Corporate Disclosure, Government Bailout, and Liquidity Crisis

Kyounghun Lee and Frederick Dongchuhl Oh[1]
KAIST College of Business, Korea Advanced Institute of Science and Technology,
85 Hoegi-Ro, Dongdaemoon-Gu, Seoul 02455, Korea

Version: September 11, 2022

This study examines the effects of a government bailout on corporate disclosure when a firm is exposed to the risk of investors withdrawing their investments from the firm. The government bailout affects the behavior of investors, which, in turn, alters the disclosure behavior of the firm. We find that the firm discloses less (more) than the case without a bailout when investors have pessimistic (optimistic) beliefs about the firm. These changes in disclosure decision reduce investors' expectations about the firm's fundamentals. Therefore, the government bailout can increase the likelihood of the firm facing a liquidity crisis if it distorts the disclosure behavior of the firm. (JEL M40, G01, G28, D82, D83)

Key Words: Corporate Disclosure; Government Bailout; Liquidity Crisis; Coordination Failure; Global Game

1. INTRODUCTION

Government bailout, or the provision of financial assistance to firms that are close to bankruptcy, is one of the most prevalent policy measures utilized to overcome financial crises. As lenders of last resort, many governments consider bailout plans for firms during financial crises—even if they finally decide not to intervene. However, although the purpose of these interventions is to restore confidence in the financial system, concerns about financial markets generally do not easily disappear. Many studies argue that the lack of transparency is the primary reason that trust is eroded in firms (e.g., Flannery, Kwan & Nimalendran, 2013; Morgan, 2002; Summers, 2000). For example, the disclosure of the Supervisory Capital Assessment Program results in May 2009 is generally perceived as improving transparency of U.S. banking firms and thus, as helping to rebuild trust in the financial system. This raises the question of why firms themselves do not decide to increase their transparency during crisis periods.

In this regard, the present study develops a model in which a government bailout interacts with a firm's disclosure policy. Bouvard, Chaigneau, and Motta [2015] examine the optimal disclosure by a government regulator facing the problem of firms' exposure to investment withdrawals. Specifically, investors in firms decide whether or not to withdraw their investments based on the regulator's disclosure. The regulator, concerned with the long-term viability of firms, chooses its disclosure policy so as to reduce investment withdrawals from firms. The current model in this study generally refers to this setting but differs in two respects: First, we study the disclosure decision of a firm, not a regulator. While the disclosure in Bouvard,

[1]Corresponding author. E-mail: dcoh415@kaist.ac.kr, Phone: +82-2-958-3416, Fax: +82-2-958-3160.

Chaigneau, and Motta [2015] is not costly to the regulator, the firm incurs a private disclosure cost in our model. This implies that the firm should compare the benefits and costs of disclosure. Second, we consider the possibility of a government bailout. Thus, investors make withdrawal decision based on the amount of the bailout as well as information disclosed by the firm. By focusing on these two aspects, our study analyzes how the bailout influences the firm's disclosure behavior. In addition, we examine the effects of changes in the disclosure decision on the likelihood of the firm encountering a liquidity crisis.

With regard to liquidity crises, this study focuses on self-fulfilling crises, that is, crises that arise from investors' pessimistic beliefs about future events. This self-fulfilling nature has attracted attention from researchers, because a firm's liquidity crisis often results from coordination failure among investors (e.g., Goldstein & Pauzner, 2005; Morris & Shin, 2008; Oh, 2013; Pereira, 2021). Specifically, we consider a withdrawal game among investors. In the proposed model, investors invest in a firm's investment project. They can either withdraw their investments in the interim stage (in this case, they obtain full repayment) or stay until a return on the project is realized (in this case, they obtain the return). The return depends on not only the fundamentals of the firm but also the proportion of investors who withdraw investments. Thus, investors' coordinated action on investment withdrawal influences the likelihood of a firm facing a liquidity crisis. However, considering this coordination problem often tends to produce multiple equilibrium outcomes, making it difficult to characterize the withdrawal decision.[2] We resolve this multiplicity of outcomes by employing the global game method introduced by Carlsson and van Damme [1993]. This method allows for unique equilibrium outcomes, and thus, the determination of an optimal bailout and disclosure policy.

The government, being aware of the possibility of this coordination failure, has an incentive to provide capital for a firm based on the information disclosed by the firm. Following Zwart [2007], we assume that the government seeks to bail out a firm if it is likely to suffer a coordination failure without additional financial assistance. This injection of capital improves the firm's fundamentals, and thus, encourages investors not to withdraw their investments. In other words, the government bailout ex post reduces the probability of a liquidity crisis. Nevertheless, the literature on bailouts has emphasized that the existence of a bailout may alter the firm's behavior related to a liquidity crisis. While most studies focus on the monitoring efforts or the risk-taking behavior of firms (e.g., Dam & Koetter, 2012; Farhi & Tirole, 2020; Kareken & Wallace, 1978; Keister, 2016; Morris & Shin, 2006), our study examines how a government bailout influences the firm's disclosure behavior, which is also an important coordination factor among investors.[3] The effects of corporate disclosure on liquidity crises differ from those of monitoring efforts and risk-taking behavior in that corporate disclosure affects the behavior of external users rather than the firm's fundamentals.

For the corporate disclosure setting, we assume that the firm determines disclo-

[2] It should be noted that such a model with multiple equilibria cannot capture the effects of a government bailout on the firm's disclosure behavior because both the government and the firm make their decisions based on the expected outcomes of investment withdrawals.

[3] Cordella, Dell'Ariccia, and Marquez [2018] present a model in which a government bailout affects a bank's risk-taking and information disclosure. However, they do not consider the coordination problem among investors, which is the present study's central focus. Specifically, while the bailout amount is exogenously given in Cordella, Dell'Ariccia, and Marquez [2018], the government in our model chooses a bailout amount to prevent coordination failure among investors. This implies that the firm has an incentive to change its disclosure behavior to receive a bailout.

sure precision (i.e., the firm's transparency) to maximize the return on its project. Once the firm commits to this precision, the firm publicly discloses a noisy signal about its expected fundamentals with this precision before the government's bailout and investors' withdrawal decisions are made. Hence, the public signal disclosed by the firm plays an important role in identifying the equilibrium outcome of investors' withdrawal game in this study. The impacts of public information on the coordination problem among investors have been extensively studied because investors update their beliefs about the firm's fundamentals, and conjecture other investors' decisions based on the public signal (e.g., Acharya & Ryan, 2016; Beatty & Liao, 2014; Edmond, 2013; Goldstein & Huang, 2020; Lee & Oh, 2021a; Morris & Shin, 2002; Oh, 2022). We extend this literature by endogenizing the precision of public information and investigating the effects of the government bailout on the firm's disclosure behavior.[4]

To understand how a government bailout influences a firm's disclosure policy, we first analyze the optimal disclosure precision when the firm does not expect a bailout. As in the model of Morris and Shin [2001], the proposed model of this study guarantees the unique equilibrium of investors' withdrawal game with a mild condition about the precision of investors' private information. Under this condition, we examine the optimal disclosure precision chosen by the firm. The result indicates that the firm's transparency is adversely related to investors' prior beliefs about the firm's fundamentals. When investors believe that the state of the firm's fundamentals is weak ex ante (i.e., bad times), the firm discloses precise information on the firm's fundamentals as long as the disclosure cost is low enough. Conversely, the firm decides not to disclose any information when investors have optimistic beliefs about the firm (i.e., good times). This disclosure behavior is solely driven by the firm's concern about investment withdrawals, and thus, reduces the probability of a firm suffering a liquidity crisis.

After demonstrating the firm's disclosure policy without a bailout, this study shows that the anticipation of a bailout may alter the firm's disclosure. Specifically, we find that disclosure precision can decrease during bad times but increase during good times if the firm expects a bailout. The intuition behind this result is as follows: the firm anticipates that the government will inject the resources necessary to avoid investment withdrawals. Thus, the firm does not have any incentive to disclose information that would help in restoring investors' prior beliefs about the firm. Instead, as a bailout directly increases the firm's return, the purpose of the firm's disclosure is to increase the probability of receiving a bailout. That is, the firm has incentives (i) to disclose more precise information in good times because the government only intervenes if it observes negative information with high precision, and (ii) to disclose less precise information in bad times because the government intervenes under the investors' prior beliefs alone. Consequently, if the government

[4] Indeed, many studies consider the "optimal disclosure games" in which a sender can commit to his or her disclosure policy (e.g., Alonso & Zachariadis, 2021; Aoyagi, 2014; DellaVigna & Gentzkow, 2010; Kamenica & Gentzkow, 2011; Kolotilin, 2015; Lee & Oh, 2022). Our study contributes to the literature by considering a sender's information design problem with multiple receivers and costly information acquisition (e.g., Arieli & Babichenko, 2019; Hedlund, 2015; Inostroza & Pavan, 2021; Kamenica & Gentzkow, 2014). Specifically, in our proposed model, the firm decides its costly disclosure mechanism to minimize investors' withdrawals. Further, unlike the recent literature that has examined the interactions between the government's bailout policy and information design (e.g., Faria-e-Castro, Martinez & Philippon, 2017; Inostroza, 2020) or information design and the firm's disclosure policy (e.g., Quigley & Walther, 2020), this study explores how the government bailout affects the firm's disclosure behavior.

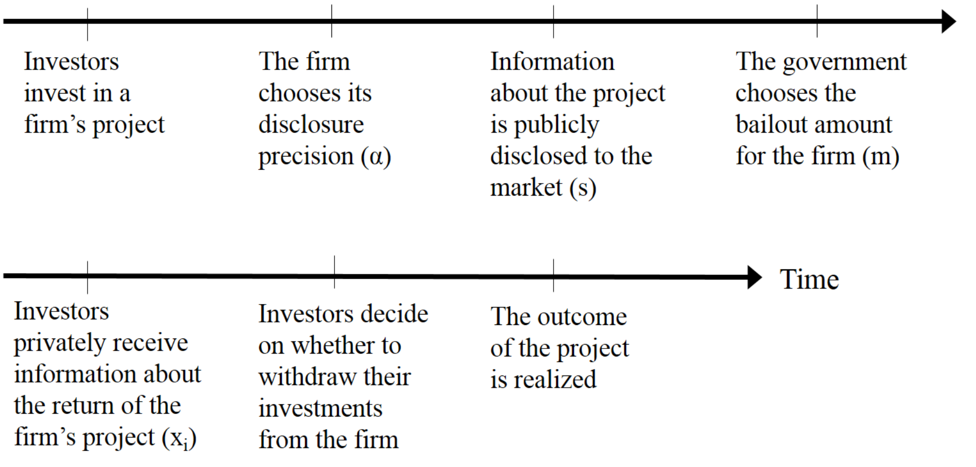

FIG. 1 Timeline

cannot bail out all firms, then the likelihood of a liquidity crisis can be higher in the case with a bailout because of the distorted firm's disclosure behavior. This implies that a bailout policy that does not include an appropriate disclosure requirement may aggravate financial stability.[5]

The remainder of this paper proceeds as follows: Section 2 presents the model. Section 3 first analyzes a benchmark case in which a firm decides its disclosure policy without the possibility of a bailout and then demonstrates how the firm's disclosure policy is influenced by the anticipation of a bailout. Section 4 defines the bailout effect on a liquidity crisis and discusses its implications. Section 5 discusses empirical implications and extensions of our model, and Section 6 concludes. All proofs are in the Appendix.

2. THE MODEL

We consider three types of risk-neutral agents in our model: a firm, investors, and a government. The firm has an investment project requiring capital. The firm's project is financed only through short-term instruments from investors. The timing of events (see FIG. 1) is as follows: First, investors invest in the firm's project. Second, the firm chooses its disclosure precision (α). Third, the firm publicly discloses information on the project (s). Fourth, the government chooses the amount of bailout for the firm (m) based on the disclosed information. Fifth, after observing the public signal and bailout amount, investors receive a private signal (x_i) about the return of the project. Sixth, investors decide whether to withdraw their investments from the firm. Seventh, the return on the project is realized and distributed to the remaining investors. We describe the details of each event below.

[5] For the issue of financial stability, see also Allen, Carletti, Goldstein, and Leonello [2018], who analyze the effects of government guarantees on the liquidity creation of banking firms. They show that the government guarantees can increase the probability of banking firms facing large withdrawals if banking firms over provide liquidity insurance in response to the guarantee. Our argument that a bailout can increase withdrawals is in line with their conclusion, although we focus on the disclosure behavior of firms.

Initially, investors provide the firm with financing for the long-term investment project. The group of investors consist of a continuum $[0, 1]$ of small investors such that the share of any investor as a whole is negligible. All investors invest one unit of capital in the project. The project is characterized by the state of the firm's fundamentals, r, which represents the profitability of the project. A high r value indicates a better return on investment.

After the financing of the firm's project is undertaken by investors, the firm publicly discloses a signal related to r. This public signal can be interpreted as corporate disclosure: the firm disseminates information on the project via its disclosure policy. However, the firm's disclosure does not fully reflect the state of the firm's fundamentals.[6] Specifically, we assume that $r = \theta + \psi$ consists of two parts: θ is the component of fundamentals captured by corporate disclosure, and ψ is the residual information not captured by the disclosed signal. The residual part of fundamentals, ψ is normally distributed with mean zero and variance $1/\gamma$ so that θ represents the average quality of the firm's project. The value of θ can be either θ_g (for a good-quality project) with probability p or θ_b (for a bad-quality project) with probability $1 - p$, where $\theta_g > \theta_b$ and $0 < p < 1$. The public signal of θ, denoted by s, also can take two values, s_H (high signal) or s_L (low signal).[7]

The firm can choose the precision at which it will disclose a public signal. We assume that the disclosure precision is committed by the firm and becomes common knowledge to other agents.[8] That is, after choosing the disclosure precision, the firm should disclose a public signal $s \in \{s_H, s_L\}$ with that precision. If the disclosure precision is α, then the conditional probabilities of signals for different project types are as follows:

$$\Pr[s_H \mid g] = \Pr[s_L \mid b] = \frac{1+\alpha}{2},$$

where $0 \leq \alpha \leq 1$ and g (b) represents that the project is good (bad). After observing a signal, the government and investors update their beliefs about the value of θ. The posterior beliefs are given by

$$\Pr[g \mid s_H] = \frac{(1+\alpha)p}{1-\alpha+2\alpha p},$$
$$\Pr[g \mid s_L] = \frac{(1-\alpha)p}{1+\alpha-2\alpha p}.$$

The signals provide the following information about the project type: a high (low) signal leads to a higher posterior probability of the project being a good (bad) one (i.e., $\Pr[g \mid s_H] \geq p \geq \Pr[g \mid s_L]$). As α increases, $\Pr[g \mid s_H]$ increases and $\Pr[g \mid s_L]$

[6] In general, firms use various channels to report financial or non-financial information. However, firms cannot disclose all relevant information owing to a measurement issue or costs of disclosure (e.g., Healy & Palepu, 2001; Ittner & Larcker, 1998; Leuz & Wysocki, 2016). For example, although many public traded firms do not disclose customer satisfaction, Fornell, Morgeson, and Hult [2016] find that customer satisfaction has a significant effect on firms' stock returns.

[7] It should be noted that we assume the binary state of nature $\theta \in \{\theta_g, \theta_b\}$ in the model. Unlike our approach, Kamenica and Gentzkow [2011] investigate the optimal disclosure policy under multiple states of nature. They show that the results for a binary state can be applied to the case of arbitrary state spaces. As an interesting direction for future research, we would extend the current model to a case in which θ can take more than two values.

[8] As argued in Admati and Pfleiderer [2000] and Zhang [2021], altering the disclosure mechanism is costly and time consuming because firms' information systems and the internal control procedures cannot be easily adjusted in the short term. These difficulties of changing disclosure policy indicate that the firm has limited discretion to choose precision based on its private information.

decreases, implying that signals become more informative. On the one hand, when $\alpha = 0$, the signals reveal no information, and thus, the government and investors retain their prior beliefs about the project type (i.e., $\Pr[g \mid s_H] = p = \Pr[g \mid s_L]$). On the other hand, when $\alpha = 1$, the signals are perfectly informative for knowing the type of project (i.e., $\Pr[g \mid s_H] = 1$ and $\Pr[g \mid s_L] = 0$).

The firm incurs a private disclosure cost in choosing the precision α (e.g., Berger & Hann, 2007; Ellis, Fee & Thomas, 2012; Verrecchia, 1993). The cost may be the building costs of an accounting system to gather information, payment for verifying reports, or loss of competitive advantage in an industry.[9] Specifically, following Admati and Pfleiderer [2000], we assume that the cost of disclosure is $c_\alpha \alpha$, where $c_\alpha > 0$. The firm chooses the precision of the signal to maximize the expected return on its project, considering the disclosure cost.[10]

The return on the firm's investment project depends on three factors: its fundamentals (r), the amount of the government bailout (m), and the proportion of investors who withdraw investments from the firm before the return is realized (l). When there is neither a bailout nor withdrawals (i.e., $m = l = 0$), the project generates a per-unit return that equals the state of fundamentals, r. However, if investors withdraw their money, the firm's project has to be downsized or even pushed into default. In other words, early withdrawals negatively affect the return on the project, whereas the government bailout has the opposite effect by providing the firm with capital. Formally, the net return on the project equals $r + m - 2c_l l$, where $c_l > 0$ captures the cost of early withdrawals. This specification is similar to that of Morris and Shin [2001] in that a coordination problem among investors (i.e., a high l value) may result in the failure of the project (i.e., $r + m - 2c_l l \leq 0$). As the project with a higher value of c_l is more likely to fail due to a coordination failure among investors, we refer to c_l as the strategic complementarity parameter.

The government can inject capital into a firm that is likely to suffer a coordination failure. The purpose of the bailout is to minimize the social loss caused by investors' withdrawals from a fundamentally sound firm. As mentioned in Zwart [2007], we consider two principles of the government's bailout policy: First, the government provides a bailout only when it expects that the firm is fundamentally sound (i.e., $\mathbb{E}[r] > 0$), but there is a possibility that the firm itself might not be able to resolve the coordination problem (i.e., $\mathbb{E}[r - 2c_l l] \leq 0$ without the government bailout). Second, the government is concerned about its fiscal balance. Thus, it wants to provide the smallest bailout possible so that the firm's project does not fail (i.e., $\mathbb{E}[r + m - 2c_l l] > 0$). After observing the public information disclosed by the firm, the government chooses the amount of the bailout to achieve its goals.[11]

[9] Zhang [2021] shows that competition among financial institutions exposed to rollover risk may make them more opaque. Similarly, Oh and Park [2019] find that the possibilities of a new firm entering a market can create incentives for an existing firm to reduce disclosure of their product quality.

[10] It should be noted that whether the firm observes its fundamentals (i.e., r) or not does not affect the firm's disclosure policy because disclosure itself is not related to fundamentals.

[11] Alternatively, we can model the government's payoff function as in Morris and Shin [2006]: the government's objective is to minimize $2c_l l + \tau m$, where $\tau > 0$ is a cost of a bailout. This objective function captures the social loss from a coordination and the cost of a bailout. Indeed, as long as the bailout cost is sufficiently small (i.e., $0 < \tau \leq 2$), the government's behavior is the same (see Proposition 3).

The government decision is then described as followed:

$$m(s,\alpha) = \begin{cases} \inf\{m : \mathbb{E}[r + m - 2c_l l \mid s, \alpha, m] > 0\} & \text{if } 0 < \mathbb{E}[r \mid s, \alpha] \leq 2c_l \mathbb{E}[l \mid s, \alpha, m = 0], \\ 0 & \text{otherwise.} \end{cases} \tag{1}$$

Here, we assume that investors make withdrawal decisions after observing the bailout decision of the government, following the previous studies on bailouts (e.g., Morris & Shin, 2006; Wang, 2013; Zwart, 2007). As mentioned in Wang [2013], bank run indices increased after the announcement of the Troubled Asset Relief Program (TARP) in 2008. He also shows that the stock price abnormal returns of banks decrease after bailout announcements, implying that investors' withdrawals could happen after the intervention of the government. Instead, one could assume that the bailout decision is determined after investors' withdrawals. In this case, the anticipation of a bailout eliminates the incentive for investors to withdraw investments as in Allen, Carletti, Goldstein, and Leonello [2018]. However, because our modeling choice is to highlight the government's capital injection to prevent coordination failures among investors, we focus on investment withdrawals after a bailout announcement.

Specifically, following Morris and Shin [2001], there are two periods in this withdrawal game: period 1 (interim stage) and period 2 (maturity). In period 1, investors have an opportunity to review their investments. Hence, in this period, each investor has to decide whether to withdraw his or her investments. If an investor keeps his or her investments until period 2, then he or she earns a return on the project. However, an investor who withdraws the investments in period 1 receives full repayment of his or her investments.[12] The payoffs to an investor are summarized in the following table:

	Stay	Withdraw
Payoff	$1 + r + m - 2c_l l$	1

To derive the equilibrium of the government's bailout policy and the firm's disclosure policy, we should first characterize investors' withdrawal decisions. However, as noted by Obstfeld [1996], multiple equilibrium outcomes may arise when investors know the value of the part of the fundamentals not included in the corporate disclosure (i.e., ψ). Given the value of s and m, the investors' optimal strategy is as follows. If $\psi > 2c_l - \mathbb{E}[\theta \mid s] - m$, then all investors stay regardless of other investors' decisions, because the project would yield a positive return on average even if all other investors were to recall their investments. Conversely, if $\psi \leq -\mathbb{E}[\theta \mid s] - m$, then it is optimal for investors to withdraw investments, because the project has a non-positive expected return even if all other investors did not withdraw. When $\psi \in (-\mathbb{E}[\theta \mid s] - m, 2c_l - \mathbb{E}[\theta \mid s] - m]$, a coordination problem arises among investors. In other words, the equilibrium outcomes are driven solely by investors' beliefs about the decisions of other investors: if all other investors stay, then the project succeeds, and thus, staying is optimal; on the other hand, if

[12] A vast literature has emphasized that banking firms are vulnerable to such early withdrawals (e.g., Acharya, Gale & Yorulmazer, 2011; Acharya, Schnabl & Suarez, 2013; Bouvard, Chaigneau & Motta, 2015; Gorton & Metrick, 2012). Thus, the assumption of investment withdrawals is especially suitable for banking firms. Nevertheless, we believe that our analysis also applies to non-banking firms because they are often exposed to rollover risk (e.g., Goldstein & Huang, 2020; Lee & Oh, 2021b; Morris & Shin, 2004; Oh & Park, 2022).

all other investors recall investments, then the project fails, and thus, early withdrawal is optimal. Therefore, investors' common knowledge of ψ leads to multiple equilibrium outcomes.

We resolve this multiplicity of equilibria by applying a global game method in which ψ is not common knowledge. Instead, before investors decide whether to withdraw investments, each investor privately receives imperfect information on ψ. Specifically, each investor i receives a noisy private signal: $x_i = \psi + \epsilon_i$, where ϵ_i is normally distributed with mean 0 and variance $1/\beta$. The noise terms $\{\epsilon_i\}$ are independent of each other.

The global game method allows us to obtain a unique equilibrium for the rollover game played among investors. Moreover, previous studies on global games point out that uniqueness carries over to a limiting case as long as investors' private information is precise enough. Because our main interest is not investors' withdrawals but the interactions between a bailout and disclosure, we take the limit as the precision of ψ (i.e., γ) goes to infinity but the precision of ϵ_i (i.e., β) keeps the pace face enough to ensure uniqueness, satisfying $\gamma^2/\beta \to 0$. The limiting case keeps our analysis tractable to investigate the effects of the bailout on disclosure. Therefore, throughout the paper, we focus on the limiting case when analyzing investors' withdrawals.

A *strategy* for investors is a decision rule that maps each realization of $\{x_i, s, m, \alpha\}$ to an action, that is, withdrawing investments or not. Similarly, a strategy for the government is a decision rule that maps each realization of $\{s, \alpha\}$ to an amount of the bailout m; a strategy for the firm is a decision rule to choose a disclosure precision α. An *equilibrium* consists of (1) the firm's optimal disclosure precision (α^*); (2) the government's optimal bailout ($m^*(s, \alpha^*)$); and (3) the investors' switching private signal ($x^*_{ij}(m, \alpha^*)$, where $j = H$ if $s = s_H$ and $j = L$ if $s = s_L$), satisfying the following conditions:

1. Based on (1) the amount of the bailout m; (2) the disclosed public signal $s = s_j$ with precision α; (3) the private signal x_{ij}, every investor i who observes a signal x_{ij} below $x^*_{ij}(m, \alpha)$ withdraws investments;[13]

2. Based on the disclosed public signal $s = s_j$ with precision α, the government chooses the amount of bailout $m^*(s_j, \alpha)$ to satisfy Equation (1);

3. Given the investors' switching signal $x^*_{ij}(m, \alpha)$ and the amount of the bailout $m^*(s_j, \alpha)$, the firm chooses the disclosure precision α^* to maximize $\mathbb{E}[r - 2c_l l(x^*_{ij}(m^*(s_j, \alpha), \alpha)) + m^*(s_j, \alpha)] - c_\alpha \alpha$.

3. SOLVING THE MODEL

In this section, we first analyze a benchmark case in which the government commits never to bail out the firm. This model allows us to focus on the effects of disclosure on coordination among investors and the trade-off relationship between the benefits of reducing withdrawals and costs of disclosure. We then examine how the anticipation of a bailout affects the firm's disclosure behavior. The analysis highlights conditions under which the government bailout alters the precision of information disclosed by the firm.

[13] The global game literature shows that this type of strategy survives the iterated deletion of dominated strategies only under the uniqueness condition (e.g., Morris & Shin, 2003; Oh & Baek, 2015; Vives, 2005). Thus, we confine our attention to switching strategies.

3.1. Baseline: Equilibrium without Bailout

When there is no government bailout, an equilibrium means (1) *the firm's optimal disclosure precision* (α^*_{NB}), which maximizes the firm's payoff, and (2) *the investors' switching private signals* (x^*_{ij}, where $j = H$ or $j = L$), below which they withdraw investments. The model is solved by backward induction. Specifically, we first characterize the investors' withdrawals given the public signal and its precision. Using the equilibrium values for the investors' withdrawal game in the limit case (i.e., $\gamma \to \infty$, $\beta \to \infty$, and $\gamma^2/\beta \to 0$), we calculate the optimal precision for the firm.

3.1.1. Investors' withdrawal decision

After obtaining the public signal and private signals in period 1 (i.e., s_j and x_i), each investor has to decide whether to withdraw their investments or not. At $x_i = x^*_{ij}$, the investor is indifferent between these two options, which implies that the expected payoff from staying equals the payoff from withdrawing:

$$\underbrace{0}_{\text{Payoff from withdrawing}} = \underbrace{\mathbb{E}\left[r - 2c_l l \,|\, x_i = x^*_{ij},\, s_j,\, \alpha\right]}_{\text{Payoff from staying}}. \tag{2}$$

Under the uniqueness condition in which the precision of the private signal is large enough relative to the underlying uncertainty on the project (i.e., $\frac{\gamma^2(\gamma+\beta)}{\beta(\gamma+2\beta)} < \frac{\pi}{2c_l^2}$), we obtain unique equilibrium values x^*_{ij} by using the following indifference condition:

PROPOSITION 1. *Provided that $\lambda := \frac{\gamma^2(\beta+\gamma)}{\beta(2\beta+\gamma)} < \frac{\pi}{2c_l^2}$, a unique equilibrium exists for the rollover game played among investors (i.e., x^*_{ij}). The unique equilibrium value is determined by*

$$\mu_j + \frac{\beta x^*_{ij}}{\beta+\gamma} - 2c_l\Phi\left[\frac{\sqrt{\lambda}\beta x^*_{ij}}{\beta+\gamma}\right] = 0, \tag{3}$$

where $\mu_j = \Pr[g \,|\, s_j]\theta_g + \Pr[b \,|\, s_j]\theta_b$ is the conditional expectation of θ given the public signal s_j and the disclosure precision α, and $\Phi(\cdot)$ is the cumulative distribution function of the standard normal distribution.

Indeed, Proposition 1 guarantees the existence and uniqueness of the equilibrium for rollover game played among investors. However, because the investors' switching private signals (i.e., x^*_{ij}) are implicitly determined by Equation (3), it is difficult to analyze the firm's disclosure decision with Proposition 1 itself. Instead, as mentioned earlier, we examine the following limiting case to keep our analysis tractable:

COROLLARY 1. *In the limit in which underlying uncertainty on the project becomes very small and the private signal becomes very precise (i.e., $\beta \to \infty$, $\gamma \to \infty$, and $\lambda \to 0$), every investor withdraws investments if and only if the expected profitability of the project is less than the strategic complementarity parameter (i.e., $\mu_j < c_l$).*

This corollary implies that the proportion of withdrawals is determined by the expected profitability (i.e., μ_j) and the strategic complementarity parameter (i.e.,

c_l). In other words, investors are more likely to recall their investments when the expected value of the firm's fundamentals is not high enough to endure the strategic uncertainty about other investors' decisions. Note that if there is only one investor in the firm (i.e., no strategic uncertainty), then the withdrawal decision is socially optimal, that is, the investor chooses to withdraw from the firm if and only if $\mu_j \leq 0$. Therefore, firms with $\mu_j \in (0, c_l)$ suffer large withdrawals simply because investors believe that the project is going to fail.

3.1.2. Firm's disclosure decision

When investors decide whether to withdraw investments from the firm, they should consider all available information, including both public and private signals about the firm's fundamentals (i.e., x_i and s_j). Moreover, the informativeness of the signal is determined by the disclosure precision chosen by the firm (i.e., α). Hence, although the disclosed signal is the same, the outcome of the project is different depending on the firm's disclosure. Based on the investors' equilibrium given by Equation (3), the expected payoff to the firm is as follows:

$$\begin{aligned}
\Pi_{NB}(\alpha) :&= \mathbb{E}\left[r - 2c_l l \mid \alpha\right] - c_\alpha \alpha \\
&= \mu - 2c_l \cdot \left\{ \begin{array}{l} l_H(\alpha) \cdot [\Pr(g)\Pr(s_H \mid g) + \Pr(b)\Pr(s_H \mid b)] \\ +l_L(\alpha) \cdot [\Pr(g)\Pr(s_L \mid g) + \Pr(b)\Pr(s_L \mid b)] \end{array} \right\} - c_\alpha \alpha \\
&= \mu - c_l \cdot [(1 - \alpha + 2\alpha p) l_H(\alpha) + (1 + \alpha - 2\alpha p) l_L(\alpha)] - c_\alpha \alpha,
\end{aligned} \tag{4}$$

where $\mu = p\theta_g + (1-p)\theta_b$ is the unconditional mean of θ and $l_H(\alpha)$ ($l_L(\alpha)$) is the proportion of withdrawals if the disclosed signal is s_H (s_L). The firm chooses α to maximize $\Pi^*_{NB}(\alpha)$, and thus, the optimal disclosure precision α^*_{NB} is given by

$$\alpha^*_{NB} = \arg\max_{\alpha \in [0,1]} \Pi_{NB}(\alpha).$$

Here, to focus on more interesting cases, we assume the following:

$$0 < \theta_b < c_l < \frac{\theta_g + \theta_b}{2} < \theta_g.$$

Assumption $0 < \theta_b$ implies that early withdrawals are always inefficient, that is, the net expected return of the project is greater than zero in the absence of the coordination problem among investors.[14] We also assume that if investors perfectly know the type of project, then a firm with a bad project faces early withdrawals ($\theta_b < c_l$), whereas a firm with a good project does not ($c_l < \theta_g$). Furthermore, when the expected profitability is low ($\mu < c_l$), investors believe that the project is more likely to be bad than good ($c_l < (\theta_g + \theta_b)/2$).[15] These assumptions make the proportion of investors withdrawing investments critically dependent on the disclosure precision.

[14] Alternatively, the assumption $\theta_b < 0$ indicates that the firm with a bad project is not fundamentally sound. In this case, the government is less likely to bail out a firm whose signal is of a low type. This, in turn, implies that the firm tends to reduce the disclosure precision when investors have optimistic beliefs about the firm (see Proposition 4). It requires us to analyze more cases in Proposition 4, but does not change our results qualitatively.

[15] This assumption simplifies the case for the firm's optimal disclosure precision without bailout (see Proposition 2). However, our results are qualitatively the same even if we assume $c_l \geq (\theta_g + \theta_b)/2$: the firm chooses the precision that minimizes withdrawals as long as the cost of disclosure is not too high.

We now discuss the graph of $\Pi_{NB}(\alpha)$ under this assumption. It depends on l_H and l_L, that is, the response of investors to the firm's disclosure. By Corollary 1, the proportion of withdrawals equals one if the expected profitability of the project is less than the cost of withdrawals (i.e., $\mu_j < c_l$) and zero otherwise. Thus, we need to examine how μ_j changes in α. We consider two cases: $\mu \geq c_l$ and $\mu < c_l$.

If $\mu \geq c_l$, then the expected profitability conditional on the high signal exceeds c_l regardless of the value of α as the high signal conveys positive information on the project (i.e., $\mu_H \geq \mu \geq c_l$). Meanwhile, if the disclosed signal is of a low type, then the conditional mean of θ is below the unconditional mean (i.e., $\mu_L \leq \mu$). This conditional mean further decreases with the precision of the signal; specifically, if the low signal perfectly reveals the value of θ, then all investors withdraw investments (i.e., $\mu_L = \theta_b < c_l$). As a result, if $\mu \geq c_l$, then the firm makes no effort to improve the disclosure precision, because this effort only increases the proportion of withdrawals.

Meanwhile, if $\mu < c_l$, then the firm choosing $\alpha = 0$ certainly faces large withdrawals. The firm has an incentive to increase the precision of the signal in this case. In particular, on the one hand, when the signal is perfectly informative, investors keep their investments if the disclosed signal is of a high type (i.e., $\mu_H = \theta_g > c_l$). On the other hand, a low signal does not increase withdrawals regardless of α, because the expected profitability of the project is already bad (i.e., $\mu_L \leq \mu < c_l$). Thus, it is optimal for the firm to improve the disclosure precision until investors observing the high signal no longer withdraw. However, the effort to enhance the precision of the signal is costly, and therefore, the firm determines the optimal precision α^* by trading off the benefit of reducing withdrawals against the disclosure cost. These arguments are summarized in the following proposition:

Proposition 2. *Let p_g^{NB} and p_b^{NB} be the investors' prior beliefs about the firm's project such that*

$$\mu(p_g^{NB}) := p_g^{NB}\theta_g + \left(1 - p_g^{NB}\right)\theta_b = c_l$$

and

$$\alpha_H = \frac{1}{1 - 2p_b^{NB} + c_\alpha/c_l} \text{ for } \alpha_H \text{ satisfying } \mu_H(\alpha_H) := \Pr\left[g|s_H, \alpha_H\right]\theta_g + \Pr\left[b|s_H, \alpha_H\right]\theta_b = c_l.$$

Then, the optimal disclosure precision without bailout, α_{NB}^* is

$$\alpha_{NB}^* = \begin{cases} 0 & \text{if } p \geq p_g^{NB}; \\ \alpha_H & \text{if } p_b^{NB} \leq p < p_g^{NB}; \\ 0 & \text{if } p < p_b^{NB}. \end{cases} \tag{5}$$

FIG. 2 illustrates the optimal precision as a function of the prior beliefs about the firm's project, p, assuming $c_l = 1$, $c_\alpha = 0.3$, $\theta_g = 2$, and $\theta_b = 0.1$. First, when p is very low (i.e., $p < p_b^{NB}$), the optimal precision is zero. In this case, the firm should disclose a sufficiently precise signal to restore investors' confidence in the project (i.e., $\alpha \geq \alpha_H$) because they believe that there is a high probability of the project being bad (i.e., $\mu < c_l$). The cost of such disclosure is greater than the benefit of reducing withdrawals, and thus, the firm chooses not to disclose, that is, $\alpha_{NB}^* = 0$. Second, when p lies in an intermediate range (i.e., $p_b^{NB} \leq p < p_g^{NB}$), the optimal precision jumps discontinuously and decreases linearly. The firm discloses the public

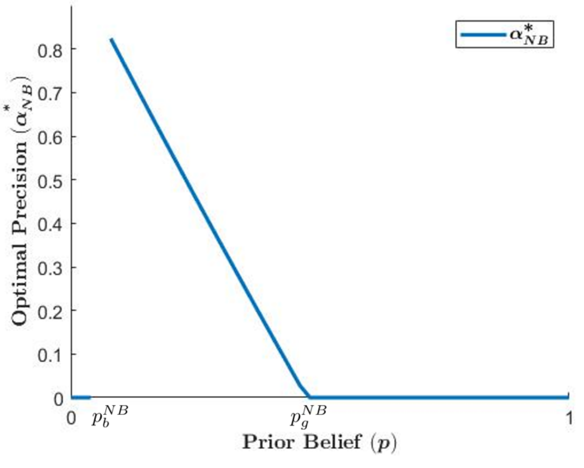

FIG. 2 α^*_{NB} as a Function of p ($c_l = 1$, $c_\alpha = 0.3$, $\theta_g = 2$, and $\theta_b = 0.1$)

signal with precision α_H, because the benefit from preventing withdrawals is now greater than the disclosure cost. The optimal precision α_H is decreasing in p as a large p implies that investors have more optimistic beliefs about the project. Finally, when p is very large so that $p \geq p_g^{NB}$, the optimal precision remains zero. Intuitively, although the firm does not disclose any information, all investors keep their investments owing to their optimistic beliefs about the firm (i.e., $\mu \geq c_l$). Thus, it is optimal for the firm not to undertake a costly effort to improve precision. This disclosure behavior described in FIG. 2 is consistent with prior literature on disclosure such as Bannier and Heinemann [2005] and Quigley and Walther [2020].[16]

3.2. Equilibrium with Bailout

In this subsection, we analyze the influence of a government bailout on corporate disclosure described in Proposition 2. The model is also solved by backward induction. In other words, we first obtain the switching private signals conditional on the government bailout and the public signal. Next, we characterize the government's bailout policy using the equilibrium values for investors in the limit case characterized by Corollary 1. The firm's disclosure decision is then determined by the bailout amount and the proportion of withdrawals.

3.2.1. Government's bailout decision

The withdrawal game among investors is very similar to that discussed in Subsection 3.1.1. The only difference is that after the government provides capital m to the firm, the state of the firm's fundamentals becomes $r + m$. By substituting this into Corollary 1, we obtain the following corollary:

Corollary 2. *After observing the amount of the bailout, every investor withdraws investments if and only if the sum of expected profitability of the project*

[16] Regarding an empirical evidence, Bergman and Roychowdhury [2008] report that firms' managers increase long-term earnings forecasts during low-sentiment periods, while they reduce these forecasts during high-sentiment periods.

and the bailout amount is less than the strategic complementarity parameter (i.e., $\mu_j + m < c_l$).

Given the investors' withdrawals conditional on the bailout amount, the government can decide its optimal bailout policy. Recall that the government has the following objectives: (1) to bail out a firm that is expected to be fundamentally sound (i.e., $\mathbb{E}[r \mid s, \alpha] > 0$); (2) to bail out a firm that is expected to suffer withdrawals without additional capital (i.e., $\mathbb{E}[r - 2c_l l \leq 0 \mid s, \alpha, m = 0]$); and (3) to provide the smallest amount of capital that leads to a positive expected return on the project. Then, the government's optimal bailout amount is as follows:

PROPOSITION 3. *The optimal amount of bailout given the public signal is*

$$m^* = \begin{cases} 0 & \text{if } \mu_j \geq c_l, \\ c_l - \mu_j & \text{if } \mu_j \in (0, c_l). \end{cases} \tag{6}$$

The intuition of the government's optimal bailout policy given by Equation (6) is similar to that of Morris and Shin [2006]. Based on the disclosed information about the firm, the government provides a bailout whenever a coordination problem among investors leads to the failure of the project yet the state of the firm's fundamentals is sound. The amount of bailout is just enough to ensure that the additional capital is sufficient to prevent inefficient withdrawals, that is, $m^* = c_l - \mu_j$. Finally, note that the expected return on the project with $\mu_j \in (0, c_l)$ increases to $\mu_j + m^* - 2c_l l = c_l$. Hence, the government bailout provides insurance against the risk of disclosing bad news (i.e., $\mu_L < c_l$).

3.2.2. Firm's disclosure decision

With the anticipation of a bailout, the firm's payoff differs from Equation (4) in two respects: First, the state of the firm's fundamentals now becomes $r + m^*$ instead of r. Because the amount of the bailout is a function of μ_j, the firm should consider this fact when setting its disclosure policy. Second, the proportion of investors who withdraw their investments is always zero regardless of the disclosed signal owing to assumption $0 < \theta_b$ and the government's bailout policy. In other words, the government always provides capital for firms that are expected to face large withdrawals, because all firms are fundamentally sound. In summary, the firm's expected payoff is

$$\Pi_B(\alpha) := \mathbb{E}\left[r + m^* - 2c_l l \mid \alpha\right] - c_\alpha \alpha = \mu + \mathbb{E}[m^* \mid \alpha] - c_\alpha \alpha. \tag{7}$$

Similar to Subsection 3.1.2, we analyze Equation (7) by separating two cases, $\mu \geq c_l$ and $\mu < c_l$. Consider the case in which $\mu \geq c_l$ first. In this case, the firm may have an incentive to disclose precise information, which is in contrast to the situation in which the government commits never to bail it out. Although a precise low signal leads investors to lower their expectation for the firm's fundamentals, the government eliminates the possibility of withdrawals by injecting capital into the firm. Hence, the return on the firm's project increases by the amount of the bailout after disclosing the bad news. The firm determines its optimal precision by trading off this benefit and the cost of disclosure. On the contrary, when $\mu < c_l$, a precise high signal reduces the bailout amount because it implies that the state of the firm's fundamentals is not as bad as expected. Thus, the optimal precision can be either too high or too low compared to the case without a bailout. The following proposition summarizes these arguments:

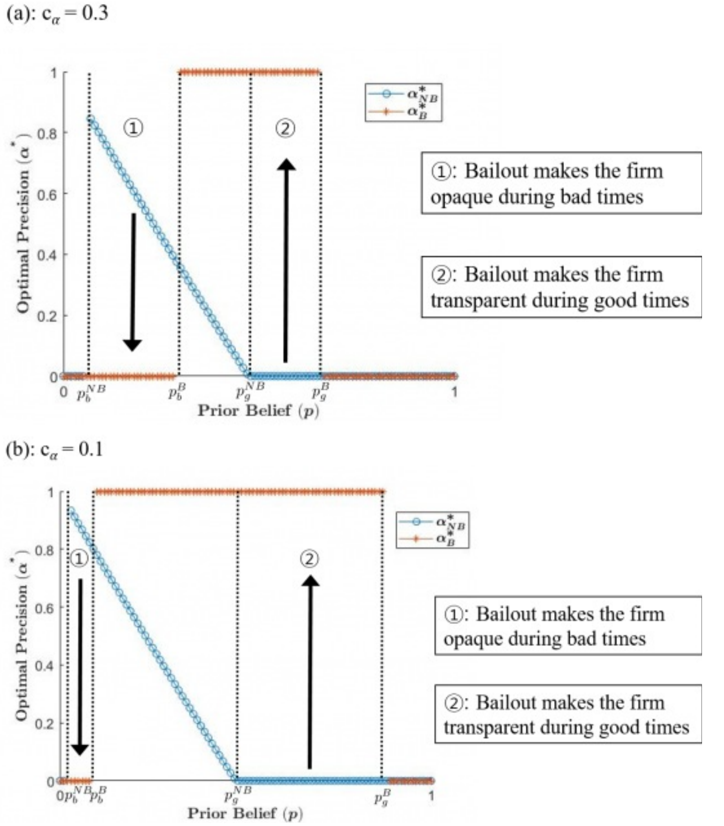

FIG. 3 α^*_{NB} and α^*_B as a Function of p ($c_l = 1$, $\theta_g = 2$, and $\theta_b = 0.1$)

PROPOSITION 4. *Let*

$$p_g^B := 1 - \frac{c_\alpha}{c_l - \theta_b} \text{ and } p_b^B := \frac{c_\alpha}{\theta_g - c_l}.$$

Then, the optimal disclosure precision with bailout α^*_B *is*

$$\alpha^*_B = \begin{cases} 0 & \text{if } p \geq p_g^{NB} \text{ and } p > p_g^B; \\ 1 & \text{if } p \geq p_g^{NB} \text{ and } p \leq p_g^B; \\ 1 & \text{if } p < p_g^{NB} \text{ and } p \geq p_b^B; \\ 0 & \text{if } p < p_g^{NB} \text{ and } p < p_b^B. \end{cases} \tag{8}$$

FIG. 3(a) shows the optimal precisions α^*_{NB} and α^*_B as a function of p assuming $c_l = 1$, $c_\alpha = 0.3$, $\theta_g = 2$, and $\theta_b = 0.1$. There are two noteworthy ranges of p: First, when the prior belief is pessimistic (i.e., $p < p_g^{NB}$), the firm should disclose precise information to improve the investors' beliefs (i.e., $\alpha \geq \alpha_H$). However, when $p_b^{NB} \leq p < p_b^B$, no information is disclosed if the firm anticipates a bailout (i.e., $\alpha^*_B = 0$). In other words, the government bailout makes the firm opaque. The imprecise information does not improve expectations about the firm's fundamentals, and thus, the firm needs a bailout to prevent investors from withdrawing investments. This bailout effect on disclosure decreases when the cost of disclosure (i.e., c_α)

becomes smaller because the firm can raise the disclosure precision at a lower cost (see FIG. 3(b)). Second, when p lies in the range $p_g^{NB} \leq p \leq p_g^B$, the firm that anticipates a bailout fully discloses its information. For this range, the firm chooses high precision to ensure that it receives a bailout when a bad signal is disclosed, even though investors' prior belief is that the fundamentals are relatively good (i.e., $p \geq p_g^{NB}$ or $\mu \geq c_l$). If the firm discloses a precise low signal, then investors lower their expectation for the firm, which would lead to investment withdrawals without a bailout. Thus, the highest precision has the potential to trigger coordination failure, as addressed in many studies on transparency (e.g., Banerjee & Maier, 2016; Bouvard, Chaigneau & Motta, 2015; Liang & Zhang, 2018).[17]

Overall, a firm that anticipates a bailout seeks to receive it by choosing a level of precision that increases the probability of conveying bad information about the firm's fundamentals.[18] Indeed, several empirical evidence supports our prediction. Flannery, Kwan, and Nimalendran [2013] show that historically, banking firms are more opaque than non-banking firms during crisis periods, but not during normal periods. Moreover, the 2008 amendment to the International Accounting Standard (IAS) 39 provides empirical evidence of the applicability of the results of this proposition. During the 2008 financial crisis, the European Commission pressed the International Accounting Standard Board (IASB) to suspend or weaken fair value accounting of financial assets.[19] As a result, the IASB amended IAS 39 to weaken the fair value requirements on October 13, 2008. This amendment allows banks to reclassify their financial assets into categories that require less fair value accounting. On the same day, European governments announced a €2 trillion bailout plan for banks. The weakened fair value requirement and the bailout plan indicate that banks had more discretion to choose a level of precision and anticipation of a bailout, which is consistent with the proposed model's assumptions. Indeed, according to Acharya and Ryan [2016], large banks exploited this amendment and received a sizeable bailout. However, many studies suggest that relaxing the fair value requirements led to less timely disclosure of banks' fundamentals, and consequently, could not restore investors' confidence (e.g., Badertscher, Burks & Easton, 2011; Ball, 2008; Laux & Leuz, 2010). This disclosure behavior of large banks is in line with the result of our model.

4. GOVERNMENT BAILOUT EFFECTS

In the previous section, we assume that the government always bails out the firm that discloses a low signal about the expected return on the firm's project. As a result, the probability that investors withdraw their investments from the firm is always zero. In reality, however, the government cannot rescue all firms in trouble, as bailouts are funded through taxation or sovereign bonds. Both are costly to the government in that they may lead to a deadweight loss or an increase

[17] It should be noted that, as FIG. 3(b) illustrates, the range of this region increases when the disclosure cost decreases.

[18] Of course, if the government commits to its bailout based on the firm's disclosure policy, then the firm will choose an optimal disclosure precision to minimize withdrawals. For example, if the government commits to bail out only the firm disclosing accurate information in bad times but withholding information in good times (i.e., $\alpha = \alpha_H$ if $\mu < c_l$ and $\alpha = 0$ if $\mu \geq c_l$), then the firm will choose the optimal precision to minimize withdrawals.

[19] Fair value accounting has been blamed for exacerbating the crisis by injecting excessive volatility into the price of financial assets. Specifically, Plantin, Sapra, and Shin [2008] present a model in which fair value accounting can trigger fire sales and illiquidity of these assets.

of sovereign credit risk (e.g., Acharya, Drechsler & Schnabl, 2014; Faria-e-Castro, Martinez & Philippon, 2017; König, Anand & Heinemann, 2014; Leonello, 2018). In this regard, following Cordella, Dell'Ariccia, and Marquez [2018], we now examine the probability of the firm experiencing large withdrawals under the assumption that the government bails out the firm with probability $q \in (0, 1)$ if a bad signal is disclosed.[20] That is, the government provides no capital for the firm when it anticipates that there will be no investment withdrawals without a bailout (i.e., $\mu_j \geq c_l$). The bailout is implemented with probability q only when the firm is expected to suffer large withdrawals without the government's intervention (i.e., $m = c_l - \mu_j$ with probability q given that $\mu_j < c_l$). Then, we are interested in the difference in the expected value of withdrawals with a bailout and without a bailout (i.e., bailout effect):

$$\mathbf{BE} := \mathbb{E}\left[l \mid \alpha_B^*(q), q\right] - \mathbb{E}\left[l \mid \alpha_{NB}^*\right], \tag{9}$$

where α_{NB}^* is the optimal precision defined by Equation (5), and $\alpha_B^*(q)$ is the optimal precision conditional on the probability of a bailout (i.e., q). Here, $\mathbf{BE} > 0$ ($\mathbf{BE} < 0$) implies that the government bailout has a negative (positive) effect on the proportion of investors who keep their investments, respectively.

An increase in the probability of a bailout has two opposite effects on the expected value of withdrawals. Intuitively, the higher the probability that the government will provide capital for the firm, the lesser the proportion of investors withdrawing investments because the additional capital improves the firm's fundamentals. On the contrary, as discussed in Subsection 3.2.2, the anticipation of a bailout creates an incentive for the firm to rely on the bailout rather than to choose a precision that minimizes withdrawals. As a result, these two effects of the bailout determine the sign of **BE**. The first effect dominates the second effect in general, and hence, the existence of a bailout reduces the expected value of withdrawals. However, there are cases in which the second effect dominates the first effect; that is, the presence of a bailout *increases* the probability that investors withdraw their investments from the firm.

PROPOSITION 5. *When the government bails out the firm with probability q, the expected values of withdrawals without a bailout and with a bailout are*

$$\mathbb{E}[l \mid \alpha_{NB}^*] = \begin{cases} 0 & \textit{if } \mu \geq c_l; \\ \frac{1}{2}(1 + \alpha_H - 2\alpha_H p) & \textit{if } \mu < c_l \textit{ and } \alpha_{NB}^* = \alpha_H; \\ 1 & \textit{if } \mu < c_l \textit{ and } \alpha_{NB}^* = 0, \end{cases} \tag{10}$$

[20] Although we do not explicitly model the decision problem of the government, the bailout probability q captures the assumption that the government implements a bailout plan only when the social loss of firms' crises is expected to be large. For example, Corona, Nan, and Zhang [2019] microfound the government's bailout decision. In their model, the government bails out firms only when the proportion of firms facing crises is large enough so that firm failures have significant negative effects on the economy. Under this bailout rule, each firm faces uncertainty about whether it obtains a capital injection from the government because the firm cannot fully know how many other firms will suffer crises. Similarly, if the social loss of the firm's crisis is uncertain, then the firm expects that the government provides capital with a probability.

and

$$\mathbb{E}[l \mid \alpha_B^*(q), q] = \begin{cases} 0 & \textit{if } \mu \geq c_l \textit{ and } \alpha_B^*(q) = 0; \\ (1-p)(1-q) & \textit{if } \mu \geq c_l \textit{ and } \alpha_B^*(q) = 1; \\ \frac{1}{2}(1+\alpha_H - 2\alpha_H p)(1-q) & \textit{if } \mu < c_l \textit{ and } \alpha_B^*(q) = \alpha_H; \\ (1-p)(1-q) & \textit{if } \mu < c_l \textit{ and } \alpha_B^*(q) = 1; \\ (1-q) & \textit{if } \mu < c_l \textit{ and } \alpha_B^*(q) = 0, \end{cases} \tag{11}$$

respectively. Therefore, the anticipation of a government bailout can increase the ex-ante probability that investors withdraw investments (i.e., $\mathbf{BE} > 0$*) when the firm becomes opaque in bad times (i.e.,* $\alpha_B^*(q) < \alpha_{NB}^*$ *and* $\mu < c_l$*) or becomes transparent in good times (i.e.,* $\alpha_B^*(q) > \alpha_{NB}^*$ *and* $\mu \geq c_l$*).*

The intuition behind this proposition is based on the changes in the firm's disclosure behavior. As noted in Subsection 3.2.2, there are two possibilities by which the optimal precision with a bailout increases the expected value of withdrawals: (1) being opaque in bad times (i.e., $\alpha_B^* = 0 < \alpha_{NB}^*$ when $\mu < c_l$) (see FIG. 4(a)); and (2) being transparent in good times (i.e., $\alpha_B^* = 1 > \alpha_{NB}^* = 0$ when $\mu \geq c_l$) (see FIG. 4(b)).

FIG. 4(a) shows that **BE** is positive when investors have relatively pessimistic prior beliefs about the firm (i.e., p is low). For this range of prior beliefs, the firm should make a considerable effort to increase its precision to restore investors' confidence in the firm's project. However, a low signal may be disclosed even though the firm chooses high precision, which implies that the firm does not obtain any compensation for costs related to the disclosure in this case. This possibility of disclosing a low signal becomes a risk to the firm in improving its disclosure precision. Because we assume that the government cannot always rescue the firm, the anticipation of a bailout does not perfectly eliminate the risk. By contrast, because deciding to disclose nothing is costless in our model, it is optimal for the firm to become opaque in expectation of a bailout rather than to take such a risk. In other words, the government bailout and the cost of disclosure make the firm risk averse in choosing a precision to reduce withdrawals. This results in an increase of expected withdrawals in FIG. 4(a).

Meanwhile, FIG. 4(b) illustrates the bailout effect assuming c_α is low but q is high. We observe that **BE** is positive when investors have relatively optimistic prior beliefs about the firm (i.e., p is high). As discussed in Subsection 3.2.2, the firm chooses the highest disclosure precision for this range of p, although the firm should not disclose information to minimize the proportion of withdrawals. This disclosure policy is a risky strategy for the firm, because disclosing a precise low signal may lead to large withdrawals. However, if the cost of disclosure is low, then the possibility of a bailout reduces the risk of announcing bad information, and thus, the firm seeks to receive a bailout even choosing a level of precision that does not improve the investors' beliefs about the firm. An increase in the expected value of withdrawals results from this disclosure policy.

The results of Proposition 5 provide a better understanding of the effects of the government bailout on corporate disclosure, and in turn, on the stability of the financial system. Specifically, our results are closely related to the disclosure behavior of banking firms during financial crisis periods. It has long been argued that banking firms are often exposed to the sudden withdrawals of capital, as their assets are typically financed by short-term instruments (e.g., Acharya, Schnabl &

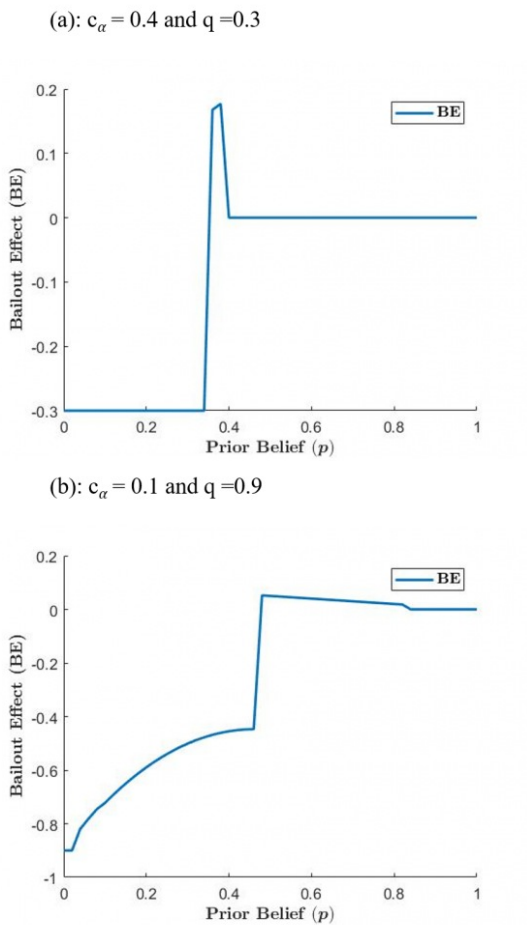

FIG. 4 BE as a Function of p ($c_l = 1$, $\theta_g = 2$, and $\theta_b = 0.1$)

Suarez, 2013; Gorton & Metrick, 2012). If a large group of investors withdraws investments from a firm solely based on fear that the firm's project will fail, then the firm might face a liquidity crisis. Among various causes of liquidity crises due to this coordination failure, bank opacity has been emphasized in the banking literature as the primary cause. In other words, the lack of transparency on a firm's fundamentals leads investors to lose confidence in the firm, and thereby, exposes the entire financial system to bank runs, contagion, and other strains of systemic risk (e.g., Morgan, 2002). In this regard, our analysis suggests the anticipation of a bailout as a factor of bank opacity: When firms expect bailouts, they might become too opaque if investors have pessimistic beliefs about the firm.

5. EMPIRICAL IMPLICATIONS AND EXTENSIONS

In this section, we discuss empirical implications and extensions of our model. We start out with discussions on the firm's and government's disclosure policy. We then relate our analysis to other approaches, namely assumptions on the firm's disclosure policy and the government's bailout policy.

The main prediction of our analysis is the association between investors' beliefs about the firm and the firm's disclosure precision. For example, if investors' sentiment is pessimistic about the firm, the firm's disclosure quality is lower when it anticipates a bailout (e.g., Bergman & Roychowdhury, 2008; Hribar & McInnis, 2012; Reeb & Zhao, 2013). Another implication is that such disclosure behavior of the firm worsens investor coordination. That is, the withdrawal of investments could increase after the firm announces information about its fundamentals. Further, these two hypotheses are more significant when the firm is more exposed to the risk of investors' withdrawals (e.g., in banking industries) or the government is more likely to implement a bailout policy (e.g., during financial crises).

Our analysis also has an implication for the government's disclosure policy. In practice, the government acts not only as lenders of last resort but also as providers of information about the firms. For example, after the 2008 financial crisis, many governments periodically performed stress tests on large banking firms and disclosed their results. The public disclosure of stress test results is controversial, however, because highly precise public information does not always produce favorable outcomes (i.e., a reduction in the possibility of a liquidity crisis for a firm). Our findings show that such disclosure is desirable only when the firm's fundamentals are expected to be weak ex ante. In other words, the government should disclose information about the firm during bad times (i.e., investors' pessimistic beliefs about the firm), because firms that anticipate a bailout might not provide sufficient information.[21] By contrast, during good times (i.e., investors' optimistic beliefs about the firm), disclosing additional information is not desirable, because it may lead investors to lower expectations about the firm. This argument is in line with the conclusions of Bouvard, Chaigneau, and Motta [2015] and Goldstein and Leitner [2018], albeit based on a different perspective.

Next, in the remainder of this section, let us discuss several extensions of our proposed model. The first issue is the assumption of the government's bailout policy. Specifically, in the model, the government bails out a firm that is likely

[21] As discussed in Proposition 1, the optimal precisions to minimize withdrawals are α_H when $\mu < c_l$ and 0 otherwise. Thus, if the government expects that the firm will not disclose any information despite investors' pessimistic beliefs (i.e., $\mu < c_l$ but $\alpha^*_B(q) = 0$), it could reduce the expected withdrawals and bailout injection by disclosing a public signal with precision α_H.

to suffer a liquidity crisis, regardless of the firm's disclosure decision. Instead, an appropriate requirement of corporate disclosure can mitigate the adverse effects of a bailout. For example, if the government commits to bail out only firms disclosing accurate information in bad times but withholding information in good times, then firms will choose the optimal precision to minimize withdrawals. This indicates that the commitment power of the government is important to determine the firm's disclosure behavior.

Second, in the proposed model, we have taken bailout as simple transfers to a firm's investors. The project's net return increases with the bailout amount because we define bailout as simple transfers to the firm. In practice, bailout often takes different forms such as credit line or equity injection like the Troubled Asset Relief Program (TARP) in 2008. We could incorporate this possibility with different functions of the net return on the project. In this case, the decreased benefits from the bailout weaken our results for good times but not for bad times. In good times, the firm does not have an incentive to increase disclosure precision because it does not directly benefit from the bailout itself. In contrast, the firm is still opaque in bad times because it can avoid large withdrawals by receiving a bailout. As long as the cost of disclosure to restore investors' confidence is greater than that of the bailout, the firm chooses not to disclose any information and anticipates government intervention.[22]

Third, we assume that the firm does not observe a signal before disclosing it. Thus, our current model is closer to one of regulatory disclosure (e.g., whether to adopt fair value accounting or not) than one of voluntary disclosure (e.g., management forecasts). Because the disclosure policy cannot be easily changed in the short term, the firm does not choose an optimal precision after learning a private signal. However, if the firm has private information before disclosing it, it has an incentive to disclose good information but withhold bad information. This disclosure incentive generates signaling effects, possibly leading to multiple equilibria for investors' withdrawal decisions (e.g., Angeletos, Hellwig & Pavan, 2006; Angeletos & Pavan, 2013; Bouvard, Chaigneau & Motta, 2015). Assessing the extensions of our resutls thus requires speculation on the equilibria. Without a bailout, we speculate that the results for disclosure precision qualitatively remain because only high signal with high precision can improve the investor's beliefs about the firm. Based on Edmond [2013] and Lee and Oh [2022], we expect that the firm partially reveals a low signal in bad times and fully reveals a low signal with the lowest precision in good times. However, with the anticipation of a bailout, the firm has more incentive to disclose a low signal to receive a bailout. This implies that with the anticipation of a bailout, the firm possibly discloses a low signal but not in the case without a bailout. In this regard, introducing the privately informed firm in the proposed model is challenging yet an interesting avenue left for future research.

Lastly, we have focused on a single firm's disclosure choices. While this assumption keeps our model tractable to analyze the effects of a bailout, it eliminates the possibility that a disclosure choice made by the firm may affect the disclosure behavior of other firms. Unlike our approach, Corona, Nan, and Zhang [2019] examine how the risk-taking decisions of firms influence each other and, in turn, the

[22] An alternative approach is to assume that the disclosure cost (i.e., c_α) increases because, in our model, the firm chooses an optimal precision to receive a bailout. An increase in disclosure cost prevents the firm from anticipating a bailout by disclosing precise information. However, it does not change the firm's disclosure behavior in bad times because the firm chooses zero disclosure precision.

bailout likelihood. They show that firms may coordinate into risk-taking in bad times because their behavior increases the likelihood of a bailout. Similarly, if we consider the disclosure choice of multiple firms, the disclosure incentive of firms to receive a bailout would become even stronger.

6. CONCLUDING REMARKS

This study explores how a government bailout influences a firm's disclosure decisions when the firm is vulnerable to investment withdrawals. Prior to examining the effects of a bailout, we first identify the firm's disclosure policy in the absence of a bailout. Our analysis shows that optimal precision is adversely related to investors' prior beliefs about the firm. When investors expect the firm's fundamentals to be weak ex ante, the firm has an incentive to disclose precise information on its fundamentals. Specifically, the firm chooses high precision to restore investors' beliefs if the cost of improving disclosure precision is less than the benefit of reducing withdrawals. By contrast, the disclosed information should be of lower precision for the firm when investors have optimistic beliefs. We then examine the firm's disclosure decisions when the firm anticipates a bailout. The results indicate that a government bailout induces the firm to distort its disclosure precision relative to the case without a bailout. In other words, the firm might not disclose any information in bad times but raises the precision in good times. This disclosure behavior reduces the probability of conveying positive information on the firm, which leads investors to withdraw their investments. As a result, the government bailout can increase the likelihood of a liquidity crisis for the firm.

In short, our theoretical findings suggest important implications for understanding the effects of the government bailout on corporate disclosure, and in turn, on a liquidity crisis.

APPENDIX: PROOFS AND DERIVATIONS

Proof of Proposition 1

Investors share the common prior $\psi \sim \mathcal{N}(0, 1/\gamma)$ and receive noisy signals $x_i = \psi + \epsilon_i$, where $\epsilon_i \sim \mathcal{N}(0, 1/\beta)$. Thus, Equation (2) becomes Equation (3) as follows:

$$\begin{aligned}
0 &= \mathbb{E}\left[r - 2c_l l \,|\, x_i = x_{ij}^*,\, s_j,\, \alpha\right] \\
&= \mathbb{E}[\theta \,|\, s_j, \alpha] + \mathbb{E}[\psi \,|\, x_i = x_{ij}^*] - 2c_l \mathbb{E}[x_k < x_{ij}^* \,|\, x_i = x_{ij}^*] \\
&= \mu_j + \frac{\beta x_{ij}^*}{\beta + \gamma} - 2c_l \Phi\left[\frac{\sqrt{\lambda}\beta x_{ij}^*}{\beta + \gamma}\right],
\end{aligned}$$

where x_k is the private signal of an investor $k \neq i$.

We first show that Equation (3) has a unique solution x_{ij}^*. Denote the left-hand side of Equation (3) by $f(x_{ij}^*)$. Note that $f(x_{ij}^*) \to \infty$ as $x_{ij}^* \to \infty$ and $f(x_{ij}^*) \to -\infty$ as $x_{ij}^* \to -\infty$. Hence, if $f(x_{ij}^*)$ is a strictly increasing function, then Equation (3) has a unique solution by the intermediate value theorem. The slope of $f(x_{ij}^*)$ is

$$\frac{df(x_{ij}^*)}{dx_{ij}^*} = \frac{\beta}{\beta + \gamma}\left(1 - 2c_l\sqrt{\lambda}\phi\left(\frac{\sqrt{\lambda}\beta x_{ij}^*}{\beta + \gamma}\right)\right),$$

where $\phi(\cdot)$ is the probability density function of the standard normal distribution. Provided that $\lambda < \frac{\pi}{2c_l^2}$, we obtain

$$1 - 2c_l\sqrt{\lambda}\phi\left(\frac{\sqrt{\lambda}\beta x_{ij}^*}{\beta+\gamma}\right) \geq 1 - 2c_l\sqrt{\lambda}\cdot\frac{1}{\sqrt{2\pi}} > 0.$$

This implies that $f(x_{ij}^*)$ is a strictly increasing function, and thus, there is a unique solution x_{ij}^*. Moreover, we can verify that the equilibrium by x_{ij}^* is indeed the unique equilibrium by using the iterated deletion of dominated strategies. The proof is standard in the global game literature and hence, is omitted for brevity (see Morris & Shin, 2001).

Proof of Corollary 1

Given the switching private signal x_{ij}^*, the proportion of investors who withdraw is $\Pr[x_i < x_{ij}^* \,|\, s_j, \alpha, \psi]$. As λ goes to zero and β goes to infinity, $x_i = \psi + \epsilon_i \to \psi$ and $x_{ij}^* \to c_l - \mu_j$ from Equation (3). Thus, the proportion of withdrawals converges to $\Pr[\psi < c_l - \mu_j] = \Phi[\sqrt{\gamma}(c_l - \mu_j)]$. If $\gamma \to \infty$, then the probability goes to one if $\mu_j < c_l$ and zero if $\mu_j > c_l$.

Proof of Proposition 2

After observing the disclosed signal, investors update the expected value of θ as follows:

$$\mu_H(\alpha) = \Pr[g\,|\,s_H]\theta_g + \Pr[b\,|\,s_H]\theta_b = \frac{(1+\alpha)p}{1-\alpha+2\alpha p}\theta_g + \frac{(1-\alpha)(1-p)}{1-\alpha+2\alpha p}\theta_b; \quad \text{(A1)}$$

$$\mu_L(\alpha) = \Pr[g\,|\,s_L]\theta_g + \Pr[b\,|\,s_L]\theta_b = \frac{(1-\alpha)p}{1+\alpha-2\alpha p}\theta_g + \frac{(1+\alpha)(1-p)}{1+\alpha-2\alpha p}\theta_b, \quad \text{(A2)}$$

where $\mu_H(\alpha)$ ($\mu_L(\alpha)$) denotes the expected value of θ conditional on s_H (s_L) with precision α. From Equations (A1) and (A2), it can be easily verified that $\mu_H(\alpha) \geq \mu \geq \mu_L(\alpha)$ for all $\alpha \in [0,1]$. Moreover, $\mu_H(\alpha)$ is increasing in α, whereas $\mu_L(\alpha)$ is decreasing in α.

We now consider the two following cases: $\mu \geq c_l$ and $\mu < c_l$.

- $\mu \geq c_l$: if the public signal is s_H, then by Corollary 1, $l_H(\alpha) = 0$ for all α, because $\mu_H \geq \mu \geq c_l$. Meanwhile, if the public signal is s_L, then the value of $l_L(\alpha)$ depends on α. Let α_L such that $\mu_L(\alpha_L) = c_l$. There exists a unique value of $\alpha_L \in [0,1]$ satisfying this condition, because $\mu_L(\alpha)$ strictly decreases with α and $\mu_L(0) = \mu \geq c_l$ and $\mu_L(1) = \theta_b < c_l$. Thus, $l_L(\alpha) = 0$ for $\alpha \leq \alpha_L$ and $l_L(\alpha) = 1$ for $\alpha > \alpha_L$. As a result, the firm's payoff is

  $$\Pi_{NB}(\alpha) = \begin{cases} \mu - c_\alpha\alpha & \text{if } \alpha \leq \alpha_L, \\ \mu - c_l(1+\alpha-2\alpha p) - c_\alpha\alpha & \text{if } \alpha > \alpha_L. \end{cases}$$

  For the range $\alpha \leq \alpha_L$, $\Pi_{NB}(\alpha)$ is strictly decreasing, and hence, it achieves the maximum at $\alpha = 0$. For the range $\alpha > \alpha_L$, note that $1+\alpha-2\alpha p > 0$ for all $\alpha \in [0,1]$ and $p \in (0,1)$. Then, we have

  $$\Pi_{NB}(\alpha) = \mu - c_l(1+\alpha-2\alpha p) - c_\alpha\alpha \leq \mu = \Pi_{NB}(0).$$

  This implies that $\Pi_{NB}(\alpha)$ for $\alpha > \alpha_L$ is always less than $\Pi_{NB}(0)$. Therefore, the maximum value of $\Pi_{NB}(\alpha)$ occurs when $\alpha = 0$.

- $\mu < c_l$: in this case, the proportion $l_L(\alpha) = 1$ for all α, because $\mu_L \leq \mu < c_l$. Similar to the case in which $\mu \geq c_l$, let $\alpha_H \in [0,1]$ such that $\mu_H(\alpha_H) = c_l$. Then, it follows that $l_H(\alpha) = 1$ for $\alpha < \alpha_H$ and $l_H(\alpha) = 0$ for $\alpha \geq \alpha_H$. By applying this condition, we obtain

$$\Pi_{NB}(\alpha) = \begin{cases} \mu - 2c_l - c_\alpha \alpha & \text{if } \alpha < \alpha_H, \\ \mu - c_l(1 + \alpha - 2\alpha p) - c_\alpha \alpha & \text{if } \alpha \geq \alpha_H. \end{cases}$$

On the one hand, for the range $\alpha < \alpha_H$, $\Pi_{NB}(\alpha)$ achieves the maximum at $\alpha = 0$, because it is a strictly decreasing function. On the other hand, for the range $\alpha \geq \alpha_H$, note that the probability that the project is good is less than one half, because $\mu = p\theta_g + (1-p)\theta_b < c_l < \frac{\theta_g + \theta_b}{2}$. Thus, $\Pi_{NB}(\alpha)$ is decreasing in this range, which implies that its maximum occurs at $\alpha = \alpha_H$. The maximum value is

$$\Pi_{NB}(\alpha_H) = \mu - c_l(1 + \alpha_H - 2\alpha_H p) - c_\alpha \alpha_H.$$

If $\Pi_{NB}(\alpha_H) \geq \Pi_{NB}(0)$, then the optimal precision α^* is α_H; otherwise α^* is zero.[23] Therefore, the firm chooses $\alpha^* = \alpha_H$ if and only if

$$\begin{aligned} &\Pi_{NB}(\alpha_H) = \mu - c_l(1 + \alpha_H - 2\alpha_H p) - c_\alpha \alpha_H \geq \Pi_{NB}(0) = \mu - 2c_l \\ &\Leftrightarrow \alpha_H \leq \frac{1}{1 - 2p + c_\alpha / c_l}. \end{aligned}$$

Combining these two cases, we have Equation (5).

Proof of Proposition 3

We show how Equation (1) becomes Equation (6). After the firm discloses s_j, the expected value of the firm's fundamentals is μ_j. Let us consider the two following cases: $\mu_j \geq c_l$ and $0 < \mu_j < c_l$.

If $\mu_j \geq c_l$, then the proportion of withdrawals without a bailout is zero by Corollary 1. This implies that the expected return on the firm's project is $\mathbb{E}[r - 2c_l l \,|\, s, \alpha, m = 0] = \mu_j \geq c_l > 0$. Hence, the government does not provide a bailout for these firms.

Meanwhile, if $\mu_j \in (0, c_l)$, then all investors withdraw their investments in the absence of a government bailout, which implies that the firm's project will fail, because $\mathbb{E}[r - 2c_l l \,|\, s, \alpha, m = 0] = \mu_j - 2c_l < \mu_j - c_l < 0$. Thus, the government has an incentive to provide capital for the firm to prevent inefficient withdrawals. By Corollary 2, the proportion of withdrawals l_j given the public signal and the bailout amount is

$$l_j = \begin{cases} 0 & \text{if } m \geq c_l - \mu_j, \\ 1 & \text{if } m < c_l - \mu_j. \end{cases}$$

Therefore, the smallest bailout that makes the expected return on the project positive is $m^* = c_l - \mu_j$.

Proof of Proposition 4

[23] We assume that if the firm is indifferent between choosing $\alpha = 0$ and $\alpha = \alpha_H$, then it chooses a higher one. This assumption does not drive the results.

We start by considering the case $\mu \geq c_l$. Define the value of α_L as in the proof of Proposition 2. In other words, α_L is the value satisfying $\mu_L(\alpha_L) = c_l$. If the firm discloses a signal with $\alpha < \alpha_L$, then the firm does not receive a bailout, because $\mu_H \geq \mu_L > c_l$. Hence, the firm's payoff is $\Pi_B(\alpha) = \mu - c_\alpha \alpha$. The value of α maximizing this payoff is $\alpha = 0$. Meanwhile, if the firm discloses a signal with $\alpha \geq \alpha_L$, then the firm receives a bailout $m^* = c_l - \mu_L$ only when the disclosed signal is $s = s_L$. Consequently, the firm's payoff is

$$\begin{aligned}\Pi_B(\alpha) &= \mu + \Pr[s_L \,|\, \alpha] \cdot [c_l - \mu_L(\alpha)] - c_\alpha \alpha \\ &= \mu + \frac{1}{2}\left[(1+\alpha-2\alpha p)c_l - (1-\alpha)p\theta_g - (1+\alpha)(1-p)\theta_b\right] - c_\alpha \alpha,\end{aligned}$$

where $\Pr[s_L|\alpha] = \frac{1}{2}(1+\alpha-2\alpha p)$ is the probability that the firm will disclose a low signal. The firm's payoff may be either increasing or decreasing, and thus, it has the maximum value when $\alpha = \alpha_L$ or $\alpha = 1$. However, the payoff of choosing $\alpha = \alpha_L$ is less than that of choosing $\alpha = 0$ because $\Pi_B(\alpha_L) = \mu + \Pr[s_L \,|\, \alpha_L] \cdot [c_l - \mu_L(\alpha_L)] - c_\alpha \alpha_L = \mu - c_\alpha \alpha_L < \mu = \Pi_B(0)$. This implies that we only need to compare $\Pi_B(1)$ and $\Pi_B(0)$. The firm chooses the optimal precision $\alpha_B^* = 1$ if and only if

$$\Pi_B(1) = \mu + (1-p)(c_l - \theta_b) - c_\alpha \geq \mu \Leftrightarrow c_l - \theta_b \geq \frac{c_\alpha}{1-p}.$$

Similarly, when $\mu < c_l$, denote the value of α_H such that $\mu_H(\alpha_H) = c_l$. The firm's payoff is

$$\Pi_B(\alpha) = \begin{cases} c_l - c_\alpha \alpha & \text{if } \alpha \leq \alpha_H, \\ \mu + \frac{1}{2}\left[(1+\alpha-2\alpha p)c_l - (1-\alpha)p\theta_g - (1+\alpha)(1-p)\theta_b\right] - c_\alpha \alpha & \text{if } \alpha > \alpha_H. \end{cases}$$

For the range $\alpha \leq \alpha_H$, the firm's payoff achieves the maximum value at $\alpha = 0$. Thus, the firm chooses precision $\alpha > \alpha_H$ if and only if

$$\Pi_B(\alpha) \geq \Pi_B(0) \Leftrightarrow \alpha \cdot \left[(1-2p)c_l + p\theta_g - (1-p)\theta_b - 2c_\alpha\right] \geq c_l - \mu. \tag{A3}$$

Denote $\Sigma = (1-2p)c_l + p\theta_g - (1-p)\theta_b - 2c_\alpha = c_l - \mu + 2p(\theta_g - c_l) - 2c_\alpha$. If $\Sigma \leq 0$, then $\alpha\Sigma \leq 0 < c_l - \mu$, which implies $\alpha_B^* = 0$. Conversely, if $\Sigma > 0$, then the left-hand side of Equation (A3) has the maximum value when $\alpha = 1$. Thus, the firm chooses $\alpha = 1$ if and only if $\Pi_B(1) = \Sigma \geq c_l - \mu$. By arranging the terms of this inequality, we have $\theta_g - c_l \geq \frac{c_\alpha}{p}$. Furthermore, $\theta_g - c_l \geq \frac{c_\alpha}{p}$ implies $\Sigma > 0$ because $\Sigma = c_l - \mu + 2p(\theta_g - c_l) - 2c_\alpha \geq c_l - \mu > 0$. Therefore, the firm chooses $\alpha_B^* = 1$ if and only if $\theta_g - c_l \geq \frac{c_\alpha}{p}$.

Combining these two cases, we have Equation (8).

Proof of Proposition 5

First, we calculate the optimal disclosure precision α_B^* with the probability of a bailout, q. We use a similar way to that used in the proof of Proposition 4 to derive α_B^*; that is, we solve the model by separating the cases, $\mu \geq c_l$ and $\mu < c_l$.

If $\mu \geq c_l$, then the amount of the bailout and the proportion of withdrawals given s_j and α are as follows:

$$m^* = \begin{cases} 0 & \text{if } 0 \le \alpha \le \alpha_L \text{ and } s_j \in \{s_H, s_L\}; \\ 0 & \text{if } \alpha_L < \alpha \le 1 \text{ and } s_j = s_H; \\ c_l - \mu_L & \text{with probability } q, \text{ if } \alpha_L < \alpha \le 1 \text{ and } s_j = s_L; \\ 0 & \text{with probability } 1-q, \text{ if } \alpha_L < \alpha \le 1 \text{ and } s_j = s_L, \end{cases}$$

$$l = \begin{cases} 0 & \text{if } 0 \le \alpha \le \alpha_L \text{ and } s_j \in \{s_H, s_L\}; \\ 0 & \text{if } \alpha_L < \alpha \le 1 \text{ and } s_j = s_H; \\ 0 & \text{with probability } q, \text{ if } \alpha_L < \alpha \le 1 \text{ and } s_j = s_L; \\ 1 & \text{with probability } 1-q, \text{ if } \alpha_L < \alpha \le 1 \text{ and } s_j = s_L. \end{cases}$$

Thus, the firm's payoff is

$$\Pi_B(\alpha) = \begin{cases} \mu - c_\alpha \alpha & \text{if } 0 \le \alpha \le \alpha_L; \\ \mu + \Pr[s_L|\alpha] \cdot [q(c_l - \mu_L) - 2c_l(1-q)] - c_\alpha \alpha & \text{if } \alpha_L < \alpha \le 1. \end{cases}$$

For the range $\alpha \le \alpha_L$, the maximum value of $\Pi_B(\alpha)$ occurs when $\alpha = 0$. For the range $\alpha_L < \alpha \le 1$, the maximum value occurs when $\alpha = \alpha_L$ or $\alpha = 1$. However, $\Pi_B(\alpha_L)$ is less than $\Pi_B(0)$ as follows:

$$\begin{aligned} \Pi_B(\alpha_L) &= \mu + \Pr[s_L \mid \alpha_L] \cdot [q(c_l - \mu_L(\alpha_L)) - 2c_l(1-q)] - c_\alpha \alpha_L \\ &= \mu - 2c_l \Pr[s_L \mid \alpha_L](1-q) - c_\alpha \alpha_L < \mu = \Pi_B(0). \end{aligned}$$

Hence, we need only compare $\Pi_B(1)$ and $\Pi_B(0)$. The firm chooses $\alpha = 1$ if and only if

$$\begin{aligned} & \Pi_B(1) = \mu + (1-p)\{q(c_l - \theta_b) - 2(1-q)c_l\} - c_\alpha \ge \mu = \Pi_B(0) \\ & \Leftrightarrow q(c_l - \theta_b) - 2(1-q)c_l \ge \frac{c_\alpha}{1-p}. \end{aligned} \tag{A4}$$

Meanwhile, if $\mu < c_l$, then the amount of the bailout and the proportion of withdrawals are given by

$$m^* = \begin{cases} c_l - \mu_j & \text{with probability } q, \text{ if } 0 \le \alpha < \alpha_H \text{ and } s_j \in \{s_H, s_L\}; \\ 0 & \text{with probability } 1-q, \text{ if } 0 \le \alpha < \alpha_H \text{ and } s_j \in \{s_H, s_L\}; \\ 0 & \text{if } \alpha_H \le \alpha \le 1 \text{ and } s_j = s_H; \\ c_l - \mu_L & \text{with probability } q, \text{ if } \alpha_H \le \alpha \le 1 \text{ and } s_j = s_L; \\ 0 & \text{with probability } 1-q, \text{ if } \alpha_H \le \alpha \le 1 \text{ and } s_j = s_L, \end{cases}$$

$$l = \begin{cases} 0 & \text{with probability } q, \text{ if } 0 \le \alpha < \alpha_H \text{ and } s_j \in \{s_H, s_L\}; \\ 1 & \text{with probability } 1-q, \text{ if } 0 \le \alpha < \alpha_H \text{ and } s_j \in \{s_H, s_L\}; \\ 0 & \text{if } \alpha_H \le \alpha \le 1 \text{ and } s_j = s_H; \\ 0 & \text{with probability } q, \text{ if } \alpha_H \le \alpha \le 1 \text{ and } s_j = s_L; \\ 1 & \text{with probability } 1-q, \text{ if } \alpha_H \le \alpha \le 1 \text{ and } s_j = s_L. \end{cases}$$

Thus, the firm's payoff is

$$\Pi_B(\alpha) = \begin{cases} \mu + q(c_l - \mu) - 2c_l(1-q) - c_\alpha \alpha & \text{if } 0 \le \alpha < \alpha_H, \\ \mu + \Pr[s_L|\alpha] \cdot [q(c_l - \mu_L) - 2c_l(1-q)] - c_\alpha \alpha & \text{if } \alpha_H \le \alpha \le 1. \end{cases}$$

Of course, $\Pi_B(\alpha)$ achieves the maximum at $\alpha = 0$ for the range $0 \leq \alpha < \alpha_H$. The payoff at $\alpha = 0$ is $\Pi_B(0) = \mu + q(c_l - \mu) - 2c_l(1-q)$. It follows that the firm chooses $\alpha \geq \alpha_H$ if and only if $\Pi_B(\alpha) \geq \Pi_B(0)$, that is,

$$\mu + \Pr[s_L|\alpha] \cdot [q(c_l - \mu_L) - 2c_l(1-q)] - c_\alpha \alpha \geq \mu + q(c_l - \mu) - 2c_l(1-q) \qquad \text{(A5)}$$
$$\Leftrightarrow \alpha \left\{q \cdot [(1-2p)c_l + p\theta_g - (1-p)\theta_b] - 2c_l(1-q)(1-2p) - 2c_\alpha\right\} \geq q(c_l - \mu) - 2c_l(1-q).$$

Denote $\Sigma' = q \cdot [(1-2p)c_l + p\theta_g - (1-p)\theta_b] - 2c_l(1-q)(1-2p) - 2c_\alpha$. If $\Sigma' \geq 0$, then the left-hand side of Inequality (A5) is increasing in α, and thus, has the maximum value when $\alpha = 1$. In this case, the firm chooses $\alpha = 1$ if and only if

$$\Sigma' \geq q(c_l - \mu) - 2c_l(1-q) \Leftrightarrow q(\theta_g - c_l) + 2c_l(1-q) \geq \frac{c_\alpha}{p}. \qquad \text{(A6)}$$

Conversely, if $\Sigma' < 0$, then the left-hand side of Inequality (A5) has the maximum value when $\alpha = \alpha_H$. The firm chooses $\alpha = \alpha_H$ if and only if

$$\alpha_H \Sigma' \geq q(c_l - \mu) - 2c_l(1-q). \qquad \text{(A7)}$$

In summary, the optimal disclosure precision with the probability of a bailout is as follows:

$$\alpha_B^*(q) = \begin{cases} 0 & \text{if } \mu \geq c_l \text{ and } q(c_l - \theta_b) - 2(1-q)c_l < \frac{c_\alpha}{1-p}; \\ 1 & \text{if } \mu \geq c_l \text{ and } q(c_l - \theta_b) - 2(1-q)c_l \geq \frac{c_\alpha}{1-p}; \\ 1 & \text{if } \mu < c_l,\ \Sigma' \geq 0, \text{ and } q(\theta_g - c_l) + 2c_l(1-q) \geq \frac{c_\alpha}{p}; \\ 0 & \text{if } \mu < c_l,\ \Sigma' \geq 0, \text{ and } q(\theta_g - c_l) + 2c_l(1-q) < \frac{c_\alpha}{p}; \\ \alpha_H & \text{if } \mu < c_l,\ \Sigma' < 0, \text{ and } \alpha_H\Sigma' \geq q(c_l - \mu) - 2c_l(1-q); \\ 0 & \text{if } \mu < c_l,\ \Sigma' < 0, \text{ and } \alpha_H\Sigma' < q(c_l - \mu) - 2c_l(1-q). \end{cases} \qquad \text{(A8)}$$

Note that there is a set of parameters (i.e., $\{\theta_g, \theta_b, c_l, c_\alpha, p, q\}$) that satisfies Inequalities (A4)–(A7). In other words, all cases in Equation (A8) can arise in some set of parameters.

Second, we calculate the expected value of withdrawals. If the government commits never to bail out the firm, then the firm chooses the precision α_{NB}^* given by Equation (5). Under this precision, the expected value of withdrawals is given by

$$\mathbb{E}[l \mid \alpha_{NB}^*] = \begin{cases} 0 & \text{if } \mu \geq c_l; \\ \frac{1}{2}(1 + \alpha_H - 2\alpha_H p) & \text{if } \mu < c_l \text{ and } \alpha_{NB}^* = \alpha_H; \\ 1 & \text{if } \mu < c_l \text{ and } \alpha_{NB}^* = 0. \end{cases} \qquad \text{(A9)}$$

On the contrary, if there is a possibility of a bailout, then the firm chooses the precision $\alpha_B^*(q)$ given Equation (A8). Thus, we obtain the expected value of withdrawals as follows:

$$\mathbb{E}[l \mid \alpha_B^*(q), q] = \begin{cases} 0 & \text{if } \mu \geq c_l \text{ and } \alpha_B^*(q) = 0; \\ (1-p)(1-q) & \text{if } \mu \geq c_l \text{ and } \alpha_B^*(q) = 1; \\ \frac{1}{2}(1 + \alpha_H - 2\alpha_H p)(1-q) & \text{if } \mu < c_l \text{ and } \alpha_B^*(q) = \alpha_H; \\ (1-p)(1-q) & \text{if } \mu < c_l \text{ and } \alpha_B^*(q) = 1; \\ (1-q) & \text{if } \mu < c_l \text{ and } \alpha_B^*(q) = 0. \end{cases} \qquad \text{(A10)}$$

Comparing Equations (A9) and (A10), the expected value of withdrawals can increase in the following two cases: (1) $\mu \geq c_l$, $\alpha_{NB}^* = 0$, and $\alpha_B^*(q) = 1$ and (2)

$\mu < c_l$, $\alpha^*_{NB} = \alpha_H$, and $\alpha^*_B(q) = 0$. Numerical examples show that both cases are possible (see FIG. 4), which implies that a government bailout can increase the expected value of withdrawals.

ACKNOWLEDGMENTS

We are very grateful to the editor (Paul Glasserman), associate editor, and two reviewers for their guidance and constructive comments. We also wish to thank Meong Ae Kim, Junyong Lee, and Sunyoung Park for their discussions about the empirical implication of our model. Any remaining errors are ours.

REFERENCES

[1] Acharya, V. V, I. Drechsler, and P. Schnabl, 2014, "A Pyrrhic Victory? Bank Bailouts and Sovereign Credit Risk," *Journal of Finance*, 69, 2689-2739.

[2] Acharya, V. V., D. Gale, and T. Yorulmazer, 2011, "Rollover Risk and Market Freezes," *Journal of Finance*, 66, 1177-1209.

[3] Acharya, V. V. and S. G. Ryan, 2016, "Banks' Financial Reporting and Financial System Stability," *Journal of Accounting Research*, 54, 277-340.

[4] Acharya, V. V., P. Schnabl, and G. Suarez, 2013, "Securitization Without Risk Transfer," *Journal of Financial Economics*, 107, 515-536.

[5] Admati, A. R. and P. Pfleiderer, 2000, "Forcing Firms to Talk: Financial Disclosure Regulation and Externalities," *Review of Financial Studies*, 13, 479-519.

[6] Allen, F., E. Carletti, I. Goldstein, and A. Leonello, 2018, "Government Guarantees and Financial Stability," *Journal of Economic Theory*, 177, 518-557.

[7] Alonso, R. and K. E. Zachariadis, 2021, "Persuading Large Investors," Working Paper, London School of Economics.

[8] Angeletos, G. M., C. Hellwig, and A. Pavan, 2006, "Signaling in a Global Game: Coordination and Policy Traps," *Journal of Political Economy*, 114, 452-484.

[9] Angeletos, G. M. and A. Pavan, 2013, "Selection-Free Predictions in Global Games with Endogenous Information and Multiple Equilibria," *Theoretical Economics*, 8, 883-938.

[10] Aoyagi, M., 2014, "Strategic Obscurity in the Forecasting of Disasters," *Games and Economic Behavior*, 87, 485-496.

[11] Arieli, I. and Y. Babichenko, 2019, "Private Bayesian Persuasion," *Journal of Economic Theory*, 182, 185-217.

[12] Badertscher, B. A., J. J. Burks, and P. D. Easton, 2011, "A Convenient Scapegoat: Fair Value Accounting by Commercial Banks During the Financial Crisis," *Accounting Review*, 87, 59-90.

[13] Ball, R., 2008, "Don't Blame the Messenger... or Ignore the Message," Working paper, University of Chicago.

[14] Banerjee, S. and M. Maier, 2016, "Public Information Precision and Coordination Failure: An Experiment," *Journal of Accounting Research*, 54, 941-986.

[15] Bannier, C. E. and F. Heinemann, 2005, "Optimal Transparency and Risk-Taking to Avoid Currency Crises," *Journal of Institutional and Theoretical Economics*, 161, 374-391.

[16] Beatty, A. and S. Liao, 2014, "Financial Accounting in the Banking Industry: A Review of the Empirical Literature," *Journal of Accounting and Economics*, 58, 339-383.

[17] Berger, P. G. and R. N. Hann, 2007, "Segment Profitability and the Proprietary and Agency Costs of Disclosure," *Accounting Review*, 82, 869-906.

[18] Bergman, N. K. and S. Roychowdhury, 2008, "Investor Sentiment and Corporate Disclosure," *Journal of Accounting Research*, 46, 1057-1083.

[19] Bouvard, M., P. Chaigneau, and A. D. Motta, 2015, "Transparency in the Financial System: Rollover Risk and Crises," *Journal of Finance*, 70, 1805-1837.

[20] Carlsson, H. and E. van Damme, 1993, "Global Games and Equilibrium Selection," *Econometrica*, 61, 989-1018.

[21] Cordella, T., G. Dell'Ariccia, R. Marquez, 2018, "Government Guarantees, Transparency, and Bank Risk Taking," *IMF Economic Review*, 66, 116-143.

[22] Corona, C., L. Nan, and G. Zhang, 2019, "The Coordination Role of Stress Tests in Bank Risk-Taking," *Journal of Accounting Research*, 57, 1161-1200.

[23] Dam, L. and M. Koetter, 2012, "Bank Bailouts and Moral Hazard: Evidence from Germany," *Review of Financial Studies*, 25, 2343-2380.

[24] DellaVigna, S. and M. Gentzkow, 2010, "Persuasion: Empirical Evidence," *Annual Review of Economics*, 2, 643-669.

[25] Edmond, C., 2013, "Information Manipulation, Coordination, and Regime Change," *Review of Economic Studies*, 80, 1422-1458.

[26] Ellis, J. A., C. E. Fee, and S. E. Thomas, 2012, "Proprietary Costs and the Disclosure of Information about Customers," *Journal of Accounting Research*, 50, 685-727.

[27] Farhi, E. and J. Tirole, 2020, "Shadow Banking and the Four Pillars of Traditional Financial Intermediation," *Review of Economic Studies*, forthcoming.

[28] Faria-e-Castro, M., J. Martinez, and T. Philippon, 2017, "Runs Versus Lemons: Information Disclosure and Fiscal Capacity," *Review of Economic Studies*, 84, 1683-1707.

[29] Flannery, M. J., S. H. Kwan, and M. Nimalendran, 2013, "The 2007-2009 Financial Crisis and Bank Opaqueness," *Journal of Financial Intermediation*, 22, 55-84.

[30] Fornell, C., F. V. Morgeson, and G. T. M. Hult, 2016, "Stock Returns on Customer Satisfaction Do Beat the Market: Gauging the Effect of a Marketing Intangible," *Journal of Marketing*, 80, 92-107.

[31] Goldstein, I. and C. Huang, 2020, "Credit Rating Inflation and Firms' Investments," *Journal of Finance*, 75, 2929-2972.

[32] Goldstein, I. and Y. Leitner, 2018, "Stress Tests and Information Disclosure," *Journal of Economic Theory*, 177, 34-69.

[33] Goldstein, I. and A. Pauzner, 2005, "Demand-Deposit Contracts and the Probability of Bank Runs," *Journal of Finance*, 60, 1293-1327.

[34] Goldstein, I. and H. Sapra, 2014, "Should Banks' Stress Test Results Be Disclosed? An Analysis of the Costs and Benefits," *Foundations and Trends(R) in Finance*, 8, 1-54.

[35] Gorton, G. and A. Metrick, 2012, "Securitized Banking and the Run on Repo," *Journal of Financial Economics*, 104, 425-451.

[36] Healy, P. M. and K. G. Palepu, 2001, "Information Asymmetry, Corporate Disclosure, and the Capital Markets: A Review of the Empirical Disclosure Literature," *Journal of Accounting and Economics*, 31, 405-440.

[37] Hedlund, J., 2015, "Persuasion with Communication Costs," *Games and Economic Behavior*, 92, 28-40.

[38] Hribar, P. and J. McInnis, 2012, "Investor Sentiment and Analysts' Earnings Forecast Errors," *Management Science*, 58, 293-307.

[39] Inostroza, N., 2020, "Persuading Multiple Audiences: An Information Design Approach to Banking Regulation," Working Paper, University of Toronto.

[40] Inostroza, N. and A. Pavan, 2021, "Persuasion in Global Games with Application to Stress Testing," Working Paper, Northwestern University.

[41] Ittner, C. D. and D. F. Larcker, 1998, "Are Nonfinancial Measures Leading Indicators of Financial Performance? An Analysis of Customer Satisfaction," *Journal of Accounting Research*, 36, 1-35.

[42] Kamenica, E. and M. Gentzkow, 2011, "Bayesian Persuasion," *American Economic Review*, 101, 2590-2615.

[43] Kamenica, E. and M. Gentzkow, 2014, "Costly Persuasion," *American Economic Review*, 104, 457-462.

[44] Kareken, J. H. and N. Wallace, 1978, "Deposit Insurance and Bank Regulation: A Partial- Equilibrium Exposition," *Journal of Business*, 51, 413-438.

[45] Keister, T., 2016, "Bailouts and Financial Fragility," *Review of Economic Studies*, 83, 704-736.

[46] Kolotilin, A., 2015, "Experimental Design to Persuade," *Games and Economic Behavior*, 90, 215-226.

[47] König, P., K. Anand, and F. Heinemann, 2014, "Guarantees, Transparency and the Interdependency Between Sovereign and Bank Default Risk," *Journal of Banking and Finance*, 45, 321-337.

[48] Laux, C. and C. Leuz, 2010, "Did Fair-Value Accounting Contribute to the Financial Crisis?" *Journal of Economic Perspectives*, 24, 93-118.

[49] Lee, K. and F. D. Oh, 2021a, "Public Information and Global Games with Strategic Complements and Substitutes," *Economics Letters*, 199, 109703.

[50] Lee, K. and F. D. Oh, 2021b, "Credit Ratings and Liquidity Crises," *International Journal of Economic Theory*, 17, 309-324.

[51] Lee, K. and F. D. Oh, 2022, "Information Disclosure and Liquidity Crisis," *Journal of Accounting and Public Policy*, 41, 106942.

[52] Leonello, A., 2018, "Government Guarantees and the Two-Way Feedback Between Banking and Sovereign Debt Crises," *Journal of Financial Economics*, 130, 592-619.

[53] Leuz, C. and P. D. Wysocki, 2016, "The Economics of Disclosure and Financial Reporting Regulation: Evidence and Suggestions for Future Research," *Journal of Accounting Research*, 54, 525-622.

[54] Liang, P. J. and G. Zhang, 2018, "On the Social Value of Accounting Objectivity in Financial Stability," *Accounting Review*, 94, 229-248.

[55] Morgan, D. P., 2002, "Rating Banks: Risk and Uncertainty in an Opaque Industry," *American Economic Review*, 92, 874-888.

[56] Morris, S. and H. S. Shin, 2001, "Rethinking Multiple Equilibria in Macroeconomic Modeling," *NBER Macroeconomic Annual 2000*, 15, 139-161.

[57] Morris, S. and H. S. Shin, 2002, "Social Value of Public Information," *American Economic Review*, 92, 1521-1534.

[58] Morris, S. and H. S. Shin, 2003, "Global Games: Theory and Applications," *Advances in Economics and Econometrics (Proceedings of the Eighth World Congress of the Econometric Society)*, edited by M. Dewatripont, L. P. Hansen, and S. J. Turnovsky, Cambridge University Press.

[59] Morris, S. and H. S. Shin, 2004, "Coordination Risk and the Price of Debt," *European Economic Review*, 48, 133-153.

[60] Morris, S. and H. S. Shin, 2006, "Catalytic Finance: When Does It Work?" *Journal of International Economics*, 70, 161-177.

[61] Morris, S. and H. S. Shin, 2008, "Financial Regulation in a System Context," *Brookings Papers on Economic Activity*, 39, 229-274.

[62] Obstfeld, M., 1996, "Models of Currency Crises with Self-Fulfilling Features," *European Economic Review*, 40, 1037-1047.

[63] Oh, F. D., 2013, "Contagion of a Liquidity Crisis Between Two Firms," *Journal of Financial Economics*, 107, 386-400.

[64] Oh, F. D., 2022, "Central Bank Transparency and Contagious Currency Crises," Working Paper, Korea Advanced Institute of Science and Technology.

[65] Oh, F. D. and S. Baek, 2015, "Unique Equilibrium in a Model of Takeovers Involving Block Trades and Tender Offers," *Finance Research Letters*, 15, 208-214.

[66] Oh, F. D. and J. Park, 2019, "Potential Competition and Quality Disclosure," *Journal of Economics and Management Strategy*, 28, 614-630.

[67] Oh, F. D. and J. Park, 2022, "A Large Creditor in Contagious Liquidity Crises," Working Paper, Korea Advanced Institute of Science and Technology.

[68] Pereira, A. E., 2021, "Rollover Risk and Stress Test Credibility," *Games and Economic Behavior*, 129, 370-399.

[69] Plantin, G., H. Sapra, and H. S. Shin, 2008, "Marking-to-Market: Panacea or Pandora's Box?" *Journal of Accounting Research*, 46, 435-460.

[70] Quigley, D. and A. Walther, 2020, "Inside and Outside Information: Reverse Unraveling and Stress Test Design," Working Paper, University of Oxford.

[71] Reeb, D. M. and W. Zhao, 2013, "Director Capital and Corporate Disclosure Quality," *Journal of Accounting and Public Policy*, 32, 191-212.

[72] Summers, L. H., 2000, "International Financial Crises: Causes, Prevention, and Cures," *American Economic Review*, 90, 1-16.

[73] Verrecchia, R. E., 1983, "Discretionary Disclosure," *Journal of Accounting and Economics*, 5, 179-194.

[74] Vives, X., 2005, "Complementarities and Games: New Developments," *Journal of Economic Literature*, 43, 437-479.

[75] Wang, C., 2013, "Bailouts and Bank Runs: Theory and Evidence from TARP," *European Economic Review*, 64, 169-180.

[76] Zhang, G., 2021, "Competition and Opacity in the Financial System," *Management Science*, 67, 1895-1913.

[77] Zwart, S., 2007, "The Mixed Blessing of IMF Intervention: Signalling Versus Liquidity Support," *Journal of Financial Stability*, 3, 149-174.