Disclosure Standards, Investment Externalities, and CSR *

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Abstract

Modern firm investments, such as corporate social responsibility (CSR) and research and development (R&D) activities, often generate positive externalities that firms do not fully internalize. Firms follow different disclosure standards, ranging from full disclosure to simplified categorical ratings, to demonstrate these investments to stakeholders. In this paper, we develop a disclosure model to study how these standards affect firms' investment incentives. Our analysis shows that simplified disclosure, while less informative, can induce some firms to overinvest, thereby partially internalizing externalities and increasing social welfare. Our paper informs policymakers' design of disclosure standards and materiality thresholds for externality-generating investments.

Keywords: Corporate social responsibility, disclosure, investment, public policy, stakeholders

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1 Introduction

Firm investments can generate positive externalities in various settings, including environmentally friendly technologies, workplace safety initiatives, and socially beneficial research and development (R&D). Information disclosure about these investments â€" often structured through reporting requirements or transparency policies â€" not only reflects firms' investment activities but can also influence their investment decisions. In this paper, we study how information disclosure affects firms' investment behavior. In a nutshell, we find that simplified disclosure structures, such as categorical ratings or measures incorporating a materiality threshold, can encourage greater socially beneficial investment compared to more granular disclosure formats. As a result, simplified disclosures, in addition to having lower implementation costs, may be preferred by policymakers.

Firm investments that generate externalities and interact with disclosure standards are relevant in many real-world settings. A leading example concerns firms' climate-related investments. When firms allocate resources to renewable energy infrastructure, carbon capture technologies, or energy-efficient production systems, they create substantial positive externalities â€" including reduced greenhouse gas emissions, improved air quality, and accelerated green technology diffusion.

Climateâ€'related investment disclosure takes different formats. For example, in the European Union (EU) it has evolved from no or highly aggregated disclosure to detailed quantitative reporting and, more recently, to simplified or thresholdâ€'based regimes.[1] Early voluntary Environmental, Social, and Governance (ESG) reporting often provided only highâ€'level narrative or aggregate sustainability figures. The EU Taxonomy Regulation then marked a shift toward full, activityâ€'level quantitative disclosure of green capital and operational expenditures.[2] In

[1] A broadly similar trend appears in the United States. As adopted in March 2024, the SEC's final climate disclosure rule would have required registrants to provide detailed climateâ€'related risk disclosures and to report several key quantitative items, including Scope 1 and 2 emissions, subject to traditional materiality assessments and issuerâ€'size thresholds. However, in March 2025, the SEC voted to end its defense of these climate disclosure rules in ongoing litigation. See SEC "The Enhancement and Standardization of Climate-Related Disclosures for Investors" (Final Rule, 2024); SEC "SEC Votes to End Defense of Climate Disclosure Rules," Press Release No. 2025â€'58.

[2] See the EU regulation: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32020R0852.

parallel, private rating agencies such as MSCI developed simplified, categorical disclosure formats that compress firms' underlying environmental investments and climate performance into discrete letterâ€'grade ratings from AAA to CCC.[3] More recently, the EU has started to roll back the previous level of detail in mandatory climateâ€'related disclosures. The ESG Omnibus Simplification Package shifts the EU Taxonomy away from highly granular reporting toward more streamlined templates, substantially reducing the number of required datapoints and introducing materiality thresholds for Taxonomy assessments.[4]

Another salient example involves firms' R&D investment, a core business activity that can generate significant positive externalities through knowledge spillovers and technological progress that firms do not fully capture (e.g., Arora et al., 2021). Meanwhile, R&D disclosure plays a critical role in investors' assessment of firm value. In practice, R&D disclosure varies across regimes. For example, under U.S. GAAP, public companies must disclose most total R&D expenditures in financial statements.[5] Under IFRS, development expenditures are capitalized and separately disclosed only when projects meet certain criteria; otherwise, they are expensed. In addition, the Chinese government offers High-Tech Enterprise Recognition â€" a national qualification certification that reveals whether a firm's R&D investment exceeds statutory thresholds.[6] These different disclosure formats â€" detailed or simplified â€" can have distinct effects on firms' incentives to invest in R&D.

In this paper, we develop a model to study how disclosure standards affect firms' investment decisions when those investments generate externalities. For brevity, we hereafter refer to such investments as CSR investments to emphasize their external effects, while noting that our implications also apply to other investments â€" such as R&D â€" that generate externalities valued by regulators but potentially ignored by firms.

[3] See MSCI's ESG Ratings Methodology (2024).

[4] See European Commission. (2025). Commission simplifies rules on sustainability and EU investments (ESG Omnibus Simplification Package), Press Release IP/25/614, 25 February 2025

[5] The only exception is software development costs.

[6] See *Administrative Measures for the Recognition of High-tech Enterprises*, 2016, Ministry of Science and Technology, Ministry of Finance, and State Administration of Taxation.

We model a market in which firms differ in their marginal returns to CSR.[7] Firms invest in CSR initiatives and disclose them to stakeholders to maximize expected profits. The greater the stakeholders' perceived level of investment, the greater the benefits to the firm. Disclosure must follow a standard set by a public policymaker who values both firm profits and total CSR investment, and thus seeks to balance the two. Because firms do not fully internalize the positive externalities generated by CSR investment, the investment level that is optimal from a firm's private perspective need not coincide with the policymaker's preferred level. In line with typical practice, we consider three types of disclosure standards: (i) nondisclosure, under which firms do not disclose any information regarding their CSR investments; (ii) full disclosure, under which firms disclose the exact amount of their CSR investments; and (iii) discrete disclosure, under which firms only disclose whether or not their CSR investment passes a pre-specified threshold set according to public policy. We then compare equilibrium outcomes under the three disclosure standards to examine their impacts on firm investment behavior and social welfare.

Our model delivers several notable results. First, firms do not invest in CSR under a nondisclosure regime but choose their privately optimal investment under full disclosure. When CSR allocations are unobservable, stakeholders must rely on fixed conjectures; given these fixed beliefs, firms have no incentive to incur the cost of CSR and therefore rationally refrain from investing under nondisclosure. Under full disclosure, by contrast, each dollar of CSR investment is observed and rewarded by stakeholders, so firms invest up to the point where the marginal cost equals their respective marginal return. This condition characterizes the firm's private optimum, not necessarily the social optimum, because firms do not fully internalize the external benefits of CSR investment.

Interestingly, under discrete disclosure, the investment decision becomes binary: firms either invest at exactly the threshold level or do not invest at all. The reason is that, if a firm's investment does not cross the threshold, stakeholders retain their fixed conjectures regarding firm value, which causes the firm to not invest at all. Once the firm meets the threshold and this information

[7] An alternative interpretation is that firms have investors with heterogeneous CSR preferences who value CSR investments differently.

is disclosed, stakeholders correctly surmise that the firm invests at the threshold level, and the firm has no reason to invest beyond that level.

Relative to full disclosure, both under- and over-investment can arise under discrete disclosure, depending on the firm's marginal return to CSR. Because a firm's investment strategy is binary under discrete disclosure, it either distorts its investment level *downward* to zero to avoid costly (and unobserved) expenditures into CSR or *upward* to the disclosure threshold to then signal this qualification to stakeholders. When its marginal return to CSR is low, the firm prefers downward distortion and, therefore, underinvests in CSR. When its marginal return to CSR is high (but not too high), the firm prefers upward distortion and, therefore, overinvests in CSR.

Second, we find that disclosure standards significantly impact the payoff of public policymakers. When the policymaker is primarily concerned with firm profits, they prefer full disclosure to discrete disclosure; however, when they are primarily concerned with CSR investment, discrete disclosure yields a (weakly) higher payoff than full disclosure. This is because, by strategically choosing a disclosure threshold, the public policymaker can induce more firms to overinvest (or underinvest less) in CSR activities, thereby generating a higher aggregate CSR investment. Though the firms are worse off making privately suboptimal investment decisions, the policymaker is overall better off due to more CSR investments. As such, detailed disclosure policies are not always better, and public policymakers are recommended to set strategic disclosure standards to induce their desired outcomes. This finding also justifies the prevalence of discrete CSR/ESG ratings, especially when addressing firms that underinvest in CSR.

Finally, we consider two extensions to discrete disclosure: multiple levels of discrete disclosure and censored disclosure. Under multiple levels of discrete disclosure, the public policymaker establishes categories based on the level of CSR investment and discloses which category a firm belongs to. Under censored disclosure, the public policymaker sets a disclosure threshold below which nothing is disclosed. When a firm's investment exceeds this threshold, however, the policymaker discloses the exact amount the firm invested in CSR activities.

We show that both multi-level discrete disclosure and censored disclosure induce greater CSR

investment than full disclosure and raise the public policymaker's payoff. Censored disclosure also supports the use of materiality thresholds â€" disclosing only when investment is significant. This aligns with the aforementioned EU Taxonomy for sustainable activities, which requires disclosing specific green investments that qualify as "environmentally sustainable," i.e., meet certain sustainable thresholds.

Our results provide novel empirical and regulatory implications. In particular, we show that even when CSR investments can be measured precisely, a regulator that cares sufficiently about the magnitudes of such investments may prefer discrete or partial disclosure to induce overinvestment. Our result also justifies disclosing CSR investments only if they surpass some materiality threshold (e.g., Khan et al., 2016; Grewal et al., 2019). Finally, we have the counterintuitive policy implication that when policymakers care more about CSR, they should increase the disclosure threshold â€" fewer firms will disclose, but those that do will overinvest more in CSR. The intuition of those implications stems from the subtle interaction between the regulator's chosen disclosure policy and firms' strategic behavior in response to such disclosure policy that we discuss in more detail in the main text.

The rest of the paper is organized as follows. After reviewing related literature, Section 2 introduces the model, which is solved in Section 3. Sections 4 and 5 study the two extensions to discrete disclosure. Section 6 discusses model implications. Section 7 concludes.

Related Literature Our paper contributes to several streams of literature, the first of which relates to the growing body of work on the economic consequences of CSR/ESG disclosures.[8] Our paper most closely relates to the real effects of such disclosure. For example, Mahieux et al. (2025) study how mandating greenhouse gas emissions (GHGs) disclosure can result in emissions leakages, while Xue (2023) shows how measuring the outcome of ESG investments can discipline firm investments that have both cash flow and ESG impact. Friedman et al. (2024) study the interaction between ESG reports and financial reports and how they may discipline managers' unobservable investment/effort decisions. Banerjee and Prokopev (2025) and Smith (2026) study the effect of

[8]See Grewal et al. (2020), Christensen et al. (2021), and Friedman and Ormazabal (2024) for excellent reviews.

climate risk exposure disclosure on risk-sharing among investors: While Smith (2026) finds that more risk disclosure always improves risk-sharing when firms' risk exposures are exogenous, Banerjee and Prokopev (2025) find that this is not necessarily the case when firms can endogenously choose their risk exposure in response to disclosure requirements. Interpreting climate risk as an example of a systematic risk factor that affects firms' cash flows, Banerjee et al. (2025) study how the feedback effect of stock prices differentially affects investment when the manager cares about cash flows versus prices.

Our paper focuses on how discrepancy between a public policymaker and a firm (which may fail to fully account for the positive externalities of their CSR investment) may be a reason for the policymaker to use mandatory disclosure regulations to encourage CSR commitments. Different from Friedman et al. (2024), we focus exclusively on CSR disclosures, and, differing from Mahieux et al. (2025) and Xue (2023), we measure unobservable CSR investments rather than the outcomes of those investments, rendering the issue of measurement precision moot, as it is well-known in the real effects literature that noisy measures of any endogenous decision lack information content, e.g., Matthews and Mirman (1983); Kanodia et al. (2005).

We nevertheless show that imperfect disclosure in the form of discrete or censored disclosure can be optimal in maximizing social welfare; in this sense, our study's focus on the disclosure of ex-ante CSR investments has notably different implications when compared to those of literature that measures ex-post CSR outcomes. Our findings are also aimed to be more implementable: While valuable, precisely measuring certain ex-post outcomes (e.g., level 3 GHGs or innovation outcomes) may be extremely challenging, whereas it is more manageable to precisely measure ex-ante investments (e.g., amount invested into green technologies that aim to reduce GHGs and amounts of R&D expenditures) and, if beneficial, implement imprecise measures or thresholds (e.g., discrete ratings based on a firm's level of investment into green technologies and requiring firms to disclose R&D investment only when such investment exceeds a threshold).

In addition, while we focus on the granularity of mandatory disclosure in a static setting, a related set of papers studies green disclosure and its real effects along complementary dimensions;

none, however, shares our central mechanism—that coarsening an otherwise precise disclosure standard induces firms to overinvest and thereby internalize a positive externality. Aghamolla and An (2024) compare voluntary and mandatory ESG disclosure regimes; in their setting overinvestment is a welfare-reducing distortion evaluated from shareholders' perspective, and they do not consider the design of disclosure granularity. Gupta and Starmans (2025) study the temporal stringency of disclosure, where welfare gains arise from inducing non-adopting firms to enter the green transition rather than from inducing already-investing firms to invest more. Cartellier et al. (2023) take disclosure precision as exogenous and examine how investors' preferences discipline the greenwashing of a negative externality. Closely related, Inderst and Opp (2025) analyze a minimum sustainability standard above which profit-motivated firms do not invest further, paralleling our threshold; their standard is nonetheless a real financing-eligibility requirement working through a warm-glow greenium rather than a disclosure rule, and improves welfare only when financial constraints bind. Bisceglia et al. (2022) study socially responsible investing as an alternative mechanism to mitigate externalities, and Chen and Schneemeier (2026) analyze settings where firms can misreport their CSR activities, whereas we assume credible disclosure enforced by the regulator and focus on optimal disclosure granularity.

Second, our results on the optimality of censored disclosure (i.e., full disclosure if and only if the CSR investment is above a certain threshold) are related to the materiality threshold widely discussed in CSR/ESG disclosures (e.g., Khan et al., 2016; Jebe, 2019). While the materiality threshold is usually referred to as "relevant to investor decision-making", in our model, it relates to the magnitude of the investment, which aligns it more closely to the materiality threshold considered in financial accounting (e.g., separately disclosing items that are of sufficient magnitude). To the extent that this magnitude reflects how important CSR is to a firm and/or its stakeholders, it can also be considered relevant to investor decision-making. Note that such a materiality threshold can only be generated through a discrete disclosure rule rather than signal plus noise in the usual continuous disclosure setting. This result is also consistent with investor responses and, in turn, stock prices responding to investor information, as documented by Moss et al. (2022).

Thirdly, our result that a threshold-based disclosure rule will induce firms' manipulation around the threshold is related to the "classification manipulation" literature (e.g., Dye, 2002; Gao, 2013; Gao and Jiang, 2020). While Gao (2013) and Gao and Jiang (2020) emphasize the importance of ex-ante earnings manipulation, in our setting firms manipulate their CSR investments ex post around the threshold set up ex ante, similar to Dye (2002). However, Dye (2002) focuses on the difference between the "official standard" and "shadow standard" conditional on the threshold-based standard, whereas we focus on comparing discrete standards and continuous standards, as in Gao and Jiang (2020).

Fourth, our study is related to information design before a signaling game (e.g., Jiang and Yang (2017); see Bergemann and Morris (2019) for a review) and, more generally, security design before a signaling game (e.g., DeMarzo and Duffie, 1999). In our study, firms can distort their production decision to (partially) signal their unverifiable private information and such distortion is affected by the ex-ante information design. The distortion of real decisions to signal private information has also been studied by, e.g., Beyer and Guttman (2012), Einhorn and Ziv (2012), and more recently, Matsuno (2024). However, those papers focus on firms' voluntary disclosure of their decisions, whereas we study mandatory disclosure and ask how the design of such rules—in particular their granularity—shapes real investment.

This question connects to a recurring theme across several literatures: limiting or coarsening information can be welfare-improving relative to full disclosure—the broad insight underlying our results. For example, the classic Hirshleifer (1971) effect shows that disclosure can destroy valuable risk-sharing, a point Goldstein and Leitner (2018) extend to bank stress tests. In certification, coarse grades can serve a profit-seeking intermediary's rents (Lizzeri, 1999; Albano and Lizzeri, 2001), encourage participation (Harbaugh and Rasmusen, 2018), or let a welfare-minded designer curb a monopolist's market power (Zapechelnyuk, 2020) or regulate oligopolistic quality distortions (Vatter, 2025). In cheap-talk models (e.g., Crawford and Sobel, 1982; Morgan and Stocken, 2003), information is coarsened to limit the receiver's strategic use of the sender's message; these are ex-post models with zero lying cost, whereas our disclosure rule is set ex ante

and requires the firm's commitment. Our mechanism also differs in direction and source: coarsening an otherwise precise standard is constructive rather than defensive, inducing high-return firms to bunch upward at the threshold and overinvest, thereby partially internalizing a positive externality—a rationale for coarse disclosure new to this literature.

2 The Model

We consider a model with three types of agents: a continuum of firms that make investments generating positive externalities, a policymaker who determines the disclosure policy for these investments, and stakeholders whose beliefs about firms' investments affect firm profits and are, in turn, shaped by the disclosed information.

The game unfolds in three stages. In the first stage, the policymaker chooses one of three disclosure regimes â€" nondisclosure, full disclosure, or discrete disclosure â€" which we specify below. In the second stage, each firm chooses its investment and discloses according to the regime selected in the first stage. In the third stage, stakeholders observe the disclosed information, infer each firm's investment, and firm profits are realized.

2.1 Firms

There is a continuum of firms of unit measure (i.e., on $[0, 1]$), and each firm makes an investment. We use $s_i \geq 0$ to denote firm i's investment, with a higher s_i representing a greater investment. The key feature of this investment is its *externality*: firm investments generate positive externalities that are valued by the regulator but may be only partially internalized by firms. For instance, a power plant can invest in cleaner technologies that reduce carbon emissions, a tech company can expand digital access to underserved communities, and an agricultural goods manufacturer can improve the livelihoods of small farmer suppliers. Beyond these corporate social responsibility activities, many types of firmsâ€™ research and development also generate substantial positive externalities â€" for example, pharmaceutical R&D that creates vaccines used world-

wide, semiconductor R&D that underpins innovation across multiple downstream industries, or clean-energy R&D whose knowledge spillovers accelerate the diffusion of low-carbon technologies across the economy. For brevity, we hereafter refer to these investments as CSR investments to emphasize the externality and use the CSR setting to interpret the model.

Firms' investments are not directly observed by stakeholders. Although firms can in principle disclose their investments voluntarily, such self-reported information is not verifiable and is therefore not given full credence by the market. In our setting, only disclosures made under the policy chosen by the regulator are recognized by stakeholders (we will introduce the disclosure policy in Section 2.3). We denote by $\hat{s}_i$ stakeholders' belief regarding firm i's investment level, which depends on the information disclosed and is specified below.

A firm chooses its investment to maximize its expected profit, which takes the following form:

$$\pi_i = \underbrace{\alpha_i \cdot \hat{s}_i}_{\text{Benefit}} - \underbrace{s_i^2/2}_{\text{Cost}}. \tag{1}$$

First, as specified in equation (1), firm i enjoys a monetary payoff of $\alpha_i \cdot \hat{s}_i$ for its investments, where $\alpha_i \geq 0$ captures the firm's marginal benefit from the investment. To highlight the role of disclosure policy in shaping investment incentives, we assume that firms benefit from their investments indirectly through a reputation effect: stakeholders' beliefs $\hat{s}_i$ about the investment level affect firm value through channels such as brand image, consumer trust, and cost of capital (e.g., Becker-Olsen et al., 2006; Khan et al., 2016; Pástor et al., 2021).[9] Thus, depending on the context, stakeholders may include consumers, investors, employees, suppliers, or other parties whose perceptions influence firm value.

In addition, the realization of α_i is privately known only to firm i and is not directly observed by stakeholders. Stakeholders know only that $\alpha_i \sim U[L, H]$ and form beliefs about the firm's investment based on the disclosure prescribed by the regime, as described in Section 2.3. For

[9]These investments may also generate direct monetary benefits for the firm â€" for example, investments in energy-efficient technologies can reduce operating costs. While we do not model these direct benefits explicitly, our main results continue to hold in their presence.

the remainder of the paper, we normalize $H = 1$ without loss of generality. In practice, firms are heterogeneous in how much they benefit from CSR investment. This heterogeneity can stem from differences in firm characteristics such as management quality, industry context, customer base, or investor composition (e.g., Isaksson and Woodside, 2016; Lins et al., 2017; Servaes and Tamayo, 2013).

Second, as shown in equation (1), when investing, firms incur a cost, which we assume is $s_i^2/2$. As noted by Wang and Bansal (2012), the more resources a firm allocates to CSR activities, the fewer resources remain available to improve its core business. Such a quadratic function captures decreasing marginal returns to CSR investment, e.g., it becomes increasingly costly for a power plant to develop and implement better technologies to reduce carbon emissions.

2.2 Public Policymaker

The model includes a public policymaker who chooses a disclosure policy (specified below) to maximize the following objective function:[10]

$$\Pi = \beta \underbrace{\int s_i di}_{\text{Total investment}} + (1-\beta) \underbrace{\int \pi_i di}_{\text{Total firm profit}}, \tag{2}$$

where $0 \leq \beta < 1$ is the weight placed on investment and $1 - \beta$ is the weight placed on firms' profits. In this specification, $\int \pi_i di$ represents the aggregate profit of all firms in the economy, and $\int s_i di$ represents the aggregate investment by all firms. When $\beta = 0$, the policymaker cares only about firm profits; as β approaches one, the policymaker places nearly all weight on investment levels. In general, the policymaker balances both objectives.

In practice, the policymaker can represent either a government regulator (e.g., the SEC or the EU Commission) or a third-party standard-setter and rating agency (e.g., MSCI or Sustainalytics), insofar as these entities care about investments with positive externalities and their disclosure

[10]This objective function also serves as the social welfare function. Note that we do not explicitly model how firms' investment translates into measurable social benefits. Instead, we treat the parameter β as a reduced-form representation of the social value generated by the investment.

frameworks are widely recognized by the market. We treat disclosure regulation as a second-best policy instrument that shapes firms' investment incentives through stakeholders' information environment.[11]

In specification (2), the policymaker values firm profits because i) higher profits generate greater tax revenue (for government regulators), ii) a higher firm payoff from CSR investments makes CSR activities more sustainable and yields long-term social benefits, and iii) higher firm profits are associated with higher wages, increased consumption, and lower unemployment. At the same time, the policymaker values higher investment levels because these investments generate positive externalities that firms do not fully internalize. For instance, investments in pollution reduction, workplace safety, and product quality improvements contribute to societal well-being beyond their direct impact on firm value.

2.3 Disclosure Policy

As previously discussed, a firm's investment is not directly observed by stakeholders unless the information is certified and disclosed according to standards set by the policymaker. In line with real-world practice, we consider three disclosure regimes: nondisclosure (N), full disclosure (F), and discrete disclosure (D, or category disclosure). We explore additional disclosure policies in Sections 4 and 5. Let I_i denote the information disclosed by firm i.

Nondisclosure Under nondisclosure, a firm's investment is always withheld (i.e., $I_i^N = \emptyset$ for all firms), so that stakeholders do not receive any additional information regarding the firms' investment beyond the prior. We use superscript N to denote nondisclosure.

Note that there are no regulations preventing firms from voluntarily disclosing their investments. However, in the absence of certification and verification, such disclosure becomes cheap talk and does not carry any informational weight, rendering it equivalent to nondisclosure. In

[11] In many settings, regulators and standard setters have clearer authority to mandate disclosure than to prescribe firms' real investment decisions directly. Direct investment mandates also require the policymaker to specify, verify, and enforce appropriate CSR investments across heterogeneous firms, which can be difficult when such investments are multidimensional and firm-specific.

other words, voluntary disclosure without verifiable information is equivalent to no disclosure.[12]

Full disclosure Under full disclosure, firm i truthfully discloses its investment (i.e., $I_i^F = s_i$ for all firms),[13] and there is no information asymmetry between the firm and its stakeholders. Under guidance such as the Sustainability Accounting Standards Board (SASB) standards, firms are allowed to voluntarily disclose their sustainability information and, if they so choose, firms always truthfully disclose their entire CSR activities, thus facilitating full disclosure. In real-life practice, the rating agency EcoVadis assigns an EcoVadis score (0â€“100), which reflects the quality of a firm's sustainability management and is largely in line with full disclosure.[14] We use superscript F to denote full disclosure.

Discrete disclosure Under discrete disclosure, a public policymaker sets a disclosure threshold, δ^D. If a firm's investment is below this threshold, nothing is disclosed. If the investment is equal to or greater than the threshold, the policymaker certifies and discloses that the firm has a high investment. Mathematically, the disclosure policy can be written as

$$I_i^D = \begin{cases} \emptyset & \text{if } \ s_i < \delta^D, \\ \text{High} & \text{if } \ s_i \geq \delta^D. \end{cases} \tag{3}$$

As discussed later, the policymaker can decide on the threshold δ^D to maximize its objective (2).

Discrete disclosure policies are widely adopted in practice. For instance, the nonprofit organization B Lab Global offers B Corporation Certifications to firms that meet a minimum score on the B Impact Assessment, which evaluates social and environmental performance. Fairtrade International, a nonprofit that advocates for farmers and workers through fair trade, also certifies products that have been manufactured according to fair trade standards. Furthermore, public policymakers often adopt multiple discrete levels of disclosure, such as by rating a firmâ€™s CSR

[12] See Jiang et al. (2023) for a discussion on the importance of certification in facilitating the efficiency of unobservable investments, particularly CSR investments.

[13] While a firm can also choose not to disclose, according to the unraveling principle, nondisclosure is treated as no investment and is dominated by disclosure.

[14] https://support.ecovadis.com/hc/en-us/articles/210460227-Understanding-EcoVadis-Medals-and-Badges

as good, satisfactory, or non-satisfactory (e.g., the red/yellow/green "traffic-light" system used by the eToro platform).[15] We discuss further in Section 4 and show that allowing multiple levels of disclosure only strengthens our results.

As explained earlier, because stakeholders do not observe s_i directly, they rely on available information and form expectations about firm i's investments. Thus, given one of the disclosure policies, we can rewrite the firm's payoff (1) as

$$\pi_i = \alpha_i E[s_i|I_i] - \frac{s_i^2}{2}, \tag{4}$$

where $E[s_i|I_i]$ is stakeholders' expectation of the firm's investment given the information disclosed. When making inferences, stakeholders apply the Bayes' rule whenever applicable.

2.4 Further Discussion

In our setting, firm investments generate positive externalities, which we model through misaligned interests between firms and the policymaker. Specifically, firms fail to fully internalize the social benefits of their investments, while the policymaker values both firm profits and aggregate investment levels. Thus, an investment level can be privately optimal for the firm even though the policymaker would prefer a higher level because of the externality. Given this framework, we examine how disclosure policy can be designed to (partially) address the externality problem. To isolate the role of disclosure, we deliberately abstract from any direct private benefits of investment to firms and assume that firms benefit solely through stakeholders' perceptions, which are shaped by the disclosure policy.

One might ask why a regulator concerned with investment externalities would use disclosure standards rather than â€" or in addition to â€" more direct tools such as taxes or subsidies. We view disclosure policy as complementary to, rather than a substitute for, traditional Pigouvian

[15] See B Lab Global: https://www.bcorporation.net/en-us/certification/; Fairtrade International: https://www.fairtrade.net/en/why-fairtrade/how-we-do-it/how-does-the-label-work/how-fairtrade-certification-works.html; and eToro platform: https://www.etoro.com/investing/esg/.

instruments. While governments can subsidize investment inputs (e.g., through R&D tax credits), fiscal and political constraints can make large-scale subsidies or targeted taxes difficult to implement. Disclosure standards, by contrast, leverage market discipline: once credible information is revealed, stakeholders (investors, consumers, employees) impose market-based rewards or penalties that shape firm incentives without requiring direct fiscal transfers. Our focus is therefore on how, for a given fiscal policy environment, regulators can use *information design* â€" specifically, the granularity and structure of investment disclosure â€" to tilt investment toward socially desirable levels.

3 Model Analysis

In this section, we analyze the equilibrium outcome under the three disclosure regimes as introduced in Section 2.3. Then, we compare their equilibrium outcomes to derive the public policymaker's optimal disclosure policy.

3.1 Nondisclosure

Under the nondisclosure regime, no firms disclose, and, as such, all are indistinguishable to stakeholders who hold the same belief about their investments. Let $\hat{s}_i^N$ be the stakeholders' common belief regarding firm i's investment, which is a constant. Firm i thus chooses an investment s_i^N to maximize its payoff

$$\pi_i^N = \alpha_i \cdot \hat{s}_i^N - \frac{(s_i^N)^2}{2}.$$

It follows immediately that firm profit is maximized at $s_i^N = 0$. Lemma 1 summarizes this discussion:

Lemma 1 (Nondisclosure)**.** *Under the nondisclosure regime, no firm invests, i.e., $s_i^N = 0$. In equilibrium, all firms make zero profits, and the public policymaker's payoff is $\Pi^N = 0$.*

Because firms cannot disclose any information regarding their investments, stakeholders always hold the same belief regardless of the actual amount or level invested. In other words, investing does not change stakeholders' beliefs, so firms have no incentive to invest. Furthermore, in equilibrium, stakeholders also hold the rational belief that firms will not invest. As a result, the market for investment breaks down completely, with no investment taking place. This lemma suggests that disclosure is necessary to incentivize investment with positive externalities.

3.2 Full Disclosure

Under the full disclosure regime, all firms truthfully disclose their exact investment s_i^F, leaving no information asymmetry between them and their stakeholders, i.e., $\hat{s}_i^F = s_i^F$. As such, firm i makes its investment decision s_i^F to maximize its payoff

$$\pi_i^F = \alpha_i \cdot s_i^F - \frac{(s_i^F)^2}{2}.$$

It follows immediately that, by choosing $s_i^F = \alpha_i$, firm i's profit is maximized at $\alpha_i^2/2$. This choice is privately optimal because it maximizes firm i's own payoff; it is not generally the policymaker's preferred investment level when $\beta > 0$. Given the firms' optimal strategies, the aggregate investment and aggregate firm profit are respectively (note we normalized $H = 1$):

$$\Delta^F = \int_L^1 \alpha_i dF(\alpha_i) = \frac{1+L}{2} \text{ and } \pi^F = \int_L^1 \frac{\alpha_i^2}{2} dF(\alpha_i) = \frac{1+L+L^2}{6}.$$

The following lemma summarizes the result.

Lemma 2 (Full disclosure). *Under the full disclosure regime, firm i chooses $s_i^F = \alpha_i$, and makes a profit of $\pi_i^F = \frac{\alpha_i^2}{2}$. The public policymaker's payoff is $\Pi^F = \frac{\beta(1+L)}{2} + \frac{(1-\beta)(1+L+L^2)}{6}$.*

Lemma 2 shows that, compared to nondisclosure, full disclosure restores private investment incentives by allowing stakeholders to reward observed investment, leading to both higher firm profits and investments. Consequently, the policymaker strictly prefers full disclosure over nondis-

closure.

3.3 Discrete Disclosure

Under the discrete disclosure regime, the public policymaker chooses a disclosure threshold δ^D and certifies and discloses whether or not a firm's investment passes this threshold. Because there are only two disclosed states, we use $\hat{s}_L^D = E[s_i^D | I^D = \emptyset]$ and $\hat{s}_H^D = E[s_i^D | I^D = \text{High}]$ to denote stakeholders' belief regarding firm i's investment when the disclosure threshold is met and not met, respectively. In equilibrium, the conjecture must be consistent with the firm's equilibrium investment decision. It directly follows from the definition of the threshold that $\hat{s}_H^D \geq \delta^D > \hat{s}_L^D$.

Taking δ^D as given, each firm makes its investment decision to maximize its profit, s_i^D. Firm i effectively chooses between the following two strategies: (1) It makes a low investment $s_i^D < \delta^D$. In this case, the firm's payoff is $\pi_i^D = \alpha_i \hat{s}_L^D - \frac{(s_i^D)^2}{2}$. (2) It makes a high investment $s_i^D \geq \delta^D$. In this case, the firm's payoff is $\pi_i^D = \alpha_i \hat{s}_H^D - \frac{(s_i^D)^2}{2}$. The following lemma characterizes the firms' investment decision.

Lemma 3 (Investment under discrete disclosure)**.** *In equilibrium, firm i's investment must satisfy that $s_i^D \in \{0, \delta^D\}$.*

Following Lemma 3, because stakeholders' beliefs must be consistent with the firms' equilibrium investment decisions, $\hat{s}_L^D = 0$ and $\hat{s}_H^D = \delta^D$. To maximize its payoff, firm i compares its two investment choices (i.e., $s_i^D \in \{0, \delta^D\}$), which reveals that its investment decision also follows a threshold strategy:

$$s_i^D = \begin{cases} 0 & \text{if } \alpha_i < \frac{\delta^D}{2}, \\ \delta^D & \text{otherwise.} \end{cases} \tag{5}$$

Intuitively, if firm i's investment does not exceed the threshold, stakeholders hold a fixed belief regarding the investment made. Similar to nondisclosure, the only consistent conjecture stakeholders make is that firm i will not/does not invest; thus, in equilibrium, firm i does not invest. When firm i's investment exceeds the threshold, stakeholders again hold a fixed, but

higher, belief regarding the investment. Firm i does not invest beyond the conjectured level, given that additional investments are costly and do not come without additional benefits. In equilibrium, when the marginal return to investment α_i is sufficiently large, the capital market benefit of investing at a higher level outweighs the cost, so firm i chooses to invest at a higher level.

3.4 The Effect of Discrete Disclosure on Firms' Investment

Thus far, we have derived firms' equilibrium investment decisions under three disclosure regimes. We have shown that there is no investment under nondisclosure. We now compare the firms' investment under full and discrete disclosure and summarize the results in the following proposition:

Proposition 1 (Investment under discrete disclosure versus full disclosure)**.** *Compared to full disclosure, under discrete disclosure, a firm makes more investment when* $\frac{\delta^D}{2} \leq \alpha_i < \delta^D$ *and invests less otherwise.*

Proposition 1 uncovers a key finding that a firm can invest more under discrete disclosure. Under full disclosure, regardless of the amount or level invested, the firm can perfectly communicate this information to its stakeholders. Under discrete disclosure, however, as illustrated in Lemma 3, the firm only has two options: (1) not invest at all, i.e., $s_i^D = 0$, or (2) invest at the threshold level, i.e., $s_i^D = \delta^D$. When $\alpha_i > \delta^D$, the firm distorts its investment downward to δ^D relative to the privately optimal full-disclosure benchmark. When $0 \leq s_i^F = \alpha_i < \delta^D$, the firm distorts its investment either downward to $s_i^D = 0$ or upward to $s_i^D = \delta^D$. Overall, a mass of firms equal to $1 - \frac{\delta^D}{2}$ underinvest, while the remaining mass $\frac{\delta^D}{2}$ overinvest.[16] As the policymaker endogenously sets the threshold (to be discussed shortly), she can choose it strategically so that the distortion from overinvestment outweighs that from underinvestment, and thus firms end up investing more under discrete disclosure.

[16]We assess over- or under-investment under discrete disclosure relative to the privately optimal investment chosen under full disclosure. Alternatively, one could benchmark against the investment that maximizes the policymaker's objective function (2). Comparing with this alternative benchmark does not make any qualitative difference.

We illustrate this result using the following numerical example: $\alpha_i = 0.5$ and $\delta^D = 0.8$. Under full disclosure, the firm chooses an optimal investment level $s_i^F = 0.5$, making a profit of $\pi_i^F = 0.125$. Under discrete disclosure, the firm either cuts its investment to $s_i^D = 0$ for a payoff of $\pi_i^D = 0$ or increases its investment to $s_i^D = \delta^D = 0.8$ for a payoff of $\pi_i^D = 0.08$. Comparing these two strategies, the firm chooses to invest more.

Taken together, Proposition 1 implies that public policymakers can strategically use discrete disclosure policies as a tool to influence and incentivize (some) firms' investment decisions.

Following this discussion, we can immediately derive the policymaker's payoff under discrete disclosure as follows:

$$\Pi^D = \begin{cases} \frac{\delta^D(1+\beta+(1-\beta)(L-\delta^D))}{2} & \text{if } \delta^D < 2L, \\ \frac{\delta^D(2-\delta^D)(2+2\beta-\delta^D+\beta\delta^D)}{8(1-L)} & \text{if } 2L \leq \delta^D \leq 2, \\ 0 & \text{if } \delta^D > 2. \end{cases} \tag{6}$$

In equation (6), when $\delta^D < 2L$, the threshold for disclosure is too low, and all firms make high investments (i.e., $s_i^D = \delta^D$) to be recognized as high-CSR firms. When $\delta^D > 2$, the threshold is prohibitively high, and no firm invests (i.e., $s_i^D = 0$). Lastly, when the disclosure threshold δ^D is moderate, firms with lower marginal returns (i.e., $\alpha_i \leq \frac{\delta^D}{2}$) choose not to invest, while firms with higher marginal returns (i.e., $\alpha_i > \frac{\delta^D}{2}$) invest at the threshold level.

3.5 Public Policymaker's Optimal Decision for δ^D Under Discrete Disclosure

Following our discussion on the equilibrium outcome given the disclosure threshold δ^D, we now work backward to investigate the public policymaker's optimal decision for δ^D. Following equation (6), the public policymaker chooses between the following options:

(1) Low threshold $\delta^D < 2L$. In this case, the policymaker's payoff is $\Pi^D = \frac{\delta^D(1+\beta+(1-\beta)(L-\delta^D))}{2}$.

Solving the policymaker's maximization problem, we find that the policymaker's payoff is

maximized at

$$\delta^D = \min\left(2L, \frac{1+\beta}{2(1-\beta)} + \frac{L}{2}\right). \tag{7}$$

(2) Moderate threshold $2L \leq \delta^D \leq 2$. In this case, the policymaker's payoff is $\Pi^D = \frac{\delta^D(2-\delta^D)(2+2\beta-\delta^D+\beta\delta^D)}{8(1-L)}$. Solving the policymaker's maximization problem, we find that the policymaker's payoff is maximized at

$$\delta^D = \max\left(2L, \frac{4-2\sqrt{1+3\beta^2}}{3(1-\beta)}\right). \tag{8}$$

(3) High threshold $\delta^D \geq 2$. In this case, the policymaker's payoff is always 0.

Comparing the policymaker's payoffs under these scenarios, we arrive at the following proposition:

Proposition 2 (Optimal threshold under discrete disclosure)**.** *Under discrete disclosure, the public policymaker's optimal decision on δ^D is as follows: When $L \leq 0.5$,*

$$\delta^{D*} = \begin{cases} \frac{1+\beta+L-L\beta}{2(1-\beta)} & \text{if } \beta \leq \frac{3L-1}{1+3L}, \\ 2L & \text{if } \frac{3L-1}{1+3L} < \beta < \frac{1-4L+3L^2}{3L^2-1}, \\ \frac{4-2\sqrt{1+3\beta^2}}{3(1-\beta)} & \text{otherwise.} \end{cases} \tag{9}$$

When $L \geq 0.5$,

$$\delta^{D*} = \begin{cases} \frac{1+\beta+L-L\beta}{2(1-\beta)} & \text{if } \beta \leq \frac{3L-1}{1+3L}, \\ 2L & \text{otherwise.} \end{cases} \tag{10}$$

Proposition 2 characterizes the optimal threshold under discrete disclosure given L and β. For a given L, the optimal disclosure threshold increases with β. This result is intuitive. As β increases, the policymaker cares more about CSR investment and thus is more willing to tolerate overinvestments. Correspondingly, the policymaker sets δ^D to be higher.

Panel (a) of Figure 1 illustrates the public policymaker's optimal decision on δ^D when $L = 0.45$. When β is low, the policymaker is concerned primarily with firm profits and chooses a moderate threshold δ^D. When $\beta = 0$, the policymaker chooses a threshold $\delta^D = 0.725$; then firms with low marginal returns to CSR $\alpha_i \in [0.45, 0.725)$ overinvest in CSR with an investment of $s_i^D = \delta^D > \alpha_i$ while firms with high marginal returns to CSR $\alpha_i \in (0.725, 1]$ underinvest in CSR with an investment of $s_i^D = \delta^D < \alpha_i$. While firms always distort their investment decisions, the magnitude of the distortion, $|\alpha_i - \delta^D|$, is relatively small, which guarantees sufficient profits.

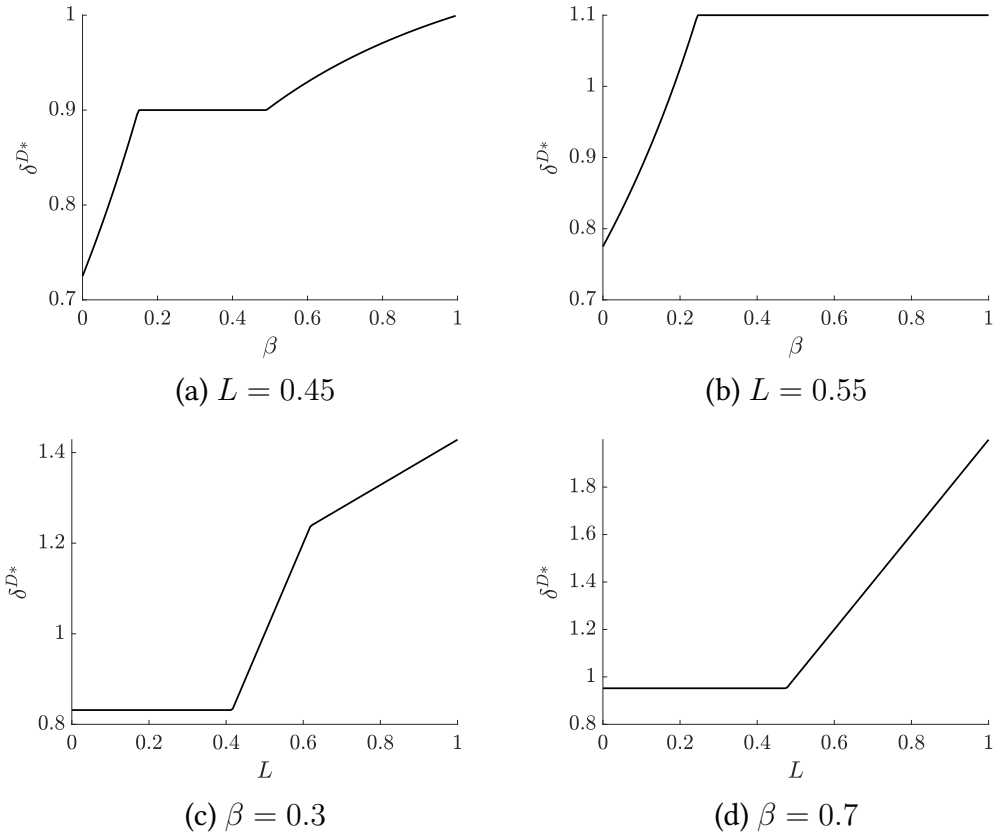
As β approaches one, the policymaker places nearly all weight on CSR and thus selects a high threshold that approaches $\delta^D = 1$. In this case, firms with very low marginal returns $\alpha_i \in [0.45, 0.5)$ underinvest with an investment of $s_i^D = 0 < \alpha_i$ while firms with moderate or high marginal returns $\alpha_i \in (0.5, 1)$ overinvest with an investment of $s_i^D = \delta^D > \alpha_i$. Because the latter firms invest aggressively, the aggregate investment amount is maximized regardless of underinvestment from other firms.

Furthermore, Proposition 2 demonstrates that, when L is small, the public policymaker may set a higher disclosure threshold (relative to L) compared to when L is large. When L is small, the private payoff loss generated from firms overinvesting can become even higher; therefore, the policymaker chooses δ^D that is relatively high to preclude firms with low α_i from investing. This explains why δ^{D*} has three possible solutions when L is small, including one solution with a threshold that is higher than that of $2L$, which is not present when L is large.

Panel (b) of Figure 1 illustrates the optimal disclosure threshold for various values of β when L is set to a larger value, specifically $L = 0.55$. In comparison to Panel (a), the optimal threshold in Panel (b) is higher in absolute terms, which is intuitive since a higher L implies that the firm perceives, on average, higher benefits from investment, allowing the policymaker to set a higher threshold since firms that do not invest enough become less of a concern.

In Panels (c) and (d) of Figure 1, we examine how the optimal threshold δ^D varies with L for different values of β. As L increases â€" meaning that firms become less heterogeneous in their marginal investment returns and on average benefit more from investment â€" the policymaker

sets a higher disclosure threshold. This finding is consistent with the comparison between Panels (a) and (b).



(a) $L = 0.45$ (b) $L = 0.55$

(c) $\beta = 0.3$ (d) $\beta = 0.7$

Panels (a) and (b) of this figure plot the optimal disclosure threshold under discrete disclosure for different values of β when L is fixed at a lower level ($L = 0.45$) and a higher level ($L = 0.55$), respectively. Panels (c) and (d) plot the optimal disclosure threshold for different values of L given β is fixed at a lower level ($\beta = 0.3$) and a higher level ($\beta = 0.7$), respectively.

Figure 1: Optimal threshold under discrete disclosure

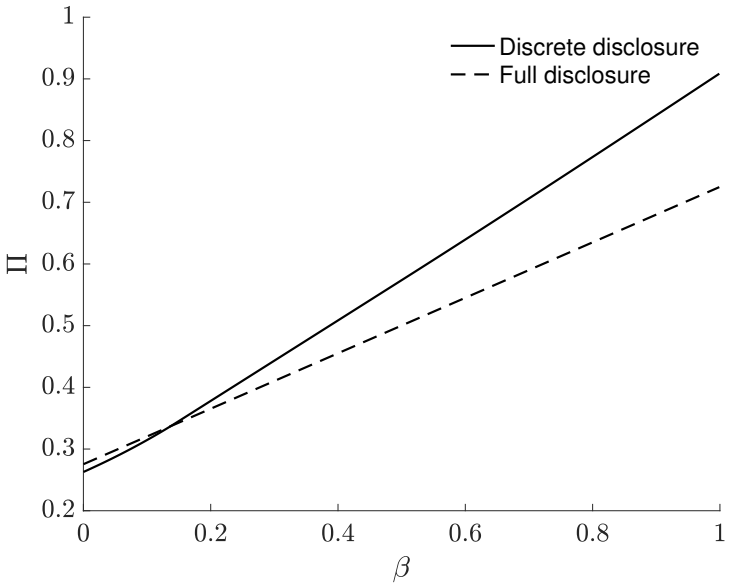
3.6 Discrete Disclosure vs. Full Disclosure

Our analysis shows that, compared to no disclosure, both full and discrete disclosure policies incentivize firms to invest, thereby benefiting firms and society as a whole. However, it remains unclear which of the two disclosure policies is more effective from the perspective of public policymaker. We thus compare the policymaker's payoff under the two disclosure regimes and summarize our results in the following proposition:

Proposition 3 (Discrete disclosure vs. Full disclosure)**.** *When the public policymaker is concerned primarily with firm profits (i.e., when β is low enough), they prefer full disclosure over discrete disclosure, i.e., $\Pi_F > \Pi_D$. When they are concerned primarily with aggregate investment (i.e., when β is high enough), discrete disclosure weakly dominates full disclosure, i.e., $\Pi_D \geq \Pi_F$, with equality if and only if $L = 0$.*

Proposition 3 presents our paper's main finding: the public policymaker prefers discrete disclosure over full disclosure when they are sufficiently concerned about aggregate CSR investment. As outlined in Proposition 1, when the disclosure threshold is high but not too high, firms are incentivized to overinvest, which may reduce their profit but is still more profitable than not investing at all. As for public policymakers, overinvestments reduce firm profits but increase aggregate investment, which is preferred when they prioritize CSR investment. In other words, the disclosure threshold provides policymakers with a tool that (partially) internalizes the externalities of firm investments: while full disclosure allows firms to fine-tune capital market incentives and ignore the social benefits of their investments, discrete disclosure, by distorting capital market incentives, results in firms distorting their investments and thus effectively internalizing the investment externalities.

Figure 2 illustrates the result of Proposition 3. It can be seen that, when β is low, the public policymaker's payoff is higher under full disclosure, which encourages firms to choose their privately optimal investment levels. When β is high, the public policymaker's payoff is higher under discrete disclosure, which encourages the majority of firms to overinvest. Such improvements can be substantial: for instance, when $L = 0.45$ and β approaches one, the public policymaker's payoff approaches $\Pi^F = 0.725$ under full disclosure but $\Pi^D \approx 0.909$ under discrete disclosure, a limiting improvement of 25.4%. This result showcases the significant role that disclosure policies play in incentivizing firm investments.



This figure compares the policymaker's payoff across different values of β, holding the other parameter fixed at $L = 0.45$.

Figure 2: Discrete vs. Full Disclosure

4 Multiple Levels for Discrete Disclosure

In the base model, we assume that there is a single level of disclosure under discrete disclosure, e.g., the firm either passes or fails the public policymaker's certification threshold. However, in practice, policymakers often adopt refined, multi-level disclosure policies. For instance, the EU's energy label provides consumers with product information on energy efficiency, categorizing products into seven grades ranging from A to G. Likewise, the MSCI ESG ratings assign firms into seven categories spanning from AAA to CCC. The Ministry of Health of Singapore also implements Nutri-Grade labelling requirements for beverages sold in Singapore, grading beverages into four categories ranging from A to D.[17]

In this section, we consider the effect of having multiple levels of discrete disclosure. For the sake of tractability, we consider two levels of disclosure and assume that $L = 0$. Our results also hold for other $L < 1$. We use δ_1^M and δ_2^M to represent the two thresholds, where $\delta_1^M < \delta_2^M$.

[17]See EU's energy label: https://energy-efficient-products.ec.europa.eu/ecodesign-and-energy-label/understanding-energy-label_en; MSCI ESG ratings: https://www.msci.com/sustainable-investing/esg-ratings; and Singapore's Nutri-Grade labelling: https://www.hpb.gov.sg/healthy-living/food-beverage/nutri-grade.

Superscript M stands for multiple disclosure.

Given the disclosure thresholds, the firms make their disclosure decisions. As discussed in the base model, firms' equilibrium investment decisions must satisfy $s_i^M \in \{0, \delta_1^M, \delta_2^M\}$. Solving the firms' optimal disclosure decision, we arrive at the following lemma:

Lemma 4 (Investment under multiple disclosure)**.** *With multiple disclosure thresholds, the firms' optimal investment decision is as follows:*

$$s_i^M = \begin{cases} 0 & \text{if } \alpha_i < \frac{\delta_1^M}{2}, \\ \delta_1^M & \text{if } \frac{\delta_1^M}{2} \leq \alpha_i \leq \frac{\delta_1^M + \delta_2^M}{2}, \\ \delta_2^M & \text{otherwise.} \end{cases} \tag{11}$$

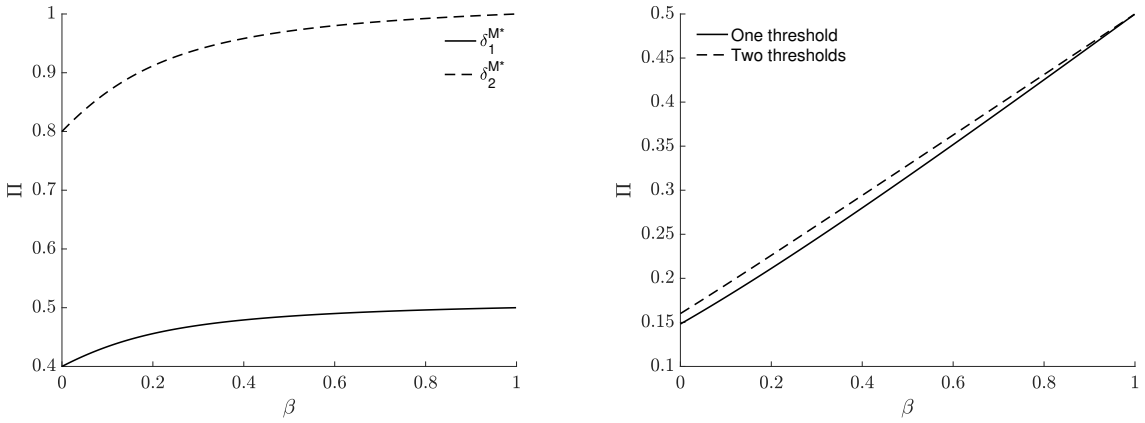
Lemma 4 suggests that firms with low marginal returns to CSR investment do not invest, firms with moderate marginal returns make a moderate investment by choosing $s_i^M = \delta_1^M$, and firms with high marginal returns make a high investment by choosing $s_i^M = \delta_2^M$. The intuition is similar to when disclosure is limited to a single level: The number of firms' investment levels equals the number of disclosure thresholds set, because stakeholders' beliefs (given each disclosure threshold) are fixed and there is no additional benefit to investing beyond those thresholds. Firms that stand to gain higher marginal benefits from investing incur either less cost associated with overinvesting or more costs associated with underinvesting; thus, they are willing to choose higher levels of investment.

Next, we investigate the public policymakerâ€™s optimal choice for the disclosure thresholds. We relegate the analysis to the appendix and present our results in the following proposition:

Proposition 4 (Optimal threshold under multiple disclosure)**.** *With multiple disclosure thresholds, the public policymaker's optimal thresholds are*

$$\delta_1^{M*} = \frac{2}{15}\left(\frac{4}{1-\beta} - \frac{\sqrt{1+15\beta^2}}{1-\beta}\right) \text{ and } \delta_2^{M*} = \frac{4}{15}\left(\frac{4}{1-\beta} - \frac{\sqrt{1+15\beta^2}}{1-\beta}\right).$$

Panel (a) of Figure 3 illustrates how the policymaker's optimal thresholds change with β. Akin



(a) Optimal thresholds

(b) The effect of multiple thresholds

Panel (a) of this figure plots the optimal thresholds under multiple disclosure, while Panel (b) compares the policymaker's payoff under discrete disclosure with one threshold versus two thresholds, holding $L = 0$ fixed.

Figure 3: Multiple disclosure

to the base model, the policymaker prioritizes the aggregate firm investment as β increases. In response, they set higher thresholds δ_1^M and δ_2^M, which encourage firms with moderate and high marginal returns to invest aggressively.

Panel (b) of Figure 3 shows the effect that multiple thresholds have on the public policymaker's payoff. It follows immediately that the policymaker is better off adopting two disclosure thresholds. That is, when there is only one disclosure threshold (discrete disclosure), firms with either low or high marginal returns can choose to underinvest; in fact, even if they prefer to invest (and thus benefit) more, they cannot credibly communicate such an investment to stakeholders due to the binary nature of the disclosure suppressing too much information. With two disclosure thresholds, however, firms can more manageably match one of the thresholds according to the marginal benefits they stand to gain from their investments, which alleviates the issue of underinvestment. As a result, firm profits and the aggregate investment increase, and so does the public policymaker's payoff.

5 Censored Disclosure

In the base model, we showed that, when the public policymaker is sufficiently concerned with aggregate firm investment (i.e., when β is high enough), they tend to prefer discrete disclosure over full disclosure. Nonetheless, discrete disclosure also generates inefficiencies associated with underinvesting: that is, underinvesting reduces firm profitability as well as the aggregate investment, thereby hurting both the firm and social welfare. In this section, we consider an alternative type of disclosure, censored disclosure, which reduces the inefficiency caused by underinvestment and improves the public policymaker's payoff.

Mathematically, consider the following disclosure policy. Similar to discrete disclosure, the public policymaker chooses a threshold δ^C, where the superscript C stands for censored disclosure.[18] If the firm's investment falls below the threshold δ^C (i.e., $s_i^C < \delta^C$), nothing is disclosed (i.e., $I_i^C = \emptyset$). However, if the investment is equal to or greater than the threshold δ^C, the firm is allowed to disclose the exact amount of the investment to stakeholders:

$$I_i^C = \begin{cases} \emptyset & \text{if } \ s_i < \delta^C, \\ s_i^C & \text{otherwise.} \end{cases} \tag{12}$$

In this sense, censored disclosure can be viewed as a hybrid between nondisclosure and full disclosure: nondisclosure is adopted when the investment is low, and full disclosure is implemented when it is high.

Given the disclosure threshold, the firms' optimal investment decision is as follows.

$$s_i^C = \begin{cases} 0 & \text{if } \ \alpha_i < \frac{\delta^C}{2}, \\ \delta^C & \text{if } \ \frac{\delta^C}{2} \leq \alpha_i < \delta^C, \\ \alpha_i & \text{otherwise.} \end{cases} \tag{13}$$

[18] While our model features a single materiality threshold, it also conceptually captures disclosure frameworks with multiple materiality dimensions, such as the double materiality concept in the European Sustainability Reporting Standards (ESRS).

The firm's investment strategy in equation (13) has three segments: When the firm's marginal return to CSR investment is low enough (i.e., when $\alpha_i < \frac{\delta^C}{2}$), the firm does not invest at all since it cannot afford to invest at least $s_i^C = \delta^C$. When its marginal return is high but not too high (i.e., when $\frac{\delta^C}{2} \leq \alpha_i < \delta^C$), the firm invests exactly at the threshold level to ensure disclosure. If its marginal return is high enough (i.e., when $\alpha_i > \delta^C$), the firm invests beyond the threshold to benefit more from its investment.

Consider next the public policymaker's optimal decision on the disclosure threshold δ^C. Straightforward algebra yields that, when $L \leq 0.5$, the policymaker's payoff is

$$\Pi^C = \begin{cases} \frac{1+2\beta+L(1+L+2\beta-L\beta)}{6} & \text{if } \delta^C \leq L, \\ \frac{1-3L^2\delta^C+3L(\delta^C)^2-(\delta^C)^3+\beta(2+\delta^C(3L^2-3L(2+\delta^C)+\delta^C(3+\delta^C)))}{6(1-L)} & \text{if } L \leq \delta^C \leq 2L, \\ \frac{4-(\delta^C)^3+\beta(8+(\delta^C)^3)}{24(1-L)} & \text{if } 2L \leq \delta^C \leq 1, \\ \frac{\delta^C(2-\delta^C)(2+2\beta-\delta^C+\beta\delta^C)}{8(1-L)} & \text{if } 1 \leq \delta^C \leq 2, \\ 0 & \text{if } \delta^C > 2. \end{cases} \tag{14}$$

When $L \geq 0.5$, the policymaker's payoff is

$$\Pi^C = \begin{cases} \frac{1+2\beta+L(1+L+2\beta-L\beta)}{6} & \text{if } \delta^C \leq L, \\ \frac{1-3L^2\delta^C+3L(\delta^C)^2-(\delta^C)^3+\beta(2+\delta^C(3L^2-3L(2+\delta^C)+\delta^C(3+\delta^C)))}{6(1-L)} & \text{if } L \leq \delta^C \leq 1, \\ \frac{\delta^C(1+\beta+(1-\beta)(L-\delta^C))}{2} & \text{if } 1 < \delta^C < 2L, \\ \frac{\delta^C(2-\delta^C)(2+2\beta-\delta^C+\beta\delta^C)}{8(1-L)} & \text{if } 2L \leq \delta^C \leq 2, \\ 0 & \text{if } \delta^C > 2. \end{cases} \tag{15}$$

We then investigate the public policymaker's optimal decision on δ^C and obtain the following lemma:

Lemma 5 (Optimal threshold under censored disclosure). *Under censored disclosure, when* $L \leq$

0.5, *the public policymaker's optimal disclosure threshold is*

$$\delta^{C*} = \begin{cases} L + \frac{2\beta}{1-\beta} & \text{if } \beta < \frac{L}{2+L}, \\ 2L & \text{otherwise.} \end{cases} \tag{16}$$

When $L \geq 0.5$, *the public policymaker's optimal disclosure threshold is*

$$\delta^{C*} = \begin{cases} L + \frac{2\beta}{1-\beta} & \text{if } \beta < \frac{1-L}{3-L}, \\ \frac{1+L+\beta-L\beta}{2-2\beta} & \text{if } \frac{1-L}{3-L} \leq \beta \leq \frac{3L-1}{3L+1}, \\ 2L & \text{otherwise.} \end{cases} \tag{17}$$

The intuition for Lemma 5 is essentially the same as that of Proposition 2, with the key difference being that there are more possible solutions for optimal thresholds when L is large relative to when L is small. Intuitively, under censored disclosure, the policymaker cares only about inducing firms that have an incentive to underinvest to invest more; when L is large, the cost to induce underinvesting firms is smaller, and the policymaker can thus set a more refined threshold to encourage increased investments from these firms that would otherwise choose nondisclosure.

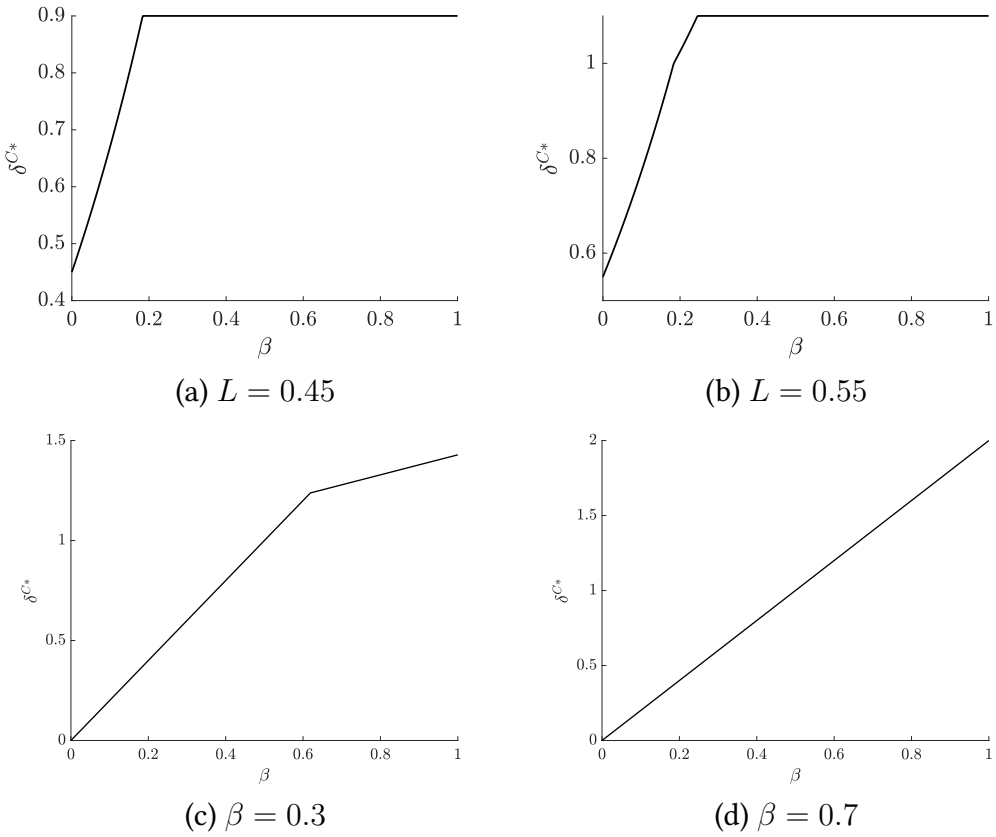
Moreover, Figure 4 plots the optimal disclosure threshold under censored disclosure. As in Proposition 2, the threshold increases with L and β, i.e., the policymaker sets a higher threshold to encourage more investment when firms are more willing to invest and when the policymaker prioritizes firm investment, respectively.

The following proposition summarizes the implications of censored disclosure for the policymaker.

Proposition 5 (Censored disclosure vs. full disclosure vs. discrete disclosure)**.** *In comparing censored disclosure with discrete and full disclosure, we observe the following:*

(1) The public policymaker (weakly) prefers censored disclosure over full disclosure: $\Pi^C \geq \Pi^F$, *where the inequality is strict when* $L > 0$ *and* $\beta > 0$.

(2) The public policymaker (weakly) prefers censored disclosure over discrete disclosure: $\Pi^C \geq \Pi^D$,



(a) $L = 0.45$ (b) $L = 0.55$

(c) $\beta = 0.3$ (d) $\beta = 0.7$

Panels (a) and (b) of this figure plot the optimal disclosure threshold under censored disclosure for different values of β when L is fixed at a lower level ($L = 0.45$) and a higher level ($L = 0.55$), respectively. Panels (c) and (d) plot the optimal disclosure threshold for different values of L given β is fixed at a lower level ($\beta = 0.3$) and a higher level ($\beta = 0.7$), respectively.

Figure 4: Optimal threshold under censored disclosure

where the inequality is strict when $L < 1/2$*, or when* $L \geq 1/2$ *and* $\beta < \frac{1-L}{3-L}$.

The policymaker's preference in Part (1) of Proposition 5 is intuitive: by setting a low threshold (i.e., $\delta^C \leq L$), censored disclosure can always replicate full disclosure and thus $\Pi^C \geq \Pi^F$. The strict gain from censored disclosure comes from using the threshold to push marginal firms to invest slightly more than they would under full disclosure. This gain is available when $L > 0$: since all firms already have marginal returns bounded away from zero, a threshold just above L raises the investment of the lowest existing firms without introducing a new group of firms that finds investment unattractive. When $L = 0$, by contrast, the type distribution starts at zero. Any positive threshold also affects firms with very low returns, for whom reaching the

threshold is too costly, so the optimal censored rule does not raise the threshold and simply replicates full disclosure. In addition, when $\beta = 0$, the policymaker values only firm profits, so inducing additional investment beyond the full-disclosure benchmark has no policy benefit. Taken together, the two regimes yield the same payoff only when $L = 0$ or $\beta = 0$.

Part (2) of Proposition 5 states that the policymaker weakly prefers censored disclosure over discrete disclosure. With discrete disclosure, firms with high marginal returns underinvest. More specifically, consider a firm with $\alpha_i > \delta^D$: if the firm could disclose its investment directly to stakeholders, it chooses an investment level of $s_i = \alpha_i > \delta^D$. However, when the firm can only disclose whether or not its investment is greater than the threshold, it has no incentive to invest above δ^D; in this case, the firm caps its investment at $s_i^D = \delta^D$. Censored disclosure removes this downward distortion for types above the threshold by allowing them to disclose their exact investment. This strictly improves the policymaker's payoff when $L < 1/2$, or when $L \geq 1/2$ and $\beta < \frac{1-L}{3-L}$. Otherwise, the optimal discrete-disclosure threshold is at least one, the upper bound of the type distribution; hence there is no positive measure of firms with $\alpha_i > \delta^{D*}$ whose underinvestment can be corrected, so censored disclosure and discrete disclosure yield the same payoff.

6 Empirical and Policy Implications

Our results have empirical and policy implications. First, in Lemma 1 and Proposition 3, we show that, while disclosing CSR investments is always better than not disclosing, discrete disclosure is preferred over full disclosure, in particular for public policymakers who emphasize and encourage the externalities of CSR investment. Our results not only justify the disclosure of CSR activities but also caution disclosures against becoming too granular, especially when some activities (e.g., investments into green technologies that reduce level 3 GHGs) cannot be perfectly measured. Discrete disclosure also supports the use of discrete CSR ratings such as MSCI ESG ratings. As discussed before, our investigation of discrete disclosure is different from continuous but noisy

measurements of CSR investments, which result in severe underinvestment. This makes our discrete disclosure also related to vague or qualitative statements, if such vague or qualitative statements are informationally equivalent to conveying an interval that firms' CSR investments lie in.

Second, we demonstrate in Proposition 5 that, even if CSR investments can be measured precisely, censored disclosure reduces underinvestment from firms with high marginal private returns to CSR investments and thus improves upon both full and discrete disclosure, if the policymaker cares sufficiently about CSR. To the extent that the disclosure threshold corresponds to the materiality threshold, this result justifies disclosing CSR investments only if they surpass some materiality threshold, as discussed in, e.g., Khan et al. (2016) and Grewal et al. (2019).

Finally, our comparative statics results in Figures 1 and 4 provide empirical implications regarding how the disclosure/materiality threshold should vary with exogenous parameters. For example, perhaps counterintuitively, the disclosure threshold increases — which results in fewer disclosures or a higher proportion of firms with subpar CSR performance — when policymakers care more about externalities and CSR than firm profits. In this case, policymakers increase the disclosure threshold to alleviate underinvestment, resulting in increased levels of investment in CSR specifically by firms that have higher private returns from CSR or, to the extent that α_i is also a proxy for CSR preference amongst stakeholders, by firms that have higher proportions of stakeholders who emphasize the importance of CSR. The overall CSR investment from these firms is higher than what is observed under full or discrete disclosure, even though it is associated with a higher proportion of firms that do not (or, more precisely, cannot) disclose (i.e., firms with subpar CSR performance that do not invest to the disclosure threshold).

7 Conclusion

Many firms' investments generate positive externalities that improve social welfare, yet firms only partially internalize these benefits. Meanwhile, firms follow various disclosure standards to

communicate these investments to stakeholders. For example, modern firms are increasingly investing in CSR activities to address stakeholders' concerns about social justice and responsibility and to earn long-term benefits from improved processes and reputation. To realize the benefits of CSR engagement â€" such as enhanced brand image and consumer satisfaction â€" firms must disclose their investments. Different standards exist for CSR disclosure: some require comprehensive transparency of every detail, while others simply provide an aggregate grade for a firm's overall CSR performance.

In this paper, we build a model to understand the role that disclosure standards play in such investments and their ensuing benefits to society as a whole. We consider three disclosure regimes in the base model. Under nondisclosure, firms cannot disclose anything to their stakeholders; under full disclosure, firms disclose all investments to their stakeholders; under discrete disclosure, firms only disclose whether their investments pass a certain threshold. We further endogenize firms' investment decisions to investigate how disclosure standards affect such decisions.

We find that the selected disclosure policy can significantly influence firms' investment incentives. More specifically, under discrete disclosure, a firm can only choose between making no investments or investing to an established threshold; therefore, a firm can overinvest or underinvest under this policy. Taking this into consideration, policymakers can strategically choose a threshold that induces the desired level of firm investment. If the policymaker is primarily concerned with aggregate investment over firm profits, a discrete disclosure policy is optimal compared to no or full disclosure since it garners more investments on average. Collectively, these results suggest the non-trivial role that disclosure standards play and recommend that regulators account for firms' strategic responses when designing public policies.

Our work can be extended in several directions. First, our model is a partial equilibrium framework that focuses exclusively on investments with positive externalities without considering their interaction with other investment activities. For example, if customers respond to low externality-generating investments by reducing purchases and investors respond by withholding capital, then firms may also curtail other investments, rendering the overall welfare impact

ambiguous. Second, by abstracting from other investment types, we also sidestep measurement issues that arise when firms engage in multiple activities. For example, if separating CSR and non-CSR activities necessarily involves measurement noise, as in, e.g., separating operating versus investing cash flows (Kanodia and Mukherji, 1996; Jiang et al., 2023), how should the regulator choose between full disclosure and discrete disclosure? Those are interesting questions that we leave for future research.

A Appendix: Proofs

Proof of Lemmas 1 and 2. See the main text.

Proof of Lemma 3. Assume for the sake of contradiction that firm i's investment intensity is $s_i^D \notin \{0, \delta^D\}$. There are two cases to consider: (1) $0 < s_i^D < \delta^D$ and (2) $s_i^D \geq \delta^D$. In the former case, the firm's investment falls short of the threshold and, therefore, stakeholders hold the belief that the firm's investment intensity is $\hat{s}_L^D$. In this sense, firm i's profit is given by $\pi_i^D = \alpha_i \hat{s}_L^D - (s_i^D)^2/2$. Clearly, the firm can do better by making an investment of $s_i^D = 0$. By doing so, the firm's payoff will be $\alpha_i \hat{s}_L^D > \alpha_i \hat{s}_L^D - (s_i^D)^2/2$, higher than before. In the latter case, the firm's investment is above the threshold and, therefore, stakeholders believe the firm's investment to be $\hat{s}_H^D$. As such, firm i's profit is $\pi_i^D = \alpha_i \hat{s}_H^D - (s_i^D)^2/2$. Clearly, the firm can do better by making an investment of $s_i^D = \delta^D$ instead, under which its profit will be $\alpha_i \hat{s}_H^D - (\delta^D)^2/2 > \alpha_i \hat{s}_H^D - (s_i^D)^2/2$, higher than before. This completes the proof. Q.E.D.

Proof of Proposition 1. By comparing the firm's investment under the discrete disclosure s_i^D as given by (5) with that under the full disclosure as given by $s_i^F = \alpha_i$, we find that $s_i^D > s_i^F$ when $\frac{\delta^D}{2} \leq \alpha_i < \delta^D$, which is equivalent to the condition $\alpha_i < \delta^D \leq 2\alpha_i$. Q.E.D.

Proof of Proposition 2. The optimal threshold δ^D is given by (7) and (8), depending on δ^D relative to L and β. Note that $L \in (0, 1)$ and $\beta \in [0, 1)$. Denote the two thresholds of β as $\bar{\beta}_1 \equiv \frac{3L-1}{3L+1}$ and $\bar{\beta}_2 \equiv \frac{3L^2-4L+1}{3L^2-1}$. We have the following findings: (i) When $L < 1/3$, both $\bar{\beta}_1 < 0$ and $\bar{\beta}_2 < 0$. Thus, $\delta^{D*} = \frac{4-2\sqrt{1+3\beta^2}}{3(1-\beta)}$. (ii) When $1/3 < L < 1/2$, $0 < \bar{\beta}_1 < \bar{\beta}_2 < 1$. Thus, if $\beta < \bar{\beta}_1$, $\delta^{D*} = \frac{1+\beta+L(1-\beta)}{2(1-\beta)}$, if $\bar{\beta}_1 < \beta < \bar{\beta}_2$, $\delta^{D*} = 2L$, and otherwise, $\delta^{D*} = \frac{4-2\sqrt{1+3\beta^2}}{3(1-\beta)}$. (iii) When $L > 1/2$, in equation (8) we always have $\delta^D = 2L$ for the moderate threshold. Thus, the optimal threshold is determined by equation (7). The proposition summarizes these results. Q.E.D.

Proof of Proposition 3. Consider first the case of $\beta = 0$. In this case, the public policymaker maximizes the firms' total payoff. Firm i's payoff under full disclosure is $\pi_i^F = \alpha_i^2/2$, where its payoff under discrete disclosure is $\pi_i^D = \max\left(\alpha_i \delta^D - (\delta^D)^2/2, 0\right)$. For any fixed disclosure threshold δ^D, we have $\pi_i^F \geq \pi_i^D$ for every firm i, with strict inequality for a positive measure of firms whenever discrete disclosure distorts investment away from the full-disclosure choice. Therefore, aggregate firm profit, and thus the policymaker's payoff, is strictly higher under full disclosure than under discrete disclosure: $\Pi^F > \Pi^D$.

Consider next the limiting case as $\beta \uparrow 1$. In this case, the public policymaker places nearly all weight on aggregate investment. Under full disclosure, the aggregate investment is $\Delta^F = \frac{1+L}{2}$. Under discrete disclosure, by choosing $\delta^D = 1$, the public policymaker can achieve an aggregate investment at:

$$\Delta^D = \begin{cases} \frac{1}{2(1-L)} & \text{if } L \leq \frac{1}{2}, \\ 1 & \text{otherwise,} \end{cases} \tag{18}$$

which is weakly greater than $\Delta^F = \frac{1+L}{2}$, with equality only at $L = 0$. Note that the investment in equation (18) is just a lower bound for aggregate investment as the public policymaker can potentially do better by charging a different δ^D. Therefore, when $L > 0$, the public policymaker is strictly better off with discrete disclosure as β approaches one; at the boundary $L = 0$, discrete disclosure weakly matches full disclosure in the limit as β approaches one.

Finally, because both Π^D and Π^F are continuous, for $L > 0$ we prove that the public policymaker prefers full disclosure when β is low enough but discrete disclosure when β is high enough. Q.E.D. **Proof of Lemma 4**. If firm i chooses $s_i^M = 0$, its profit will be $\pi_{i0}^M = 0$. If firm i chooses $s_i^M = \delta_1^M$, its profit will be $\pi_{i1}^M = \alpha_i \delta_1^M - (\delta_1^M)^2/2$. If firm i chooses $s_i^M = \delta_2^M$, its profit will be $\pi_{i2}^M = \alpha_i \delta_2^M - (\delta_2^M)^2/2$. Comparing firm profits under the above three strategies, we prove the lemma. Q.E.D.

Proof of Proposition 4. Assume that $0 \leq \delta_1^M \leq \delta_2^M \leq 1$ (we verify later that this is indeed the case). Then, we can write the aggregate investment and firm profit as follows:

$$\Delta^M = \int_{\delta_1^M/2}^{(\delta_1^M+\delta_2^M)/2} \delta_1^M d\alpha_i + \int_{(\delta_1^M+\delta_2^M)/2}^{1} \delta_2^M d\alpha_i = \frac{(2-\delta_2^M)\delta_2^M}{2},$$

$$\pi^M = \int_{\delta_1^M/2}^{(\delta_1^M+\delta_2^M)/2} \alpha_i \delta_1^M - \frac{(\delta_1^M)^2}{2} d\alpha_i + \int_{(\delta_1^M+\delta_2^M)/2}^{1} \alpha_i \delta_2^M - \frac{(\delta_2^M)^2}{2} d\alpha_i = \frac{\delta_2^M((2-\delta_2^M)^2 - (\delta_1^M)^2 + \delta_1^M \delta_2^M)}{8}.$$

The public policymaker's payoff, $\Pi^M = \beta \Delta^M + (1-\beta)\pi^M$, can be written as

$$\Pi^M = \frac{\delta_2^M(4 - 4\delta_2^M - ((\delta_1^M)^2 - \delta_1^M \delta_2^M - (\delta_2^M)^2)(1-\beta) + 4\beta)}{8}.$$

Maximizing the public policymaker's payoff, we prove the proposition. Q.E.D.

Proof of Lemma 5. Define the following regions based on the relationships between L and δ:

- Region 1 where $L < 1 < \delta/2$, equivalent to $\delta > 2$;
- Region 2 where $L < \delta/2 < 1 < \delta$, equivalent to $\max(2L, 1) < \delta < 2$;
- Region 3 where $L < \delta/2 < \delta < 1$, equivalent to $2L < \delta < 1$;
- Region 4 where $\delta/2 < L < 1 < \delta$, equivalent to $1 < \delta < 2L$;
- Region 5 where $\delta/2 < L < \delta < 1$, equivalent to $L < \delta < \min(1, 2L)$;
- Region 6 where $\delta/2 < \delta < L < 1$, equivalent to $\delta < L$.

The corresponding payoff for the policymaker in Region i is denoted as Π^{Ci}.

Consider the case when $L < 0.5$. The policymaker's payoff is given by equation (14); noting that Region 4 is empty. Examining the policymaker's payoff we find: (i) Π^{C2} is monotonically decreasing in δ in Region 2; (ii) Π^{C3} is monotonically decreasing in δ in Region 3; (iii) Π^{C5} is monotonically increasing when $L < \delta < L + \frac{2\beta}{1-\beta}$ and decreasing when $\delta > L + \frac{2\beta}{1-\beta}$; and (iv) Π^{C6} is independent of δ. Thus, the optimal threshold depends on the relative relationship between $2L$ and $L + \frac{2\beta}{1-\beta}$, as stated in the lemma.

Consider the case when $L > 0.5$. The policymaker's payoff is given by equation (15); noting that Region 3 is empty. Similar to the case when $L < 0.5$, the optimal threshold cannot be obtained in Regions 1, 2, or 6. Examining the policymaker's payoff we find: (i) Π^{C5} is monotonically increasing when $L < \delta < L + \frac{2\beta}{1-\beta}$ and decreasing when $\delta > L + \frac{2\beta}{1-\beta}$; (ii) Π^{C4} is increasing when $L < \frac{1+\beta+L(1-\beta)}{2(1-\beta)}$ and decreasing otherwise. Therefore, we have the following results: (1) If $\beta > \frac{3L-1}{3L+1}$, Π^C is increasing in Regions 4 and 5 and thus $\delta^{C*} = 2L$. (2) If $\frac{1-L}{3-L} < \beta < \frac{3L-1}{3L+1}$, Π^C is increasing in Region 5 and peaks at $\delta^{C*} = \frac{1+\beta+L(1-\beta)}{2(1-\beta)}$ in Region 4. (3) If $\beta < \frac{1-L}{3-L}$, Π^C peaks at $\delta^{C*} = \frac{1+\beta+L(1-\beta)}{2(1-\beta)}$ in Region 5 and is decreasing in Region 4. Q.E.D.

Proof of Proposition 5. *Proof of Part (1) of Proposition 5.* As shown by the policymaker's payoff functions (14) and (15), setting a low threshold (i.e., $\delta^C \leq L$) allows the policymaker to always achieve a payoff equivalent to that under full disclosure. Therefore, censored disclosure weakly dominates full disclosure, i.e., $\Pi^C \geq \Pi^F$. When $L > 0$ and $\beta > 0$, the result $\lim_{\delta^C \to +L} \frac{\partial \Pi^C}{\partial \delta^C} > 0$ implies that the policymaker strictly benefits from setting a threshold higher than L and thus $\Pi^C > \Pi^F$. The equality holds only when

$L = 0$ or $\beta = 0$, so that the optimal censored threshold is zero; in this case, censored disclosure replicates full disclosure.

Proof of Part (2) of Proposition 5. Let δ^{D*} be the optimal threshold under discrete disclosure. Then, the firms' optimal investment decision will be

$$s_i^{D*} = \begin{cases} 0 & \text{if } \alpha_i < \frac{\delta^{D*}}{2}, \\ \delta^{D*} & \text{otherwise.} \end{cases} \tag{19}$$

Now, under censored disclosure, suppose that the public policymaker chooses a threshold $\delta^C = \delta^{D*}$. In this case, the firms' optimal investment decision will be

$$s_i^C = \begin{cases} 0 & \text{if } \alpha_i < \frac{\delta^{D*}}{2}, \\ \delta^{D*} & \text{if } \frac{\delta^{D*}}{2} \leq \alpha_i < \delta^{D*}, \\ \alpha_i & \text{otherwise.} \end{cases} \tag{20}$$

Comparing equations (19) and (20), the firms' investment decision differs only when $\delta^{D*} < \alpha_i \leq 1$. Within this region, firm i's investment satisfies $s_i^C = \alpha_i > s_i^{D*} = \delta^{D*}$, and the firm's profit satisfies

$$\pi_i^C = \frac{\alpha_i^2}{2} > \alpha_i \delta^{D*} - \frac{(\delta^{D*})^2}{2} = \pi_i^{D*}.$$

Thus, censored disclosure weakly improves upon discrete disclosure by allowing firms above the discrete threshold to disclose and choose their preferred investment levels. The improvement is strict if and only if $\delta^{D*} < 1$, so that the set of firms with $\alpha_i > \delta^{D*}$ has positive measure. It remains to translate this condition into primitives. When $L < 1/2$, Proposition 2 implies $\delta^{D*} < 1$: in the first two regions, $\delta^{D*} \leq 2L < 1$, while in the last region $\delta^{D*} = \frac{4-2\sqrt{1+3\beta^2}}{3(1-\beta)} < 1$ for all $0 \leq \beta < 1$. When $L \geq 1/2$, Proposition 2 implies that the only case in which $\delta^{D*} < 1$ is the first region, where

$$\delta^{D*} = \frac{1 + \beta + L - L\beta}{2(1-\beta)} < 1 \quad \iff \quad \beta < \frac{1-L}{3-L}.$$

Therefore, the improvement is strict when $L < 1/2$, or when $L \geq 1/2$ and $\beta < \frac{1-L}{3-L}$. Otherwise, Proposition 2 implies $\delta^{D*} \geq 1$, so the improvement region is empty up to a zero-measure boundary and censored

disclosure and discrete disclosure yield the same payoff. This completes the proof. Q.E.D.

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