Disclosure of Disaggregated Information in the Presence of Reputational Concerns

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Abstract

This study examines a reputation-concerned entrepreneur's incentives to provide disaggregated information about a project's future performance when he seeks to increase both the market price of the project and the market assessment of his ability as a project manager. Two factors determine equilibrium: (i) the informational quality of the signal related to the entrepreneur's ability; and (ii) the magnitude of reputational concerns. If the former is relatively low, the entrepreneur with moderate reputational concerns is more likely to provide disaggregated information when the signal about the project's overall performance is intermediate than when it is sufficiently good or bad. Also, given any value of the signal about the overall performance, this entrepreneur withholds disaggregated information when the signal about his ability is intermediate, rather than sufficiently good or bad. The comparative static results provide novel empirical predictions about disclosure of aggregate versus disaggregated information.

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1. Introduction

Managers' talents and skills are critical for firm performance (Hayes and Schaefer 1999; Bertrand and Schoar 2003; Graham et al. 2013). Specifically, manager ability is essential for creating investment opportunities, developing innovative products, improving production efficiency, enhancing customer satisfaction, and recruiting/retaining high-quality workers. Managers also use their personal networks for these tasks (Ittner and Larcker 1998; Lev and Zarowin 1999; Eccles et al. 2001; Ulrich and Smallwood 2004; Lev 2018). Due to this importance, the market demands information to better assess manager ability (Murphy and Zábojník 2004, 2007; Tervio 2008; Lazear 2009; Pan et al. 2015; Larcker et al. 2017; Balakrishnan et al. 2020; Cao et al. 2022).

However, the information about manager ability is to a large extent private to managers. Although the Securities Exchange Commission (SEC) recently required public companies to expand disclosure of human capital resources, firms are given wide latitude to tailor their disclosures.[1] Relatedly, when explaining firm performance, some firms (e.g., Adidas and Fresenius) voluntarily provide detailed information, in various forms, to disentangle the effects of factors that are beyond manager ability/control (e.g., the effects of the COVID-19 pandemic on earnings).[2] Nonetheless, there are subjective areas in determining those effects. Similarly, although Cao et al. (2022) find that disaggregated segment information enables the market to more precisely assess manager ability in several dimensions, firms have considerable discretion over how to define segments (e.g., see the cases of Amazon, Citigroup, and Wells Fargo in Ebert et al. 2017). In addition, to measure manager ability (as proposed by prior studies, e.g., Murthi et al. 1996, Demerjian et al. 2012, Leverty and Grace 2012), outsiders need various raw data whose disclosure is largely under manager discretion.[3] In summary, although there exists significant demand for information about

[1] This pertains to Regulation S-K, applicable to disclosure of the description of the business (Item 101), legal proceedings (Item 103), and risk factors (Item 105). In response, for example, companies disclose executives' human capital and experience related to leadership, scaling businesses, and mergers and acquisitions; see the report by Ernst & Young, "How and why human capital disclosures are evolving" (https://assets.ey.com/content/dam/ey-sites/ey-com/en_us/topics/cbm/ey-how-and-why-human-capital-disclosures-are-evolving.pdf).

[2] See "How COVID-19 infects financial reporting and results presentations" and "How COVID-19 continues to infect financial reporting" by Deloitte (https://www2.deloitte.com/ch/en/pages/audit/articles/financial-reporting-survey-q1-2020.html and https://www2.deloitte.com/ch/en/pages/audit/articles/financial-reporting-survey-q3-2020.html).

[3] Demerjian et al. (2012, p. 1230) discuss the limitations of their measure of manager ability. For instance, they suggest that information about the operational and geographical diversification of a firm's operations should be considered in measuring manager ability because it is more challenging to efficiently run the firm if the diversification is greater. However, as is well known, managers have considerable discretion over the disclosure of such information.

manager ability, its availability largely depends on management's voluntary disclosure. This suggests that reputation-concerned managers could have incentives to disclose or withhold such information to favorably influence the market assessment of their ability.

Prompted by Fama (1980) and Holmstrom (1982), researchers have examined the effects of reputational concerns on managers' decision making in various contexts. However, relatively little attention has been paid to the effects on disclosure. This is rather surprising because, according to Graham et al. (2005) and Kothari et al (2009), managers' reputation/career concerns are a key determinant of corporate financial disclosure. Beyer et al. (2010) notes, "our understanding of how management's career concerns affect their disclosure strategies is still limited, a fact previously noted in the survey by Healy and Palepu (2001)." Although some researchers have responded to this call for research, unaddressed questions remain. For example, do managers with reputational concerns always prefer to reveal (hide) information about their ability that improves (downgrades) the market perception of their ability? If not, how does the standard partial disclosure equilibrium (e.g., Verrecchia 1983; Dye 1985) change? How does the overall firm performance (which also depends on factors other than manager ability) affect managers' incentives to disclose or withhold their ability-related information? The objective of this study is to address these questions to better understand the effect of reputational concerns on voluntary disclosure.

To this end, we develop a model in which disclosure of disaggregated information enables the market to better assess manager ability and firm performance. Under certain conditions (elaborated below), we obtain two main results. First, disaggregated information is more likely to be provided when the information about the overall firm performance is intermediate than when it is sufficiently good or bad. This means that the overall firm performance has a *nonmonotonic* effect on disaggregated information disclosure. Second, for any given information about the overall firm performance, disaggregated information is withheld when the information related to manager ability is *intermediate*, rather than when it is sufficiently good or bad. Below, we elaborate on our model and explain these results in detail.

In our model, an entrepreneur has a project that requires capital investment for implementation. Lacking capital, he needs to raise the required funds from investors (e.g., venture capitalists). For simplicity, we assume that the entrepreneur seeks to sell the project to investors, after which he manages the project. If traded, the project is implemented and will generate a cash flow in the future. This cash flow can be disaggregated into two components. One component is closely related to the entrepreneur's ability as a project manager (e.g., cost-reducing or marketing skills, expertise in supply chain management, and administration experience). The other component is affected by factors that are largely beyond his ability/control (e.g., business cycles, regulations, or environmental changes).[4] Prior to a potential trade of the project, the entrepreneur has information about the project's total future cash flow, referred to as an *aggregate* signal, which he must disclose. With a positive probability, however, he may have more refined information; he may have two signals, each of which provides separate information about each component of the total future cash flow. In this case, although he must disclose the sum of these signals as an aggregate signal (as noted above), he has discretion over whether to disclose each signal individually as *disaggregated* information. In deciding whether to reveal the two signals individually or to disclose their sum only, the entrepreneur seeks to maximize a weighted average of the market price of the project and the market assessment of his ability. The weight he places on the ability assessment relative to the project price is referred to as his *reputational concerns*. Investors in the competitive market decide whether to buy the project and supply capital to implement it. If not traded and thus unfunded, the project cannot be implemented, in which case there is no cash flow. Irrespective of project implementation, the market assesses entrepreneur ability using the available information.

Note that because an aggregate signal is always public, disclosing the two signals is equivalent to disclosing only one of them. We thus focus on the entrepreneur's incentives to reveal the signal about the cash flow related to his ability, which we call the "ability-related signal" for short. We show that this signal is not always disclosed; that is, disaggregated information is not always provided, which we refer to as partial disclosure. The most interesting result is that, depending on the informational quality of each signal and the magnitude of reputational concerns, the equilibrium nondisclosure set can be intermediate values of the ability-related signal.[5] This contrasts with the standard partial disclosure equilibrium in the literature (Verrecchia 1983; Dye 1985). The two factors mentioned above are critical for this result because they determine how the entrepreneur's

[4] For instance, the COVID-19 pandemic directly affected certain industries (e.g., travel, leisure, sports, and movie industries), and many firms (e.g., Airbnb and Warner Music) had to postpone their initial public offerings (IPOs). Ironically, subsequent government policies to increase market liquidity, which is also relatively unrelated to management's capability, attracted many firms to raise capital through public listings. To the extent that capital availability affects investment decisions, these factors influence the affected firms' future cash flows.

[5] As will be formalized in Section 3, the informational quality of a signal refers to the precision of the noise contained in the signal, normalized by the total precision of the signal.

payoff under disclosure changes with his ability-related signal. To elaborate, consider each component of the payoff under disclosure. The first component is the market price of the project. If the market posterior expectation of the project's total future cash flow is positive, the project price equals this expectation. Otherwise, the project price is zero because the project is unfunded and thus there is no future cash flow. Note that, given a value of the aggregate signal, disclosing a higher value of the ability-related signal reveals a lower value of the other signal. Also, Bayesian investors' expectation of the project's total future cash flow is more sensitive to a signal when its informational quality is higher than that of the other signal. Collectively, these imply that if the ability-related signal is more precise, the project price is zero below a cutoff value of the ability-related signal, and increases with it above the cutoff value. Thus, in this case, the change of the project price with respect to the ability-related signal is similar to the change of a *call option* value with respect to its underlying asset value. In contrast, if the ability-related signal is less precise, the project price is similar to a *put option* value. That is, the market valuation of the projects in this case is positive below the cutoff value of the ability-related signal (because the other signal eliciting a greater market reaction is high), it decreases as the ability-related signal increases (because the other signal decreases), and it becomes zero above the cutoff value. The other component of the entrepreneur's payoff under disclosure is the market assessment of his ability, which always increases with the ability-related signal.

Now recall that the entrepreneur seeks to maximize a weighted average of the project price and the ability assessment. The above discussion of the behavior of the project price and ability assessment indicates that if the ability-related signal is higher-quality information than the other signal is, the payoff under disclosure increases with the ability-related signal. Because the payoff under nondisclosure is a constant, the entrepreneur withholds *low* values of the signal about his ability, similar to the low-end pooling partial disclosure equilibrium in prior studies.

Our focus is on the other case in which the ability-related signal is lower-quality information. In this case, depending on the magnitude of reputational concerns, the equilibrium can change dramatically. To sharpen the intuition, consider a benchmark in which the entrepreneur has *no* reputational concerns; that is, he seeks to maximize the project price only. We know from the earlier discussion that the project price in this case is nonincreasing in the ability-related signal. As a result, the equilibrium nondisclosure set is a *high*-end pool of that signal (Figure 2). This contrasts with the main result that (i) if the entrepreneur has *moderate* reputational concerns, he withholds *intermediate* values of the ability-related signal (Figure 3), whereas (ii) if reputational concerns are *excessive*, he withholds *low* values of that signal (Figure 4). The key economic forces underlying the latter two types of partial disclosure equilibrium are as follows.

First, suppose that the entrepreneur has moderate reputational concerns, in which case he places a relatively small weight on the market assessment of ability. Given the behavior of the project price and the ability assessment, his payoff under disclosure is a *V-shaped* function of the ability-related signal. Because the payoff under nondisclosure is a constant, it follows that the equilibrium nondisclosure set contains only the intermediate values of the ability-related signal. To be specific, let an aggregate signal be given and suppose that the entrepreneur has a sufficiently low value of the ability-related signal. Disclosing this ability-related signal has a negative effect on the ability assessment, but doing so reveals a sufficiently high value of the other signal, to which the market reacts more in its valuation of the project; recall that the latter signal is higher-quality information. Because the entrepreneur assigns a relatively small weight to the ability assessment, he gains more from disclosure. Conversely, suppose that he has a sufficiently high value of the ability-related signal. Although disclosing this signal reveals a sufficiently low value of the other signal and thus negatively affects the project price, recall that the price is bounded below by zero. Thus, the entrepreneur discloses it to improve ability assessment. In sum, for any given value of the aggregate signal, the entrepreneur trades off the effect that disaggregated information disclosure has on the project price against its effect on the ability assessment. This leads to a unique equilibrium nondisclosure set containing intermediate values of the ability-related signal (i.e., an interval bounded from below and above). We further show that: (i) when the aggregate signal is below (above) a threshold, undisclosed information is bad (good) news about entrepreneur ability; and (ii) the ability-related signal is less likely to be disclosed when the aggregate signal is sufficiently high or low, rather than intermediate. In Section 5.2, we discuss the details of the economic intuition for these results and how they translate into empirical predictions.

Next, suppose that the entrepreneur has excessive reputational concerns, in which case he assigns a large weight to the ability assessment. In this case, his payoff under disclosure is no longer V-shaped; instead, it increases with the ability-related signal because of the large weight placed on the ability assessment. This leads to an equilibrium in which relatively low values of the ability-related signal are undisclosed. The comparative static results in this case are different from those in the case of moderate reputational concerns. In particular, the equilibrium nondisclosure set expands when the aggregate signal increases (see Section 5.3 for details). From an empirical viewpoint, our results collectively suggest that it is important to consider the overall firm performance as well as managers' reputational concerns when examining corporate voluntary disclosure.

Below, Section 2 provides a literature review. Section 3 lays out the model, and Section 4 provides preliminary analyses. We show the equilibrium results, their comparative statics, and efficiency implications in Section 5. Section 6 concludes. All proofs are provided in the appendix.

2. Literature Review

Although some prior studies have examined reputation-concerned managers' disclosure incentives, relatively little attention has been paid to these incentives in the context of disaggregated information disclosure that leads to better assessments of manager ability and firm performance.[6] We address this issue by extending the uncertain information endowment model (Dye 1985; Jung and Kwon 1988) to a setting in which an entrepreneur may have disaggregated information about the overall performance of a project. We identify conditions under which intermediate values of a signal about entrepreneur ability are withheld. This contrasts with low-end pooling partial disclosure equilibria in earlier studies, wherein managers seek to maximize firm value only. Some prior studies also derive intermediate pooling (non)disclosure equilibria, which they attribute to product market competition (Wagenhofer 1990; Feltham and Xie 1992), shareholder litigation risk (Trueman 1997), uncertainty in the investor interpretation of information (Dutta and Trueman 2002), a tradeoff between the effect of bad news disclosure on long-term investment efficiency and that on the short-term stock price (Kumar et al. 2012), or strategic stock repurchases (Kumar et al. 2017). By contrast, the key driving force in our model is a reputation-concerned entrepreneur's incentives to induce a favorable market assessment of ability.

In our model, disclosure of the signal about a project's overall prospects is mandatory, but disclosure of the disaggregated signals about the prospects is voluntary. Thus, our study is related

[6] Disclosure studies considering manager reputation in the context of a single signal include Trueman (1986), Nagar (1999), Kothari et al. (2009), Pae et al. (2016), Baginski et al. (2018), Ali et al. (2019), Feller and Schafer (2019), Aghamolla et al. (2021), and Kim et al. (2021). On the other hand, similar to our model, Gao and Liang (2013) and Friedman et al. (2022) consider settings in which a firm's total future cash flow consists of the one from assets in place and the other from growth opportunities. However, managers' reputational concerns are absent in these studies. Pae (2005) and Guttman et al. (2014) examine settings in which a firm manager who has no reputational concerns may have multiple signals about a single unknown value, which is different from the setting considered in our model. Milbourn et al. (2001) and Pae (2021) examine ex ante production of information in the presence of reputational concerns.

to the studies examining the interaction between mandatory and voluntary disclosures, although they typically do not consider managers' reputational concerns (e.g., Bagnoli and Watts 2007; Bertomeu and Magee 2015; Cianciaruso and Sridhar 2018; Friedman et al. 2020; Versano 2021). Gigler and Hemmer (1998, 2001) and Lundholm (2003) show that mandatory disclosure could lend credibility to voluntary disclosure of private information. Hughes and Pae (2004) examine supplemental disclosure pertaining to the precision of mandatorily disclosed information. Einhorn (2005) shows that mandatory disclosure can be an important determinant of voluntary disclosure. Recently, Friedman et al. (2020) examine a firm's design of a mandatory reporting system when it can also disclose more precise information through a different channel. Friedman et al. (2022) focus on the effects of mandatory disclosure on the acquisition and disclosure of additional information. Bertomeu et al. (2021) examine properties of an efficient mandatory disclosure policy in the context of costly voluntary disclosure. In contrast to all of these studies, reputational concerns play a central role in determining disaggregated information disclosure in our study.

Last, numerous studies have examined aggregate versus disaggregated information disclosure (e.g., Lev 1968; Lim and Sunder 1991; Banker and Datar 1989; Feltham et al. 1992; Ohlson and Penman 1992; Datar and Gupta 1994; Bushman et al. 1995; Hayes and Lundholm 1996; Ettredge et al. 2002; Dye and Sridhar 2004; Nanda and Zhang 2008; Arya and Glover 2014; Lu 2019; Cao et al. 2022). In the context of segment reporting, Arya et al. (2010) demonstrate that providing detailed information through disaggregation can have proprietary costs of damaging competitive advantages in product markets (à la Verrecchia 1983).[7] In contrast, we model an entrepreneur's dual concerns about financial and labor markets in the *absence* of proprietary costs associated with disaggregated information disclosure. Showing that reputational concerns can also be a factor in determining disaggregated information disclosure, our study complements this stream of the literature.[8] Without considering reputational concerns, Ebert et al. (2017) examine the incentives to aggregate information to maximize firm value. They show that high-end pooling nondisclosure may occur. Although the underlying economic forces are different, this is similar to the equilibrium

[7] As anecdotal evidence, Apple, Caterpillar, and Dell withheld segment information, claiming that providing detailed information could give a competitive advantage to their competitors (Greenberg 2006). Also see Ebert et al. (2017).

[8] In general, as shown in prior research, incentives to reveal or hide proprietary information are subtle and context-specific, especially when firms consider both financial and product markets. See, e.g., Darrough and Stoughton (1990), Wagenhofer (1990), Feltham and Xie (1992), Newman and Sansing (1993), Gigler (1994), Evans and Sridhar (2002), and Hughes and Pae (2015). This may be a reason for mixed empirical evidence on disaggregated information disclosure; e.g., see Botosan and Stanford (2005), Berger and Hann (2007), and the references therein.

nondisclosure set in our benchmark of no reputational concerns.

3. Model

All parties have risk-neutral preferences, and the risk-free interest rate is zero. An entrepreneur has a project whose implementation requires a fixed amount of capital $k > 0$. Lacking the required capital, he seeks to sell the project to investors in the competitive market who can supply k to implement it. If implemented, the project will generate a stochastic cash flow in the future, which can be disaggregated into two components. The first one is closely related to the entrepreneur's ability as a project manager (e.g., project-related knowledge and skills) that allows him to increase the project's cash flow. This ability is denoted as a and, to save notation, we also use a to denote the first cash flow component. The second component, denoted as x, is less related to entrepreneur ability than the first component is. For example, x is more influenced by macroeconomic cycles, regulations, or environmental changes. To simplify the analysis, we assume that x is unrelated to a. Taken together, if the project is implemented, its total future cash flow is

$$z \equiv a + x. \tag{1}$$

All parties in the model have common prior beliefs that

$$a \sim N(\theta, h_a^{-1}) \text{ and } x \sim N(0, h_x^{-1}), \tag{2}$$

where a zero mean of x is only for notational simplicity. Note that, ex ante, the project has a positive expected cash flow if and only if $E[z] = \theta > k$.

Prior to a potential trade of the project, the entrepreneur is required to provide a public report as an estimate of the project's total future cash flow, z. As in Dye (1985) and Jung and Kwon (1988), (i) the market has uncertainty about his information endowment, and (ii) any disclosure is truthful. Specifically, the entrepreneur always has information about z, represented by a signal

$$y \equiv z + \varepsilon, \tag{3}$$

where ε is white noise. We call y an aggregate signal. He discloses y as required. However, with probability $\lambda \in (0, 1)$, he may have two private signals about each component of z. They are

$$y_a \equiv a + \varepsilon_a \text{ and } y_x \equiv x + \varepsilon_x, \tag{4}$$

where (i) $y_a + y_x = y$, and (ii) $\varepsilon_a \sim N(0, q_a^{-1})$ and $\varepsilon_x \sim N(0, q_x^{-1})$ are white noise independent of all random variables. Although the entrepreneur who has y_a and y_x must disclose their sum y (as an estimate of total cash flow z), he has discretion over the separate disclosure of y_a and y_x, which is equivalent to providing disaggregated information. Based on available information, investors decide whether to purchase the project and supply k for its implementation. If not traded, the project is not funded and thus cannot be implemented, in which case there is no future cash flow.

If the entrepreneur has y only, disclosure is a nonissue because he must disclose it. However, if he has y_a and y_x, he has *dual* concerns when deciding whether to disclose them separately or to provide their sum y only. Specifically, when making this decision, he seeks to maximize a weighted average of the market price of the project, $P(\eta) \equiv \max\{E[z \mid \eta] - k, 0\}$, and the market expectation of the cash flow related to his ability, $A(\eta) \equiv E[a \mid \eta]$, where η is the set of publicly available information. Throughout the paper, we call $A(\eta)$ the market assessment of the entrepreneur's ability or, for short, the ability assessment. To formalize, let his objective function be

$$W(\eta) \equiv P(\eta) + \alpha \cdot A(\eta), \tag{5}$$

where $\alpha > 0$ is a weight that he places on $A(\eta)$ relative to $P(\eta)$. We interpret α as the magnitude of the entrepreneur's reputational concerns. The model structure is common knowledge.

Before proceeding, we provide remarks on our modeling choices and their implications (see the appendix for further remarks). Assuming that the entire project is sold to investors is for simplicity. Our main results would not change if a fraction of the project ownership, rather than its entirety, were sold to outsiders (e.g., venture capitalists or private equity firms) in return for their capital to implement the project. This is because the equilibrium fraction would make the entrepreneur's payoff the same as that stated in (5). Also, we assume mandatory disclosure of aggregate signal y to focus on the incentives to provide disaggregated information. If disclosure of y were also allowed to be voluntary, it would always be disclosed in equilibrium due to unraveling (Grossman 1981; Milgrom 1981); recall that the market knows that the entrepreneur always has y.

Next, our assumptions on the distributions of cash flows and signals imply that the market posterior expectation of the project's total future cash flow (conditional on available information) may be negative, in which case the project cannot be funded. This means there is a possibility that it cannot be implemented. In that case, because there is no future cash flow, the market price of the project, $P(\eta)$, must be zero.

Last, note that we do not formalize how the ability assessment, $A(\eta)$, affects the entrepreneur's future payoff. Instead, presuming that they are positively related, we only capture the idea that he cares about the ability assessment. For example, an entrepreneur who is perceived to have a high cash-generating ability tends to have a high reputation among venture capitalists, and thus is likely to obtain funds at a lower cost of capital when he develops other projects in the future. In this sense, $A(\eta)$ in the objective function is a reduced-form representation, similar to the models of Prendergast and Stole (1996) and Pae (2021). As will be shown, the fact that the project price, $P(\eta)$, is bounded below by zero and the ability assessment, $A(\eta)$, increases with the market belief about entrepreneur ability is critical in establishing the result that intermediate values of the ability-related signal, y_a, may be withheld. Here, the magnitude of reputational concerns α also plays a key role. This is because, as a weight assigned to $A(\eta)$ relative to $P(\eta)$, α determines how the entrepreneur's total payoff, $W(\eta)$, changes with the ability-related signal when it is disclosed.

4. Preliminary Analysis

Given that the aggregate signal, $y = y_a + y_x$, is always disclosed, we only need to consider the entrepreneur's decision whether to reveal y_a and y_x separately, in addition to y. However, note that disclosing both y_a and y_x in the presence of y is equivalent to disclosing only one of them, because the other can be inferred. Thus, it suffices to examine the decision whether to disclose the ability-related signal, y_a, along with the aggregate signal, y. Let $\eta \in \{(y, y_a), (y, n)\}$ be publicly available information, where n denotes nondisclosure of y_a.

Suppose that the market observes disclosure of y and y_a; that is, $\eta = (y, y_a)$. Using the normality assumption and $y = y_a + y_x$, the Bayes' rule implies that investors' expectation of the project's total future cash flow, net of the capital required for project implementation, is

$$\pi(y, y_a) \equiv E[z \mid y, y_a] - k = E[a + x \mid y_a, y_x] - k$$
$$= \beta_a y_a + \beta_x y_x + C = (\beta_a - \beta_x)y_a + \beta_x y + C, \tag{6}$$

where $$C \equiv (1 - \beta_a)\theta - k,$$

$$\beta_a \equiv \frac{q_a}{h_a + q_a} \in (0,\ 1) \ \text{ and } \ \beta_x \equiv \frac{q_x}{h_x + q_x} \in (0,\ 1). \tag{7}$$

For each $i = a$ and x, note that β_i, which is the ratio of the precision of the noise contained in y_i to the total precision of y_i, determines the sensitivity of the market expectation of the project's total cash flow to y_i, and it increases with noise precision q_i but decreases with cash flow precision h_i. This means that, for example, ability-related signal y_a has a greater effect on the market expectation when y_a is more precise about ability a or when the prior uncertainty about a is higher. Henceforth, based on the definition of β_i, we call β_i the normalized precision or informational quality of y_i;

unless the modifier "normalized" needs to be explicit, we omit it for brevity.[9] As noted above, the key role of β_i in the analysis is that the market expectation is more sensitive to signal y_i when its precision is high, rather than low. The following result is immediate from (6), but we formally state it to facilitate subsequent discussion.

Lemma 1 *$\pi(y, y_a)$ decreases with y_a if and only if $\beta_a < \beta_x$.*

In the presence of an aggregate signal y, how the market expectation of the project's total cash flow, $\pi(y, y_a)$, changes with ability-related signal y_a depends on the relative precision of each signal. For the intuition, fix y and note that a higher value of y_a implies a lower value of the other signal, y_x ($= y - y_a$). First, suppose that y_a is less precise than y_x (i.e., $\beta_a < \beta_x$). Because the market reacts less to y_a in this case, the positive effect of an increase in the ability-related signal on the market expectation of the project's total cash flow, $\pi(y, y_a)$, is smaller than the negative effect of the corresponding decrease in the other signal. Thus, $\pi(y, y_a)$ decreases with y_a. Second, if y_a is more precise than y_x (i.e., $\beta_a > \beta_x$), these effects are reversed, implying that $\pi(y, y_a)$ increases with y_a. As will be clear, these properties of $\pi(y, y_a)$ play a key role in our analysis.[10]

In what follows, we rule out the knife-edge case in which the two signals have the same precision (i.e., $\beta_a = \beta_x$). In that case, as is clear in (6), the market expectation of the project's total future cash flow would only depend on the aggregate signal, y, implying that disclosure of dis-aggregated information would be irrelevant to that expectation.[11]

Given the expected total cash flow, $\pi(y, y_a)$, the competitive market price of the project is

$$P(y, y_a) = \max\{\pi(y, y_a), 0\}. \tag{8}$$

That is, if $\pi(y, y_a) > 0$, investors purchase the project at a positive price and implement it. Otherwise, the project is not traded and thus is not implemented. Because there is no future cash flow, $P(y, y_a)$

[9] With some abuse of terminology, this omission is also made in some prior studies (e.g., Kanodia and Lee 1998; Hughes and Pae 2004). That is, strictly speaking, the precision of y_i is $Var[y_i]^{-1}$ and its informational quality typically refers to the precision of the noise in it, which is q_i.

[10] Our result that $\pi(y, y_a)$ can decrease with y_a is reminiscent of Lundholm (1988), although he considers neither disclosure incentives nor reputational concerns. Using the model of Diamond and Verrecchia (1981), he shows that when a trader's private signal is positively correlated with a publicly available signal (similar to y_a and y in our model), higher values of one signal may have a negative impact on the firm security price in the presence of the other signal.

[11] However, because y_a is positively related to a, its disclosure matters to the ability assessment. In that case, it is easy to show that low-end pooling of y_a is a unique equilibrium nondisclosure set; details are available upon request.

= 0. Define y_a^T to be the value of the ability-related signal y_a that satisfies $\pi(y, y_a) = 0$:

$$y_a^T \equiv \frac{\beta_x}{\beta_x - \beta_a} y + \frac{C}{\beta_x - \beta_a}. \tag{9}$$

This shows that y_a^T increases or decreases with y depending on the sign of $\beta_a - \beta_x$ or, equivalently, the relative informativeness of each signal. We know from Lemma 1 that if $\beta_a < \beta_x$, then $\pi(y, y_a)$ decreases with ability-related signal y_a. This means that y_a^T is the *upper* bound of y_a, below which disclosure of y_a leads to a trade of the project. Also, note from the last expression in (6) that an increase in aggregate signal y shifts $\pi(y, y_a)$ upward. This expands the set of y_a whose disclosure leads to a project trade. As a result, y_a^T increases with y. On the other hand, if $\beta_a > \beta_x$, the converse is true. The fact that $\pi(y, y_a)$ increases with y_a in this case implies that y_a^T is the *lower* bound of y_a, above which disclosure of y_a results in a project trade. Accordingly, y_a^T decreases with y.

Next, given (y, y_a), the market assesses entrepreneur ability through its expectation of a,

$$A(y_a) \equiv E[a \mid y, y_a] = \beta_a y_a + (1 - \beta_a)\theta. \tag{10}$$

Note that although aggregate signal y is available, it is redundant in the ability assessment because y_a is a sufficient statistic to infer ability a. Also note that $A(y_a)$ increases with y_a, implying that disclosure of a higher value of y_a always improves the market assessment of ability.

Combining (8) and (10) yields the entrepreneur's payoff under disclosure of y and y_a,

$$W(y, y_a) \equiv P(y, y_a) + \alpha A(y_a) = \begin{cases} \alpha A(y_a) & \text{if } \pi(y, y_a) \le 0 \\ \pi(y, y_a) + \alpha A(y_a) & \text{if } \pi(y, y_a) > 0. \end{cases} \tag{11}$$

Although the ability assessment, $A(y_a)$, increases with ability-related signal y_a, the payoff under disclosure, $W(y, y_a)$, may be *nonmonotonic* with respect to y_a. The reason is that the market expectation of the project's total cash flow, $\pi(y, y_a)$, may increase or decrease with y_a (Lemma 1). The next lemma shows how $W(y, y_a)$ changes with y_a, depending on the model parameters.

Lemma 2 *Let an aggregate signal y and reputational concerns $\alpha > 0$ be given.*

(i) *If $\beta_a < \beta_x$, $W(y, y_a)$ is a V-shaped function of y_a for any $\alpha < \alpha_m$, and is nondecreasing in y_a for any $\alpha \ge \alpha_m$, where $\alpha_m \equiv (\beta_x/\beta_a) - 1 > 0$.*

(ii) *If $\beta_a > \beta_x$, $W(y, y_a)$ increases with y_a.*

(Insert Figure 1 about here.)

Part (i) shows that if the precision of y_a is lower than that of y_x (i.e., $\beta_a < \beta_x$), the magnitude of reputational concerns α is critical for the behavior of $W(y, y_a)$ as a function of y_a. Lemma 1 shows that $\pi(y, y_a)$ decreases with y_a in this case; thus, $\pi(y, y_a) \leq 0$ if and only if $y_a \geq y_a^T$. First, consider $y_a \geq y_a^T$. Because the project price, $P(y, y_a) = \max\{\pi(y, y_a), 0\}$, is zero, $W(y, y_a) = \alpha A(y_a)$. Given that the ability assessment, $A(y_a)$, increases with y_a, $W(y, y_a)$ increases with y_a. Second, consider $y_a < y_a^T$. Because $\pi(y, y_a) > 0$, $W(y, y_a) = \pi(y, y_a) + \alpha A(y_a)$. Recall that disclosure of a high y_a has a negative effect on $\pi(y, y_a)$. This creates a tension against its positive effect on $A(y_a)$. We show that there is a threshold value of reputational concerns α, denoted as α_m, such that the decrease in $\pi(y, y_a)$ dominates the increase in $\alpha A(y_a)$; thus, $W(y, y_a) = \pi(y, y_a) + \alpha A(y_a)$ decreases with y_a if and only if $\alpha < \alpha_m$. This means that if $\alpha < \alpha_m$, the payoff under disclosure first decreases and then increases with ability-related signal y_a. This is why $W(y, y_a)$ is a V-shaped function of y_a; Figure 1 depicts this payoff with two dashed lines. Although not depicted in Figure 1, one can use the above results to see that: (i) if $\alpha = \alpha_m$, $W(y, y_a)$ remains constant for all $y_a \leq y_a^T$, but increases with $y_a > y_a^T$, similar to a *call option value*; and (ii) if $\alpha > \alpha_m$, $W(y, y_a)$ increases with y_a in the entire range of y_a.

Part (ii) follows immediately. If the precision of y_a is higher than that of y_x (i.e., $\beta_a > \beta_x$), the market expectation of the project's total cash flow, $\pi(y, y_a)$, increases with y_a. Given that $A(y_a)$ also increases with y_a, $W(y, y_a)$ increases with y_a for any given y and $\alpha > 0$.

Now suppose that only an aggregate signal y is disclosed; that is, $\eta = (y, n)$. If investors were sure that the entrepreneur had y only, their expectation of the ability-related signal would be

$$m(y) \equiv E[y_a \mid y] = \theta + \beta_{agg}(y - \theta), \text{ where } \beta_{agg} \equiv \frac{h_a^{-1} + q_a^{-1}}{h_x^{-1} + q_x^{-1} + h_a^{-1} + q_a^{-1}} \in (0,1). \qquad (12)$$

However, they know the possibility that he may have disaggregated signals y_a and y_x. We say that y_a greater (less) than $m(y)$ is good (bad) news about a. In the same vein, we say that y_x greater (less) than $E[y_x \mid y] = (1 - \beta_{agg})(y - \theta)$ is good (bad) news about x. Note that

$$E[y_a \mid y] + E[y_x \mid y] = y. \qquad (13)$$

This implies that, given $y = y_a + y_x$, if the entrepreneur has good news y_a, he has bad news y_x, and vice versa. When pricing the project and assessing entrepreneur ability in the absence of disclosure of y_a, the market needs to infer y_a, considering that the entrepreneur may withhold it strategically. As a result, the rational expectation of y_a must be different from $m(y)$ stated above.

To formalize, let the market expectation of y_a, given y and nondisclosure of y_a, be

$$y_a^n \equiv E[y_a \mid y, n]. \qquad (14)$$

This expectation changes with y for two reasons: (i) the distribution of y_a depends on y; and (ii) as shown below, the set of undisclosed y_a changes with y. The law of iterated expectation yields the market expectation of total cash flow z and the assessment of ability a, respectively, as follows:

$$\pi(y, y_a^n) \equiv E[z \mid y, n] - k = E[E[z \mid y, y_a] \mid y, n] - k = (\beta_a - \beta_x)y_a^n + \beta_x y + C, \tag{15}$$

and

$$A(y_a^n) \equiv E[a \mid y, n] = E[E[a \mid y, y_a] \mid y, n] = \beta_a y_a^n + (1 - \beta_a)\theta. \tag{16}$$

Comparing these expressions with (6) and (10), we can see that y_a^n here replaces y_a. It follows that, given (y, y_a^n), the entrepreneur's payoff under nondisclosure of y_a is

$$W(y, y_a^n) \equiv \begin{cases} \alpha A(y_a^n) & \text{if } \pi(y, y_a^n) \le 0 \\ \pi(y, y_a^n) + \alpha A(y_a^n) & \text{if } \pi(y, y_a^n) > 0. \end{cases} \tag{17}$$

Based on the payoffs with and without disclosure of y_a, $W(y, y_a)$ and $W(y, y_a^n)$, he decides whether to disclose y_a, in addition to the aggregate signal, $y = y_a + y_x$, that he must disclose.[12] We say that partial disclosure occurs if y_a is not always disclosed. We will show that, for any given y, there exists a unique partial disclosure equilibrium, whose characterization depends on $(\beta_a, \beta_x, \alpha)$.

5. Equilibrium, Comparative Statics, and Efficiencies (when $\beta_a < \beta_x$)

This section shows the partial disclosure equilibrium that prevails when the ability-related signal is less precise information than the other signal; that is, $\beta_a < \beta_x$, and thus the market expectation of the project's total cash flow, $\pi(y, y_a)$, is less sensitive to y_a than it is to y_x. We also provide results on comparative statics and efficiency. We relegate the results on the partial disclosure equilibrium that prevails when $\beta_a > \beta_x$ to the appendix. We do so because the equilibrium in that case is a low-end pool of undisclosed y_a, similar to the standard result in the literature on voluntary disclosure (e.g., Verrecchia 1983; Dye 1985); see the appendix for details.[13] When $\beta_a < \beta_x$, Lemma

[12] Technically, there can be a continuum of signal y_a with which the entrepreneur is indifferent between disclosure of y and disclosure of (y, y_a). In that case, we assume that he chooses to disclose y only. Introducing disclosure costs into our model (à la Verrecchia 1983) would make him strictly prefer nondisclosure, except for a single value of y_a, and this would not qualitatively change our main results. For model simplicity, we assume away any disclosure costs.

[13] Although we have no a priori assumption on the magnitudes of β_a and β_x, the following points may be helpful. Using (7), it is easy to verify that $\beta_a < \beta_x$ if and only if $q_a/h_a < q_x/h_x$. This means that $\beta_a < \beta_x$ is more likely to hold in the following circumstances. First, a and x may have approximately the same amount of prior uncertainty ($h_a \approx h_x$), but the noise in the ability-related signal may be much greater than the noise in the other signal ($q_a < q_x$). The latter may be due to the difficulties in estimating cash flow contributions made by the entrepreneur's ability (which is intangible human capital: e.g., Lev and Zarowin 1999; Eccles et al. 2001; Ulrich and Smallwood 2004; Lev 2018). Second, it may be possible to estimate a and x with approximately the same amount of noise ($q_a \approx q_x$). In this case, suppose that the entrepreneur's ability contributes to the project cash flow in a relatively stable manner, but that the economic/technological environments beyond his ability/control change rapidly with large volatility. Then, the variance of a is smaller

2(i) shows that the payoff under disclosure, $W(y, y_a)$, may nonmonotonically change with y_a. This leads to different types of equilibrium depending on the magnitude of reputational concerns α. For example, *intermediate* values of y_a may be withheld, and these values may be either good or bad news about entrepreneur ability a. To highlight the role of α, we start with a benchmark.

5.1. Benchmark: $\alpha = 0$ (no reputational concerns)

Suppose that the entrepreneur has *no* reputational concerns. That is, he seeks to maximize the project price without any consideration of the market assessment of his ability. This can be represented by $\alpha = 0$, in which case the payoff with disclosure is $W(y, y_a) = P(y, y_a) = \max\{\pi(y, y_a), 0\}$, and the payoff without disclosure is $W(y, y_a^n) = P(y, y_a^n) = \max\{\pi(y, y_a^n), 0\}$. Recall from Lemma 1 that when y_a is less precise information than y_x is, $\pi(y, y_a)$ decreases with y_a. This is because, given an aggregate signal y ($= y_a + y_x$), disclosure of a high value of y_a (good news about the ability-related cash flow) implies a low value of y_x (bad news about the other cash flow), to which the market reacts more. Also, y_a^T satisfying $\pi(y, y_a) = 0$ is a cutoff value of y_a, above which disclosure of y_a induces investors not to buy the project. Thus, similar to a *put option value*, the payoff with disclosure, $W(y, y_a) = \max\{\pi(y, y_a), 0\}$, decreases with y_a if $y_a < y_a^T$, and equals zero if $y_a \geq y_a^T$. In contrast, given any y and y_a^n, the payoff without disclosure, $W(y, y_a^n)$, is a constant. Thus, the equilibrium nondisclosure set must be a *high*-end pool of y_a. Although the mechanism is different, this resembles Ebert et al.'s (2017) result that pooling occurs at the *top*. In the space of (y, y_a), Figure 2 depicts the partial disclosure equilibrium in this benchmark ($\beta_a < \beta_x$ and $\alpha = 0$). The two thick lines represent y_a^T and y_a^n, and the equilibrium nondisclosure region is the shaded area. Below, we explain how the market forms an expectation of y_a in the presence of an aggregate signal y only, which is $y_a^n \equiv E[y_a \mid y, n]$, and how this expectation changes with y.

(Insert Figure 2 about here.)

Let y be given. First, suppose that $y_a^n \geq y_a^T$. Because $\pi(y, y_a^n) \leq 0$, there is no project trade in the absence of disclosure; thus, $P(y, y_a^n) = 0$. If the entrepreneur has a signal $y_a < y_a^T$, he is better off by disclosing it, because the project can be traded at the price of $P(y, y_a) = \pi(y, y_a) > 0$. In contrast, if he has $y_a \geq y_a^T$, disclosing it does not lead to a trade. Thus, he is indifferent between disclosure and nondisclosure, in which case he chooses nondisclosure (as assumed). In sum, if y_a^n

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than that of x ($h_a > h_x$). In both circumstances, $\beta_a < \beta_x$ is more likely to hold. Otherwise, the converse is true.

$\geq y_a^T$, the equilibrium nondisclosure set of y_a must be an interval $[y_a^T, \infty)$. Accordingly,

$$y_a^n \equiv E[y_a \mid y, n] = \frac{(1-\lambda)m(y) + \lambda[1-F(y_a^T \mid y)]E[y_a \mid y, y_a \geq y_a^T]}{(1-\lambda)+\lambda[1-F(y_a^T \mid y)]}, \tag{18a}$$

where $m(y) \equiv E[y_a \mid y]$ is stated in (12), and F is the distribution function of y_a conditional on y. In words, investors' equilibrium expectation of y_a is a weighted average of the expected value of y_a when the entrepreneur does not have y_a and the expected value of y_a when he has undisclosed y_a belonging to $[y_a^T, \infty)$. Also, this y_a^n must be consistent with the supposition that $y_a^n \geq y_a^T$.

Second, suppose that $y_a^n < y_a^T$, in which case the project is traded with no disclosure of y_a at the price of $P(y, y_a^n) = \pi(y, y_a^n) > 0$. If the entrepreneur has $y_a \geq y_a^T$, disclosing it leads to no project trade because $\pi(y, y_a) \leq 0$. Thus, he is better off by withholding it. On the other hand, if he has $y_a < y_a^T$, disclosing it leads to a project trade because $\pi(y, y_a) > 0$. This means that there is a tradeoff between disclosure and nondisclosure of that y_a, and he compares $\pi(y, y_a)$ and $\pi(y, y_a^n)$. Because $\pi(y, y_a)$ decreases with y_a, he discloses y_a only when it is less than y_a^n. In sum, if $y_a^n < y_a^T$, the equilibrium nondisclosure set must be $[y_a^n, \infty)$, where y_a^n is the signal y_a with which the entrepreneur is indifferent between disclosure and nondisclosure. Thus, the market expectation of y_a is

$$y_a^n \equiv E[y_a \mid y, n] = \frac{(1-\lambda)m(y) + \lambda[1-F(y_a^n \mid y)]E[y_a \mid y, y_a \geq y_a^n]}{(1-\lambda)+\lambda[1-F(y_a^n \mid y)]}. \tag{18b}$$

Again, consistency with the supposition requires that $y_a^n < y_a^T$. Note that (18b) can be restated as

$$y_a^n = m(y) + \frac{\lambda}{1-\lambda}\int_{y_a^n}^{\infty}[1-F(y_a \mid y)]dy_a, \tag{18c}$$

implying that y_a^n solving (18c) is greater than $m(y)$. The following proposition shows that, for any given y, a unique equilibrium satisfying the consistency requirements exists.

Proposition 1 [High-end pooling nondisclosure] *Suppose that $\beta_a < \beta_x$ and $\alpha = 0$. There exists a unique value of aggregate signal y, denoted as y^o, such that:*

(i) *For $y \leq y^o$, the equilibrium nondisclosure set is $[y_a^T, \infty)$, where y_a^T is stated in* (9). *The market expectation of y_a given nondisclosure is y_a^n ($\geq y_a^T$) stated in* (18a).

(ii) *For $y > y^o$, the equilibrium nondisclosure set is $[y_a^n, \infty)$, where y_a^n ($< y_a^T$) solves* (18c).

The equilibrium nondisclosure set satisfies the consistency requirement, which is $y_a^n \geq y_a^T$ in part (i), and $y_a^n < y_a^T$ in part (ii). As shown in Figure 2, y^o is a critical value of aggregate signal

y, such that: (i) when $y \leq y^o$, y_a^n given in (18a) is located above y_a^T (and thus no project trade occurs under nondisclosure); and (ii) when $y > y^o$, y_a^n solving (18c) is located below y_a^T (and thus a project trade occurs under nondisclosure).[14] For the key intuition, recall that aggregate signal y (= $y_a + y_x$) must be disclosed, and that the market reacts less to ability-related signal y_a (because $\beta_a < \beta_x$). Therefore, the basic incentive of an entrepreneur with no reputational concerns ($\alpha = 0$), who seeks to maximize the market price of the project only, is to disclose low values of y_a, through which he communicates high values of y_x (= $y - y_a$). Given no disclosure, the market expectation of y_a is y_a^n, implying that the expectation of y_x is $y - y_a^n$. This is greater than $y - y_a$ in the case of disclosure if and only if $y_a^n < y_a$. As a result, the equilibrium nondisclosure set must be a high-end pool of y_a.

Corollary 1 *When $\beta_a < \beta_x$ and $\alpha = 0$, the equilibrium nondisclosure set shrinks as y increases.*

For the intuition, note that as aggregate signal y increases, y_a is more likely to be high, which ceteris paribus increases the market expectation of undisclosed y_a. This reduces the market expectation of y_x and thus the project price under nondisclosure. Hence, the entrepreneur with boundary signal y_a^T or y_a^n, who chooses nondisclosure, is strictly better off by disclosing it. That is, by informing the market of the actual y_x through disclosure of y_a, he obtains a higher project price, relative to the price based on the expected value of y_x with no disclosure of y_a.

5.2. When $0 < \alpha < \alpha_m$ (moderate concerns about reputation)

Although Proposition 1 is logically consistent with no reputational concerns ($\alpha = 0$), its results are somewhat counterintuitive in that the entrepreneur reveals his poor management skills and talents by disclosing low values of ability-related signal y_a. In reality, with varying degrees, managers are concerned about reputation. In our model, we capture this with $\alpha > 0$. That is, the entrepreneur not only cares about the project price, but also has reputational concerns, assigning a positive weight to the market assessment of his ability.

Before proceeding, recall that the high-end pooling nondisclosure set in the case of $\alpha = 0$ is sustained because the payoff under disclosure, $W(y, y_a) = P(y, y_a)$, is nonincreasing in y_a. In the case of $\alpha > 0$, however, the payoff under disclosure includes ability assessment $A(y_a)$ that always

[14] The critical value, y^o, satisfies $y_a^n = y_a^T$, where y_a^n solves (18c) and y_a^T is given by (9). See the proof for the details.

increases with y_a. When $W(y, y_a) = P(y, y_a) + \alpha A(y_a)$, Lemma 2(i) shows that this payoff changes with y_a differently, for which α is critical. In this section, we show that if reputational concerns are moderate in the sense that α is less than a threshold, which is $\alpha_m > 0$ stated in Lemma 2(i), the equilibrium nondisclosure set is a pool of *intermediate* values of y_a. Also, depending on aggregate signal y, undisclosed ability-related signal y_a is either good or bad news about entrepreneur ability. Using graphical illustrations, we first explain the key driving forces behind these results.

Figure 1 shows that when $\alpha \in (0, \alpha_m)$, the payoff under disclosure, $W(y, y_a)$, is a V-shaped function of ability-related signal y_a, and it has a unique minimum at $y_a = y_a^T$ that satisfies $\pi(y, y_a) = 0$. In contrast, recall that the payoff under nondisclosure, $W(y, y_a^n)$, is a constant. Thus, for any given y, if an equilibrium nondisclosure set exists, it must be a pool of intermediate values of y_a. Here, two points are noteworthy. First, unlike typical disclosure incentives in prior models, the entrepreneur in our model has disclosure incentives that change with y_a nonmonotonically; the incentive to disclose y_a is stronger when it is relatively small or large than when it is intermediate. Second, these incentives depend on the publicly observed aggregate signal, y. This is because y affects not only the distribution of y_a and thus the market inference of undisclosed y_a, but also the value at which the payoff under disclosure, $W(y, y_a)$, is minimized; recall that y_a^T increases with y (because $\beta_a < \beta_x$). Collectively, these imply that the lower and upper bounds of the equilibrium nondisclosure set vary with y. The shaded area in Figure 3 is the equilibrium nondisclosure region in the space of (y, y_a). For example, when $y = y^\dagger$, the vertical line passing $(y^\dagger, 0)$ is the equilibrium nondisclosure set. Note that, depending on whether y is less or greater than a critical value (denoted as y^*), y_a belonging to a nondisclosure set is either less or greater than $m(y)$. This implies that undisclosed values of y_a can be either bad or good news about entrepreneur ability. Below, we formalize these arguments; see Proposition 2 for a summary.

(Insert Figure 3 about here.)

Fix y and let $y_a^n \equiv E[y_a \mid y, n]$ be given. First, suppose that $y_a^n \geq y_a^T$. Because $\pi(y, y_a^n) \leq 0$, there is no project trade without disclosure. Hence, the payoff under nondisclosure is $W(y, y_a^n) = \alpha A(y_a^n)$. Consider $y_a < y_a^T$. Because $\pi(y, y_a) > 0$, disclosure of this y_a leads to a project trade. Thus, the payoff under disclosure is $W(y, y_a) = \pi(y, y_a) + \alpha A(y_a)$. Comparing $\alpha A(y_a^n)$ and $\pi(y, y_a) + \alpha A(y_a)$, the entrepreneur with $y_a < y_a^T$ prefers disclosure if and only if $y_a < y_a^L$, where

$$y_a^L \equiv \frac{1}{\beta_x - (1+\alpha)\beta_a}\left[\beta_x y - \alpha\beta_a y_a^n + C\right]. \qquad (19)$$

Here, the primary motive for disclosing lower values of y_a is to increase the project price, although disclosing them has a negative effect on ability assessment. Next, consider $y_a \geq y_a^T$. Its disclosure does not affect the project price because $P(y, y_a) = 0$ for all $y_a \geq y_a^T$. Thus, reputational concerns are the sole determinant of disclosure incentives. Comparing $A(y_a)$ and $A(y_a^n)$, the entrepreneur discloses $y_a \in (y_a^n, \infty)$. In summary, under the supposition that $y_a^n \geq y_a^T$, the equilibrium nondisclosure set must be an interval $[y_a^L, y_a^n]$, and the primary disclosure incentives are: (i) to increase the project price when y_a is low, and (ii) to improve the ability assessment when y_a is high. Because the upper bound, y_a^n, is the market expectation of y_a under no disclosure, it is given by

$$y_a^n \equiv E[y_a \mid y, n] = \frac{(1-\lambda)m(y) + \lambda[F(y_a^n \mid y) - F(y_a^L \mid y)]E[y_a \mid y, y_a \in [y_a^L, y_a^n]]}{(1-\lambda) + \lambda[F(y_a^n \mid y) - F(y_a^L \mid y)]}. \tag{20}$$

This y_a^n must be consistent with the supposition that $y_a^n \geq y_a^T$.

Second, suppose that $y_a^n < y_a^T$. Because $\pi(y, y_a^n) > 0$, the project is traded without disclosure, and thus the payoff with no disclosure is $W(y, y_a^n) = \pi(y, y_a^n) + \alpha A(y_a^n)$. If $y_a < y_a^T$, the payoff with disclosure is $W(y, y_a) = \pi(y, y_a) + \alpha A(y_a)$. Given that $\alpha \in (0, \alpha_m)$, the entrepreneur prefers disclosure if and only if $y_a < y_a^n$. Specifically, recall that if $y_a < y_a^T$, $P(y, y_a) = \pi(y, y_a) > 0$ declines with y_a. Thus, when y_a is sufficiently low, disclosing it has a positive effect on the project price although doing so has a negative effect on ability assessment. Because the entrepreneur places a relatively small weight $\alpha < \alpha_m$ on the latter effect, the former positive effect is dominant. Thus, he reveals y_a. However, when y_a is between y_a^n and y_a^T, disclosing it reduces the project price but increases the ability assessment, compared with those under nondisclosure. Again, because $\alpha < \alpha_m$, the former negative effect is dominant, which leads to nondisclosure of y_a. Next, consider $y_a \geq y_a^T$. In this case, the tradeoff in disclosure changes. Revealing a higher y_a has no negative effect on the project price (because the price is zero for all $y_a \geq y_a^T$), but doing so has a positive effect on ability assessment. Although disclosing $y_a \geq y_a^T$ results in a loss of the project price that he could obtain under nondisclosure, $P(y, y_a^n) = \pi(y, y_a^n) > 0$, the entrepreneur who has a sufficiently high y_a opts for disclosure to improve ability assessment. Specifically, he prefers disclosure if and only if $\alpha A(y_a) > \pi(y, y_a^n) + \alpha A(y_a^n)$. This condition is equivalent to $y_a > y_a^H$, where

$$y_a^H \equiv \frac{1}{\alpha\beta_a}\left[\beta_x y + [(1+\alpha)\beta_a - \beta_x]y_a^n + C\right]. \tag{21}$$

Collectively, under the supposition that $y_a^n < y_a^T$, the equilibrium nondisclosure set must be an interval [y_a^n, y_a^H]. Accordingly, given nondisclosure, the market expectation of y_a is

$$y_a^n \equiv E[y_a \mid y, n] = \frac{(1-\lambda)m(y) + \lambda[F(y_a^H \mid y) - F(y_a^n \mid y)]E[y_a \mid y, y_a \in [y_a^n, y_a^H]]}{(1-\lambda) + \lambda[F(y_a^H \mid y) - F(y_a^n \mid y)]}, \qquad (22)$$

and this y_a^n must be less than y_a^T to be consistent with the supposition. A summary is as follows.

Proposition 2 [Intermediate pooling nondisclosure] *Suppose that* $\beta_a < \beta_x$ *and* $0 < \alpha < \alpha_m$. *There exists a unique value of aggregate signal y, denoted as* y^*, *such that:*

(i) *For* $y < y^*$, *the equilibrium nondisclosure set is* [y_a^L, y_a^n], *where* y_a^L *is given by* (19) *and* y_a^n ($> y_a^T$) *solves* (20).

(ii) *For* $y > y^*$, *the equilibrium nondisclosure set is* [y_a^n, y_a^H], *where* y_a^H *is given by* (21) *and* y_a^n ($< y_a^T$) *solves* (22).

The existence of a critical value of aggregate signal y, denoted as y^*, is the key in establishing the equilibrium consistent with the above discussion. The shaded area in Figure 3 is the nondisclosure region, implying that, for any given y, intermediate values of ability-related signal y_a are undisclosed. For example, the equilibrium nondisclosure set is vertical line segment [y_a^L, y_a^n] when $y = y^\dagger$, whereas it is [y_a^n, y_a^H] when $y = y^\ddagger$.[15] As explained earlier, these intervals reflect the tradeoff in the entrepreneur's disclosure incentives in the presence of dual concerns about the project price and ability assessment, and the intervals differ across the levels of the aggregate signal because the tradeoff changes with y. Specifically, if y is *less* than its critical value y^*, the primary incentive is to improve ability assessment by withholding low values of ability-related signal y_a. This leads to the fact that the undisclosed values of y_a are *bad* news about ability; that is, the nondisclosure region is located below the line representing the mean of y_a conditional on y, which is $m(y) \equiv E[y_a \mid y]$ stated in (12). In contrast, if y is *greater* than y^*, the primary disclosure incentive is to increase the project price by revealing low values of y_a. Therefore, in this case, the undisclosed values of y_a are *good* news about ability; that is, the nondisclosure region is located above $m(y) \equiv E[y_a \mid y]$. However, it should also be noted that the entrepreneur does not always withhold bad or good news about his ability. In particular, when $y < y^*$, sufficiently bad news about ability, which is y_a below the lower bound of the nondisclosure set [y_a^L, y_a^n], is disclosed. As noted above, this is

[15] If $y = y^*$, the equilibrium nondisclosure set reduces to a single value of y_a, which is equivalent to full disclosure. Except for this knife-edge case, the intermediate pooling partial disclosure equilibrium is non-degenerating.

due to a large positive effect on the project price (despite a negative effect on the ability assessment). In contrast, when $y > y^*$, sufficiently good news about ability, which is y_a above the upper bound of the nondisclosure set $[y_a^n, y_a^H]$, is disclosed because of the incentive to increase the ability assessment (and the fact that the project price is bounded below by zero).

Corollary 2 *If $y < y^*$, then $\frac{dy_a^L}{dy} > \frac{dy_a^n}{dy} > 0$. If $y > y^*$, then $\frac{dy_a^H}{dy} > \frac{dy_a^n}{dy} > 0$.*

These results pertain to the effects of aggregate signal y on the boundaries of the nondisclosure region, which are illustrated in Figure 3. If $y < y^*$, both the lower and upper bounds of $[y_a^L, y_a^n]$ increase with y, and y_a^L increases faster. This means that, as y approaches y^* from below, the nondisclosure set of y_a *shrinks*. The positive effect of y on the market expectation of the total cash flow under disclosure, $\pi(y, y_a)$, is the driving force. For the details, we need to investigate how y_a^L and y_a^n characterized by (19) and (20) change with y. Suppose that y ($< y^*$) increases. First, holding the upper bound y_a^n constant, an increase in y improves the market expectation, $\pi(y, y_a)$. Given that the project is not traded under nondisclosure (recall that $\pi(y, y_a^n) < 0$), this makes disclosure strictly more attractive to the entrepreneur whose ability-related signal is y_a^L. He thus reveals it. As a result, the lower bound of the nondisclosure set, y_a^L, increases. Second, both the increase in y and the abovementioned increase in y_a^L have positive effects on the upper bound of the nondisclosure set, y_a^n. This is because: (i) given that y_a^n is the market expectation of undisclosed y_a, a greater y increases y_a^n due to its first-order stochastic dominance effect on the distribution of y_a; and (ii) a greater y_a^L increases y_a^n because lower values of y_a are removed from the nondisclosure set. Although this increase in y_a^n has a negative effect on y_a^L, the proof shows that the direct positive effect of y on y_a^L is dominant because $\alpha < \alpha_m$. Thus, the net effect of y on y_a^L is positive. In addition, this effect of y on y_a^L exceeds the effect of y on y_a^n. This is why y_a^L increases with y faster.

If $y > y^*$, both the lower and upper bounds of $[y_a^n, y_a^H]$ increase with y, and the upper bound increases faster. Therefore, the equilibrium nondisclosure set *expands* as y increases in this case. The driving force is the positive effect of y on the market expectation of the total cash flow under nondisclosure, $\pi(y, y_a^n)$. Because the details are similar to the case of $y < y^*$, we omit them.

In summary, when reputational concerns are moderate, the equilibrium nondisclosure set of y_a either shrinks or expands with an increase in y, depending on whether the increase occurs in the range of $(-\infty, y^*)$ or (y^*, ∞). This contrasts with Corollary 1, which shows that an increase in y monotonically affects the equilibrium nondisclosure sets characterized in Proposition 1.

Corollary 3 *If $y < y^*$, then $\frac{dy_a^L}{d\alpha} < 0$ and $\frac{dy_a^n}{d\alpha} < 0$. If $y > y^*$, then $\frac{dy_a^H}{d\alpha} < 0$ and $\frac{dy_a^n}{d\alpha} < 0$.*

In words, greater reputational concerns decrease the upper and lower bounds of the equilibrium nondisclosure sets, $[y_a^L, y_a^n]$ and $[y_a^n, y_a^H]$. In Figure 3, this can be envisioned as a downward shift of the nondisclosure region. To see the intuition, recall that when α increases, the entrepreneur places a greater weight on ability assessment $A(\cdot)$. This alters the payoffs with and without disclosure and thus disclosure incentives. Specifically, the payoff under disclosure, $W(y, y_a) = \pi(y, y_a) + \alpha A(y_a)$ depicted with dashed lines in Figure 1, becomes smaller and flatter for $y_a < y_a^T$, whereas it becomes larger and steeper for $y_a > y_a^T$. These changes strengthen the incentive to improve ability assessment by hiding lower values of y_a when $y < y^*$ and by revealing higher values of y_a when $y > y^*$. In both cases, the market expectation of y_a given no disclosure decreases.[16]

We conclude with remarks on the empirical implications of our results. First, Corollary 2 shows that when the signal about the project's overall performance, represented by y, deviates more from an intermediate level y^*, the incentives to disclose y_a—and thereby provide disaggregated information—become weaker. This suggests that, in the real world, disaggregated information about firm performance is less likely to be provided when the overall firm performance is sufficiently high or low than when it is intermediate.[17] This nonmonotonic relation between the overall firm performance and disaggregated information disclosure may be a reason for the mixed evidence in the empirical literature.[18] Second, Proposition 2 shows that undisclosed signals are

[16] The details are as follows. First, consider $y < y^*$, in which case the nondisclosure set is $[y_a^L, y_a^n]$ and $y_a^n > y_a^T$. As noted above, an increase in α reduces $W(y, y_a)$ for all $y_a < y_a^T$. As a result, with y_a^n being fixed, the entrepreneur who has y_a^L finds nondisclosure more attractive than before. This decreases the lower bound of the nondisclosure set. In response to the inclusion of lower values of y_a in the nondisclosure set, the market reduces its expectation of y_a, which results in a decrease in the upper bound, y_a^n. Although this decrease in y_a^n has a positive effect on y_a^L (see (19)), the direct negative effect of α on y_a^L explained above is dominant. Therefore, both the lower and upper bounds of the nondisclosure set, $[y_a^L, y_a^n]$, decrease with α. Second, consider $y > y^*$, in which case the nondisclosure set is $[y_a^n, y_a^H]$ and $y_a^n < y_a^T$. Following steps similar to those in the case of $y < y^*$, one can easily verify that both the lower and upper bounds of the nondisclosure set decrease with α.

[17] In general, it is unclear how the probability of disclosure of y_a (i.e., disclosure of disaggregated information) changes with y. The reason is that a change in y affects not only the lower and upper bounds of the nondisclosure set with different rates (as shown in Corollary 2), but also the distribution of y_a. Nonetheless, using Proposition 2 and Corollary 2, it can be shown that the probability of disclosure converges to 1 if y is sufficiently close to y^*, whereas it converges to a probability strictly less than 1 if y is sufficiently small or large, both of which are also evident in Figure 3.

[18] For the evidence of a negative relation, see Luez (2004) and Dedman and Lennox (2009); Ebert et al (2017) also

bad (good) news about entrepreneur ability if y is sufficiently low (high). This result can be used to refine the test for how the overall firm performance affects the nature of undisclosed information when that information can affect managers' career prospects. Last, for any given y, Corollary 3 implies that the market inference of the undisclosed information about entrepreneur ability decreases when the entrepreneur has greater reputational concerns; recall that y_a^n decreases with α. This result can be used to examine how the market incorporates the magnitudes of managers' reputational concerns (which conceivably differ across managers, e.g., young vs. old managers) when assessing manager ability in the absence of specific information about their ability.

5.3. When $\alpha \geq \alpha_m$ (excessive concerns about reputation)

We now move to the case in which the entrepreneur has excessive reputational concerns, which we represent with α exceeding the threshold level α_m stated in Lemma 2(i). In this case, large concerns about ability assessment incentivize him to hide bad news about ability. To elaborate, recall from the previous section that when the entrepreneur has moderate reputational concerns, $\alpha \in (0, \alpha_m)$, intermediate values of y_a are undisclosed because the payoff under disclosure, $W(y, y_a) = \max\{\pi(y, y_a), 0\} + \alpha A(y_a)$, is a V-shaped function of y_a. However, when $\alpha \geq \alpha_m$, $W(y, y_a)$ is nondecreasing in y_a. Specifically, for any given y, (i) $\pi(y, y_a)$ decreases with y_a, (ii) $A(y_a)$ increases with y_a, and (iii) α_m is the value of α above which the effect of y_a on $A(y_a)$ is dominant. Therefore, if $\alpha = \alpha_m$, $W(y, y_a)$ is a constant in the range of $y_a \in (-\infty, y_a^T]$ and increases with $y_a \in (y_a^T, \infty)$, similar to a call option value. If $\alpha > \alpha_m$, $W(y, y_a)$ always increases with y_a. In either case, because the payoff under disclosure, $W(y, y_a)$, is nondecreasing in y_a and the payoff under nondisclosure, $W(y, y_a^n)$, is a constant, the equilibrium nondisclosure set must be a *low*-end pool of y_a. That is, it must be an interval $(-\infty, y_a^n]$, where y_a^n is the value of y_a with which the entrepreneur is indifferent between disclosing and withholding it. Bayesian updating yields

$$y_a^n \equiv E[y_a \mid y, n] = \frac{(1-\lambda)m(y) + \lambda F(y_a^n \mid y)E[y_a \mid y, y_a \leq y_a^n]}{(1-\lambda) + \lambda F(y_a^n \mid y)}. \tag{23a}$$

Integrating by parts, we can restate the above expression as

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discuss anecdotal evidence. For the evidence of a positive relation, see Chen et al. (2008), Hope and Thomas (2008), and Bao et al. (2019).

$$y_a^n = m(y) - \frac{\lambda}{1-\lambda}\int_{-\infty}^{y_a^n} F(y_a \mid y)dy_a. \tag{23b}$$

Because $y_a^n < m(y)$ for any given y, undisclosed signals (i.e., $y_a \leq y_a^n$) are bad news about a.

Proposition 3 [Low-end pooling nondisclosure] *Suppose that $\beta_a < \beta_x$ and $\alpha \geq \alpha_m$. There exists a unique value of aggregate signal y, denoted as y^+, such that:*

(i) *If $y \leq y^+$, the equilibrium nondisclosure set is* $(-\infty, y_a^n]$, *where y_a^n* $(\geq y_a^T)$ *solves* (23b).

(ii) *Suppose that $y > y^+$. If $\alpha = \alpha_m$, the equilibrium nondisclosure set is* $(-\infty, y_a^T]$, *and*

$$y_a^n \equiv E[y_a \mid y, n] = \frac{(1-\lambda)m(y) + \lambda F(y_a^T \mid y)E[y_a \mid y, y_a \leq y_a^T]}{(1-\lambda) + \lambda F(y_a^T \mid y)} < y_a^T. \tag{24}$$

If $\alpha > \alpha_m$, the equilibrium nondisclosure set is $(-\infty, y_a^n]$, *where y_a^n* $(< y_a^T)$ *solves* (23b).

(Insert Figure 4 about here.)

The main intuition for the low-end pools of undisclosed ability-related signal y_a is that, due to the entrepreneur's excessive reputational concerns, his primary disclosure incentive is to reveal high values of y_a to increase ability assessment $A(y_a)$. The critical value of aggregate signal y, denoted as y^+, plays the same role for the consistency requirement as that in the previous propositions. That is, given y and nondisclosure, the market expectation of undisclosed y_a is such that the project is traded if and only if $y > y^+$. The partial disclosure equilibrium that prevails in the case of $\alpha > \alpha_m$ is depicted in Figure 4, where the shaded area is the nondisclosure region. The case of $\alpha = \alpha_m$ is not shown in Figure 4, but one can easily verify that: (i) in the range of $y \leq y^+$, the shaded area remains unchanged; but (ii) in the range of $y > y^+$, the shaded area is below y_a^T. We relegate detailed discussions of Proposition 3 to the appendix.

Corollary 4 *Suppose that $\beta_a < \beta_x$ and $\alpha \geq \alpha_m$.*

(i) *The equilibrium nondisclosure set expands as y increases.*

(ii) $\alpha \in (\alpha_m, \infty)$ *has no effect on the equilibrium nondisclosure set.*

Recall that an increase in aggregate signal y has a first-order stochastic dominance effect on the distribution of ability-related signal y_a. This makes the entrepreneur with the boundary signal, $y_a = y_a^n$, strictly better off by withholding it. Thus, the equilibrium nondisclosure set expands.

This contrasts with the change of the equilibrium nondisclosure set in response to an increase in the aggregate signal in the case of no or moderate reputational concerns (Corollaries 1 and 2). Somewhat surprisingly, the magnitude of reputational concerns α does *not* affect the nondisclosure set, which contrasts with its effect in the case of moderate reputational concerns (Corollary 3). This is because whenever there is a tradeoff between disclosure and nondisclosure, the effects of α on the payoffs under disclosure and nondisclosure are symmetric and wash out.

5.4. Efficiency implications

This section examines efficiency implications of the partial disclosure equilibria derived in Sections 5.2 and 5.3. In our model, an efficiency loss arises when a project that has a positive expected cash flow, referred to as a positive NPV project, is not traded and thus abandoned, or when a negative NPV project that should be abandoned is traded and implemented. Because an aggregate signal y ($= y_a + y_x$) about the project's total future cash flow z ($= a + x$) is always available in the market, disclosure of y_a enables the market to assess the project's prospects with full information, which is $\pi(y, y_a)$. In this case, because the project is traded if and only if $\pi(y, y_a) > 0$, there is no efficiency loss. We thus examine how the nondisclosure of y_a affects the efficiency in project implementation.[19] The next results follow from Propositions 2 and 3.

Corollary 5 *Suppose that $\beta_a < \beta_x$.*

(i) *If $\alpha \in (0, \alpha_m)$, an efficiency loss arises when $y < y^*$ and $y_a \in [y_a^L, y_a^T)$ is undisclosed, or when $y > y^*$ and $y_a \in (y_a^T, y_a^H]$ is undisclosed.*

(ii) *If $\alpha \geq \alpha_m$, an efficiency loss arises when $y < y^+$ and $y_a \in (-\infty, y_a^T)$ is undisclosed.*

Corollary 5 shows that not only reputational concerns α but also aggregate signal y plays a key role in determining efficiency. This is because y affects the distribution of y_a, with which the market revises beliefs about potentially undisclosed y_a. Because these beliefs in turn affect the entrepreneur's disclosure strategy, y is crucial to the efficiency of partial disclosure equilibrium. The details are as follows.

[19] If the entrepreneur has y only, he has no discretion over its disclosure and thus cannot affect project efficiency. Also, recall that $\pi(y, y_a) = 0$ at $y_a = y_a^T$. Hence, disclosure or nondisclosure of $y_a = y_a^T$ has no efficiency implication.

Part (i) is for the case of moderate reputational concerns. For any given y, there exists an undisclosed y_a that engenders inefficiency. Proposition 2(i) shows that when $y < y^*$, $y_a^T < y_a^n$ and thus $\pi(y, y_a^n) < 0$, implying no project trade without disclosure. However, if $y_a \in [y_a^L, y_a^T)$ were disclosed, the project would be traded because $\pi(y, y_a) > 0$. This means that a positive NPV project is abandoned because of nondisclosure. When $y > y^*$, Proposition 2(ii) shows that $y_a^n < y_a^T$ and thus $\pi(y, y_a^n) > 0$, implying a project trade without disclosure. If $y_a \in (y_a^T, y_a^H]$ were disclosed, there would be no project trade because $\pi(y, y_a) < 0$. This means that a negative NPV project is implemented because of nondisclosure. Part (ii) is for the case of excessive reputational concerns. Proposition 3(i) shows that when $y < y^+$, $y_a^T < y_a^n$ and thus $\pi(y, y_a^n) < 0$, implying no project trade without disclosure. However, if $y_a \in (-\infty, y_a^T)$ were disclosed, the project would be traded because $\pi(y, y_a) > 0$. This means that a positive NPV project is abandoned because of nondisclosure.

6. Summary

This paper examines the effect of an entrepreneur's reputational concerns on the incentives to provide disaggregated information about the future performance of a project. In our model, the project's total future cash flow has two components, one of which is more closely related to the entrepreneur's managerial ability than the other component is. Disaggregated information (represented by two signals about each cash flow component) allows the market to price the project and assess entrepreneur ability more precisely, relative to aggregate information (represented by the sum of the two signals). The entrepreneur seeks to maximize a weighted average of the market price of the project and the market assessment of his ability. The concerns about the latter, referred to as reputational concerns, incentivize him to disclose disaggregated information selectively.

Two factors are critical to the type of partial disclosure equilibrium: (i) the informational quality of each signal; and (ii) the magnitude of reputational concerns. We focus on the case in which the ability-related signal is less precise than the other signal and the market expectation of the project's total future cash flow is therefore less sensitive to the ability-related signal. In this case, two different types of equilibrium emerge. First, if reputational concerns are moderate, the equilibrium nondisclosure set is an intermediate pool of the ability-related signal. Second, if reputational concerns are excessive, the entrepreneur provides disaggregated information only when the signal about his ability is relatively high. Our comparative static results provide empirically testable predictions.

The literature on the effects of reputational concerns on corporate disclosure is nascent. We contribute to this literature by providing new insights into the incentives to disclose disaggregated information in the presence of reputational concerns. Proprietary costs associated with disclosing detailed business information have been frequently used as a rationale for not providing disaggregated information. In contrast, our study shows that, even in the absence of proprietary costs, reputational concerns can be a key determinant of management's decision whether to provide disaggregated or aggregate information.

Appendix

A1. Further Discussion of Modeling Assumptions

We provide additional remarks on our modeling choices. First, the normality assumption regarding the distribution of the cash flows and signals, (x, a, y_x, y_a), can be relaxed under certain monotonicity conditions. Specifically, as long as $E[z \mid y, y_a]$ decreases with y_a, and thus $\pi(y, y_a) \equiv E[z \mid y, y_a] - k < 0$ for some y_a, an intermediate pooling equilibrium similar to the one derived in the present model would be obtained. The reasons is that when α is relatively small, the payoff under disclosure, $W(y, y_a) \equiv P(y, y_a) + \alpha A(y_a)$, would still be a nonmonotonic function of y_a. Nonetheless, we employ the normality assumption because it provides closed-form expressions for $E[z \mid y, y_a]$ and $A(y_a) \equiv E[a \mid y, y_a]$, which help us sharpen the economic intuitions for the main results and obtain comparative static results relatively easily.

Second, to simplify the analysis, we assume that the two cash flow components, (x, a), are independent, with only a being related to entrepreneur ability. This can be relaxed to allow the ability to be related to both x and a. In that case, under suitable conditions on the covariance structure of the ability and the two cash flow components, our main results remain unchanged qualitatively.[20] In essence, as in the present model, the key is that: (i) one cash flow component is more closely related to entrepreneur ability than the other is; and (ii) the entrepreneur with private information about each component has incentives to disclose or withhold disaggregated information to improve the market assessment of his ability.

Third, we model the project as requiring a fixed amount of capital for implementation. One could alternatively consider a case in which project investment is a continuous variable (along with certain regularity conditions). In either case, the project price must be zero if there is no investment and thus no future cash flow. As long as there is a possibility that the project price is zero for a positive measure of signals, our main results remain qualitatively unchanged.

Last, given that reputational concerns arise due to a multi-period consideration, a dynamic model would be more appropriate than the present model to examine the effects of reputational

[20] Specifically, unlike (1) and (2), denoting the project's two cash flow components as x_1 and x_2, we can consider a general stochastic relation between (x_1, x_2) and ability a, specified by a distribution of (a, x_1, x_2) and define $A(\eta) \equiv E[a \mid \eta]$. Under this formulation, it can be shown that our main results remain qualitatively unchanged as long as $Cov[a, x_1] > Cov[a, x_2]$ and $Cov[x_1, x_2] > \delta$ where δ is a constant. The current model simplifies this structure by setting $x_1 = a$ and $x_2 = x$, along with independence of a and x, in which case the two conditions always hold, with δ being a negative constant. Details are available upon request.

concerns on disclosure. However, to avoid analytical complexities and tractability problems in dynamic settings, we use a single-period model in which the entrepreneur's objective function includes his future payoff in a reduced form. Although our modeling choice is not uncommon in the literature, a full-fledged analysis using a dynamic model awaits future research.[21]

A2. Detailed discussion of Proposition 3

Part (i) states that when y is less than a critical value y^+, the equilibrium nondisclosure set is $(-\infty, y_a^n]$, where y_a^n solves (23b). Because $y_a^n \geq y_a^T$, no disclosure results in no project trade, and hence the payoff under nondisclosure is $W(y, y_a^n) = \alpha A(y_a^n)$. First, suppose that $y_a < y_a^T$. Because disclosure of y_a leads to a trade, the payoff under disclosure is $W(y, y_a) = \pi(y, y_a) + \alpha A(y_a)$. Given that $y_a^n \geq y_a^T$, it is easy to verify that $W(y, y_a^n) > W(y, y_a)$ for all $y_a < y_a^T$. Thus, there is no incentive to disclose $y_a < y_a^T$. In essence, due to excessive reputational concerns, the entrepreneur withholds y_a to enjoy a high ability assessment although he could obtain a positive project price with disclosure. Second, suppose that $y_a \geq y_a^T$. In this case, a tradeoff arises. When this y_a is disclosed, the project is not traded because $\pi(y, y_a) \leq 0$. However, disclosure of a higher y_a improves $A(y_a)$. Therefore, comparing $W(y, y_a) = \alpha A(y_a)$ and $W(y, y_a^n) = \alpha A(y_a^n)$, the entrepreneur discloses y_a if and only if $y_a > y_a^n$. In sum, for any given $y \leq y^+$, combining the results for all y_a yields that the equilibrium nondisclosure set must be an interval $(-\infty, y_a^n]$. It is clear from the above discussion that the primary disclosure incentives are reputational concerns.

Part (ii) characterizes the partial disclosure equilibrium when $y > y^+$. In this case, the market expectation of y_a, which is given by either (24) or (23b), is less than the critical value for a project trade; that is, $y_a^n < y_a^T$. This means that the project is traded with no disclosure at the price of $\pi(y, y_a^n) > 0$, and thus the payoff under nondisclosure is $W(y, y_a^n) = \pi(y, y_a^n) + \alpha A(y_a^n)$. First, suppose that $y_a < y_a^T$, in which case the payoff under disclosure is $W(y, y_a) = \pi(y, y_a) + \alpha A(y_a)$. Comparing $W(y, y_a)$ and $W(y, y_a^n)$, the entrepreneur prefers nondisclosure if and only if

[21] From a modeling perspective, although we define a as an ability-related cash flow to examine reputational concerns (using a reduced-form payoff), it can also represent a cash flow related to some other factors that the entrepreneur cares about for other reasons. In that case, one can use our model to address issues other than reputational concerns. For instance, managers in a multi-divisional firm may have incentives to induce a favorable assessment of a particular division's performance because of their favoritism in organizations (Prendergast and Topel 1996). Reinterpreting reputational concerns in the present model as favoritism toward a particular division, one can examine discretionary segment reporting in such a context. We thank an anonymous reviewer for directing us to these points.

$$[(1+\alpha)\beta_a - \beta_x]y_a \leq [(1+\alpha)\beta_a - \beta_x]y_a^n.$$

Here, note that if $(1 + \alpha)\beta_a - \beta_x = 0$ or, equivalently, if $\alpha = \alpha_m$, both sides are zero. This means that the entrepreneur is indifferent, in which case he chooses nondisclosure (as assumed). If $\alpha > \alpha_m$, he chooses nondisclosure when $y_a \leq y_a^n$. Second, suppose that $y_a \geq y_a^T$, in which case $\pi(y, y_a) \leq 0$, and hence the payoff under disclosure is $W(y, y_a) = \alpha A(y_a)$ with no project trade. Because $\alpha \geq \alpha_m$, this payoff is strictly greater than the payoff under nondisclosure, $W(y, y_a^n) = \pi(y, y_a^n) + \alpha A(y_a^n)$. Thus, when $y_a \geq y_a^T$, disclosure is always optimal. In sum, for any given $y > y^+$, the equilibrium nondisclosure set must be $(-\infty, y_a^T]$ if $\alpha = \alpha_m$, and $(-\infty, y_a^n]$ if $\alpha > \alpha_m$.

A3. Partial Disclosure Equilibrium When $\beta_a > \beta_x$

This section provides the equilibrium results for the case of $\beta_a > \beta_x$. In this case, a unique equilibrium is characterized by a *low*-end pool of undisclosed y_a. Thus, the standard partial disclosure equilibrium result of prior studies (e.g., Verrecchia 1983; Dye 1985) is extended to our setting. In essence, low-end pooling occurs because the payoff under disclosure increases with y_a for any given y and $\alpha > 0$, as shown in Lemma 2(ii). To be specific, fix y and suppose that y_a is disclosed. Section 4 shows that the project price is $P(y, y_a) = \max\{\pi(y, y_a), 0\}$, where $\pi(y, y_a)$ increases with y_a because $\beta_a > \beta_x$. This means that (i) $P(y, y_a) = 0$ for all $y_a \leq y_a^T$, and (ii) $P(y, y_a) = \pi(y, y_a) > 0$ increases with y_a for all $y_a > y_a^T$. We also know that ability assessment $A(y_a)$ increases with y_a. Collectively, although the payoff under disclosure, $W(y, y_a) = P(y, y_a) + \alpha A(y_a)$, has a kink at $y_a = y_a^T$, it strictly increases with y_a. Next, suppose that y_a is not disclosed. For any y and y_a^n, $W(y, y_a^n)$ is a constant. Thus, it follows that the set of undisclosed y_a must be an interval $(-\infty, y_a^n]$, where y_a^n, the market expectation of y_a under no disclosure, is given by (23b).

Proposition 4 [Low-end pooling nondisclosure] *Suppose that $\beta_a > \beta_x$.*

(i) *For any given aggregate signal y, the equilibrium nondisclosure set of y_a is an interval* $(-\infty, y_a^n]$*, where y_a^n is a unique solution to* (23b). *The upper bound, y_a^n, increases with y.*

(ii) *There exists a unique value of aggregate signal y, denoted as y^{**}* satisfying *$y_a^n = y_a^T$, such that when there is no disclosure of y_a, the firm is traded if and only if y is greater than y^{**}.*

(Insert Figure 5 about here.)

Figure 5 depicts the partial disclosure equilibrium for the case of $\beta_a > \beta_x$, where the shaded area is the nondisclosure region. Except that the payoff under disclosure, $W(y, y_a) = P(y, y_a) + \alpha A(y_a)$, monotonically increases with y_a, the tradeoff in disclosure incentives are essentially the same as that in the case of $\beta_a < \beta_x$, which we discussed at length in the main text.

Corollary 6

(i) *The equilibrium nondisclosure set expands as y increases.*

(ii) *α has no effect on the equilibrium nondisclosure set.*

(iii) *An efficiency loss arises when $y > y^{**}$ and $y_a \in (-\infty, y_a^T)$ is undisclosed.*

Parts (i) and (ii) immediately follow from Proposition 4(i). Part (iii) follows from Proposition 4(ii) and the fact that y_a^T decreases with y. As depicted in Figure 5, when $y > y^{**}$, $y_a^n > y_a^T$ and thus $\pi(y, y_a^n) > 0$, implying a project trade without disclosure. Hence, an efficiency loss arises from nondisclosure of $y_a < y_a^T$; if this y_a were disclosed, there would be no trade because $\pi(y, y_a) < 0$.

A4. Proofs

Proof of Lemmas 1 and 2:

Since the results immediately follow from the explanations in the main text, we omit their proofs. ■

Proof of Proposition 1:

First, we show that, for any given y, there exists a unique value y_a^n satisfying (18b) or, equivalently, (18c). Fix y and use (18c) to note that y_a^n is the value of u that satisfies

$$G(u) \equiv (1-\lambda)[u - m(y)] - \lambda \int_u^{\infty} (1 - F(y_a \mid y)) dy_a = 0.$$

Note that

$$\frac{\partial G(u)}{\partial u} = (1-\lambda) + \lambda[1 - F(u \mid y)] > 0 \text{ and } \lim_{u \to m(y)} G(u) < 0 < \lim_{u \to \infty} G(u).$$

Given the continuity of $G(u)$, it follows from the intermediate value theorem that there exists a unique value of $u \in (m(y), \infty)$ satisfying $G(u) = 0$.

Second, given y_a^n solving (18c) and y_a^T given in (9), consider a function

$$H_1(y) \equiv y_a^n - y_a^T.$$

Using (18c), (12), and (9), it is easy to verify that

$$\frac{\partial y_a^n}{\partial y} = \beta_{agg} \in (0,1) \text{ and } \frac{\partial y_a^T}{\partial y} = \frac{\beta_x}{\beta_x - \beta_a} > 0.$$

Thus,
$$\frac{\partial H_1}{\partial y} = \beta_{agg} - \frac{\beta_x}{\beta_x - \beta_a} < 0,$$

where the inequality is obtained from the expressions for β_{agg}, β_a, and β_x in (12) and (7), respectively, and the condition $\beta_a < \beta_x$. Also, because $H_1(y)$ is linear,

$$\lim_{y\to-\infty} H_1(y) > 0 > \lim_{y\to\infty} H_1(y).$$

Given these properties of H_1, the intermediate value theorem implies that there exists a unique value of y, denoted as y', such that $H_1(y') = y_a^n - y_a^T = 0$ with $H_1(y) > 0$ if and only if $y < y'$.

Next, consider a function

$$H_2(y) \equiv y_a^n - y_a^T,$$

where y_a^n is stated in (18a) and y_a^T is given in (9). Rearranging terms yields

$$H_2(y) = \frac{(1-\lambda)[m(y) - y_a^T] + \lambda \int_{y_a^T}^{\infty} [1 - F(y_a \mid y)] dy_a}{1 - \lambda + \lambda[1 - F(y_a^T \mid y)]}.$$

Because the denominator of $H_2(y)$ is positive, the sign of $H_2(y)$ depends on the sign of the numerator, which we denote as $h(y)$. Given $\beta_a < \beta_x$, $h(y)$ is a decreasing function of y; that is

$$\frac{\partial h}{\partial y} = \left[1 - \lambda + \lambda[1 - F(y_a^T \mid y)]\right]\left(\beta_{agg} - \frac{\beta_x}{\beta_x - \beta_a}\right) < 0.$$

In addition,
$$\lim_{y\to-\infty} h(y) > 0 > \lim_{y\to\infty} h(y).$$

Therefore, there exists a unique value of y, denoted as y'', such that $h(y) > 0$ if and only if $y < y''$. This establishes that $H_2(y) > 0$ (i.e., no project trade given nondisclosure) if and only if $y < y''$.

Last, we show that y' and y'' identified in the above proof are the same value, and thus the consistency requirements are met. Evaluate both sides of (18b) at $y = y'$, and then replace y_a^n in the RHS of (18b) with y_a^T, which can be done because $y_a^n = y_a^T$ at $y = y'$; that is, $H_1(y') = 0$. With this replacement, note that the RHS of (18b) is the same as the RHS of (18a). This implies that when $y = y'$, y_a^n defined in (18a) equals y_a^n solving (18b). As a result, $H_2(y') = 0 = H_1(y')$. Because y'' is a unique value of y satisfying $H_2(y) = 0$ (as shown above), it must be the case that $y' = y''$. Letting $y^o \equiv y' = y''$ establishes that there exists a unique value y^o such that

$$H_2(y^o) = H_1(y^o) = 0,$$

$$H_2(y) \geq 0 \text{ (i.e., no project trade under nondisclosure) for all } y \leq y^o,$$

and $\qquad H_1(y) < 0$ (i.e., a project trade under nondisclosure) for all $y > y^o$. ■

Proof of Corollary 1:

We showed in the proof of Proposition 1 that both y_a^T and y_a^n increase with y. Thus, the equilibrium nondisclosure set shrinks as y increases. ■

Proof of Proposition 2:

Building on the analysis provided in the main text, the proof proceeds in three steps. First, we will show the existence of y_a^L and y_a^n satisfying (19) and (20), where $y_a^n > y_a^T$ for all $y < y'$ for some y', and then show the existence of a unique y'.[22] These proofs are referred to as Steps 1a and 1b, respectively. Similarly, we will show the existence of y_a^H and y_a^n satisfying (21) and (22), where $y_a^n < y_a^T$ for all $y > y''$ for some y'', and then the existence of y''. These proofs are referred to as Steps 2a and 2b, respectively. The last proof, Step 3, will show that $y' = y''$.

Step 1a: $\qquad$ Fix y and suppose that $y_a^n > y_a^T$. Integrating by parts in (20) and rearranging terms,

$$y_a^n = m(y) + \frac{\lambda}{1-\lambda}\left\{[y_a^n - y_a^L(y_a^n)]F(y_a^L(y_a^n) \mid y) - \int_{y_a^L(y_a^n)}^{y_a^n} F(y_a \mid y) dy_a\right\}, \tag{A1}$$

where $y_a^L(y_a^n)$ denotes the lower bound signal y_a^L stated in (19) as a function of y_a^n. Because $y_a^L(y_a^n) < y_a^n$ by construction and F increases with y_a,

$$[y_a^n - y_a^L(y_a^n)]F(y_a^L(y_a^n) \mid y) - \int_{y_a^L(y_a^n)}^{y_a^n} F(y_a \mid y) dy_a < 0 \text{ for any } y_a^n. \tag{A2}$$

This implies that $y_a^n < m(y)$ in (A1). Next, replacing y_a^n in (A1) with an arbitrary variable u and rearranging terms yield an equation,

$$Q_1(u) \equiv (1-\lambda)[u - m(y)] - \lambda\left\{[u - y_a^L(u)]F(y_a^L(u) \mid y) - \int_{y_a^L(u)}^{u} F(y_a \mid y) dy_a\right\} = 0. \tag{A3}$$

Note that $Q_1(u)$ is an increasing function of u because

$$\begin{aligned}\frac{\partial Q_1}{\partial u} &= \frac{\partial Q_1}{\partial u} + \frac{\partial Q_1}{\partial y_a^L(u)}\frac{\partial y_a^L(u)}{\partial u} \\ &= (1-\lambda) + \lambda\left\{\left[F(u \mid y) - F(y_a^L(u) \mid y)\right] + [u - y_a^L(u)] f(y_a^L(u) \mid y)\frac{\alpha\beta_a}{\beta_x - (1+\alpha)\beta_a}\right\} > 0,\end{aligned}$$

[22] Here, we abuse the notation slightly by using the same notation y' to denote some value of y as that in the proof of Proposition 1. The same remark applies to y'' that appears below.

where we use $y_a^L(u) < u$ and $\beta_x - (1+\alpha)\beta_a > 0$. Also note that, because of (A2) with y_a^n being replaced by u, we have $Q_1(m(y)) > 0$. In addition, it is easy to verify that

$$y_a^L(u) \to y_a^T \text{ as } u \to y_a^T.$$

This means that as $u \to y_a^T$, the expression inside the curly brackets in (A3) becomes zero. Using this result, along with the fact that $y_a^T < u < m(y)$, yields $Q_1(u) \to (1-\lambda)[y_a^T - m(y)] < 0$ as $u \to y_a^T$. Given that $Q_1(u)$ increases with u and

$$\lim_{u \to y_a^T} Q_1(u) < 0 < Q_1(m(y)),$$

the intermediate value theorem implies that there exists a unique value of $u \in (y_a^T, m(y))$ satisfying $Q_1(u) = 0$. Denoting that value as y_a^n completes the proof of the existence of y_a^n that satisfies (20). Given y_a^n, y_a^L is determined according to (19).

Step 1b: Define

$$H_3(y) \equiv y_a^n - y_a^T, \tag{A4}$$

where y_a^n solves (20) and y_a^T is given in (9). We showed in Step 1a that $y_a^n < m(y)$. Thus,

$$H_3(y) < m(y) - y_a^T.$$

Let $y \to \infty$ in both sides of the above inequality. Because

$$\frac{\partial m(y)}{\partial y} - \frac{\partial y_a^T}{\partial y} = \beta_{agg} - \frac{\beta_x}{\beta_x - \beta_a} < 0,$$

$H_3(y) \to -\infty$ as $y \to \infty$. Next, applying the implicit function theorem to (20) shows that y_a^n satisfying (20) is increasing in y_a^L. Let $y_a^{n\prime}$ be the solution to (20) when y_a^L in (20) is replaced with $-\infty$. That is, $y_a^{n\prime}$ is the solution to

$$\begin{aligned} y_a^{n\prime} \equiv E[y_a \mid y, n] &= \frac{(1-\lambda)m(y) + \lambda F(y_a^{n\prime} \mid y) E[y_a \mid y, y_a \le y_a^{n\prime}]}{(1-\lambda) + \lambda F(y_a^{n\prime} \mid y)} \\ &= m(y) - \frac{\lambda}{1-\lambda}\int_{-\infty}^{y_a^{n\prime}} F(y_a \mid y) dy_a. \end{aligned}$$

Taken together, it follows that y_a^n satisfying (19) and (20) is greater than $y_a^{n\prime}$. Hence,

$$H_3(y) > y_a^{n\prime} - y_a^T.$$

Let $y \to -\infty$ in both sides of the above inequality. By taking the total differentiation of the equation characterizing $y_a^{n\prime}$ in the above with respect to y, it is easy to show that

$$\frac{\partial y_a{}^{n\prime}}{\partial y} = \frac{\partial y_a{}^{n\prime}}{\partial m(y)} \frac{\partial m(y)}{\partial y} = \beta_{agg} \in (0,1).$$

Also, $y_a{}^T$ increases with y at the rate of $\beta_x/(\beta_x - \beta_a) > \beta_{agg}$. Thus, $H_3(y) \to \infty$ as $y \to -\infty$. In sum,

$$\lim_{y\to-\infty} H_3(y) > 0 > \lim_{y\to\infty} H_3(y). \tag{A5}$$

We next show that $H_3(y)$ defined in (A4) is a decreasing function of y. Replace u in (A3) with $y_a{}^n$ and use the implicit function theorem. After rearranging terms, we obtain

$$\begin{aligned}\frac{\partial y_a^n}{\partial y} &= -\frac{\partial Q_1 / \partial y}{\partial Q_1 / \partial y_a^n} = -\frac{\frac{\partial Q_1}{\partial m(y)}\frac{\partial m(y)}{\partial y} + \frac{\partial Q_1}{\partial y_a^L(y_a^n)}\frac{\partial y_a^L(y_a^n)}{\partial y}}{\partial Q_1 / \partial y_a^n} \\ &= \frac{\left\{\begin{array}{c}\left[(1-\lambda) - \lambda[y_a^n - y_a^L(y_a^n)] f(y_a^L(y_a^n) \mid y) + \lambda \int_{y_a^L(y_a^n)}^{y_a^n} f(y_a \mid y) dy_a\right]\beta_{agg} \\ + \lambda[y_a^n - y_a^L(y_a^n)] f(y_a^L(y_a^n) \mid y) \dfrac{\beta_x}{\beta_x - (1+\alpha)\beta_a}\end{array}\right\}}{\left\{\begin{array}{l}(1-\lambda) + \lambda[F(y_a^n \mid y) - F(y_a^L(y_a^n) \mid y)] \\ +\lambda[y_a^n - y_a^L(y_a^n)] f(y_a^L(y_a^n) \mid y) \dfrac{\alpha\beta_a}{\beta_x - (1+\alpha)\beta_a}\end{array}\right\}}.\end{aligned} \tag{A6}$$

On the other hand, we know that

$$\frac{\partial y_a^T}{\partial y} = \frac{\beta_x}{\beta_x - \beta_a} > 0. \tag{A7}$$

After a few more steps involving tedious algebra, it can be shown that (A6) < (A7); that is,

$$\frac{\partial H_3(y)}{\partial y} = \frac{\partial y_a^n}{\partial y} - \frac{\partial y_a^T}{\partial y} < 0, \tag{A8}$$

by exploiting the following conditions/properties: (i) the denominator of (A6) is positive; (ii) the presumed condition of $\beta_x > \beta_a$; and (iii) $F(y_a \mid y)$ is convex (concave) in y_a when y_a is less (greater) than its mean $m(y)$, which in conjunction with $y_a{}^n < m(y)$ implies that

$$\frac{\int_{y_a^L(y_a^n)}^{y_a^n} f(y_a \mid y) dy_a}{y_a^n - y_a^L(y_a^n)} = \frac{F(y_a^n \mid y) - F(y_a^L(y_a^n) \mid y)}{y_a^n - y_a^L(y_a^n)} > f(y_a^L(y_a^n) \mid y) \tag{A9}$$

where $f = F'$ is the normal density function of y_a.[23] Given (A5) and (A8), the intermediate value theorem implies that there exists a unique value of y, denoted as y', such that $H_3(y') = 0$ and $H_3(y) > 0$ (i.e., no project trade under nondisclosure) if and only if $y < y'$.

Last, let $y \to y'$. Because $H_3(y) \to 0$, we have $y_a{}^n \to y_a{}^T$, in which case we know $y_a{}^L \to y_a{}^T$.

[23] Full details of the omitted steps in proving (A8) are available upon request. Also note that (A9) implies that the numerator of (A6) is also positive, and thus $dy_a{}^n/dy > 0$. This property will be used in the proof of Corollary 2.

As a result, $y_a^n \to m(y)$ in (A1). Collectively, when $y \to y'$, all of y_a^n, y_a^T, y_a^L, and $m(y)$ converge to a unique value, as depicted in Figure 3.

Step 2a: Because the proof for the existence of y_a^H and y_a^n satisfying (21) and (22), where $y_a^n < y_a^T$ for all $y > y''$ for some y'', and the existence of y'' are similar to Steps 1a and 1b, we explain them briefly. Fix y and suppose that $y_a^n < y_a^T$. Integrating by parts in (22),

$$y_a^n = m(y) + \frac{\lambda}{1-\lambda}[y_a^H(y_a^n) - y_a^n]F(y_a^H(y_a^n) \mid y) - \frac{\lambda}{1-\lambda}\int_{y_a^n}^{y_a^H(y_a^n)} F(y_a \mid y)dy_a. \tag{A10}$$

This shows that $y_a^n > m(y)$ because, given that $y_a^H(y_a^n) > y_a^n$,

$$[y_a^H(y_a^n) - y_a^n]F(y_a^H(y_a^n) \mid y) - \int_{y_a^n}^{y_a^H(y_a^n)} F(y_a \mid y)dy_a > 0 \text{ for any } y_a^n. \tag{A11}$$

Next, replacing y_a^n in (A10) with an arbitrary variable u and rearranging terms yield

$$Q_2(u) \equiv (1-\lambda)[u - m(y)] - \lambda\left\{[y_a^H(u) - u]F(y_a^H(u) \mid y) - \int_u^{y_a^H(u)} F(y_a \mid y)dy_a\right\} = 0. \tag{A12}$$

Similar to Step 1a, along with a result that when $y_a^n > m(y)$,

$$\frac{\int_{y_a^n}^{y_a^H(y_a^n)} f(y_a \mid y)dy_a}{y_a^H(y_a^n) - y_a^n} = \frac{F(y_a^H(y_a^n) \mid y) - F(y_a^n \mid y)}{y_a^H(y_a^n) - y_a^n} > f(y_a^H(y_a^n) \mid y), \tag{A13}$$

it can be shown that $Q_2(u)$ is an increasing function of u, and that

$$Q_2(m(y)) < 0 < \lim_{u \to y_a^T} Q_2(u).$$

The intermediate value theorem implies that there exists a unique value of $u \in (m(y), y_a^T)$ satisfying $Q_2(u) = 0$. Denoting that value as y_a^n establishes the existence of y_a^n satisfying (22). Given this y_a^n, y_a^H is determined according to (21).

Step 2b: Define

$$H_4(y) \equiv y_a^n - y_a^T, \tag{A14}$$

where y_a^n solves (22) and y_a^T is given in (9). Following a procedure similar to Step 1b yields

$$\lim_{y \to -\infty} H_4(y) > 0 > \lim_{y \to \infty} H_4(y), \tag{A15}$$

and

$$\frac{\partial H_4(y)}{\partial y} = \frac{\partial y_a^n}{\partial y} - \frac{\partial y_a^T}{\partial y} < 0. \tag{A16}$$

The intermediate value theorem shows that there exists a unique value of y, denoted as y'', such that $H_4(y'') = 0$ and $H_4(y) > 0$ (i.e., no project trade under nondisclosure) if and only if $y < y''$. Last, as $y \to y''$, all of y_a^n, y_a^T, y_a^H, and $m(y)$ converge to a unique value, as depicted in Figure 3.

Step 3: It remains to show that y' identified in Step 1b as satisfying $H_3(y') = 0$ and y'' identified in Step 2b as satisfying $H_4(y'') = 0$ are the same value of y. Note that y_a^T and $m(y)$ are linearly increasing functions of y, where the slope of y_a^T is greater. Hence, they must intersect each other only once. In addition, they are common in Steps 1b and 2b, and we know that y_a^T and $m(y)$ evaluated at $y = y'$ are equal in Step 1b and they are equal when evaluated at $y = y''$ in Step 2b. This implies that $y' = y''$. Letting $y^* \equiv y' = y''$, we have

$$H_3(y^*) = H_4(y^*) = 0,$$

$$H_3(y) > 0 \text{ (i.e., no project trade under nondisclosure) for all } y < y^*,$$

and
$$H_4(y) < 0 \text{ (i.e., a project trade under nondisclosure) for all } y > y^*.$$

This completes the proof of Proposition 2. ■

Proof of Corollary 2:

First, fix $y < y^*$. Using (A1), we rewrite (19) and (20) as two implicit functions M_1 and N_1 that characterize the equilibrium pair, y_a^L and y_a^n:

$$M_1(y_a^n, y_a^L) \equiv (1-\lambda)[y_a^n - m(y)] - \lambda(y_a^n - y_a^L)F(y_a^L \mid y) + \lambda\int_{y_a^L}^{y_a^n} F(y_a \mid y)dy_a = 0, \tag{A17}$$

$$N_1(y_a^n, y_a^L) \equiv y_a^L - \frac{1}{\beta_x - (1+\alpha)\beta_a}\left[\beta_x y - \alpha\beta_a y_a^n + C\right] = 0. \tag{A18}$$

Partial derivatives are

$$\frac{\partial M_1}{\partial y_a^n} = (1-\lambda) - \lambda F(y_a^L \mid y) + \lambda F(y_a^n \mid y) > 0\,,\ \frac{\partial M_1}{\partial y_a^L} = -\lambda(y_a{}^n - y_a^L) f(y_a^L \mid y) < 0$$

$$\frac{\partial N_1}{\partial y_a^n} = \frac{\alpha\beta_a}{\beta_x - (1+\alpha)\beta_a} > 0\text{, and } \frac{\partial N_1}{\partial y_a^L} = 1 > 0.$$

Hence, the Jacobian matrix for (A17) and (A18) is

$$|J| = \begin{vmatrix} \frac{\partial M_1}{\partial y_a^n} & \frac{\partial M_1}{\partial y_a^L} \\ \frac{\partial N_1}{\partial y_a^n} & \frac{\partial N_1}{\partial y_a^L} \end{vmatrix} = \frac{\partial M_1}{\partial y_a^n}\frac{\partial N_1}{\partial y_a^L} - \frac{\partial M_1}{\partial y_a^L}\frac{\partial N_1}{\partial y_a^n} > 0.$$

Also, using (A9),

$$\frac{\partial M_1}{\partial y} = \left[-(1-\lambda) + \lambda (y_a^n - y_a^L) f(y_a^L \mid y) - \lambda \int_{y_a^L}^{y_a^n} f(y_a \mid y) dy_a \right] \frac{\partial m(y)}{\partial y} < 0$$

and $$\frac{\partial N_1}{\partial y} = -\frac{\beta_x}{\beta_x - (1+\alpha)\beta_a} < 0 \cdot$$

Applying the implicit function theorem yields

$$\frac{\partial y_a^n}{\partial y} = \frac{-1}{|J|} \begin{vmatrix} \frac{\partial M_1}{\partial y} & \frac{\partial M_1}{\partial y_a^L} \\ \frac{\partial N_1}{\partial y} & \frac{\partial N_1}{\partial y_a^L} \end{vmatrix} > 0 \text{ and } \frac{\partial y_a^L}{\partial y} = \frac{-1}{|J|} \begin{vmatrix} \frac{\partial M_1}{\partial y_a^n} & \frac{\partial M_1}{\partial y} \\ \frac{\partial N_1}{\partial y_a^n} & \frac{\partial N_1}{\partial y} \end{vmatrix} > 0.$$

Using the above results, it is also straightforward to verify that $\frac{\partial y_a^L}{\partial y} > \frac{\partial y_a^n}{\partial y}$.

Second, fix $y > y^*$. Using (A10), we rewrite (21) and (22) as two implicit functions M_2 and N_2 that characterize the equilibrium pair, y_a^H and y_a^n:

$$M_2(y_a^n, y_a^H) \equiv (1-\lambda)[y_a^n - m(y)] - \lambda (y_a^H - y_a^n) F(y_a^H \mid y) + \lambda \int_{y_a^n}^{y_a^H} F(y_a \mid y) dy_a = 0, \qquad \text{(A19)}$$

$$N_2(y_a^n, y_a^H) \equiv y_a^H - \frac{1}{\alpha\beta_a} \left[\beta_x y + [(1+\alpha)\beta_a - \beta_x] y_a^n + C \right] = 0. \qquad \text{(A20)}$$

Partial derivatives are

$$\frac{\partial M_2}{\partial y_a^n} = (1-\lambda) + \lambda F(y_a^H \mid y) - \lambda F(y_a^n \mid y) > 0, \; \frac{\partial M_2}{\partial y_a^H} = -\lambda (y_a^H - y_a^n) f(y_a^H \mid y) < 0$$

$$\frac{\partial N_2}{\partial y_a^n} = -\frac{1}{\alpha\beta_a} \left[(1+\alpha)\beta_a - \beta_x \right] > 0, \text{ and } \frac{\partial N_2}{\partial y_a^H} = 1 > 0.$$

Hence, the Jacobian matrix for (A19) and (A20) is

$$|J| = \begin{vmatrix} \frac{\partial M_2}{\partial y_a^n} & \frac{\partial M_2}{\partial y_a^H} \\ \frac{\partial N_2}{\partial y_a^n} & \frac{\partial N_2}{\partial y_a^H} \end{vmatrix} = \frac{\partial M_2}{\partial y_a^n} \frac{\partial N_2}{\partial y_a^H} - \frac{\partial M_2}{\partial y_a^H} \frac{\partial N_2}{\partial y_a^n} > 0.$$

Also, using (A13),

$$\frac{\partial M_2}{\partial y} = [-(1-\lambda) + \lambda (y_a^H - y_a{}^n) f(y_a^H \mid y) - \lambda \int_{y_a{}^n}^{y_a^H} f(y_a \mid y) dy_a] \frac{\partial m(y)}{\partial y} < 0 \text{ and } \frac{\partial N_2}{\partial y} = -\frac{\beta_x}{\alpha\beta_a} < 0.$$

Thus, $\frac{\partial y_a^n}{\partial y} = \frac{-1}{|J|}\begin{vmatrix} \frac{\partial M_2}{\partial y} & \frac{\partial M_2}{\partial y_a^H} \\ \frac{\partial N_2}{\partial y} & \frac{\partial N_2}{\partial y_a^H} \end{vmatrix} > 0$ and $\frac{\partial y_a^H}{\partial y} = \frac{-1}{|J|}\begin{vmatrix} \frac{\partial M_2}{\partial y_a^n} & \frac{\partial M_2}{\partial y} \\ \frac{\partial N_2}{\partial y_a^n} & \frac{\partial N_2}{\partial y} \end{vmatrix} > 0.$

Using the above results, it is straightforward to verify that $\frac{\partial y_a^H}{\partial y} > \frac{\partial y_a^n}{\partial y}$. ■

Proof of Corollary 3:

Fix $y < y^*$ and note that

$$\frac{\partial M_1}{\partial \alpha} = 0 \text{ and } \frac{\partial N_1}{\partial \alpha} = -\frac{\beta_a[\beta_x y + (\beta_a - \beta_x) y_a^n + C]}{[\beta_x - (1+\alpha)\beta_a]^2} > 0 .$$

Hence, $\frac{\partial y_a^n}{\partial \alpha} = \frac{-1}{|J|}\begin{vmatrix} \frac{\partial M_1}{\partial \alpha} & \frac{\partial M_1}{\partial y_a^L} \\ \frac{\partial N_1}{\partial \alpha} & \frac{\partial N_1}{\partial y_a^L} \end{vmatrix} < 0$ and $\frac{\partial y_a^L}{\partial \alpha} = \frac{-1}{|J|}\begin{vmatrix} \frac{\partial M_1}{\partial y_a^n} & \frac{\partial M_1}{\partial \alpha} \\ \frac{\partial N_1}{\partial y_a^n} & \frac{\partial N_1}{\partial \alpha} \end{vmatrix} < 0.$

Fix $y > y^*$ and note that

$$\frac{\partial M_2}{\partial \alpha} = 0 \text{ and } \frac{\partial N_2}{\partial \alpha} = \frac{\beta_x y + (\beta_a - \beta_x) y_a^n + C}{\alpha^2 \beta_a} > 0 .$$

Thus, $\frac{\partial y_a^n}{\partial \alpha} = \frac{-1}{|J|}\begin{vmatrix} \frac{\partial M_2}{\partial \alpha} & \frac{\partial M_2}{\partial y_a^H} \\ \frac{\partial N_2}{\partial \alpha} & \frac{\partial N_2}{\partial y_a^H} \end{vmatrix} < 0$ and $\frac{\partial y_a^H}{\partial \alpha} = \frac{-1}{|J|}\begin{vmatrix} \frac{\partial M_2}{\partial y_a^n} & \frac{\partial M_2}{\partial \alpha} \\ \frac{\partial N_2}{\partial y_a^n} & \frac{\partial N_2}{\partial \alpha} \end{vmatrix} < 0.$ ■

Proof of Proposition 3:

Fix y, so that the distribution of y_a is fixed. The existence of a unique $y_a^n \in (-\infty, m(y))$ that satisfies (23b) follows from Proposition 1 in Jung and Kwon (1988). Next, given the discussion in the main text, we only need to show the existence of y^+ for which the consistency requirements are met. Let y be given. First, suppose that $\alpha > \alpha_m$ and define

$$H_5(y) \equiv y_a^n - y_a^T, \tag{A21}$$

where y_a^T is given in (9) and y_a^n solves (23b). $H_5(y)$ is a decreasing function of y because

$$\frac{\partial H_5}{\partial y} = \beta_{agg} - \frac{\beta_x}{\beta_x - \beta_a} < 0. \tag{A22}$$

In addition, $$\lim_{y \to -\infty} H_5(y) > 0 > \lim_{y \to \infty} H_5(y). \tag{A23}$$

Given the continuity of $H_5(y)$, it follows from the intermediate value theorem that there exists a unique value of y' satisfying $H_5(y') = 0$, and $H_5(y) > 0$ if and only if $y < y'$.

Next, suppose $\alpha = \alpha_m$ and define

$$H_6(y) \equiv y_a^n - y_a^T, \tag{A24}$$

where y_a^T and y_a^n are given in (9) and (24), respectively. Simplifying terms yields

$$H_6(y) = \frac{(1-\lambda)[m(y) - y_a^T] - \lambda \int_{-\infty}^{y_a^T} F(y_a \mid y) dy_a}{(1-\lambda) + \lambda F(y_a^T \mid y)}.$$

Because the denominator of $H_6(y)$ is positive, the sign of $H_6(y)$ depends on the sign of the numerator, which we denote as $g(y)$. Given $\beta_a < \beta_x$, $g(y)$ is a decreasing function of y; that is,

$$\frac{\partial g}{\partial y} = [1 - \lambda + \lambda F(y_a{}^T \mid y)] \left(\beta_{agg} - \frac{\beta_x}{\beta_x - \beta_a} \right) < 0.$$

In addition, $$\lim_{y \to -\infty} g(y) > 0 > \lim_{y \to \infty} g(y).$$

Thus, there exists a unique value of y, denoted as y'', such that $g(y) > 0$ if and only if $y < y''$. This implies that $H_6(y) > 0$ if and only if $y < y''$.

Following a procedure similar to that provided at the end of the proof of Proposition 1 reveals that $y' = y''$. Letting $y^+ \equiv y' = y''$ establishes that there exists a unique value y^+, such that

$$H_5(y^+) = H_6(y^+) = 0,$$

$$H_5(y) \geq 0 \text{ (i.e., no project trade under nondisclosure) for all } y \leq y^+,$$

and $$H_6(y) < 0 \text{ (i.e., a project trade under nondisclosure) for all } y > y^+. \blacksquare$$

Proof of Corollary 4:

(i) We know that

$$\frac{\partial y_a^n}{\partial y} = \frac{\partial y_a^n}{\partial m(y)} \frac{\partial m(y)}{\partial y} = \beta_{agg} \in (0,1) \text{ and } \frac{\partial y_a^T}{\partial y} = \frac{\beta_x}{\beta_x - \beta_a} > 0.$$

Hence, the equilibrium nondisclosure sets expand as y increases.

(ii) It is easy to verify that the effects of α on the payoffs under disclosure and nondisclosure wash out. Thus, the result follows. ■

Proof of Corollary 5:

We omit proofs because the results are immediate from Propositions 2 and 3, and the discussion in the main text is in sufficient detail. ■

Proof of Proposition 4:

Given the proof of Proposition 3, and the proof of Corollary 4(i), we only need to show the existence of y^{**} for which the consistency requirements are met. Let y be given and define

$$H_7(y) \equiv y_a^n - y_a^T,$$

where y_a^n satisfies (23b) and y_a^T is given in (9). Because $\beta_a > \beta_x$, we have

$$\frac{\partial H_7}{\partial y} = \beta_{agg} - \frac{\beta_x}{\beta_x - \beta_a} > 0, \text{ and thus } \lim_{y\to-\infty} H_7(y) < 0 < \lim_{y\to\infty} H_7(y).$$

Given the continuity of $H_7(y)$, it follows from the intermediate value theorem that there exists a unique value of y, denoted as y^{**}, such that $H_7(y^{**}) = y_a^n - y_a^T = 0$ with $H_1(y) > 0$ (i.e., a project trade under nondisclosure) if and only if $y > y^{**}$. ■

Proof of Corollary 6:

We omit proofs because the results are immediate from Propositions 4. ■

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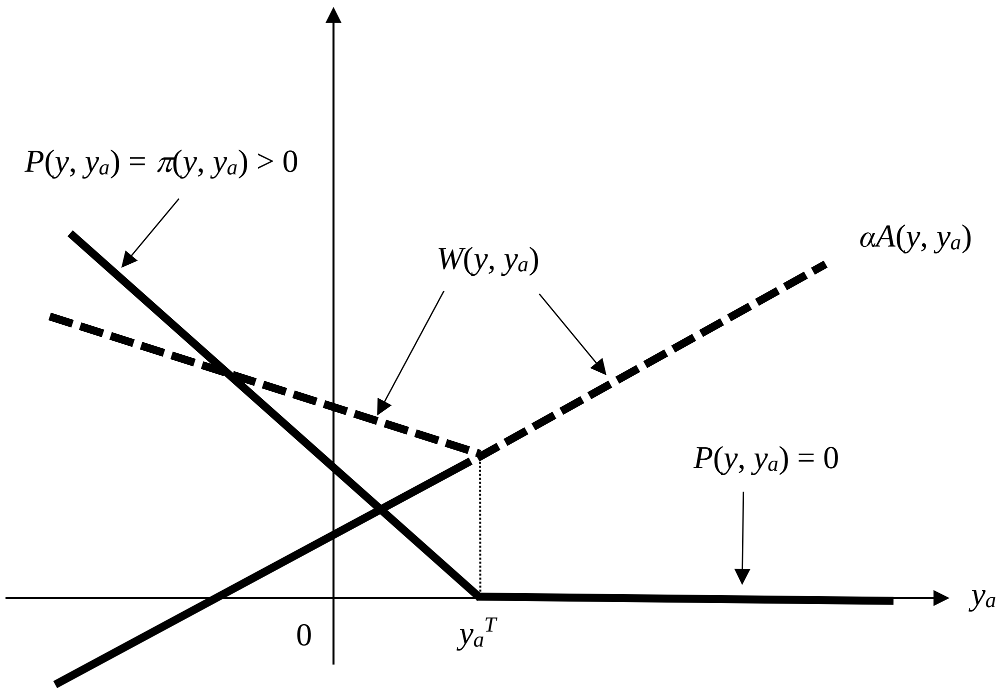

Figure 1. When $\beta_a < \beta_x$ and $0 < \alpha < \alpha_m$, $P(y, y_a) = \max\{\pi(y, y_a), 0\}$ is the market price of the project and has a kink at $y_a = y_a^T$. The two dashed lines are the entrepreneur's payoff under disclosure, which is $W(y, y_a) = P(y, y_a) + \alpha A(y, y_a)$. For $y_a < y_a^T$, $W(y, y_a) = \pi(y, y_a) + \alpha A(y, y_a)$. For $y_a \geq y_a^T$, $W(y, y_a) = \alpha A(y, y_a)$ because $P(y, y_a) = 0$.

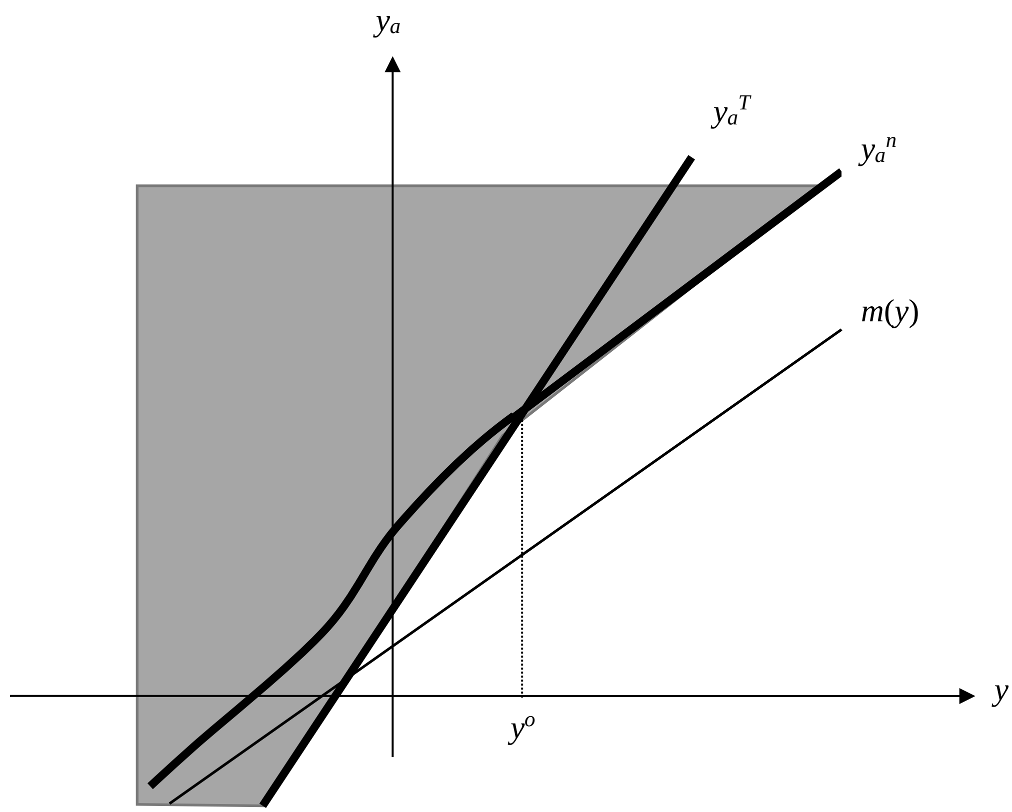

Figure 2. Partial disclosure equilibrium when $\beta_a < \beta_x$ and $\alpha = 0$. For $y \leq y^o$, the nondisclosure set is an interval $[y_a^T, \infty)$. For $y > y^o$, the nondisclosure set is an interval $[y_a^n, \infty)$. The project is traded to investors if and only if (y, y_a) in the case of disclosure or (y, y_a^n) in the case of nondisclosure is located in the region below y_a^T.

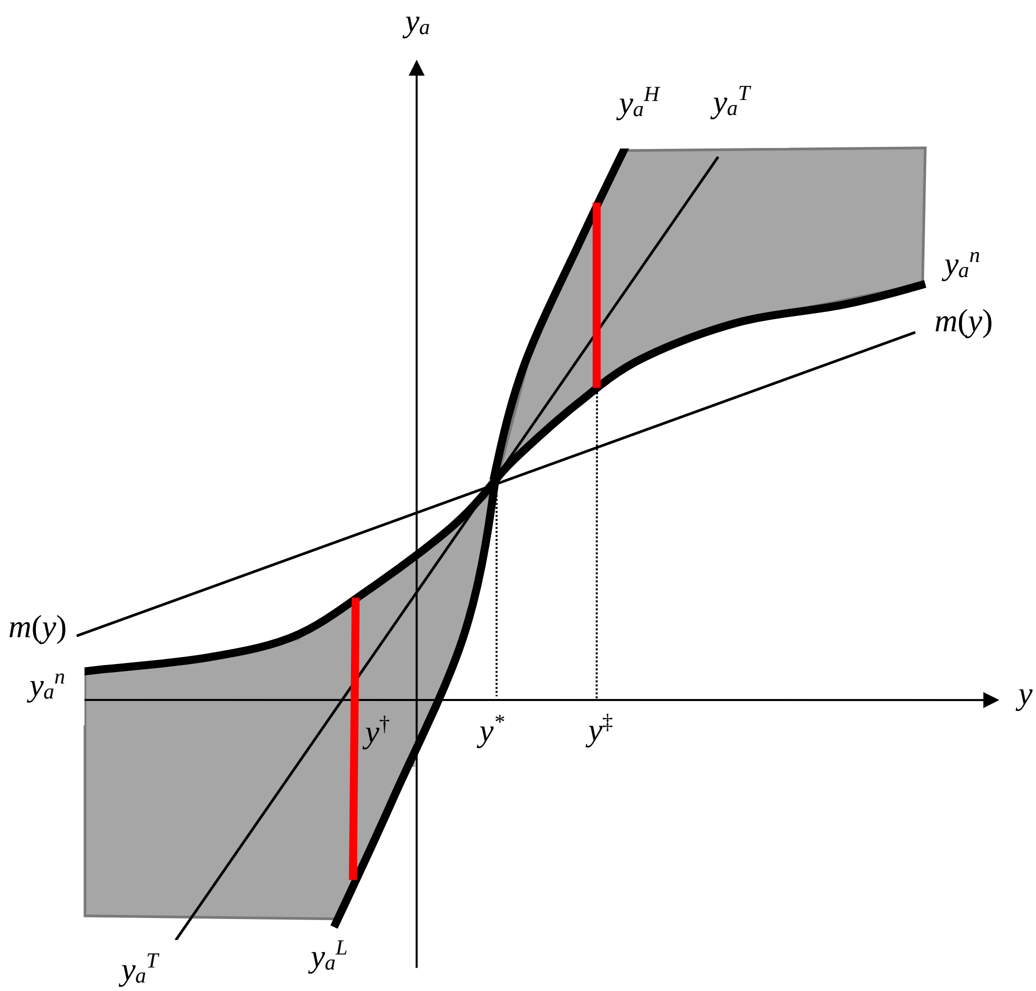

Figure 3. Partial disclosure equilibrium when $\beta_a < \beta_x$ and $0 < \alpha < \alpha_m$. For $y \leq y^*$, the nondisclosure set is vertical interval $[y_a^L, y_a^n]$. For $y > y^*$, the nondisclosure set is vertical interval $[y_a^n, y_a^H]$. The project is traded if and only if (y, y_a) in the case of disclosure or (y, y_a^n) in the case of nondisclosure is located in the region below y_a^T.

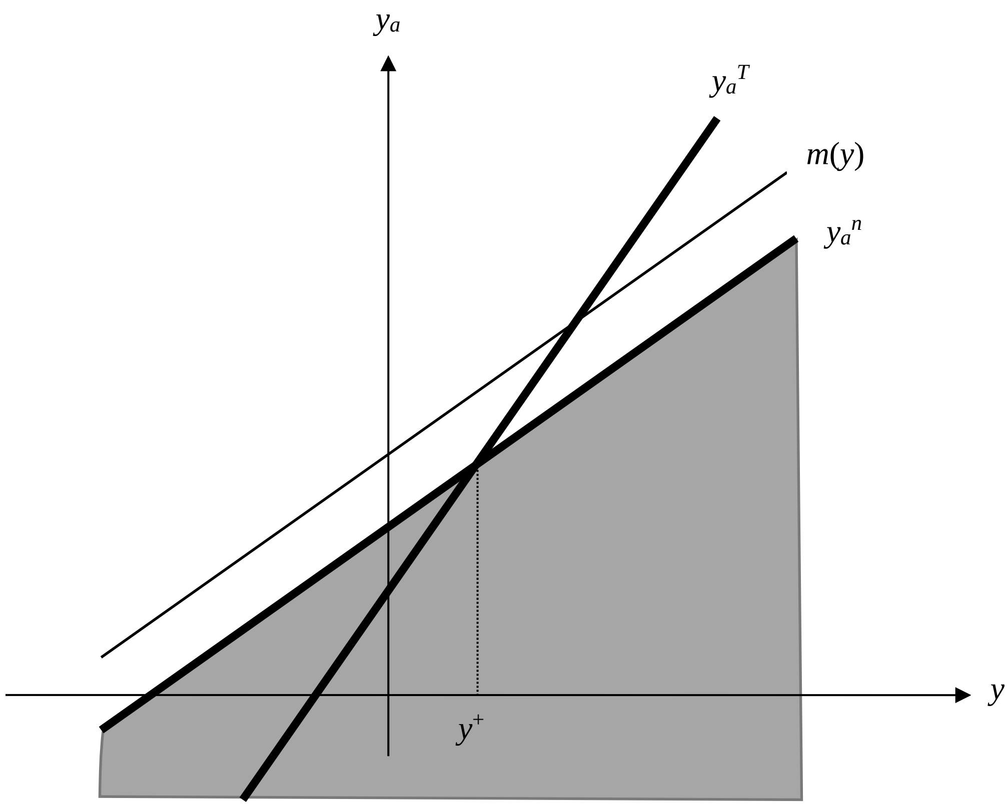

Figure 4. Partial disclosure equilibrium when $\beta_a < \beta_x$ and $\alpha > \alpha_m$. For any given y, the equilibrium nondisclosure set is an interval $(-\infty, y_a^n]$. The project is traded if and only if (y, y_a) in the case of disclosure or (y, y_a^n) in the case of nondisclosure is located in the region below y_a^T.

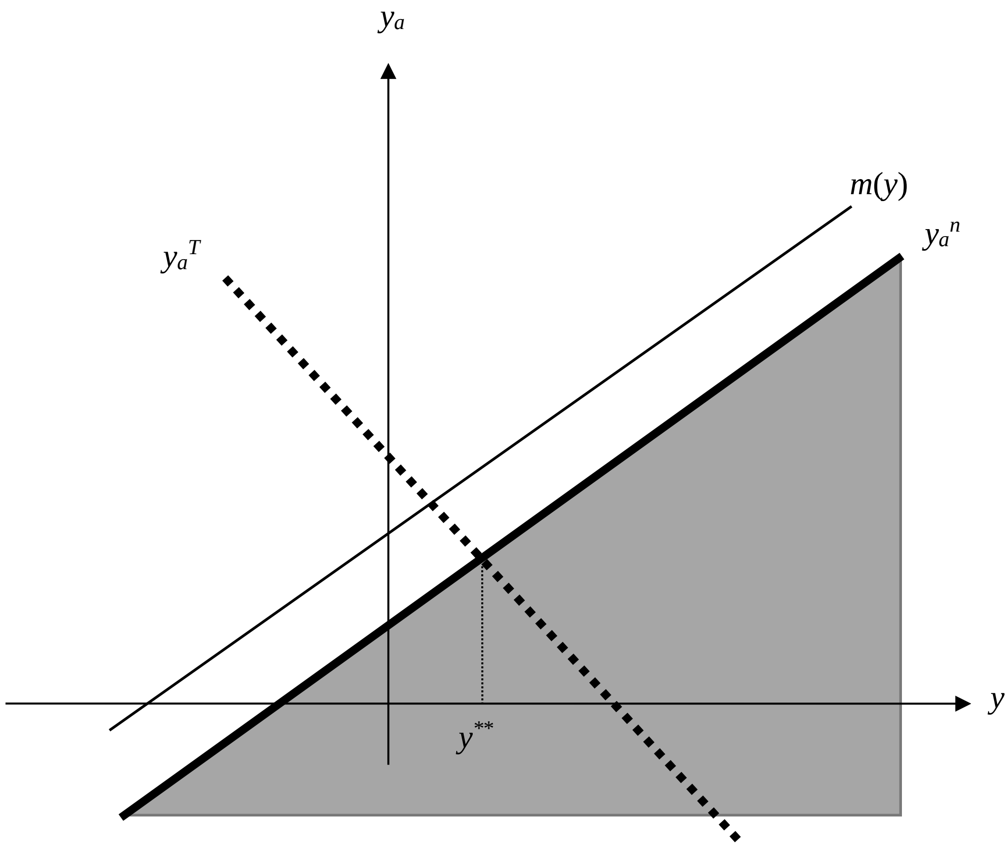

Figure 5. Partial disclosure equilibrium when $\beta_a > \beta_x$. Given any y, the nondisclosure set is an interval $(-\infty, y_a^n]$. The project is traded if and only if (y, y_a) in the case of disclosure or (y, y_a^n) in the case of nondisclosure is located in the region above y_a^T.