γ_e represents the level of pro-social preferences above which managerial effort is no longer induced.

externalities reduces the effort informativeness of market outcomes and increases the firm's cost of providing incentives. As a result, the firm is less likely to incentivize managerial effort, leading to worse financial performance.

5.2 Sustainable Investing and "ES" and "G" Performance

Our model features two distinct dimensions of what may be captured by ESG ratings in practice. The endogenous probability of high financial payoffs, which depends on managerial effort, $p_F - \Delta_F$ or p_F, can be interpreted as a measure of governance quality—the "G" component. The exogenous probability of a low social cost, p_S, can be interpreted as a measure of environmental and social quality—the "ES" components. While the different dimensions of ESG are often viewed as unrelated,[18] our analysis reveals that sustainable investing creates an endogenous link between them through its effect on market monitoring.

The relationship between ES and G, as implied by our model, emerges through the informed investor's trading behavior. To understand this relationship, we first study the effect of p_S on the

[18] See, for example, "Is it time to separate 'E' from 'S' and 'G?," Financial Times, 14 March 2022 and "It's Time to Unbundle ESG," Harvard Business Review, 20 September 2024.

equilibrium level of informed trading τ_γ^*.

Lemma 3. *For $\gamma \leq \underline{\gamma}$, the equilibrium level of informed trading is $\tau_\gamma^* = 1$ for all p_S. For $\gamma \in (\underline{\gamma}, \bar{\gamma}(0))$, where $\bar{\gamma}(0) := \lim_{p_S \to 0} \bar{\gamma}$, there exists a unique threshold $\hat{p}_S \in (0,1)$ such that τ_γ^* is constant in p_S for $p_S < \hat{p}_S$ and strictly increases in p_S for $p_S \geq \hat{p}_S$. For $\gamma \geq \bar{\gamma}(0)$, $\tau_\gamma^* = p_S$ for all p_S.*

Lemma 3 characterizes how informed trading varies with "ES quality" captured by p_s. When pro-social preferences are weak ($\gamma \leq \underline{\gamma}$), informed trading is constant and maximal as social costs never deter trading. For moderate preferences ($\gamma \in (\underline{\gamma}, \bar{\gamma}(0))$), the relationship between informed trading and p_S depends on whether p_S is below or above a threshold $\hat{p}_S$. As illustrated in Figure 7, below this threshold, there are two forces that exactly offset, resulting in constant informed trading. A higher p_S makes the state ($F = 1, S = 0$) more likely, increasing informed trading through this extensive margin. However, this increase in the extensive margin also raises the market-clearing price for high order flow, making it less likely that the informed investor buys a share in the state ($F = 1, S = \eta$), that is, she chooses a lower a^*, decreasing informed trading through an intensive margin. The informed investor's indifference condition implies that these two opposing forces are exactly offset in our model, leaving the equilibrium level of informed trading unchanged. However, once p_S reaches $\hat{p}_S$, the informed investor switches to never buying when the social cost is high ($a^* = 0$). Beyond this point, only the extensive margin operates, and informed trading increases linearly with p_S. For strong preferences ($\gamma \geq \bar{\gamma}(0)$), the informed investor never buys when social costs are high, so informed trading simply equals p_S.

The probability of a high social cost p_S affects how informative stock prices are about managerial effort, which in turn influences governance quality. The strength of this relationship depends critically on the informed investor's pro-social preferences. We first characterize how effort informativeness of prices varies with p_S.

Proposition 3. *When $\gamma \leq \underline{\gamma}$, the effort informativeness of the firm's stock price is independent of p_S: $\frac{\partial \phi_\gamma^*}{\partial p_S} = 0$. When $\gamma \in (\underline{\gamma}, \bar{\gamma}(0))$, effort informativeness is constant in p_S for $p_S < \hat{p}_S$ and strictly increases in p_S for $p_S \geq \hat{p}_S$. When $\gamma \geq \bar{\gamma}(0)$, effort informativeness strictly increases in p_S.*

The relationship between p_S and effort informativeness depends critically on the strength of the informed investor's pro-social preferences. For weak preferences ($\gamma \leq \underline{\gamma}$), social costs do not

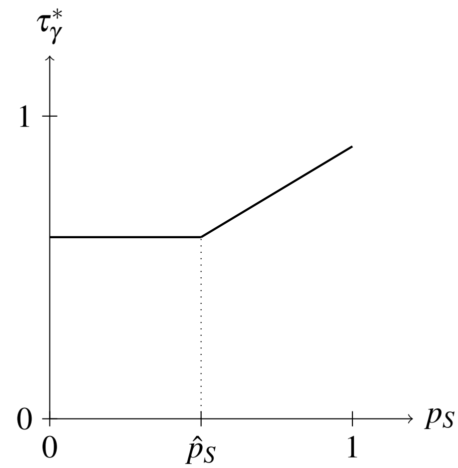

Figure 7: Equilibrium Informed Trading and p_S. This figure shows how equilibrium informed trading (τ_γ^*) varies with p_S for fixed pro-social preferences satisfying $\gamma > \underline{\gamma}$ and $\gamma < \bar{\gamma}(0)$. When p_S is low and $\gamma < \bar{\gamma}$, the informed investor follows a mixed strategy, and the intensive and extensive margin effects of higher p_S exactly offset, keeping τ_γ^* constant. Once p_S reaches the threshold $\hat{p}_S$ where $\gamma = \bar{\gamma}(\hat{p}_S)$, the informed investor switches to never buying with a high social cost ($a^* = 0$). Beyond this point, further increases in p_S raise τ_γ^* through the extensive margin effect alone.

affect trading decisions. In this case, the informed investor ignores her private information about the firm's social costs, making effort informativeness independent of p_S. For moderate preferences ($\gamma \in (\underline{\gamma}, \bar{\gamma})$), the informed investor follows a mixed strategy, requiring indifference between buying and not buying. In this region, changes in p_S have the two offsetting effects discussed earlier—the extensive margin effect of a more likely low social cost and the intensive margin effect of reduced trading with a high social cost—exactly offset, resulting in constant informed trading. For strong preferences ($\gamma \geq \bar{\gamma}$), the informed investor never buys when observing a high social cost ($a^* = 0$). While changes in the market-clearing price cannot affect this intensive margin, a higher p_S still increases informed trading through the extensive margin by making the state $(F = 1, S = 0)$ more likely. Consequently, effort informativeness increases with p_S in this region.

The preceding analysis describes local changes in p_S holding $\bar{\gamma}$ fixed. However, p_S also affects the threshold $\bar{\gamma}$ itself. Starting from $\gamma < \bar{\gamma}$, an increase in p_S lowers a^* because of the intensive margin effect. Consequently, it lowers $\bar{\gamma}$ because, at some point, the informed investor switches to never buying when the social cost is high ($a^* = 0$). When this occurs, the intensive margin can no longer adjust to offset the extensive margin effect of a higher p_S on informed trading. Consequently, effort informativeness begins to increase with p_S. This non-local effect is captured by the fact that $\bar{\gamma}$ is decreasing in p_S.

Figure 8 illustrates the effect of a discrete increase from p_S to p'_S. The red solid line shows incentive costs C_γ under the initial p_S, while the red dashed line shows costs C'_γ under the higher p'_S. The improvement in p_S has two effects: it shifts the threshold of pro-social preferences from $\bar{\gamma}$ to $\bar{\gamma}'$ and reduces incentive costs when $\gamma \geq \bar{\gamma}'$. When these costs fall below $N\Delta_F$, shareholders optimally provide managerial incentives, which can be interpreted as generating better governance outcomes for firms with higher ES quality. These effects on effort informativeness generate an endogenous relationship between ES and G quality. When pro-social preferences are weak, effort informativeness and, thus, incentive costs stay constant, resulting in governance quality that is independent of p_S. However, for sufficiently strong pro-social preferences, effort informativeness increases with p_S. A high p_S leads to more informative prices and lower incentive costs, while a low p_S results in less informative prices and higher incentive costs. This mechanism induces a positive correlation between ES and G outcomes even though the firm's initial shareholders care only about financial payoffs. In Section 6.1, we show that this relationship can induce financial shareholders to invest in improving the firm's social outcomes to capitalize on more effective market monitoring.

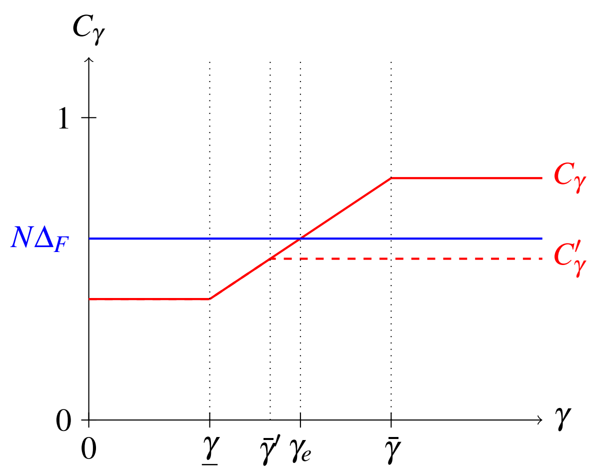

Figure 8: Effect of p_S on Incentive Costs. This figure shows how incentive costs vary with pro-social preferences (γ) for different levels of p_S. The solid red line shows the baseline incentive cost C_γ for initial p_S. The dashed red line shows incentive costs C'_γ after an increase to $p'_S > p_S$. A higher p_S shifts the threshold $\bar{\gamma}$ leftward to $\bar{\gamma}'$ and reduces incentive costs for $\gamma \geq \bar{\gamma}'$. The horizontal blue line represents the gain from managerial effort ($N\Delta_F$), below which shareholders optimally provide incentives.

5.3 Expected Returns, Price Volatility, and the Greenium

Our analysis provides insights into differences in expected and average realized returns among firms with different social costs, a central focus in the sustainable finance literature (e.g., Pastor et al., 2022), and differences in price volatility, which has received relatively less attention. We show that while expected returns may not vary with p_S, differences in average realized returns and price volatility arise naturally through the effects of sustainable investing on informed trading.

In our model, the risk-neutral market makers, who care only about financial payoffs, set prices at $t = 1$ to reflect expected financial payoffs at $t = 2$. Consequently, firms with different propensities to generate low social costs (p_S) have identical expected returns, measured by $\mathbb{E}[F - P_\gamma(q)] = 0$, implying no greenium. Importantly, this absence of a greenium does not imply that sustainable investing is not influencing financial markets, asset prices, and firm decisions. As shown in Section 5.2, pro-social preferences significantly affect equilibrium trading outcomes and firm policies.

However, the realization of social costs influences the informed investor's trading strategy and generates return differences. Define the average realized returns conditional on social costs as:

$$R_{S=0} = \mathbb{E}[F - P_\gamma(q)|S = 0],$$

and

$$R_{S=\eta} = \mathbb{E}[F - P_\gamma(q)|S = \eta].$$

which can be interpreted as the average realized returns of green and brown firms when firms are classified as such based on realized social performance.[19]

Proposition 4. *A firm with a high social cost ($S = \eta$) has higher average realized returns than one with a low social cost ($S = 0$): $R_{S=\eta} \geq R_{S=0}$, strictly so when $\tau^*_\gamma < 1$.*

Intuitively, when $\tau^*_\gamma < 1$, the informed investor sometimes foregoes buying firms with high financial payoffs ($F = 1$) but a high social cost ($S = \eta$). This reduces the incorporation of positive financial news into prices, leading to undervaluation at $t = 1$ and higher average realized returns. Because market makers set prices to reflect expected financial payoffs, we have $p_S R_{S=0} + (1 -$

[19] Note that, to simplify the analysis, we consider Dollar returns as it generates a simple linear relationship between expected and average realized returns: $p_S R_{S=0} + (1 - p_S) R_{S=\eta} = 0$.

$p_S)R_{S=\eta} = 0$, implying that higher average realized returns for high-social-cost firms and lower average realized returns for low-social-cost firms.

The impact of firms' social costs on returns thus depends critically on how they are measured empirically. When firms are classified by what can be interpreted as ex-ante ES quality (p_S), such as supply chain monitoring policies, no return differences emerge. However, when classified by ex-post performance (S), such as ES news and incidents, firms with better performance earn lower returns. This distinction may help explain the mixed empirical evidence on the existence of a greenium, generated in part by the challenge of empirically distinguishing between expected and realized returns (Pastor et al., 2022; Eskildsen et al., 2024).

Beyond returns, our framework generates predictions about price volatility. The variance of the firm's stock price at $t = 1$ is:

$$\mathrm{Var}[P_\gamma] = (1 - p_F \tau_\gamma^*)\lambda \left(P_\gamma(q=0) - p_F\right)^2 + \left(1 - (1 - p_F \tau_\gamma^*)\lambda\right)\left(P_\gamma(q>0) - p_F\right)^2.$$

Proposition 5. *For $\gamma \in (\underline{\gamma}, \bar{\gamma}(0))$, the firm's stock price volatility at $t = 1$, $\mathrm{Var}[P_\gamma]$, is constant in p_S for $p_S < \hat{p}_S$ and strictly increases in p_S for $p_S \geq \hat{p}_S$, where $\hat{p}_S$ is defined in Lemma 3. For $\gamma \geq \bar{\gamma}(0)$, stock price volatility strictly increases in p_S for all p_S.*

Figure 9 illustrates how price volatility varies with p_S. The relationship mirrors the pattern in informed trading characterized in Lemma 3. For moderate pro-social preferences ($\gamma \in (\underline{\gamma}, \bar{\gamma}(0))$) and low p_S ($p_S < \hat{p}_S$), volatility remains constant because informed trading is unchanged due to offsetting extensive and intensive margin effects. Once p_S exceeds $\hat{p}_S$, informed trading increases with p_S through the extensive margin effect alone, leading to higher price volatility as prices become more responsive to financial information. For strong pro-social preferences ($\gamma \geq \bar{\gamma}(0)$), informed trading and thus price volatility increase with p_S for all p_S. This relationship implies that empirical measures of ES quality may significantly impact second moments (volatility) through their effect on informed trading intensity even when they do not affect first moments (expected returns).

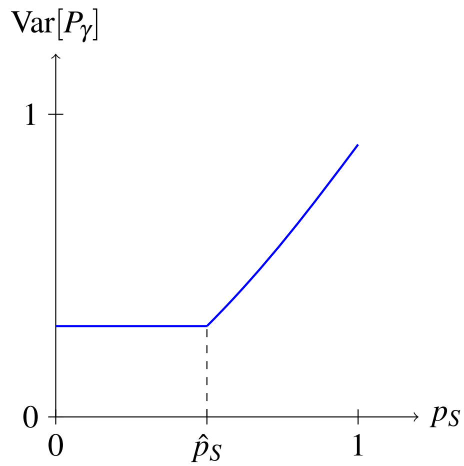

Figure 9: Price Volatility and p_S. This figure shows how price volatility (Var$[P_\gamma]$) varies with p_S for fixed pro-social preferences $\gamma \in (\underline{\gamma}, \bar{\gamma}(0))$, where $\bar{\gamma}(0)$ is defined in Lemma 3. For $p_S < \hat{p}_S$, price volatility remains constant as the equilibrium level of informed trading (τ_γ^*) is unchanged due to offsetting extensive and intensive margin effects. For $p_S \geq \hat{p}_S$, price volatility increases convexly with p_S as informed trading rises through the extensive margin effect alone. The threshold $\hat{p}_S$, implicitly defined by $\gamma = \bar{\gamma}(\hat{p}_S)$, is characterized in Lemma 3.

6 Extensions and Robustness

We explore three extensions to our baseline model. Section 6.1 examines the firm's incentives to invest in reducing the probability of a high social cost. Section 6.2 analyzes how public news about social costs affects market monitoring. Section 6.3 studies how the precision of the informed investor's signal about social costs influences governance outcomes. These extensions demonstrate the robustness of our core mechanism while yielding additional insights about the effect of sustainable investing on market-based governance.

6.1 Investment in Improving Social Performance

This section analyzes how the informed investor's pro-social preferences affect the firm's investment in reducing social costs. Specifically, we extend the model by assuming that at $t = 0$, the firm's initial controlling shareholders can make an investment at cost $c > 0$ that improves the firm's social performance by increasing the probability that its social cost is low ($S = 0$) from p_S to $p_S + \Delta_S$, where $0 < \Delta_S < 1 - p_S$.

Proposition 6. *There exists a threshold $\hat{\gamma} > \underline{\gamma}$ such that when $\gamma > \hat{\gamma}$, the investment into improving* *the firm's social performance lowers the cost of providing incentives (C_γ).*[20]

Proposition 3 implies that effort informativeness improves along with the firm's probability of a low social cost only when the informed investor has sufficiently strong pro-social preferences. When $\gamma \leq \hat{\gamma}$, the effort informativeness of the firm's stock price does not increase with p_S. As a result, the investment into improving the firm's social performance does not change the cost of providing incentives. In contrast, when the informed investor has sufficiently strong pro-social preferences ($\gamma > \hat{\gamma}$), a higher p_S increases the effort informativeness, which decreases the cost of providing incentives.

Corollary 5. *If $\gamma > \hat{\gamma}$ and inducing managerial effort is optimal for the firm's initial shareholders, then there exists a cost threshold $\bar{c} > 0$ such that they invest in improving the firm's social performance when $c \leq \bar{c}$.*

The firm's initial controlling shareholders—being financial investors—do not intrinsically value reductions in social costs. Instead, they make investments into improving the firm's social performance only if doing so lowers the cost of providing incentives for the manager, that is when the informed investor has sufficiently strong pro-social preferences ($\gamma > \hat{\gamma}$). In this case, the firm's controlling shareholders find it optimal to invest in improving its social performance, if the cost of doing so does not exceed the benefit of improved market monitoring.

Proposition 6 reveals a novel complementarity between "voice" and "exit" as mechanisms for reducing the firm's negative externalities. Specifically, when the informed investor can exit firms with poor social performance, it can motivate financial shareholders to exercise their voice to improve their firms' social performance. This complementarity between exit and voice that arises across sustainable and financial investors offers a novel perspective, as these investment strategies are typically viewed as competing approaches (e.g., Broccardo et al., 2022).

6.2 Public News about Social Costs

In this section, we examine how public news about the firm's social cost interacts with market monitoring. Specifically, we assume that there is a public signal $\sigma \in \{L, H\}$ about the firm's

[20]Note that for effort informativeness to reduce incentive costs, we require $p_S + \Delta_s > \hat{p}_S$, where $\hat{p}_S$ is defined in Lemma 3, which is equivalent to $\gamma > \hat{\gamma}$.

realized social cost after trading occurs at $t = 1$.[21] For instance, the signal may correspond to ES news and incidents (e.g., Krüger, 2015; Glossner, 2021; Derrien et al., 2022). The signal has precision $\rho \in (0,1)$, such that

$$\Pr(\sigma = L|S = 0) > \Pr(\sigma = H|S = 0),$$

$\frac{\partial \Pr(\sigma=L|S=0)}{\partial \rho} > 0$, and $\frac{\partial Pr(\sigma=L|S=\eta)}{\partial \rho} < 0$.[22] This information structure implies that observing $\sigma = L$ indicates a higher probability that the firm generates low social costs, while $\sigma = H$ signals a lower probability of low social costs. Specifically, we have

$$\underline{p}_S := \Pr(S = 0|\sigma = H) < p_S < Pr(S = 0|\sigma = L) =: \bar{p}_S.$$

An increase in ρ corresponds to a more precise signal.

This public signal helps the firm interpret the information contained in market outcomes at $t = 1$.[23] We now consider the optimal contract that can condition the manager's pay on both the order flow q and the signal σ.

Proposition 7. *When the informed investor's pro-social preferences are sufficiently strong ($\gamma > \underline{\gamma}$), an optimal incentive-compatible contract is given by*

$$W^*_\gamma(q,\sigma) = \begin{cases} 0, & \text{if } q = 0 \text{ or } \sigma = H, \\ \frac{B_F}{\Pr(\sigma=L)\Delta_F \lambda(\bar{p}_S + (1-\bar{p}_S)a^*)}, & \text{if } q > 0 \text{ and } \sigma = L, \end{cases}$$

where a^* is given by Proposition 2.

When the informed investor's pro-social preferences are sufficiently strong, Proposition 2 implies that the informed investor is less likely to trade on her private information about the firm's

[21]The assumption that the signal arrives after trading simplifies our analysis. If the signal arrives before trading, market outcomes at $t = 1$ would reflect the information contained in the signal. However, a managerial contract that conditions on both market outcomes and the signal remains optimal. In fact, the structure of the optimal incentive contract is identical to the case when the public signal realizes after trading occurs.

[22]For instance, we can set $\Pr(\sigma = L|S = 0) = \Pr(\sigma = H|S = \eta) = 1 - \frac{1}{2}(1-\rho)$, and $\Pr(\sigma = L|S = \eta) = \Pr(\sigma = H|S = 0) = \frac{1}{2}(1-\rho)$.

[23]If the signal arrives before trading at $t = 1$, then it also helps market participants update their beliefs about p_S to either $\underline{p}_S$ or $\bar{p}_S$. In this case, the market equilibrium follows Proposition 2, with $p_S = \underline{p}_S$ given a negative signal ($\sigma = H$) and with $p_S = \bar{p}_S$ given a positive signal ($\sigma = L$).

financial performance when its social cost is high. As a result, when the public signal indicates that the firm's social cost is high, the firm infers that the aggregate order flow is more likely driven by liquidity trades rather than that of the informed investor. In the extreme case where the public signal perfectly reveals the firm's high social cost ($S = \eta$) and the informed investor has very strong pro-social preferences (i.e., $\gamma > \bar{\gamma}$), the firm infers that the resulting aggregate order flow is uninformative about the manager's effort. In contrast, when the public signal indicates that the firm's social cost is low, the firm infers that the aggregate order flow is more likely to reflect information about the firm's financial payoff. A low order flow ($q = 0$) is more indicative of low financial performance ($F = 0$). A high order flow ($q > 0$) is more indicative of high financial performance ($F = 1$). Consequently, the optimal contract pays the manager only when the order flow is high and the signal indicates low social cost, which corresponds to the state with the maximum likelihood ratio.

Proposition 7 implies that the presence of compensation tied to positive news about the firm's social cost need not indicate that its controlling shareholders intrinsically value reductions in its social cost. Moreover, the firm's controlling shareholders may offer an optimal contract that features incentive pay based on the firm's social performance without intending to improve the firm's social performance. In fact, in our baseline specification, the firm's p_S is exogenous. These implications may help reconcile some conflicting evidence in the empirical literature about the effectiveness of optimal contracting in reducing firms' negative externalities (e.g., Bebchuk and Tallarita, 2022; Cohen et al., 2023).

6.3 Precision of Private Information

In our baseline model, the informed investor perfectly observes the firm's social cost S. In this section, we relax this assumption and examine how the precision of the informed investor's private information affects equilibrium. Specifically, we assume that the informed investor receives a potentially noisy private signal about the firm's social cost prior to trading at $t = 1$. The private signal $\xi \in \{L, H\}$ satisfies

$$\mathbb{E}[S|\xi = L] < (1 - p_S)\eta = \mathbb{E}[S],$$

$$\mathbb{E}[S|\xi = H] > (1 - p_S)\eta = \mathbb{E}[S],$$

$\frac{\partial \mathbb{E}[S|\xi=L]}{\partial \varepsilon} > 0$, $\frac{\partial \mathbb{E}[S|\xi=H]}{\partial \varepsilon} < 0$, where $\varepsilon \in (0,1)$ captures the amount of noise in the informed investor's private signal.[24] The expected social cost conditional on $\xi = H$ decreases with ε, while the expected social cost conditional on $\xi = L$ increases with ε. Thus, a less noisy signal leads to more dispersed conditional expectations.

To analyze the equilibrium in this setting, we need to extend the strategy space relative to the baseline model. The reason is that when $\mathbb{E}[S|\xi = L] > 0$, the informed investor may not buy with certainty upon observing a high financial payoff and a low signal ($F = 1$ and $\xi = L$), unlike in the baseline model where observing $S = 0$ and $F = 1$ always leads to buying. Specifically, let (a_L, a_H) denote the probabilities with which the informed investor buys a share upon observing $F = 1$ and signals $\xi = L$ and $\xi = H$, respectively.

Lemma 4. *The informed investor's equilibrium trading strategy must feature at least one corner solution, that is, $a_H^* \in (0,1) \Rightarrow a_L^* = 1$ or $a_L^* \in (0,1) \Rightarrow a_H^* = 0$.*

The informed investor values each share of the firm at $F - \gamma S$. A higher expected social cost reduces the informed investor's valuation. If the informed investor follows a mixed strategy when $F = 1$ and $\xi = H$ (i.e., $a_H^* \in (0,1)$), she must be indifferent between buying and not buying in that state. Since the expected social cost is strictly lower when $\xi = L$, the investor's expected utility from buying must be strictly higher than not buying in this state, breaking any potential indifference. Given this higher utility, she must strictly prefer buying and therefore choose $a_L^* = 1$. Similarly, if she follows a mixed strategy when the expected social cost is low ($a_L^* \in (0,1)$), indifference in this state implies she must strictly prefer not buying when the expected social cost is high, requiring $a_H^* = 0$.

Proposition 8. *When $a_H^* \in (0,1)$, an increase in the noise in the informed investor's signal about the firm's social cost increases effort informativeness. When $a_L^* \in (0,1)$, an increase in the noise decreases effort informativeness.*

A noisier signal decreases the dispersion in the informed investor's posterior beliefs about the firm's social cost, leading to different effects depending on the initial equilibrium. Consider

[24] For instance, we can set $\Pr(\xi = L|S = 0) = 1 - \frac{1}{2}\varepsilon$ and $\Pr(\xi = L|S = \eta) = \frac{1}{2}\varepsilon$, where the parameter $\varepsilon \in (0,1)$ captures the amount of noise in the informed investor's private signal. The baseline model corresponds to $\varepsilon \to 0$, where the signal perfectly reveals the firm's social cost. An increase in ε implies a noisier private signal. When $\varepsilon \to 1$, the signal is pure noise.

the case where $a_H^* \in (0,1)$, meaning the informed investor is initially indifferent between buying and not buying when observing a high social cost signal. As the signal becomes noisier, the conditional expectation of the social cost given a high signal decreases. This lower expected social cost makes buying more attractive to the informed investor when she learns that $F = 1$ and $\xi = H$, increasing a_H^*. This increase in informed trading based on financial information ultimately enhances effort informativeness. Conversely, when $a_L^* \in (0,1)$, additional noise in the signal raises the conditional expectation of social costs given a low signal, discouraging informed trading when the informed investor leans that $F = 1$ and $\xi = L$. The decrease in informed trading worsens effort informativeness. Lemma 4 ensures that only one of these effects operates in any given equilibrium due to the corner solution in trading strategies.

7 Conclusion

This paper identifies a novel mechanism through which sustainable investing affects firm behavior and performance. When informed investors care about firm externalities, they may choose not to trade on their private information about financial performance, reducing price informativeness for governance purposes and making it costlier to incentivize managers. This reduction in market-based governance can lead to lower managerial effort and worse financial performance, highlighting an important "agency cost of sustainable investing". However, this same mechanism can paradoxically generate positive real effects: because firms generating negative externalities face higher agency costs, purely financially motivated shareholders have incentives to reduce externalities to enhance price informativeness for governance purposes. This creates an endogenous link between firms' environmental and social performance and the effectiveness of market-based governance, revealing a previously unexplored connection between the "ES" and "G" components of ESG.

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A Proofs

Proof of Proposition 1. Consider an equilibrium in which the manager exerts effort ($e_F = 1$) and the informed investor buys one share of the firm's stock ($x = 1$) if and only if she learns that $F = 1$. In such an equilibrium, the order flow $q = x + z$ has the distribution $(1-\lambda)^q\lambda$ with support $q \in \mathbb{N}_0$ when $F = 0$, and $(1-\lambda)^{q-1}\lambda$ with support $q \in \mathbb{N}$ when $F = 1$.

The price conditional on order flow q is given by $P_0(q) = \Pr(F = 1|q)$. We have $\Pr(F = 1|q = 0) = 0$ and, for $q > 0$, we have

$$\begin{aligned}\Pr(F = 1|q > 0) &= \frac{\Pr(q > 0|F = 1)\Pr(F = 1)}{\Pr(q > 0|F = 1)\Pr(F = 1) + \Pr(q > 0|F = 0)\Pr(F = 0)} \\ &= \frac{p_F}{p_F + (1-p_F)(1-\lambda)}.\end{aligned}$$

We next confirm that the informed investor prefers to buy one share when she learns that $F = 1$. If she deviates to abstaining from buying, then her utility is equal to 0. When she indeed buys one share ($x = 1$), then $q > 0$ with probability one and the price is given by $P_0(q > 0) = \frac{p_F}{p_F+(1-p_F)(1-\lambda)} < 1$ since $p_F < 1$ and $\lambda < 1$, and thus

$$F - P_0(q > 0) = 1 - \frac{p_F}{p_F + (1-p_F)(1-\lambda)} > 0.$$

Finally, the informed investor prefers to abstain from buying when she learns that $F = 0$. If she indeed abstains from buying, then her utility is equal to 0. If she deviates to buying, then $q > 0$ and the price is given by $P_0(q > 0) = \frac{p_F}{p_F+(1-p_F)(1-\lambda)} > 0$ since $p_F > 0$. Thus, she does not deviate since

$$F - P_0(q) = -\frac{p_F}{p_F + (1-p_F)(1-\lambda)} < 0.$$

In particular, the equilibrium is unique because the expected market-clearing price at $t = 1$ must be strictly greater than zero and less than one, implying that the informed investor strictly prefers to buy upon observing $F = 1$ and to abstain when $F = 0$. ■

Proof of Lemma 1. If the manager exerts effort, then the order flow distribution is given by

$$\Pr(q=k|e_F=1)=\begin{cases}(1-p_F)\lambda, & \text{if } k=0,\\ (1-\lambda)^{k-1}\lambda\left(p_F+(1-p_F)(1-\lambda)\right), & \text{if } k>0.\end{cases}$$

If the manager does not exert effort, then the order flow distribution is given by

$$\Pr(q=k|e_F=0)=\begin{cases}(1-p_F+\Delta_F)\lambda, & \text{if } k=0,\\ (1-\lambda)^{k-1}\lambda\left(p_F-\Delta_F+(1-p_F+\Delta_F)(1-\lambda)\right), & \text{if } k>0.\end{cases}$$

Thus, we get

$$\phi_0(0)=\frac{(1-p_F)\lambda}{(1-p_F+\Delta_F)\lambda}=\frac{1-p_F}{1-p_F+\Delta_F}<1,$$

and for $k>0$, we get

$$\begin{aligned}\phi_0(k)&=\frac{(1-\lambda)^{k-1}\lambda\left(p_F+(1-p_F)(1-\lambda)\right)}{(1-\lambda)^{k-1}\lambda\left(p_F-\Delta_F+(1-p_F+\Delta_F)(1-\lambda)\right)}\\&=\frac{p_F+(1-p_F)(1-\lambda)}{p_F-\Delta_F+(1-p_F+\Delta_F)(1-\lambda)}\\&=\frac{p_F\lambda+(1-\lambda)}{(p_F-\Delta_F)\lambda+(1-\lambda)},\end{aligned}$$

which completes the proof. ■

Proof of Corollary 1. This result follows immediately from solving

$$\Pr(q>0|e_F=1)W_0^*(q>0)=\Pr(q>0|e_F=0)W_0^*(q>0)+B_F$$

for $W_0^*(q>0)$ using

$$\Pr(q>0|e_F=1)=1-(1-p_F)\lambda$$

and

$$\Pr(q>0|e_F=0)=1-(1-p_F+\Delta_F)\lambda$$

from the proof of Lemma 1. ■

Proof of Proposition 2. Consider an equilibrium in which the manager exerts effort ($e_F = 1$). Table 1 shows the distribution of the aggregate order flow in different states of the world.

F	S	$\Pr(F,S)$	Informed Trade x	Order Flow q	$\Pr(q)$
0	η	$(1-p_F)(1-p_S)$	$x=0$	$q \in \mathbb{N}_0$	$(1-\lambda)^q\lambda$
0	0	$(1-p_F)p_S$	$x=0$	$q \in \mathbb{N}_0$	$(1-\lambda)^q\lambda$
1	η	$p_F(1-p_S)(1-a)$	$x=0$	$q \in \mathbb{N}_0$	$(1-\lambda)^q\lambda$
1	η	$p_F(1-p_S)a$	$x=1$	$q \in \mathbb{N}_+$	$(1-\lambda)^{q-1}\lambda$
1	0	$p_F p_S$	$x=1$	$q \in \mathbb{N}_+$	$(1-\lambda)^{q-1}\lambda$

Table 1: Distribution of Equilibrium Aggregate Order Flow

In this case, Bayesian updating implies

$$\begin{aligned}
\Pr(F=1|q=0) &= \frac{\Pr(q=0|F=1)\Pr(F=1)}{\Pr(q=0|F=1)\Pr(F=1)+\Pr(q=0|F=0)\Pr(F=0)} \\
&= \frac{(1-p_S)(1-a)\lambda p_F}{(1-p_S)(1-a)\lambda p_F + \lambda(1-p_F)} \\
&= \frac{p_F(1-p_S)(1-a)}{p_F(1-p_S)(1-a)+(1-p_F)},
\end{aligned}$$

and

$$\begin{aligned}
\Pr(F=1|q>0) &= \frac{\Pr(q>0|F=1)\Pr(F=1)}{\Pr(q>0|F=1)\Pr(F=1)+\Pr(q>0|F=0)\Pr(F=0)} \\
&= \frac{(p_S+(1-p_S)a+(1-p_S)(1-a)(1-\lambda))p_F}{(p_S+(1-p_S)a+(1-p_S)(1-a)(1-\lambda))p_F+(1-\lambda)(1-p_F))} \\
&= \frac{p_F(1-\lambda(1-p_S)(1-a))}{p_F(1-\lambda(1-p_S)(1-a))+(1-p_F)(1-\lambda)}.
\end{aligned}$$

Hence, the market makers' pricing rule is given by

$$P_\gamma(q) = \begin{cases} \frac{p_F(1-p_S)(1-a)}{p_F(1-p_S)(1-a)+(1-p_F)}, & \text{if } q=0, \\ \frac{p_F(1-\lambda(1-p_S)(1-a))}{p_F(1-\lambda(1-p_S)(1-a))+(1-p_F)(1-\lambda)}, & \text{if } q>0. \end{cases}$$

We next solve for the informed investor's optimal trading strategy. To begin with, note that it is straightforward to confirm that the informed investor prefers to buy one share when she learns that $F=1$ and $S=0$ and to abstain from buying when she learns that $F=0$. What remains to be determined is the optimal trading strategy when $F=1$ and $S=\eta$. First, consider an equilibrium with $a = 1$, which requires

$$1 - P_\gamma(q>0)\big|_{a=1} - \gamma\eta \geq 0 \Leftrightarrow \gamma \leq \frac{1}{\eta}\left(1 - P_\gamma(q>0)\big|_{a=1}\right) = \frac{(1-p_F)(1-\lambda)}{\eta(1-(1-p_F)\lambda)} =: \underline{\gamma}.$$

Second, consider an equilibrium with $a = 0$, which requires

$$1 - P_\gamma(q>0)\big|_{a=0} - \gamma\eta \leq 0 \Leftrightarrow \gamma \geq \frac{1}{\eta}\left(1 - P_\gamma(q>0)\big|_{a=0}\right) = \frac{(1-p_F)(1-\lambda)}{\eta(1-(1-p_F p_S)\lambda)} =: \bar{\gamma}.$$

Note that $\underline{\gamma} < \bar{\gamma}$ since $p_S < 1$.

Second, consider an equilibrium with $a \in (0,1)$, which requires

$$1 - P_\gamma(q>0) - \gamma\eta = 0 \Leftrightarrow a^* = \frac{(1-p_F)(1-\lambda) - \gamma\eta(1-(1-p_F p_S)\lambda)}{\gamma\eta p_F \lambda(1-p_S)}. \tag{2}$$

We have that $a^* \in (0,1) \Leftrightarrow \gamma \in (\underline{\gamma}, \bar{\gamma})$ with $a^* = 1$ if $\gamma = \underline{\gamma}$ and $a^* = 0$ if $\gamma = \bar{\gamma}$. Moreover, a^* is a strictly decreasing function of γ on $[\underline{\gamma}, \bar{\gamma}]$. Hence, the informed investor's optimal trading strategy is a continuous decreasing function of γ for $\gamma \in [0,1]$. In particular, the equilibrium is unique. ■

Proof of Lemma 2. Let $\tau^*_\gamma := p_S + (1-p_S)a^*$ be the equilibrium level of informed trading. If the manager exerts effort, then the order flow distribution is given by

$$\Pr(q=k|e_F=1) = \begin{cases} \left[(1-p_F) + p_F(1-\tau^*_\gamma)\right]\lambda, & \text{if } k=0, \\ \left[p_F\tau^*_\gamma + \left(1-p_F+p_F(1-\tau^*_\gamma)\right)(1-\lambda)\right](1-\lambda)^{k-1}\lambda, & \text{if } k>0. \end{cases}$$

If the manager does not exert effort, then the order flow distribution is given by

$$\Pr(q=k|e_F=0) = \begin{cases} \left[(1-p_F+\Delta_F) + (p_F-\Delta_F)(1-\tau^*_\gamma)\right]\lambda, & \text{if } k=0, \\ \left[(p_F-\Delta_F)\tau^*_\gamma + \left(1-p_F+\Delta_F+(p_F-\Delta_F)(1-\tau^*_\gamma)\right)(1-\lambda)\right](1-\lambda)^{k-1}\lambda, & \text{if } k>0. \end{cases}$$

Thus we get

$$\phi_\gamma(0) = \frac{1-p_F+p_F(1-\tau^*_\gamma)}{1-p_F+\Delta_F+(p_F-\Delta_F)(1-\tau^*_\gamma)} < 1,$$

and for $k > 0$, we get

$$\phi_\gamma(k) = \frac{p_F \tau_\gamma^* + \big(1 - p_F + p_F(1-\tau_\gamma^*)\big)(1-\lambda)}{(p_F - \Delta_F)\tau_\gamma^* + \big(1 - p_F + \Delta_F + (p_F - \Delta_F)(1-\tau_\gamma^*)\big)(1-\lambda)} > 1.$$

Substituting in $\tau_\gamma^* = p_S + (1-p_S)a^*$ into the expressions above completes the proof. ■

Proof of Corollary 2. The maximum likelihood ratio increases in a^* for $a^* \in (0,1)$:

$$\frac{\partial \phi_\gamma^*}{\partial a^*} = \frac{\Delta_F(1-p_S)\lambda(1-\lambda)}{(1-\lambda+(p_S+(1-p_S)a^*)(p_F-\Delta_F)\lambda)^2} > 0.$$

Moreover, a^* decreases in γ for $\gamma \in (\underline{\gamma}, \bar{\gamma})$:

$$\frac{\partial a^*}{\partial \gamma} = -\frac{(1-\lambda)(1-p_F)}{\eta\gamma^2\lambda p_F(1-p_S)} < 0.$$

Hence, the maximum likelihood ratio weakly decreases in γ, strictly so when $\gamma \in (\underline{\gamma}, \bar{\gamma})$. ■

Proof of Corollary 3. This result follows immediately from solving

$$\Pr(q > 0 | e_F = 1) W_0^*(q > 0) = \Pr(q > 0 | e_F = 0) W_0^*(q > 0) + B_F$$

for $W_0^*(q > 0)$ using

$$\Pr(q > 0 | e_F = 1) = 1 - \big[(1-p_F) + p_F(1-\tau_\gamma^*)\big]\lambda$$

and

$$\Pr(q > 0 | e_F = 0) = 1 - \big[(1-p_F+\Delta_F) + (p_F-\Delta_F)(1-\tau_\gamma^*)\big]\lambda$$

from the proof of Lemma 2. ■

Proof of Corollary 4. This result follows immediately from Assumption 1, which can be written as $C_{\underline{\gamma}} < N\Delta_F$, and the fact that C_γ is strictly increasing for $\gamma \in (\underline{\gamma}, \bar{\gamma})$. ■

Proof of Lemma 3. As shown in Proposition 2, when $\gamma \leq \underline{\gamma}$, the informed investor always buys upon observing $F = 1$ regardless of S (i.e., $a^* = 1$). In this case, we therefore have $\tau_\gamma^* = p_S + (1 -$

$p_S)a^* = 1$ for all p_S.

Define $\bar{\gamma}(0) := \lim_{p_S \to 0} \bar{\gamma}$ and $\bar{\gamma}(1) := \lim_{p_S \to 1} \bar{\gamma}$. We have

$$\bar{\gamma}(0) = \frac{1}{\eta}(1 - p_F)$$

and

$$\bar{\gamma}(1) = \frac{(1 - p_F)(1 - \lambda)}{\eta(p_F \lambda + (1 - \lambda))} = \frac{(1 - p_F)(1 - \lambda)}{\eta(p_F + (1 - p_F)(1 - \lambda))} = \underline{\gamma}.$$

Furthermore, $\bar{\gamma}$ is strictly decreasing in p_S:

$$\frac{\partial \bar{\gamma}}{\partial p_S} = -\frac{1}{\eta} \frac{p_F(1 - p_F)\lambda(1 - \lambda)}{(1 - \lambda + p_F p_S \lambda)^2} < 0.$$

The intermediate value theorem implies that if $\gamma \in (\underline{\gamma}, \bar{\gamma}(0))$, then there exists a unique $\hat{p}_S \in (0,1)$ such that $\gamma = \bar{\gamma}(\hat{p}_S)$. Solving for $\hat{p}_S$ yields

$$\hat{p}_S = \frac{\big((1 - p_F) - \gamma\eta\big)(1 - \lambda)}{\gamma\eta p_F \lambda}.$$

For $p_S < \hat{p}_S$, we have $\gamma < \bar{\gamma}(p_S)$, so the informed investor follows a mixed strategy $a^* \in (0,1)$. Equilibrium informed trading is given by $\tau_\gamma^* = p_S + (1 - p_S)a^*$, where a^* adjusts to maintain indifference. Specifically, we have

$$\begin{aligned} a^* &= \frac{(1 - p_F)(1 - \lambda) - \gamma\eta(1 - (1 - p_F p_S)\lambda)}{\gamma\eta p_F \lambda(1 - p_S)} \\ &= \frac{(1 - \gamma\eta)(1 - p_F)(1 - \lambda)}{\gamma\eta p_F \lambda(1 - p_S)} - \frac{p_S}{\lambda(1 - p_S)} - \frac{1 - \lambda}{\lambda}, \end{aligned}$$

which implies that

$$\frac{\partial a^*}{\partial p_S} = \frac{(1 - \gamma\eta)(1 - p_F)(1 - \lambda)}{\gamma\eta p_F \lambda(1 - p_S)^2} - \frac{1}{\lambda(1 - p_S)^2}.$$

Taking the derivative of τ_γ^* with respect to p_S yields

$$\begin{aligned}\frac{\partial \tau_\gamma^*}{\partial p_S} &= 1-a^*+(1-p_S)\tfrac{\partial a^*}{\partial p_S}\\ &= \underbrace{\frac{1}{\lambda(1-p_S)}-\frac{(1-\gamma\eta)(1-p_F)(1-\lambda)}{\gamma\eta p_F\lambda(1-p_S)}}_{=1-a^*}+\underbrace{\left(\frac{(1-\gamma\eta)(1-p_F)(1-\lambda)}{\gamma\eta p_F\lambda(1-p_S)}-\frac{1}{\lambda(1-p_S)}\right)}_{=(1-p_S)\frac{\partial a^*}{\partial p_S}}\\ &= 0.\end{aligned}$$

For $p_S > \hat{p}_S$, we have $\gamma > \bar{\gamma}(p_S)$, so $a^* = 0$ and thus $\tau_\gamma^* = p_S$, which strictly increases in p_S with slope 1. For $\gamma \geq \bar{\gamma}(0)$, we have $\gamma \geq \bar{\gamma}(p_S)$ for all p_S, so $a^* = 0$ and thus $\tau_\gamma^* = p_S$ for all p_S. ■

Proof of Proposition 3. Recall that

$$\phi_\gamma^* = \frac{\lambda p_F \tau_\gamma^* + (1-\lambda)}{\lambda(p_F-\Delta_F)\tau_\gamma^*+(1-\lambda)},$$

which strictly increases in τ_γ^*:

$$\frac{\partial \phi_\gamma^*}{\partial \tau_\gamma^*} = \frac{\lambda(1-\lambda)\Delta_F}{(\lambda(p_F-\Delta_F)\tau_\gamma^*+(1-\lambda))^2} > 0.$$

Applying Lemma 3 completes the proof. ■

Proof of Proposition 4. Proposition 2 implies that

$$\begin{aligned}R_{S=0} &= \underbrace{p_F}_{=\mathbb{E}[F]} - \underbrace{\left((1-p_F)\lambda\left(\tfrac{p_F(1-\tau_\gamma^*)}{1-p_F\tau_\gamma^*}\right)+\big(1-(1-p_F)\lambda\big)\left(\tfrac{p_F(1-\lambda+\lambda\tau_\gamma^*)}{1-\lambda+p_F\lambda\tau_\gamma^*}\right)\right)}_{=\mathbb{E}[P_\gamma(q)|S=0]}\\ &= -p_F^2(1-p_F)\lambda\left(\tfrac{\tau_\gamma^*(1-\tau_\gamma^*)}{(1-\lambda+p_F\lambda\tau_\gamma^*)(1-p_F\tau_\gamma^*)}\right).\end{aligned}$$

Thus, $R_{S=0} \leq 0$, strictly so when $\tau_\gamma^* < 1$.

Further, we have

$$R_{S=\eta} = \underbrace{p_F}_{=\mathbb{E}[F]} - \underbrace{\left((1-p_F a^*)\lambda \left(\frac{p_F(1-\tau_\gamma^*)}{1-p_F\tau_\gamma^*}\right) + \left(1-(1-p_F a^*)\lambda\right)\left(\frac{p_F(1-\lambda+\lambda\tau_\gamma^*)}{1-\lambda+p_F\lambda\tau_\gamma^*}\right)\right)}_{=\mathbb{E}[P_\gamma(q)|S=\eta]}$$
$$= p_F^2(1-p_F)\lambda\left(\frac{\tau_\gamma^* p_S(1-a^*)}{(1-\lambda+p_F\lambda\tau_\gamma^*)(1-p_F\tau_\gamma^*)}\right).$$

Thus, $R_{S=\eta} \geq 0$, strictly so when $\tau_\gamma^* < 1 \Leftrightarrow a^* < 1$. ■

Proof of Proposition 5. Let $\text{Var}[P_\gamma]$ be the variance of the firm's stock price at $t = 1$ as a function of the equilibrium level of informed trading:

$$\text{Var}[P_\gamma] = \left(1-p_F+p_F(1-\tau_\gamma^*)\right)\lambda\left(\frac{1-\tau_\gamma^*}{1-p_F\tau_\gamma^*}p_F - p_F\right)^2$$
$$+\left(\left(1-p_F+p_F(1-\tau_\gamma^*)\right)(1-\lambda)+p_F\tau^*\right)\left(\frac{1-\lambda+\lambda\tau_\gamma^*}{1-\lambda+p_F\lambda\tau_\gamma^*}p_F - p_F\right)^2$$
$$= p_F^2(1-p_F)^2\lambda\left(\frac{\tau_\gamma^{*2}}{1-p_F\tau_\gamma^*} + \lambda\frac{\tau_\gamma^{*2}}{1-\lambda+p_F\lambda\tau_\gamma^*}\right).$$

Taking the derivative of $\text{Var}[P]$ with respect to τ_γ^* yields

$$\frac{\partial\,\text{Var}[P_\gamma]}{\partial\tau_\gamma^*} = p_F^2(1-p_F)^2\lambda\left(\frac{\tau_\gamma^*(2-\tau_\gamma^* p_F)}{(1-p_F\tau_\gamma^*)^2} + \lambda\frac{2\tau_\gamma^*(1-\lambda)+\tau_\gamma^{*2}p_F\lambda}{(1-\lambda+p_F\lambda\tau_\gamma^*)^2}\right) > 0.$$

Applying Lemma 3 completes the proof. ■

Proof of Proposition 6. Recall that the effort informativeness is

$$\phi_\gamma^* = \frac{\lambda p_F\tau_\gamma^* + (1-\lambda)}{\lambda(p_F-\Delta_F)\tau_\gamma^* + (1-\lambda)},$$

and the cost of incentivizing effort under the optimal incentive-compatible contract is

$$C_\gamma = \frac{B_F}{1-\frac{1}{\phi_\gamma^*}}.$$

Let $\phi_\gamma^*(p_S+\Delta_S)$ and $\phi_\gamma^*(p_S)$ be the effort informativeness of the firm's stock price with and without the investment in improving social performance, respectively.

Proposition 3 implies that when $\gamma \leq \hat{\gamma}$, where $\hat{\gamma}$ is the threshold $\bar{\gamma}$ when we replace p_S with $p_S+\Delta_S$, $\phi^*_\gamma(p_S+\Delta_S) = \phi^*_\gamma(p_S)$. When $\gamma > \hat{\gamma}$, Proposition 3 implies that $\phi^*_\gamma(p_S+\Delta_S) > \phi^*_\gamma(p_S)$. ■

Proof of Corollary 5. The firm's initial controlling shareholders optimally invest in improving p_S if and only if

$$\underbrace{Np_F - c - \frac{B_F}{1-\frac{1}{\phi^*_\gamma(p_S+\Delta_S)}}}_{\text{Expected payoff with investment}} \geq \underbrace{Np_F - \frac{B_F}{1-\frac{1}{\phi^*_\gamma(p_S)}}}_{\text{Expected payoff without investment}},$$

which can be rewritten as

$$c \leq \frac{B_F(\phi^*_\gamma(p_S+\Delta_S) - \phi^*_\gamma(p_S))}{(\phi^*_\gamma(p_S+\Delta_S)-1)(\phi^*_\gamma(p_S)-1)} =: \bar{c}.$$

Proposition 3 implies that when $\gamma \leq \hat{\gamma}$, where $\hat{\gamma}$ is the threshold $\bar{\gamma}$ when we replace p_S with $p_S+\Delta_S$, $\phi^*_\gamma(p_S+\Delta_S) = \phi^*_\gamma(p_S)$. Hence, when $\gamma \leq \hat{\gamma}$, the firm's controlling shareholders do not pay c to increase p_S. When $\gamma > \hat{\gamma}$, Proposition 3 implies that $\phi^*_\gamma(p_S+\Delta_S) > \phi^*_\gamma(p_S)$. Since $\phi^*_\gamma > 1$, we get $\bar{c} > 0$. ■

Proof of Proposition 7. Under the assumption that the manager exerts effort ($e_F = 1$) so that $\Pr(F = 1) = p_F$, the equilibrium market outcomes at $t = 1$ do not depend on the realization of σ, which arrives after trading. The informed investor's equilibrium trading strategy is given by a^* as defined in Proposition 2. Let $\phi^*_\gamma(\sigma = L)$ correspond to the likelihood ratio for $(q > 0, \sigma = L)$, which is given by

$$\frac{p_F(1-\bar{p}_S)(1-a^*)(1-\lambda) + p_F(1-\bar{p}_S)a^* + p_F\bar{p}_S + (1-p_F)(1-\lambda)}{(p_F-\Delta_F)(1-\bar{p}_S)(1-a^*)(1-\lambda) + (p_F-\Delta_F)(1-\bar{p}_S)a^* + (p_F-\Delta_F)\bar{p}_S + (1-p_F+\Delta_F)(1-\lambda)}$$

and can be rewritten as

$$\frac{\lambda p_F \tau^*_\gamma(\bar{p}_S) + (1-\lambda)}{\lambda(p_F-\Delta_F)\tau^*_\gamma(\bar{p}_S) + (1-\lambda)},$$

where $\tau^*_\gamma(\bar{p}_S) := \bar{p}_S + (1-\bar{p}_S)a^*$.

Similarly, the likelihood ratio for $(q > 0, \sigma = H)$ can be expressed as

$$\phi^*_\gamma(\sigma = H) = \frac{\lambda p_F \tau^*_\gamma(\underline{p}_S) + (1-\lambda)}{\lambda(p_F-\Delta_F)\tau^*_\gamma(\underline{p}_S) + (1-\lambda)},$$

where $\tau_\gamma^*(\underline{p}_S) = \underline{p}_S + (1-\underline{p}_S)a^*$.

Note that $\phi_\gamma^*(\sigma = L) \geq \phi_\gamma^*(\sigma = H)$, with a strict inequality when $a^* < 1$. Thus, an optimal incentive-compatible contract pays the manager a bonus $W_\gamma^*(q > 0, \sigma = L)$ in the state $(q > 0, \sigma = L)$, binding the manager's incentive constraint:

$$\Pr(q > 0, \sigma = L | e_F = 1) W_\gamma^*(q > 0, \sigma = L) = \Pr(q > 0, \sigma = L | e_F = 0) W_\gamma^*(q > 0) + B_F,$$

which can be rewritten as

$$\begin{aligned} W_\gamma^*(q > 0, \sigma = L) &= \frac{B_F}{\Pr(q > 0, \sigma = L | e_F = 1) - \Pr(q > 0, \sigma = L | e_F = 0)} \\ &= \frac{B_F}{\Pr(\sigma = L)(\Pr(q > 0 | e_F = 1, p_S = \bar{p}_S) - \Pr(q > 0 | e_F = 0, p_S = \bar{p}_S))} \\ &= \frac{B_F}{\Pr(\sigma = L)\Delta_F \lambda \tau_\gamma^*(\bar{p}_S)}. \end{aligned}$$

There are two cases to consider: $\gamma > \underline{\gamma}$ and $\gamma \leq \underline{\gamma}$. In the first case, $a^* < 1$, implying that the maximum likelihood ratio corresponds uniquely to $(q > 0, \sigma = L)$. The optimal contract only pays the manager when $\sigma = L$ and $q > 0$. In the second case, $a^* = 1$, implying that the maximum likelihood ratio is achieved in either state $(q > 0, \sigma = L)$ or $(q > 0,\ \sigma = H)$. In this case, the contract identified by the proposition remains optimal but generates the same cost as the one identified in the baseline model. ■

Proof of Lemma 4. Suppose for contradiction that there exists an equilibrium in which both components of the informed investor's trading strategy are interior: $a_H^* \in (0,1)$ and $a_L^* \in (0,1)$. Let $P_\gamma(q > 0)$ be the equilibrium market-clearing price when $q > 0$, respectively. Because $a_H^* \in (0,1)$, the informed investor must be indifferent between buying and not buying upon observing $F = 1$ and $\xi = H$, which implies that $1 - P_\gamma(q > 0) - \gamma\mathbb{E}[S|\xi = H] = 0$. However, since $\mathbb{E}[S|\xi = L] < \mathbb{E}[S|\xi = H]$, it must be that $1 - P_\gamma(q > 0) - \gamma\mathbb{E}[S|\xi = L] > 0$, which implies that the informed investor strictly prefers to buy upon observing $F = 1$ and $\xi = L$, a contradiction. Finally, since $1 - P_\gamma(q > 0) - \gamma\mathbb{E}[S|\xi = L] > 1 - P_\gamma(q > 0) - \gamma\mathbb{E}[S|\xi = H]$, implies that $a_H^* \in (0,1) \Rightarrow a_L^* = 1$ or $a_L^* \in (0,1) \Rightarrow a_H^* = 0$. ■

Proof of Proposition 8. In the first case ($a_H^* \in (0,1)$), the market equilibrium is characterized by Proposition 2, replacing the high and low social costs, $S = 0$ and $S = \eta$ with $\mathbb{E}[S|\xi = L]$ and $\mathbb{E}[S|\xi = H]$, respectively. In particular, the informed investor's trading strategy upon observing $F = 1$ and $\xi = H$ is

$$a_H^* = \frac{(1-p_F)(1-\lambda) - \gamma\mathbb{E}[S|\xi = H](1-(1-p_F p_S)\lambda)}{\gamma\mathbb{E}[S|\xi = H] p_F \lambda (1-p_S)},$$

which implies that the equilibrium level of informed trading is

$$\tau_H^* = p_\xi + (1-p_\xi)a_H^* = \frac{(1-\lambda)\big((1-p_F) - \gamma\mathbb{E}[S|\xi = H]\big)}{\gamma p_F \lambda \mathbb{E}[S|\xi = H]}.$$

Note that τ_H^* is decreasing in $\mathbb{E}[S|\xi = H]$. A reduction in the noisiness of the informed investor's signal maintaining $a_H^* \in (0,1)$ (i.e., a small increase in ε) increases $\mathbb{E}[S|\xi = H]$ and, in turn, lowers a_H^*. This reduction in informed trading reduces effort informativeness.

In the second case ($a_L^* \in (0,1)$), we have $a_H^* = 0$ by Lemma 4. The remainder of the proof follows the logic of Proposition 2. Define $p_\xi := \Pr(\xi = L)$ Table 2 shows the distribution of the aggregate order flow in different states of the world.[25]

F	ξ	$\Pr(F,S)$	Informed Trade x	Order Flow q	$\Pr(q)$
0	H	$(1-p_F)(1-p_\xi)$	$x = 0$	$q \in \mathbb{N}_0$	$\lambda(1-\lambda)^q$
0	L	$(1-p_F)p_\xi$	$x = 0$	$q \in \mathbb{N}_0$	$\lambda(1-\lambda)^q$
1	H	$p_F(1-p_\xi)$	$x = 0$	$q \in \mathbb{N}_0$	$\lambda(1-\lambda)^q$
1	L	$p_F p_\xi (1-a_L)$	$x = 0$	$q \in \mathbb{N}_0$	$\lambda(1-\lambda)^q$
1	L	$p_F p_\xi a_L$	$x = 1$	$q \in \mathbb{N}_+$	$\lambda(1-\lambda)^{q-1}$

Table 2: Distribution of Equilibrium Aggregate Order Flow

Bayesian updating for F implies that the market makers' pricing rule is given by

$$P_\gamma(q > 0) = \frac{p_F(1-\lambda+\lambda p_\xi a_L)}{p_F(1-\lambda+\lambda p_\xi a_L)+(1-p_F)(1-\lambda)}.$$

By assumption, $a_L \in (0,1)$, which means that the informed investor must be indifferent between

[25] Note that in the example provided in Footnote 24, we have $p_\xi = p_S$.

buying one share and buying none upon observing that $F = 1$ and $\xi = L$:

$$1 - \frac{p_F(1-\lambda+\lambda p_\xi a_L)}{p_F(1-\lambda+\lambda p_\xi a_L)+(1-p_F)(1-\lambda)} - \gamma\mathbb{E}[S|\xi = L] = 0. \tag{3}$$

Rearranging (3) yields

$$a_L^* = \frac{(1-\lambda)(1-p_F-\gamma\mathbb{E}[S|\xi = L])}{\gamma\mathbb{E}[S|\xi = L]\lambda p_F p_\xi},$$

which implies that the equilibrium level of informed trading is

$$\tau_L^* = p_\xi a_L^* = \frac{(1-\lambda)(1-p_F-\gamma\mathbb{E}[S|\xi = L])}{\gamma\mathbb{E}[S|\xi = L]\lambda p_F}.$$

Note that τ_L^* is decreasing in $\mathbb{E}[S|\xi = L]$. A less noisy signal corresponds to a lower $\mathbb{E}[S|\xi = L]$. Hence, a less noisy signal corresponds to more informed trading and improved effort informativeness. ■