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\* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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## Abstract

We study how inflated credit ratings affect investment decisions in bond markets using experimental coordination games. Theoretical models that feature a feedback effect between capital markets and the real economy suggest that inflated ratings can have both positive and negative real effects. We compare markets with and without a credit rating agency and find that ratings significantly impact investor behaviour and capital allocation to firms. We show that the main mechanism through which these real effects materialize is a shift in investors' beliefs about the behaviour of other investors rather than firms' underlying fundamentals. Our experimental results suggest that the positive impact of inflated ratings is likely to dominate in the presence of feedback effects since ratings act as a strong coordination mechanism resulting in enhanced market outcomes.

**JEL:** D81; D82; D83; G24

**Keywords:** Credit ratings; Imperfect information; Investor beliefs; Firm financing

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# 1 Introduction

Credit ratings play an essential role in the investment process by providing information about firms' creditworthiness, which helps investors make informed decisions on where to allocate their capital. However, the "issuer pays" business model used by the leading credit rating agencies (CRAs) has raised concerns about potential rating inflation (i.e., instances when a CRA may overestimate a firm's creditworthiness).<sup>1</sup> The potential consequences of inflated credit ratings can be significant. They promote capital misallocation, distortion of market prices, and a false sense of security for investors.<sup>2</sup> Investors may be lured into taking on more risk than they can handle, while issuers may be able to access cheaper funding than they deserve. Inflated credit ratings can also lead to moral hazard problems with adverse real economic effects, where issuers take on more risk than they otherwise would. However, inflated ratings can also foster market liquidity and facilitate firms' access to credit markets, which can benefit economic growth, particularly when improved financing conditions enable efficient investments. Understanding the role that inflated ratings play in shaping investors' behaviour and decision-making is empirically challenging, as it is difficult to establish the causal impact of ratings on investors' or firms' decisions.<sup>3</sup>

In this paper, we provide experimental evidence on the informational role of inflated credit ratings and their impact on investment decisions. We first present a parsimonious theoretical model that features a feedback effect between credit ratings and firm investment decisions.

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<sup>1</sup>See, for example, [Ashcraft and Schuermann \(2008\)](#), [Jiang \*et al.\* \(2012\)](#), [Alp \(2013\)](#), [Cornaggia and Cornaggia \(2013\)](#), [White \(2013\)](#), and [Fulghieri \*et al.\* \(2014\)](#). Factors that can lead to credit inflation include conflicts of interest, such as the desire to maintain a good relationship with an issuer ([Mählmann, 2011](#); [He \*et al.\*, 2012](#); [Strobl and Xia, 2012](#); [Frenkel, 2015](#)); (lax) regulation ([Opp \*et al.\*, 2013](#); [Bae \*et al.\*, 2015](#)); the pressure to retain market share ([Becker and Milbourn, 2011](#); [Bolton \*et al.\*, 2012](#); [Baghai and Becker, 2020](#)); or ratings-shopping ([Skreta, 2009](#); [White, 2010](#); [Bongaerts \*et al.\*, 2012](#)).

<sup>2</sup>During the Global Financial Crisis, large losses on highly-rated securities and their downgrades indicated that these securities had inflated ratings ([US Senate, 2007](#); [Benmelech and Dlugosz, 2009a,b](#); [Griffin and Tang, 2011, 2012](#); [US Government, 2011](#); [Griffin \*et al.\*, 2013](#)). Major rating agencies, such as Moody's and Standard & Poor's, paid more than \$1 billion in legal settlements to resolve allegations arising from their role in providing inflated ratings to mortgage-related securities in the run-up to the financial crisis.

<sup>3</sup>While several studies document a positive correlation between changes in ratings and firms' and investors' decisions, these studies often face an endogeneity problem, as it is difficult to causally show that investors react to the change in rating itself and not to some underlying firm fundamental that is observed by both investors and the rating agency ([Cornaggia \*et al.\*, 2018](#)).

Our theoretical framework builds on [Goldstein and Huang's \(2020\)](#) bond financing model. In the model, a firm can invest in two types of risky projects: low-risk or high-risk. To undertake a project, the firm uses two sources of financing: internal funds from ongoing activities and external financing from the bond market. Low-risk projects have higher expected returns but require a larger investment due to their scarcity and associated cost of screening. If the firm cannot secure enough funds to undertake the efficient, low-risk project, it can either invest in a high-risk project or default. Default occurs in the model whenever external funds are insufficient to cover the firm's losses from existing activities.

The firm raises external financing from investors who observe noisy private signals about the firm's internal funds and potentially a public credit rating. A CRA assesses the firm's creditworthiness and assigns it a good (inflated) or a bad rating.<sup>4</sup> The inflated rating pools high- and low-risk firms together, but it still provides positive information about a firm because it implies that the firm is less likely to default. This encourages more investors to purchase bonds, leading to more external financing and indirectly affecting the firm's project choice. However, higher availability of external funding can have opposing effects. On the positive side, firms that would have otherwise invested in high-risk projects can secure enough financing to undertake the low-risk project. On the negative side, firms that would have defaulted in the absence of the inflated rating can gamble for resurrection by undertaking an inefficient high-risk project.<sup>5</sup>

We design a laboratory experiment that allows us to evaluate these two opposing effects while controlling for investors' information sets and firm fundamentals. In the experiment, participants are investors who decide whether to finance the firm or not. The payoff from investing depends on the firm's action (i.e., invest in a low- or high-risk project or default), which is computerized based on the theoretical model's parametrization.<sup>6</sup> Before making their investment decision, participants receive a private signal about the firm's fundamentals

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<sup>4</sup>A firm receives a good rating when its internal funds are above a specific (default) threshold. When deriving the threshold, the rating agency considers the effect of the rating on investors' and firm's decisions.

<sup>5</sup>The model allows for positive and negative effects of inflated ratings that depend on the parametrization.

<sup>6</sup>This experimental design allows us to focus on participants' decision-making while shutting down the possibility for firm strategic behaviour.

(i.e., internal funds), and we elicit their beliefs about fundamentals and the behaviour of others. We consider two treatments in a between-subject design: (i) a Baseline treatment, where subjects only receive the private signal, and (ii) a CRA treatment, where subjects observe a public credit rating about the firm's ability to repay its creditors in addition to the private signal. Based on the model's predictions, we derive several testable hypotheses regarding the positive and negative effects of inflated ratings for different levels of firm fundamentals.

We find that the firm's access to external finance differs significantly across the two treatments conditional on firm fundamentals and the observed rating. First, firms in the CRA treatment with relatively high (low) fundamentals receive substantially more (less) external financing than firms in the Baseline treatment with similar fundamentals. Second, there is more investment in the CRA treatment conditional on investors observing a good (inflated) rating and less investment conditional on the observation of a bad rating. Finally, the increased availability of external financing in the CRA treatment leads to significantly more firm investment in the efficient, low-risk project compared to the Baseline treatment. At the same time, we observe significantly fewer firms investing in a high-risk project in the CRA treatment. These results point to an overall positive effect of inflated ratings leading to a more efficient allocation of capital and enhanced market outcomes.

We then study individual investment behaviour and evaluate the mechanisms that drive our results by analyzing the effects of credit ratings on investors' actions and beliefs. Our results suggest that ratings act as strong coordination devices. Investors in the CRA treatment who observe a good (bad) rating are more (less) likely to buy the firm's bonds than investors in the Baseline treatment. We document that the main channel through which the real effects materialize in the presence of feedback effects between credit ratings and firms' actions is not through the updating of investors' beliefs about the firm's fundamentals, but rather through the updating of beliefs about other investors' behaviour. On the one hand, investors in the CRA treatment who observe a good (bad) rating are much more (less) likely to believe that the other investors will (will not) buy the firm's bonds. Moreover, a bad rating has a

stronger impact on expectations about the behaviour of other investors than a good rating. On the other hand, beliefs about firm fundamentals are unaffected by ratings. These results emphasize the importance of credit ratings even if they have a limited impact on beliefs about firms' fundamentals. The reason is that observed ratings help in reducing strategic uncertainty about the actions of others and thus have a strong coordinating effect.

Our paper relates to several strands of the literature. There is a rich theoretical literature on the real effects of financial markets (see [Bond \*et al.\*, 2012](#); [Goldstein, 2023](#), for reviews), with several works specifically focusing on the real effects of credit ratings ([Boot \*et al.\*, 2006](#); [Jeon and Lovo, 2013](#); [Manso, 2013](#); [Goel and Thakor, 2015](#); [Sangiorgi and Spatt, 2017](#); [Donaldson and Piacentino, 2018](#); [Daley \*et al.\*, 2020](#); [Parlour and Rajan, 2020](#); [Terovitis, 2020](#)). Our empirical results are consistent with the theoretical predictions from [Boot \*et al.\* \(2006\)](#), who show that credit ratings can serve as coordination mechanisms.

Second, our paper relates to the empirical literature that attempts to identify the causal effects of ratings on investors' decisions. Several papers exploit various exogenous changes in firms' ratings that are unrelated to fundamentals (e.g., rating refinements or automatic rating downgrades due to sovereign risk) to overcome the endogeneity concern that the change in rating and the change in investors' behaviour can be driven by the same (unobserved) confounding factors (see, for example, [Kliger and Sarig, 2000](#); [Kisgen, 2009](#); [Tang, 2009](#); [Sufi, 2009](#); [Bannier and Hirsch, 2010](#); [Kisgen and Strahan, 2010](#); [Ellul \*et al.\*, 2011](#); [Almeida \*et al.\*, 2017](#); [Cornaggia \*et al.\*, 2018](#)).<sup>7</sup> However, this literature cannot assess the informational role of *inflated* ratings, as one cannot empirically observe which ratings are inflated. Using a laboratory experiment allows us to overcome this obstacle and study the informational channels through which rating inflation can affect investors' decisions and market outcomes.

Third, our work adds to an expanding experimental finance literature (see [Sunder, 2007](#); [Bossaerts \*et al.\*, 2009](#); [Bloomfield and Anderson, 2010](#), for reviews). Within this literature, there are a few experimental studies on credit ratings. [Keser \*et al.\* \(2017\)](#) study the repeated

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<sup>7</sup>This literature finds that CRAs' actions affect market participants and have real effects on firms' access to capital and their investments.

interaction between an issuer and a CRA and find that issuers frequently request ratings, while the CRA reciprocates with rating inflation. [Rabanal and Rud \(2017\)](#) show how market structure affects credit ratings. In contrast to these papers, we study the effect of a credit rating on investors' decisions. Importantly, in our experiment, participants play the role of investors who decide whether to buy the firm's bond, while the decisions of the firm and the rating agency are based on their optimizing behaviour. Our paper is the first to empirically study the economic efficiency of inflated ratings when there is a feedback effect between the real economy and the financial sector. In this aspect, our work relates to [Weber \*et al.\* \(2018\)](#), who study the feedback effect between a bond's initial public offering price and the probability of issuer default.

Finally, we add to a rich experimental global games literature that studies participants' reactions to private and public information in contexts of strategic complementarities. Several papers, including [Heinemann \*et al.\* \(2004\)](#), [Cabrales \*et al.\* \(2007\)](#), and [Cornand and Heinemann \(2014b\)](#), find that participants tend to overreact to public information with public signals acting as focal points. Public signals bear important welfare implications that depend on the optimal level of social coordination ([Cornand and Heinemann, 2014a](#)). [Gao \(2008\)](#) emphasizes the benefits of transparency in an experimental design based on [Allen \*et al.\* \(2006\)](#), and shows that public information in the form of accounting disclosure leads to market efficiency by driving market prices close to fundamental values. [Sanjay and Maier \(2016\)](#) study the role of the precision of public information on coordination failures and find that granular disclosure increases participants' strategic uncertainty, which, in turn, increases the likelihood of coordination failure. We complement this literature by showing how a public credit rating affects the allocation of capital and market outcomes in the presence of feedback effects between public signals and the real economy.

Our paper is structured as follows. Section 2 presents a simple model of credit ratings and investments and formulates the empirical hypotheses. Section 3 describes the experimental design and procedures. Section 4 shows our results. Section 5 concludes.



## 2 A model of credit ratings and investments

We sketch a theoretical framework that builds on the model of Goldstein and Huang (2020) to guide our experimental design. We consider an economy consisting of a continuum of investors, a credit rating agency, and a firm that raises financing from the bond market. There are three dates  $(0, 1, 2)$ , no discounting, and all agents are risk-neutral. The timing of the game is as follows. At  $t = 0$ , the CRA assigns a credit rating to the firm (the issuer). Investors observe a private signal about the firm's fundamentals and, potentially, a credit rating. Each investor then decides whether or not to buy the firm's bonds. At  $t = 1$ , the firm chooses whether to default or invest in a new risky project based on its available funds. If the firm invests, the cash flow is realized at  $t = 2$ , and bondholders are repaid in full whenever the firm is solvent (i.e., the payoff from projects exceeds the total amount owned).

### *Projects*

The firm is endowed with an ongoing project and has two additional investment opportunities: a low-risk project (LR) and a high-risk project (HR). The ongoing project produces  $\theta$  at date 0, which is drawn from a uniform distribution over  $[\underline{\theta}, \bar{\theta}]$ , with  $\underline{\theta} < 0 < \bar{\theta}$ , and represents the firm's fundamentals (internal funds). The LR project generates the following distribution of cash flows at date 2:  $V > 0$  with probability  $p \in (0, 1)$  and 0 with probability  $1 - p$ . Analogously, the HR project produces  $H > V$  with probability  $q$ , and 0 with probability  $1 - q$ , where  $0 < q < p$ . The firm can also default at  $t = 1$  and its liquidation value is  $L$ . Following Goldstein and Huang (2020), we assume that the firm's expected cash flows are ranked as follows:  $pV > L > qH$ . The fact that LR and HR projects have higher, respectively lower, expected cash flows than the firm's liquidation value allows us to generate predictions about the positive and negative implications of ratings. In our model, we interpret a firm's decision to take excessive risks by investing in an HR project instead of defaulting as a negative effect. Likewise, we interpret a firm's decision to invest in an LR project instead of defaulting or undertaking an HR project as a positive effect. The firm's investment choice is unobservable and unverifiable.

The firm needs a certain amount of funding to undertake a new project.<sup>8</sup> We assume that the LR-type of projects are in short supply and can be uncovered through costly screening efforts. The LR project requires a higher initial investment (including screening costs),  $I$ , with  $I \geq \bar{\theta}$ , whereas the HR project can be undertaken with a smaller investment,  $i < I$ .<sup>9</sup> For simplicity, we assume  $i = 0$ . We also assume that the LR project has a higher net present value:

$$pV - I > qH. \quad (1)$$

### *Funding*

The firm has two sources of financing: its own internal funds from the ongoing project,  $\theta$ , and external funds from capital markets. The firm may need to raise external funds not only to undertake a new project but also to cover any losses from the ongoing project. If the firm's available funds at  $t = 1$  are less than 0, it defaults, and creditors who financed the firm (if any) lose their investment. The firm's payoff in case of default is also zero, as any liquidation value  $L$  is lost in the bankruptcy procedure.

External financing is obtained from investors in the bond market. Each investor is endowed with 1 unit of wealth. The firm issues zero-coupon bonds with face value  $F$ , with  $1 < F < I$ , at price  $B = 1$ . The bonds mature at  $t = 2$ .<sup>10</sup> If the firm does not default at date 1 and the new project is successful, bondholders are fully repaid at date 2.<sup>11</sup> Conversely, when the risky investment returns 0, the firm is insolvent and its creditors receive nothing because of bankruptcy costs. We also assume that  $pF > 1 > qF$ , so that investors buy the bond when they know that the firm invests in the LR project, but not when the firm invests in

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<sup>8</sup>Note that our modelling approach differs from that of [Goldstein and Huang \(2020\)](#) on two important dimensions. First, we simplify the firm's liabilities and financing structure by focusing on the size of funding available to the firm and, to a lesser extent, on the financing cost. Second, we use a uniform distribution for fundamentals and signals instead of a common improper prior for fundamentals and a normal distribution.

<sup>9</sup>This specification is consistent, for example, with the idea of higher entry costs required for access to LR projects, where entry costs may be thought of as a combination of transaction and informational costs.

<sup>10</sup>Since we want to analyze the effect of the credit ratings on the amount of bonds raised and not on their price, we follow [He and Xiong \(2012\)](#) and [Goldstein and Huang \(2020\)](#) and assume that the face value and price of the bond are exogenously given.

<sup>11</sup>This implies that the payoffs of both projects, when successful, are sufficient to repay all investors. A sufficient condition for this is:  $H > V > F$ , as, when everyone invests, the maximum repayment is  $F$ .

the HR project or defaults at  $t = 1$ . Combining the two sources of funds, the total amount of financing available to the firm,  $K(\theta)$ , is:

$$K(\theta) = \theta + BW(\theta), \quad (2)$$

where we denote by  $W(\theta)$  the mass of investors that buy the firm's bond at price  $B = 1$ . The firm's expected payoff is as follows:

$$\begin{cases} p[V - I + K(\theta) - FW(\theta)] & \text{if the firm invests in LR project,} \\ q[H + K(\theta) - FW(\theta)] & \text{if the firm invests in HR project,} \\ 0 & \text{if the firm defaults at } t = 1. \end{cases} \quad (3)$$

Specifically, when available funds are large enough (i.e.,  $K(\theta) \geq I$ ) and the firm invests in the LR project, its net profit is, with probability  $p$ , the return on the LR project net of investment  $V - I$ , plus any internal funds available after paying external investors  $K(\theta) - FW(\theta)$ . With probability  $1 - p$  the LR project fails, the firm cannot repay the investors in full, and its profit is zero.<sup>12</sup> Likewise, when the total funds are positive but not very high (i.e.,  $0 < K(\theta) < I$ ), the firm's expected profit from investing in the HR project is  $q[H + K(\theta) - FW(\theta)]$ , where  $q$  is the probability of success of the HR project,  $H$  is the return on the HR project, and  $K(\theta) - FW(\theta)$  is the total amount of financing net of the amount owed to investors. With probability  $1 - q$  the HR project fails, the firm cannot repay the investors in full, and its profit is zero.

### *Information structure*

Investors do not observe the true value of  $\theta$ . However, before deciding whether to buy the bond, each investor  $i$  receives a private signal about  $\theta$ :  $x_i = \theta + \epsilon_i$ , where the error terms  $\epsilon_i$  are uniformly distributed over  $[-\epsilon, \epsilon]$  and are independent across all investors. This information structure allows us to solve the game in the standard global games framework (Carlsson and

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<sup>12</sup>With probability  $1-p$  the LR project fails and there is no payoff for the firm since:  $-I + K(\theta) - FW(\theta) < 0$ . One can verify that this is equivalent to  $(-I + \theta) + [W(\theta) - FW(\theta)] < 0$ , which holds given that  $I \geq \theta$  and  $F > 1$  by assumption.

Van Damme, 1993; Morris and Shin, 1998, 2004). All investors are identical and their actions are strategic complements (i.e., an investor's incentives to buy the bond increase with the number of other investors that also buy the bond). Furthermore, investors may observe a public credit rating provided by the CRA in addition to their private signals.

### *The Credit Rating Agency*

The CRA observes perfectly the firm's true fundamentals and its optimal investment strategy. Therefore, the forward-looking CRA assigns a rating  $R$  by taking into account its effects on the firm's optimal investment strategy and its subsequent probability of default. Following Boot *et al.* (2006) and Goldstein and Huang (2020), we restrict the space of ratings to  $R = \{0, q, p\}$ . A rating of zero is equivalent to default, with  $q$  and  $p$  corresponding to the firm's investment in the HR and LR projects, respectively. The payoff function of the CRA is as follows: it earns a revenue  $S^R$  and faces a potential cost  $C^R$  when assigning a rating  $R = p, q$ . In line with the "issuer-pays" business model, we assume that the CRA receives higher revenues when assigning better credit ratings:  $S^p > S^q > 0$ .<sup>13</sup> The cost  $C^R$  corresponds to (exogenous) reputation or legal costs in the case of firm default. We assume that if a firm with rating  $R > 0$  defaults at  $t = 1$ , the reputational costs for the CRA are very large ( $C^{\text{early default}} > S^p$ ), such that the CRA does not assign a rating to firms it foresees defaulting at  $t = 1$ . If a firm with rating  $R > 0$  defaults at  $t = 2$ , the CRA incurs a cost  $C^R$  ( $R = p, q$ ), with  $S^p > S^q > C^p > C^q > 0$ .

### *Equilibrium concept*

The equilibrium concept is a monotone perfect Bayesian equilibrium. We solve the model as follows: first, taking as given the firm's and investors' strategies, the CRA maps fundamentals into a rating by maximizing its expected profits. Next, given its total funding,  $K(\theta)$ , the firm chooses the strategy that maximizes expected profits conditional on observed fundamentals. Finally, investors use the Bayes rule to update their beliefs about the firm's fundamentals and maximize their expected profit given the other investors, the CRA, and the firm's investment

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<sup>13</sup>See Bar-Isaac and Shapiro (2013) and Sangiorgi and Spatt (2017) for a discussion of the relationship between reputational incentives and credit quality and the frictions associated with CRAs.

strategies. As in models of global games, investors' strategies are monotonic in their private signals. Investors adopt a cutoff strategy, where they invest for signals above a threshold signal,  $\tilde{x}$ , and do not buy the bond when  $x_i < \tilde{x}$ .<sup>14</sup>

## 2.1 Equilibrium without a CRA

In the following proposition, we characterize the equilibrium of a benchmark model without the CRA. We first note that we can characterize the firm's optimal investment strategy at date 1, conditional on  $\theta$ , by using the firm's expected profits conditional on investors' strategies as shown in (3), and then deriving the firm's profit-maximizing strategy. The firm always has incentives to choose the LR project over the HR project for  $K(\theta) \geq I$  since  $p[V - FW(\theta) + K(\theta) - I] > q[H - FW(\theta) + K(\theta)]$ .<sup>15</sup> When the available funds are positive but not sufficient to allow an investment in the LR project (i.e.,  $0 < K(\theta) < I$ ), choosing the HR project dominates the decision to default since  $q[H - FW(\theta) + K(\theta)] > 0$ .<sup>16</sup> Therefore, the firm's optimal investment strategy at date 1, conditional on the total available funding, is as follows:

$$\begin{cases} \text{Invest in LR project} & \text{if } K(\theta) \geq I \\ \text{Invest in HR project} & \text{if } 0 \leq K(\theta) < I. \\ \text{Default} & \text{if } K(\theta) < 0. \end{cases} \quad (4)$$

We can now characterize the equilibrium of the model in the following proposition.

**Proposition 1** The benchmark model without a CRA has a unique equilibrium described by  $(\tilde{\theta}_1, \tilde{\theta}_2, \tilde{x})$ , with  $\tilde{\theta}_1 < \tilde{\theta}_2$  and

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<sup>14</sup>This equilibrium strategy rests on the existence of *lower* and *upper dominance* regions below and above which an investor has a dominant strategy to either not buy or buy the bond. The *lower dominance* region consists of values of fundamentals so low that even if all investors bought the bond, the firm would still not cover the losses from the ongoing project and would default. Hence, in the lower dominance region, an investor's dominant action is not to buy the bond. The *upper dominance* region corresponds to high fundamentals values for which the firm can self-finance the LR project, even if nobody buys the bond. Therefore, an investor's dominant action is to buy the bond.

<sup>15</sup>One can verify that this is equivalent to  $K(\theta) > FW(\theta) - ((p(V - I) - qH)/(p - q))$ . For  $K(\theta) \geq I$  it is sufficient to show that  $I > FW(\theta) - (p(V - I) - qH)/(p - q)$ , which holds given that  $I > F$  and  $pV - I > qH$  by assumption.

<sup>16</sup>The inequality holds since  $H > F$ .

(1) The firm's investment strategy is

$$\left\{ \begin{array}{ll} \text{Invest in LR project} & \text{if } \theta \geq \tilde{\theta}_2 \\ \text{Invest in HR project} & \text{if } \theta \in [\tilde{\theta}_1, \tilde{\theta}_2), \\ \text{Default} & \text{if } \theta < \tilde{\theta}_1 \end{array} \right.$$

where  $\tilde{\theta}_1$  is obtained from the firm's indifference condition of choosing between the HR project and default

$$K(\tilde{\theta}_1) = \tilde{\theta}_1 + W(\tilde{\theta}_1) = 0, \quad (5)$$

and  $\tilde{\theta}_2$  is obtained from the firm's indifference condition of choosing between the LR and HR projects

$$K(\tilde{\theta}_2) = \tilde{\theta}_2 + W(\tilde{\theta}_2) = I. \quad (6)$$

(2) Investor  $i$  buys the firm's bonds if and only if  $x_i \geq \tilde{x}$ , where  $\tilde{x}$  is obtained from the indifference condition (of buying or not buying the bond) of the marginal investor who receives signal  $\tilde{x}$

$$\text{Prob}[\theta \geq \tilde{\theta}_2 | \tilde{x}] \times pF + \left\{ \text{Prob}[\theta < \tilde{\theta}_2 | \tilde{x}] - \text{Prob}[\theta < \tilde{\theta}_1 | \tilde{x}] \right\} \times qF = 1, \quad (7)$$

where the first term of the left-hand side is the expected payoff on the LR project (given by the probability that the firm undertakes the LR project times the probability of success of the LR project,  $p$ , times the face value of bond,  $F$ ), while the second term is the expected payoff on the HR project (given by the probability that the firm undertakes the HR project, times the probability of success of the HR project,  $q$ , times the face value of bond,  $F$ ).

Proof: See Appendix A1.

## 2.2 Equilibrium with a CRA

We extend the benchmark model to allow for the presence of a credit rating agency. We first describe the rating strategy. Next, we derive the model's equilibrium and highlight the CRA's real effects. Given its payoff structure, the CRA assigns a rating  $p$  if and only if  $S^p - \mathbb{E}(C^p) > S^q - \mathbb{E}(C^q)$ . We can show that when the ratio of revenues to cost is sufficiently high, the CRA's equilibrium strategy is to inflate the rating by assigning only two ratings:  $R(\theta) = \{0, p\}$ .<sup>17</sup>

**Lemma 1** If  $S^p - S^q \geq (1 - q)(C^p - C^q)$ , the equilibrium strategy of the CRA is to assign an inflated rating, as follows:

$$R(\theta) = \begin{cases} p & \text{if } \theta \geq \theta_1^* \\ 0 & \text{if } \theta < \theta_1^*. \end{cases} \quad (8)$$

Proof. See Appendix A2.

In equilibrium, the CRA chooses a threshold  $\theta_1^*$  above which a  $\theta$ -firm receives a rating  $R(\theta) = p$ , while below the threshold the rating is  $R(\theta) = 0$ . In this model, *rating inflation* occurs when a  $\theta$ -firm receives a rating of  $p$  (i.e., implying it will undertake the LR project at date 1), while the firm undertakes the HR project and has, in reality, a credit quality of  $q$ . While rating inflation can emerge as an equilibrium strategy of the CRA, such inflated ratings are still informative about firm fundamentals and affect the optimal decision of investors. This is because an inflated rating implies that, if  $R = p$ , all investors know that  $\theta > \theta_1^*$  and, as a result, that the firm's fundamentals are not extremely low to the extent that would trigger an immediate default at date 1. We characterize the equilibrium of the model with a CRA in the following proposition.

**Proposition 2** The model with a CRA has a unique equilibrium described by  $(\theta_1^*, \theta_2^*, x^*)$ , with  $\theta_1^* < \theta_2^*$  such that:

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<sup>17</sup>As we want to investigate the relationship between inflated ratings, investor behaviour and firm investment, we focus only on the case of inflating strategy, and do not explore further the cases when the CRA deflates the rating or accurately reveals the firm's credit quality.

- (1) The CRA assigns rating  $R = p$  if  $\theta \geq \theta_1^*$ , and  $R = 0$  otherwise.
- (2) If  $R = 0$ , no investor buys bonds and the firm defaults at date 1.
- (3) If  $R = p$ , investors buy the bonds if and only if their private signals  $x$  are larger than  $x^*$ , where  $x^*$  is obtained from the indifference condition of the marginal investor

$$\frac{\text{Prob}[\theta \geq \theta_2^* \mid x^*]}{\text{Prob}[\theta \geq \theta_1^* \mid x^*]} \times pF + \frac{\text{Prob}[\theta < \theta_2^* \mid x^*] - \text{Prob}[\theta < \theta_1^* \mid x^*]}{\text{Prob}[\theta \geq \theta_1^* \mid x^*]} \times qF = 1. \quad (9)$$

The firm invests in the HR project if  $\theta_1^* \leq \theta < \theta_2^*$  and undertakes the LR project if  $\theta \geq \theta_2^*$ , where  $\theta_1^*$  solves

$$K(\theta_1^*) = \theta_1^* + W(\theta_1^*) = 0, \quad (10)$$

and  $\theta_2^*$  solves

$$K(\theta_2^*) = \theta_2^* + W(\theta_2^*) = I. \quad (11)$$

Proof: See Appendix A3.

We show next how, for a given  $\theta$ , the presence of the CRA affects a firm's investment decision compared to the benchmark model without the CRA. To study the CRA's real effects we characterize how the equilibrium thresholds in the two models relate. We can demonstrate the following:

**Lemma 2** When noise is small enough (i.e.,  $\epsilon < \bar{\epsilon}$  with  $\bar{\epsilon} \equiv \frac{(p-q)FI}{2(pF-1)} - \frac{1}{2}$ ), the following inequalities hold: (1)  $\theta_1^* < \tilde{\theta}_1$  and, (2)  $\theta_2^* < \tilde{\theta}_2$ . The sign of  $\theta_2^* - \tilde{\theta}_1$  is ambiguous.

Proof: See Appendix A4.

The intuition for Lemma 2 is that when the CRA communicates inflated ratings, more investors buy the firm's bonds. As a result of their investment decisions, the firm has more funds available, which allows access to the LR project or helps avoid default at date 1. The lower thresholds in the model with a CRA capture these effects.

We can identify the real effects of the CRA's ratings by analyzing the firm's investment



decision (which determines investors' expected payoff). We define a positive effect as a situation where a  $\theta$ -firm invests in the LR project whereas it would have invested in the HR project without the credit rating. Credit ratings can also have negative effects when a firm that would have defaulted without the rating gambles for resurrection in the presence of inflated ratings and invests in the HR project. We can now summarize the CRA's real effects as follows:

**Corollary 1.** There are two possible scenarios:

(1) When  $\theta_2^* > \tilde{\theta}_1$ , inflated ratings have a negative effect when  $\theta_1^* \leq \theta < \tilde{\theta}_1$  because a firm invests in the HR project instead of defaulting. When  $\theta_2^* \leq \theta < \tilde{\theta}_2$ , the CRA rating has a positive effect because the firm switches from investing in the HR project to the more efficient LR project.

(2) When  $\theta_2^* \leq \tilde{\theta}_1$ , inflated ratings have a positive effect when  $\theta_2^* \leq \theta < \tilde{\theta}_2$  and a negative effect when  $\theta_1^* \leq \theta < \theta_2^*$ .

Notice that the CRA's real effects depend on the model's parameters. In what follows, we present the calibration of the model that we use for our experimental design and illustrate the real effects of inflated credit ratings for a specific parametrization.

## 2.3 Predictions and hypotheses

We adapt the theoretical model for a laboratory experiment and calibrate it in order to solve numerically for the equilibrium thresholds described in Sections 2.1. and 2.2. To do so, we first compute the thresholds considering a finite number of investors. Following Heinemann et al. (2004; 2009), we employ the binomial distribution to calculate the mass of investors who buy the bond.<sup>18</sup> Specifically, we assume that the measure of investors  $W(\theta)$  from (2) is the probability that  $0, 1, 2, \dots, n$  out of  $n$  participants invest, where each participant invests for a signal above the threshold  $x^*$ , i.e., with probability  $m(\theta) = \Pr(x \geq x^* | \theta)$ . In other words,  $W(\theta) \sim B(n, m(\theta))$ . This implies that the expected number of investors buying the bond in

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<sup>18</sup>See also Peia and Vranceanu (2019) and Bayona and Peia (2022).

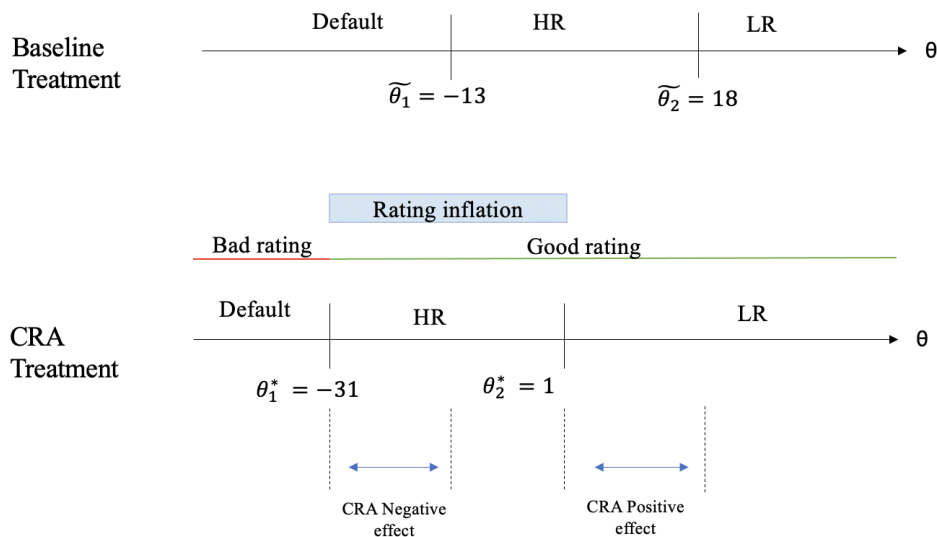
(5), (6), (10), and (11), is  $E[W] = n \times m(\theta)$ . We calibrate the model using the parameters presented in Table 1.

Table 1: Experimental parametrization

Initial endowment	100
Range of fundamentals ( $IF$ )	$[-400, 200]$
Price of bond ( $B$ )	100
Face value of bond ( $F$ )	200
Probability of success of LR project ( $p$ )	0.9
Probability of success of HR project ( $q$ )	0.2
Amount of financing to undertake LR ( $I$ )	300
Amount of financing to undertake HR ( $i$ )	0
Signal noise ( $\epsilon$ )	30

We use this calibration to compute the theoretical thresholds from Propositions 1 and 2. Figure 1 illustrates these thresholds and highlights the areas of firm fundamentals where the presence of the inflated credit rating can lead to positive and negative effects.<sup>19</sup>

Figure 1: Equilibrium illustration of firm and CRA actions.



<sup>19</sup>Investors' equilibrium threshold signals above which buying the firm's bonds is the dominant strategy are as follows:  $\tilde{x} = 14$  in the Baseline treatment and  $x^* = -5$  in the CRA treatment.

From these theoretical predictions, we develop several testable hypotheses that relate to the effects of an inflated credit rating on investors' actions and the firm's project choices.

Our first hypothesis concerns investor behaviour.

**H1** (*Investor behavior*). (i) Higher signals about fundamentals increase the probability of investing. (ii) For similar intermediate values of fundamentals, a good (but potentially inflated) rating increases investors' propensity to buy the bond compared to when there is no CRA.

Second, we conjecture that, when there is a CRA that inflates ratings, the higher level of external funds available to firms leads some of those with relatively low fundamentals to gamble for resurrection and invest in the high-risk project. As such, our second hypothesis is:

**H2** (*Negative effect of inflated ratings*). For similar levels of relatively low fundamentals, a firm that receives a good (but potentially inflated) rating has a higher propensity to choose the high-risk project instead of defaulting compared to when there is no CRA.

Hypothesis 2 follows from Corollary 1 and our specific parametrization. With our calibration, the threshold level of the firm's internal funds above which investing in the high-risk project is the firm's optimal strategy is lower in the equilibrium with a CRA than in the equilibrium without a CRA (i.e.,  $\theta_1^* < \tilde{\theta}_1$ ). We thus predict that for an intermediate range of relatively low firm fundamentals there is more investment in the high-risk project when an inflated rating is available. Subsequently, early firm default is less likely in the presence of a public credit rating. This prediction follows from Lemma 2, where we have shown that there is a lower probability of firm default at date 1 when ratings are provided. Thus, unless a firm's fundamentals are very poor, we expect that a firm enjoys an increased supply of funds from investors when the rating is available. Better access to finance, in turn, increases the probability that external funds will cover potential losses from ongoing activities reducing the likelihood of early default.

At the same time, the increased availability of external funding in the presence of inflated ratings allows some firms with relatively high fundamentals to undertake the low-risk project. Our third hypothesis predicts that:

**H3** (*Positive effect of inflated ratings*). For similar levels of intermediate fundamentals, a firm that receives a good (but potentially inflated) credit rating has a higher propensity to choose the low-risk project versus the high-risk project compared to when there is no CRA.

This hypothesis also derives from Corollary 1. Note that the threshold level of firm fundamentals above which investing in the low-risk project is the firm's optimal strategy is lower in the equilibrium with a CRA than when a CRA is absent (i.e.,  $\theta_2^* < \tilde{\theta}_2$ ). We predict that for an intermediate range of relatively high firm fundamentals, there is more investment in the low-risk project when an inflated rating is available.

### 3 Experimental design and procedures

We design a laboratory experiment to understand the informational role of (inflated) credit ratings and their impact on investment decisions. The experiment has two parts. In Part I, participants play the role of investors who decide whether to finance a firm or not. The computer plays the firm's role taking the optimal investment decisions as outlined in (4). Participants play the coordination game for 15 independent rounds in groups of five with random matching between rounds. Subjects are endowed with 100 experimental currency points (EC) in each round. They have to choose one of the following two decisions: (a) *Do not invest* and keep the initial 100 EC or (b) *Invest* and finance the firm with 100 EC.

If a participant chooses to invest, their payoff from investing depends on the firm's action. If the firm invests in the LR project, participants obtain 200 EC with 90% probability and 0 with 10% probability. When the firm invests in the HR project, participants get 200 EC with 20% probability and 0 with 80% probability. Finally, participants obtain 0 EC with certainty if the firm defaults.

The firm's action depends on how much financing is available. There are two types of funds: internal (IF) and external (EF). In each round, the firm's IF are randomly selected from the uniform distribution  $U \sim [-400, 200]$ . The IF are the same for all the investors in a group. The EF depend on how many investors from a group choose to invest. Similar to (4), the firm's decision is as follows: if  $300 \leq IF + EF$ , the firm has enough funds to take the LR project; otherwise, the firm chooses the HR project when  $0 \leq IF + EF < 300$  or defaults when  $IF + EF < 0$ .

We consider two treatments in a between-subject design, which differ in the information provided to participants: the *Baseline treatment* and the *CRA treatment*. Participants receive a private signal about the firm's IF in both treatments. The signal is drawn independently from the uniform distribution  $U[IF - 30, IF + 30]$ . In the Baseline treatment, participants do not receive further information beyond their noisy private signal. In contrast to the Baseline treatment, in the CRA treatment participants also observe a public credit rating about the firm's ability to repay its creditors.

Specifically, we inform participants in the CRA treatment that there is a credit rating agency that assigns a public credit rating to the firm before participants' decisions and the firm's action. In the instructions, we explain that a credit rating is a grade that indicates the firm's ability to repay its investors. The rating can be either *A* or *B* (corresponding to the inflated rating,  $p$ , and the default rating, 0, from Section 2, respectively). We inform participants that, in each round, the rating agency uses a theoretical scoring model to predict the ability of the firm to repay its investors. We explain how the CRA's model considers the firm's IF (which it knows perfectly), and how the rating might affect a hypothetical investor's decision and, thus, the total amount of funds available to the firm and its corresponding action. Participants receive the following information regarding the process of assigning the ratings:

*Rating of A* when the firm's IF are greater than or equal to  $-31$ . The CRA estimates that the A-rated firm will invest in the LR project and investors have a 90% probability

of being repaid.

*Rating of B* when the firm's IF are smaller than  $-31$ . The CRA estimates that the B-rated firm will default and investors have a 0% probability of being repaid.<sup>20</sup>

Participants are not directly informed that the rating is inflated.

In each round, before taking their decisions, we elicited participants' beliefs about the true level of the firm's internal funds and the behaviour of other subjects in their group. First, we asked participants to provide a point estimate for the firm's IF. Then, all participants had to state how many other subjects from their group were expected to invest.<sup>21</sup> Once beliefs were elicited, participants had access to a simulator and could take their decisions.

Participants received written instructions at the beginning of the session. In the instructions, we provide examples of the firm's actions and investors' expected payoffs conditional on hypothetical estimated values of the IF and a hypothetical number of participants that choose to invest.<sup>22</sup> Before Part I of the experiment started, each participant had to pass a test with control questions to ensure that they understood the payoff structure and the decision process.<sup>23</sup> After all participants have made their decisions, they learn at the end of each round about the true level of the firm's IF, how many other participants choose Invest, the firm's action, and their potential payoffs in EC.

In Part II of the experiment, we asked participants to conduct two individual incentivized tasks. In the first task, we elicited risk aversion as in [Eckel and Grossman \(2008\)](#) and [Dave et al. \(2010\)](#). In the second task, participants answered a loss aversion questionnaire based on [Gächter et al. \(2022\)](#). Participants earned EC points depending on the outcome of the risky lotteries they choose in each task (see Appendix C for details). After Part II of the experiment, we asked several questions regarding their behaviour throughout the experiment (using Likert scales) and elicited selected socioeconomic characteristics through

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<sup>20</sup>Note that  $-31$  corresponds to the theoretical threshold  $\theta_1^*$  from Proposition 2 under our parametrization from Table 1.

<sup>21</sup>Appendix C shows the screenshots from the first part of the experiment. Beliefs were not incentivized.

<sup>22</sup>Appendix B presents the instructions for the CRA treatment.

<sup>23</sup>Figure 10 (from Appendix D) presents the practice questions. These questions were not paid.

an on-screen questionnaire. In terms of earnings, the computer randomly selected one of the 15 rounds from Part I to determine the participants' payoffs for this part of the experiment. We informed participants about their earnings for Part I and Part II of the experiment at the end of the session. For both parts of the experiment, 15 EC translated into 1 Euro for payment.

We conducted 12 experimental sessions, with either 15 or 20 participants in each session. In total 230 students (115 in each treatment) participated in our experiment at ESADE's Decision Lab and Univeristat Pompeu Fabra BESLab, both in Barcelona (Spain).<sup>24</sup> On average, participants earned 18.05 Euros, and the experiment lasted approximately 75 minutes.

## 4 Results

We present the results by first describing aggregate investment behaviour and firm outcomes at the group level, followed by an analysis of the predictors of individual investment behaviour. We then investigate the channels that explain differences in investment behaviour across treatments.

### 4.1 Group level analysis

We start by analyzing how investment behavior changes across the two treatments for different values of the firm's internal funds. Specifically, we compare the provision of external funding for firms with similar values of IF that correspond to the good (A) or bad (B) rating, but for which the rating is only observed in the CRA treatment. Table 2 provides summary statistics of the aggregate investment behaviour per treatment depending on whether fundamentals are sufficiently high (low) to receive a good (bad) rating. For both treatments, we report the average number of investors for firms with fundamentals below and above the

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<sup>24</sup>The experiment was programmed and run using z-Ttree software (Fischbacher, 2007). Table 14 (from Appendix D) summarizes the sessions.

Table 2: Average number of participants that invest in each treatment

Treatment	Baseline		CRA		Tests (p-values)			
	(1) Rating A	(2) Rating B	(3) Rating A	(4) Rating B	(1) vs. (3) Test 1	(3) Test 2	(2) vs. (4) Test 1	(4) Test 2
Hypothetical/ Observed rating								
Invest	4.03 (1.3)	0.83 (1.02)	4.331 (0.93)	0.396 (0.67)	0.02	0.248	0.00	0.021
Observations	146	199	163	182	381	12	309	12

*Notes:* Columns (1)-(4) present the mean (standard deviation) of the number of subjects (per group) investing conditional on the treatment and observed (in the CRA treatment)/hypothetical (in the Baseline treatment) rating. Test 1 is a t-test of equality of means performed at the group level. Test 2 is a non-parametric K-sample test on the equality of medians performed at the session level.

threshold separating the two ratings in the CRA treatment.<sup>25</sup> These averages are based on group outcomes in our sample of 690 unique group-period observations (46 random groups  $\times$  15 periods).

We observe a higher average number of investors in the CRA treatment compared to the Baseline for values of the fundamentals corresponding to the good rating (A) (column 1 vs. column 3) and a lower average number of investors for the bad rating (B) (column 2 vs. column 4). Throughout the analysis, we assess the statistical significance of the differences across treatments through t-tests at the group level (690 group-period observations) and non-parametric tests at the session level (6 observations per treatment).<sup>26</sup> These tests, presented in the last four columns of Table 2, show that the observed differences are statistically significant, albeit less conclusive for the good rating, where the non-parametric test is not significant at conventional levels.<sup>27</sup>

**Result 1** Firms in the CRA treatment with a good (bad) rating receive significantly more (less) external funding than firms in the Baseline treatment with similar fundamentals.

To understand the relationship between firm fundamentals and group investment behaviour, we run a series of regression analyses on the group (firm)-level. Specifically, in Table 3, we

<sup>25</sup>The threshold above which a good (A) rating is assigned equals -31. Participants are informed about the value of this threshold in the CRA treatment instructions.

<sup>26</sup>We obtain similar statistical results (unreported, available on request) using the non-parametric Mann-Whitney U test.

<sup>27</sup>Figure 6 (from Appendix B) illustrates the impact of a credit rating on aggregate investment behaviour.



investigate whether the size of the external funding (i.e., the number of investors buying the firm's bonds) varies across the two treatments for different quartiles of fundamentals. We run a series of Poisson models where the dependent variable is the number of investors buying the firm's bond. The main covariate is an indicator variable equal to one for the CRA treatment and zero for the Baseline treatment. In all regressions, we control for the size of the firm's internal funds (IF) and a period scalar. Column (1) shows that, as expected, external financing is increasing in the firm's internal funds. This result is robust across different sub-samples of the data. However, the CRA treatment dummy in column (1) is not statistically significant, suggesting no significant difference between the treatments in average investment. Exploring further the aggregate investment behavior across varying levels of fundamentals, we find in columns (2)-(7) significant differences between the two treatments across different quartiles of internal funds. In column (3), we find that, for relatively low fundamentals (i.e., 2<sup>nd</sup> quartile), there is significantly less investment in the CRA than in the Baseline treatment (on average, 0.46 investors as compared to 0.97 in the Baseline Treatment). Conversely, results from column (4) suggest that there is significantly more investment in the CRA treatment (3.44 vs. 2.80 investors) for firms with relatively high fundamentals (i.e., 3<sup>rd</sup> quartile).<sup>28</sup> Finally, columns (6)-(7) corroborate the findings from Table 2: there is a higher average number of investors in the CRA treatment for firms with fundamentals corresponding to the good rating (A) and a lower average for those with fundamentals corresponding to the bad rating (B). These results are generally consistent with Hypothesis H1, which we will test further in Section 4.2, where we examine individual investment behaviour.

The observed variations in external funding across treatments promote significant differences in firms' actions across the two treatments, as illustrated in Figure 2. We observe a significantly higher proportion of firms undertaking the low-risk project in the CRA treatment

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<sup>28</sup>We report in Table 10 (from Appendix B) the average number of investors across quartiles of fundamentals. Corroborating the results from Table 3, we observe significant differences in the 2<sup>nd</sup> and 3<sup>rd</sup> quartiles, corresponding to values of firm IF in the interval [-137, 20], which includes the rating threshold. There is no significant difference between the two treatments in the average number of investors for low and high values of the fundamentals corresponding to the 1<sup>st</sup> and 4<sup>th</sup> quartiles.

Table 3: Size of investment across different ranges of fundamentals

Dependent variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Size of investment	All	Quartile 1	Quartile 2	Quartile 3	Quartile 4	Bad rating (B)	Good rating (A)
Internal funds (IF)	0.006*** (0.000)	0.001 (0.003)	0.013*** (0.002)	0.014*** (0.002)	0.001** (0.000)	0.006*** (0.001)	0.002*** (0.000)
CRA treatment	0.048 (0.063)	-0.513 (0.382)	-0.821*** (0.267)	0.210* (0.109)	0.020 (0.021)	-0.707*** (0.219)	0.112** (0.053)
Period	0.001 (0.006)	-0.085*** (0.029)	-0.060* (0.032)	0.006 (0.008)	0.005** (0.003)	-0.052*** (0.015)	0.010*** (0.003)
Observations	690	174	172	172	172	381	309

*Notes:* The table presents estimates from Poisson regressions where the dependent variable is the number of investors in a group buying the firm's bond. *Internal funds (IF)* captures the firm fundamentals. *CRA treatment* is an indicator variable equal to 1 if the treatment is CRA. *Period* indicates the round of the investment game. Constant terms are included, but not reported. Standard errors clustered at the session level are reported in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

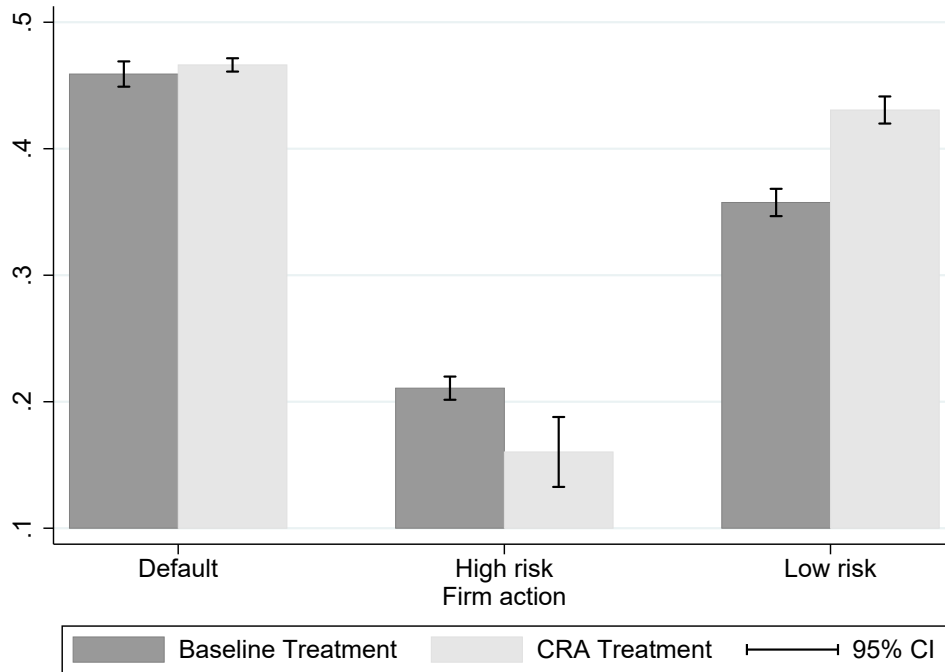
than in the Baseline treatment (43% vs. 36%).<sup>29</sup> At the same time, the proportion of high-risk projects is lower in the CRA treatment (16% vs. 21%). However, there is no significant difference in the number of early defaults between the two treatments (43% vs. 46%).

**Result 2:** Firms in the CRA treatment are more (less) likely to undertake the low- (high-) risk project than in the Baseline treatment. There is no significant difference in default rates across the two treatments.

These results are confirmed in Table 4 in a series of probit regressions that investigate differences in firms' actions conditional on the presence of a credit rating. The dependent variables are indicator variables for the different firm actions: early default in column (1), high-risk project in columns (2)-(3), and low-risk project in column (4). The main covariates are two indicator variables that allow us to compare firms with fundamentals above or below the rating threshold in the two treatments. Specifically, the variable *Bad rating (B)* takes value one for firms in the CRA treatment with IF below -31 and zero when the firm is observed in the Baseline treatment and the firm's IF are below -31. Likewise, the variable *Good rating (A)* is an indicator variable equal to one for a firm from the CRA treatment with fundamentals above -31 and zero for a firm from the Baseline treatment with fundamentals above -31. As such, the specifications in columns (1)-(4) allow us to compare the informational role of

<sup>29</sup>Table 11 (from Appendix B) shows the proportion of firms undertaking the high- (low-) risk projects or defaulting early in the two treatments, together with tests assessing the statistical significance of the differences across treatments.

Figure 2: Firms' actions across treatments



*Notes:* The figure shows the proportion of firms across the two treatments conditional on their actions. The sample size is 690 firm outcomes (groups of investors). Whiskers mark the 95% confidence interval.

ratings by looking at firms with fundamentals either below or above the rating threshold, but for which the public rating is observed only in the CRA treatment. Results from column (1) show that firms receiving a bad rating in the CRA treatment are more likely to default than firms in the Baseline treatment with similar fundamentals. In column (2), we observe that a bad rating is associated with less firm investment in the HR project in the CRA treatment. Importantly, receiving a good rating is not associated with a significantly higher probability of undertaking the HR project in the CRA treatment compared to the Baseline treatment (column (3)). Results from columns (1)-(3) suggest that firms in the CRA treatment are less likely to gamble for resurrection by investing in the HR project. These results reject Hypothesis H2 on the negative effects of inflated ratings. Finally, column (4) shows that receiving a good rating leads to a significantly higher probability of investing in the LR project for firms in the CRA treatment. This finding supports our Hypothesis H3 on the

Table 4: Ratings and firms' actions

	(1) Default	(2) High risk	(3) High risk	(4) Low risk
Internal funds (IF)	-0.023*** (0.003)	0.021*** (0.002)	-0.037*** (0.005)	0.044*** (0.006)
Bad rating (B)	0.974*** (0.343)	-0.800*** (0.248)		
Good rating (A)			-0.773* (0.396)	1.009** (0.463)
Observations	381	381	309	309

*Notes:* The table reports estimates from probit regressions where the dependent variable is an indicator variable equal to 1 if the firm defaults early (column (1)), invests in the HR project (columns (2)-(3)), or invests in the LR project (column (4)). *Internal funds (IF)* captures the firm fundamentals. *Good rating (A)* (*Bad rating (B)*) is an indicator variable equal to 1 if the treatment is CRA and the firm's IF are above (below) -31 and 0 if the treatment is the Baseline and the firm's IF are above (below) -31. Constant terms are included, but not reported. Standard errors clustered at the session level are reported in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

positive effects of inflated ratings.<sup>30</sup>

Together, these results point to a significant informational role of inflated credit ratings. Our findings suggest that the presence of the (biased) public signal can impact investors' behaviour and firms' actions. While theoretically we show that inflated ratings can have negative and positive effects, the empirical results reveal an asymmetric impact. Given the ranking of projects' efficiency assumed in Section 2 (i.e.,  $pV > qH$ , corresponding to the higher efficiency of the LR project) and the significantly higher (lower) proportion of firms undertaking the LR (HR) project in the CRA treatment (see Table 11 from Appendix B), our results point to an overall positive effect of inflated ratings on economic efficiency.

**Result 3** Firms in the CRA treatment with a good rating invest more in the low-risk project than firms in the Baseline treatment with similar fundamentals. Conversely, firms

<sup>30</sup>In Table 12 (from Appendix B) we show that these results are mainly driven by differences in firms' actions across the intermediate values of the firms' fundamentals. Specifically, we observe a significantly lower (higher) proportion of firms undertaking the high (low) risk project in the 3<sup>rd</sup> quartile of IF in the CRA treatment as compared to the Baseline treatment. For low (high) fundamentals values (i.e., in the 1<sup>st</sup> and 4<sup>th</sup> quartiles, respectively), there is no significant difference in the proportion of firms defaulting (or taking the risky projects) between the treatments.

Table 5: Probability of investing across different ranges of fundamentals

	(1) All	(2) Quartile 1	(3) Quartile 2	(4) Quartile 3	(5) Quartile 4	(6) Bad rating (B)	(7) Good rating (A)
Hint about IF	0.010*** (0.001)	0.002 (0.002)	0.012*** (0.002)	0.030*** (0.003)	0.007*** (0.002)	0.006*** (0.001)	0.014*** (0.002)
CRA treatment	-0.027 (0.111)	-0.366 (0.383)	-0.748*** (0.226)	0.395** (0.190)	0.190 (0.271)	-0.598*** (0.183)	0.562*** (0.179)
Period	-0.006 (0.008)	-0.098*** (0.032)	-0.058*** (0.022)	0.029** (0.015)	0.060** (0.026)	-0.046*** (0.013)	0.055*** (0.015)
Observations	3,450	870	860	860	860	1,905	1,545

*Notes:* The table presents estimates from probit regressions for different samples where the dependent variable is an indicator equal to 1 if the investor buys the firm's bond. *Hint about IF* captures the private information about firm fundamentals. *CRA treatment* is an indicator variable equal to 1 if the treatment is CRA. *Period* indicates the round of the investment game. Constant terms are included, but not reported. Standard errors clustered at the session level are reported in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

with a bad rating invest less in the high-risk project in the CRA treatment than in the Baseline treatment.

We next examine individual decisions and potential channels that could explain differences in investment behavior across treatments.

## 4.2 Individual investment behavior

We start by examining whether individual behaviour aligns with the global games equilibrium selection criteria (i.e., subjects' investment decisions are an increasing function of the hint about the firm's internal funds).

Table 5 presents a multivariate analysis of the individual probability of investing for different samples corresponding to varying levels of fundamentals. We observe that in all samples there is a positive and statistically significant correlation between the propensity to invest and the private signal. This result is consistent with Hypothesis H1(i). The coefficient of the *CRA treatment* dummy in columns (1), (2), and (5) is not statistically significant, suggesting that there is no significant difference between the treatments in the average probability of investing (column (1)) nor for the lowest (column (2)) and highest (column (5)) levels of fundamentals. However, similarly with the results from Table 3, the results in columns (3)-(4) confirm that for relatively low (high) fundamentals (i.e., 2<sup>nd</sup> and 3<sup>rd</sup> quartiles, respectively) there is significantly lower (higher) probability of investing in the CRA than in the Baseline

Table 6: Probability of investing across treatments

	Baseline				CRA			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Hint about IF	0.009*** (0.001)	0.006*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.011*** (0.001)	0.005*** (0.001)	0.004*** (0.001)	0.001 (0.001)
Belief about IF		0.004*** (0.001)		0.000 (0.001)		0.008*** (0.001)		0.004*** (0.001)
Belief # investors			1.137*** (0.092)	1.135*** (0.096)			1.043*** (0.103)	0.996*** (0.096)
Period	-0.011 (0.010)	-0.005 (0.010)	-0.006 (0.014)	-0.006 (0.014)	0.002 (0.009)	0.018* (0.009)	-0.004 (0.010)	0.006 (0.011)
Observations	1,725	1,725	1,725	1,725	1,725	1,725	1,725	1,725

*Notes:* The table presents estimates from probit regressions where the dependent variable is an indicator equal to 1 if the investor buys the firm's bond. *Hint about IF* captures the private information about firm fundamentals. *Belief about IF* and *Belief # investors* capture the stated beliefs (as a number) about firm fundamentals and the other participants investing, respectively. Standard errors clustered at the subject level are reported in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

treatment. Columns (6)-(7) consider the treatment effect in samples of firms with fundamentals corresponding to the bad (B) and good (A) ratings, respectively. We document a significant decrease in the probability of investing in the CRA treatment when a bad rating is disclosed and the opposite effect for a good rating.

We show next that participants' actions are consistent with their elicited beliefs. Table 6 shows how the probability of investing in each treatment relates to participants' stated beliefs about the true value of the fundamentals and the number of others investing. Recall that we elicit these beliefs before the decision to invest is taken in each period. Columns (2) and (6) consider the effect of beliefs about firm fundamentals on the investment decision. The coefficient of *Belief about IF* is positive and statistically significant, indicating that the probability of investing increases in the beliefs about fundamentals. Likewise, in columns (3) and (7), we find a similar relationship between the likelihood of investing and the beliefs about the number of others investing. The point estimates reported for *Belief # investors* in columns (3) and (7) are much larger than those reported for *Belief about IF* in columns (2) and (6), suggesting that the effect of the expected behaviour of other investors on subjects' decisions is larger than the impact of the beliefs about fundamentals. Simultaneously including beliefs about firms and other investors in columns (4) and (8) confirms that the expected behaviour of others is a stronger predictor of investment.

**Result 4:** The expected behaviour of other investors is a strong predictor of a participant's investment decision, whereas the belief about the firm's fundamentals matters less.

#### 4.2.1 Channels

We investigate two channels that can potentially explain the differences in behavior across the two treatments. The first channel relates to the impact of ratings on the beliefs about the firm's fundamentals. In the theoretical model presented in Section 2, inflated ratings have real effects because they provide useful information to investors: a good rating implies that the firm does not have extremely low fundamentals, and, as a result, will not default early. As such, we conjecture that inflated ratings increase the propensity of investing by conveying positive information about the firm. Specifically, due to the partial verifiability constraint imposed on the CRA, observing a good rating (i.e., rating A) truncates investors' posterior beliefs about the firms' fundamentals from below  $-31$ . This, in turn, could make them more optimistic about the firm prospects and more likely to purchase the bond.

We start by investigating how the credit rating affects investors' posterior beliefs about firm fundamentals. In particular, for regions of IF that are close to the rating threshold, observing the rating should allow subjects to form more accurate posterior beliefs about the firm's IF.<sup>31</sup> Figure 3 shows the average stated belief about IF and the forecast error (measured as the absolute value of the difference between stated beliefs and actual fundamentals) across treatments. We find that posterior beliefs about fundamentals are not significantly different across the two treatments (p-value=0.11; 0.5).<sup>32</sup> However, participants seem to be more optimistic in the CRA treatment about the value of IF for good ratings: they have a higher average belief about IF (panel (a)), but they also exhibit a higher forecast error (panel (b)). For the bad ratings, average beliefs are more pessimistic, and the forecast error is slightly

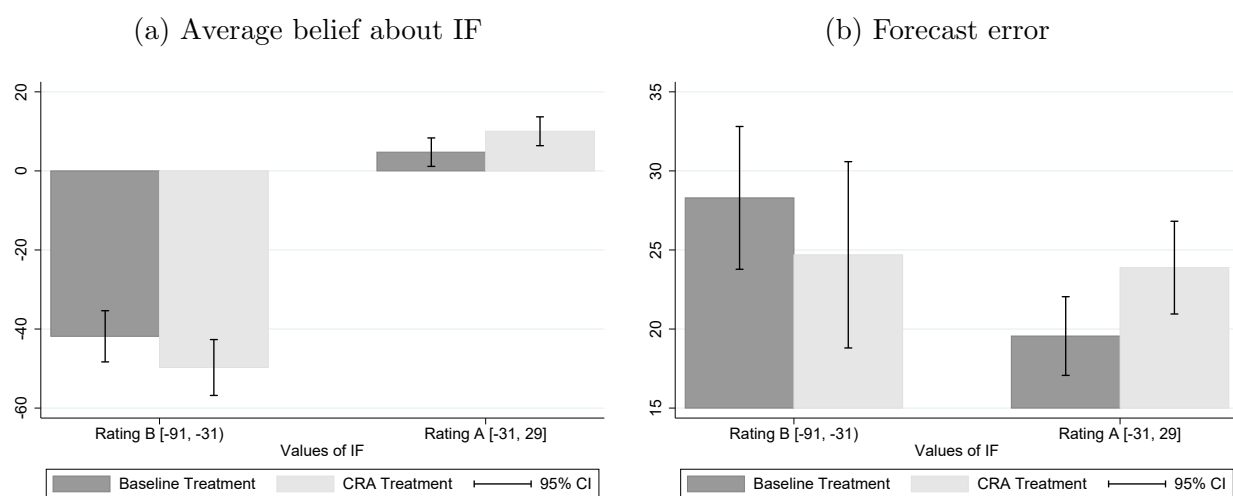
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<sup>31</sup>Specifically, for fundamentals that are  $2\epsilon$  around the theoretical threshold, observing the rating will result in a truncated posterior distribution of IF. This is because for a given  $\theta = \theta_1^*$  subjects observing the lowest ( $\theta_1^* - \epsilon$ ) or higher ( $\theta_1^* + \epsilon$ ) private signal will have a posterior distribution of  $\theta$  over the maximum interval  $[\theta_1^* - 2\epsilon, \theta_1^* + 2\epsilon]$ .

<sup>32</sup>The p-values reported in parenthesis in this section refer to (1) a t-test on the entire sample of individual decisions and (2) a non-parametric K-sample test on the equality of medians performed at the session level.

lower than in the Baseline treatment.

Figure 3: Beliefs about the firm's fundamentals



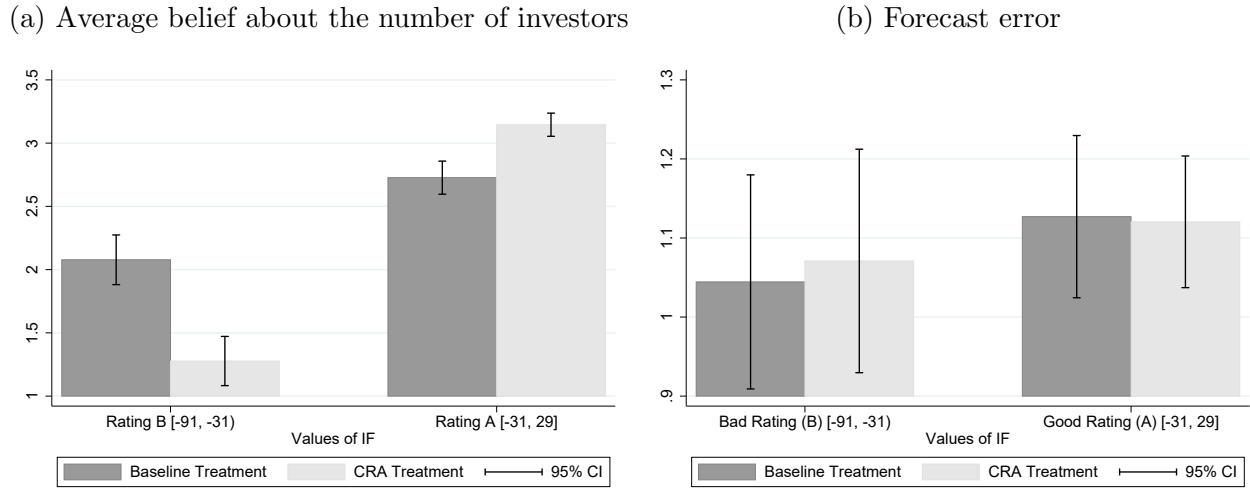
*Notes:* Panel (a) shows the average stated belief across participants about the value of the firm's fundamentals around the rating threshold (-31). Panel (b) shows the forecast error measured as the absolute value of the difference between stated beliefs and actual fundamentals. Whiskers mark the 95% confidence interval.

**Result 5:** Posterior beliefs about the firm's fundamentals are not statistically different across the treatments around the rating threshold. However, investors are more optimistic (pessimistic) about a firm's fundamentals in the case of a good (bad) rating in the CRA treatment than in the Baseline treatment. Still, investors lack accuracy in their posterior beliefs about fundamentals in both treatments.

A second channel that may explain the differences in investors' behaviour across treatments relates to the impact of the rating on the beliefs about the behavior of others. Figure 4 shows the average stated beliefs about the number of others investing around the rating threshold (panel (a)) and the forecast error (panel (b)) across the two treatments. We observe that the average stated beliefs about the number of others investing is significantly higher for values of the fundamentals that correspond to the good rating ( $p\text{-value} < 0.001; 0.02$ ) in the CRA treatment compared to the Baseline treatment. The opposite occurs for values of the fundamentals corresponding to the bad rating. Participants hold significantly lower beliefs about the number of others investing ( $p\text{-value} < 0.001; 0.02$ ) in the CRA treatment compared



Figure 4: Beliefs about the investment behavior of others



*Notes:* Panel (a) shows the average stated belief across participants about the number of others investing around the rating threshold (-31). Panel (b) shows the forecast error measured as the absolute value of the difference between stated beliefs and the actual number of other participants investing. Whiskers mark the 95% confidence interval.

to the Baseline. However, the rating does not improve the accuracy of posterior beliefs about the behaviour of others.<sup>33</sup>

**Result 6:** Posterior beliefs about others' investment behavior are statistically different across the treatments around the rating threshold. Investors are more optimistic (pessimistic) about the investing behaviour of others for a good (bad) rating in the CRA treatment than in the Baseline treatment. However, investors lack accuracy in their posterior beliefs about others' actions in both treatments.

We confirm these individual-level results through a series of regressions that allow us to cluster standard errors at the subject level to account for the correlation in investment decisions across periods. Columns (1)-(2) in Table 7 show results of probit models that investigate differences in the probability of investing conditional on the presence of a credit rating. The dependent variable is an indicator equal to 1 if a participant invests. In all

<sup>33</sup>We report in Appendix B the posterior beliefs about firm fundamentals and the behaviour of others across quartiles of fundamentals. Figure 7 illustrates the differences across the two treatments.

specifications, the variable *Good rating (A)* takes value 1 for firms in the CRA treatment with IF above -31 and 0 when the firm is observed in the Baseline treatment and the firm's IF are above -31. Likewise, the variable *Bad rating (B)* is an indicator variable equal to 1 for a firm from the CRA treatment with fundamentals below -31 and 0 for a firm from the Baseline treatment with fundamentals below -31. As such, the specifications in columns (1)-(6) allow us to compare the informational role of ratings by looking at investors in firms with fundamentals either above or below the rating threshold but for which the public rating is observed only in the CRA treatment. Similar to our group-level findings reported in Table 4, we find that investors are more (less) likely to invest in firms receiving a good (bad) rating in the CRA treatment than in firms with similar fundamentals in the Baseline treatment.

In columns (3)-(6), we confirm the results reported in Figures 3 and 4 by showing how the presence of a rating in the CRA treatment affects the beliefs about fundamentals and the number of others investing. On the one hand, the results in columns (3) and (4) confirm that the rating does not affect the posterior beliefs about firm fundamentals in our treatments. On the other hand, the estimates from columns (5) and (6) reveal that the beliefs about the number of others investing are significantly higher (lower) in the CRA treatment compared to the Baseline treatment for values of the fundamentals corresponding to a good (bad) rating. We observe that the coefficient for the *Good rating (A)* from column (5) is almost half the value (in absolute terms) of the estimate for the *Bad rating (B)* from column 6, suggesting that the effect on beliefs is larger for the bad rating.

**Result 7:** The effect of a bad rating on the beliefs about the behaviour of other investors is larger than that of a good rating.

Results 4-7 speak to models that study public and private signals in games with strategic complementarities (Heinemann *et al.*, 2004; Cornand and Heinemann, 2014b; Baeriswyl and Cornand, 2016; Shurchkov, 2016; My *et al.*, 2021). We provide novel empirical evidence on the key mechanisms emphasized in these models. A key result in this literature is that public information has a larger impact on equilibrium outcomes because public signals are

Table 7: Ratings, investment behavior and beliefs

Dependent variable	$\mathbb{1}\{\text{Invest} = 1\}$		Belief fundamentals		Belief number investors	
	(1)	(2)	(3)	(4)	(5)	(6)
Hint about IF	0.014*** (0.002)	0.006*** (0.001)	0.870*** (0.015)	0.927*** (0.011)	0.015*** (0.001)	0.010*** (0.001)
Good rating (A)	0.562*** (0.166)		5.059 (3.203)		0.574*** (0.140)	
Bad rating (B)		-0.598*** (0.150)		1.275 (7.047)		-0.961*** (0.157)
Period	0.055*** (0.015)	-0.046*** (0.017)	0.173 (0.150)	-2.628*** (0.423)	0.089*** (0.010)	-0.064*** (0.018)
Observations	1,545	1,905	1,545	1,905	1,545	1,905
Number of subjects	230	230	230	230	230	230

*Notes:* Columns (1)-(2) report estimates from probit regressions where the dependent variable is an indicator equal to 1 if a participant invests. Columns (3)-(4) present estimates from OLS regressions where the dependent variable is the stated belief about the value of the firm's internal funds (IF). Columns (5)-(6) report estimates from ordered logit regressions where the dependent variable is the stated belief about the number of participants that buy the bond. *Hint about IF* captures the private information about firm fundamentals. *Good (Bad) rating A (B)* is an indicator variable equal to 1 if the treatment is CRA and the firm's IF are above (below) -31 and 0 if the treatment is the Baseline and the firm's IF are above (below) -31. Standard errors clustered at the subject level are reported in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

more informative about the behavior of others. We confirm that the public credit ratings act as focal points for participants' coordination problem, even if they only have a modest impact on beliefs about firms' fundamentals. The reason is that observed ratings have a strong coordination effect on the beliefs of investors about their mutual investment behavior. Put differently, this pattern emphasizes the role of public credit ratings in reducing strategic uncertainty about the actions of others. Notably, the enhanced coordination has positive welfare implications in a setting with feedback effects between the financial and real sectors. As shown in Section 4.1 (see Figure 2), inflated ratings lead, on average, to a significantly higher (lower) proportion of firms undertaking the efficient, low-risk project (high-risk project). We can now provide the mechanism behind this result: for good (potentially inflated) ratings, investors hold significantly higher beliefs about the number of others investing. This leads to higher coordination on investing and, in a framework with feedback effects, to more efficient firm investment and better credit quality. Conversely, for bad ratings, investors coordinate on the decision not to invest, which results in less external

funding and less firm investment in risky projects.

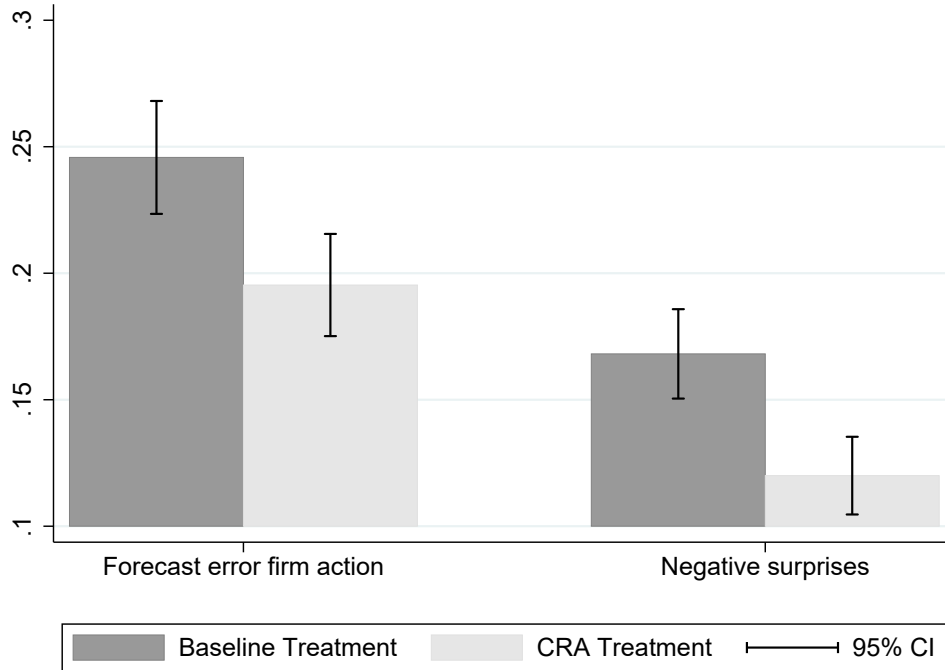
We further investigate whether participants' expected earnings from investing are also higher in the CRA treatment. To this end, we first compute for both treatments the total ex-ante expected gains of participants who invest. Specifically, the ex-ante gain from investing is 180 (200 with probability 90%) if the firm undertakes the LR project and 40 (200 with probability 20%) if the firm undertakes the HR project. We sum these anticipated gains across all investors that buy the bond and weigh this sum by the proportion of firms undertaking each type of project in each treatment. We then compare the total expected gains across the two treatments using non-parametric tests at the session level. We find that, on average, there is a significantly higher total expected return from investing in the CRA treatment than in the Baseline (p-value=0.021).

Next, we show that participants are better at forecasting the firm's action and are less likely to be negatively surprised by firm outcomes in the CRA treatment. Figure 5 (left panel) shows the average forecast error about firm action measured as the absolute value of the difference between the expected and realized firm actions. We compute the expected firm action based on a subject's stated beliefs about firm fundamentals and the behaviour of others.<sup>34</sup> We find that participants can better forecast the actual firm action in the CRA than in the Baseline treatment (p-value = 0.001). This should also lead to fewer instances where a participant is negatively surprised by the firm outcome. We define a negative surprise as a situation where (i) the firm undertook the HR project or defaulted, while the participant expected the firm to undertake the LR project, or (ii) the actual firm action was to default, while the participant expected an HR/LR project to be undertaken. In the right panel of Figure 5, we show that the percentage of cases where firms' outcomes were worse than expected based on participants' stated beliefs is significantly lower in the CRA treatment (p-value < 0.001).

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<sup>34</sup>For example, if a participant who invests has a stated belief about the firm fundamentals of 50 and their belief about the numbers of others investing is 3, the expected firm action is LR (since  $50 + 4 \times 100 > 300$ ).

Figure 5: Expectations and realized firm action



*Notes:* The left panel shows the average forecast error with regards to the firm action measured as the absolute value of the difference between the expected and realized firm actions. The expected firm action is computed based on the stated beliefs about firm fundamentals and behaviour of others. Firm actions are codified as 1, 2, and 3 corresponding to Default, HR and LR, respectively. The right panel shows the percentage of negative surprises, where negative surprises are measured as instances when the firm outcome is worse than expected. Whiskers mark the 95% confidence interval.

**Result 8:** Investors are better at forecasting the firm’s action and are less likely to be negatively surprised by firm outcomes in the CRA treatment.

### 4.3 Robustness tests and additional results

We provide several additional results and robustness tests for our main findings from the previous sections. First, we show that our individual-level results are robust to controlling for risk and loss aversion metrics, as well as for participants’ socioeconomic characteristics or experience in the game. Table 8 replicates the results from Table 7 including these additional covariates. We include indicator variables capturing risk and loss aversion, following the tests

proposed in [Dave \*et al.\* \(2010\)](#) and [Gächter \*et al.\* \(2022\)](#), respectively.<sup>35</sup> We control for the following selected socioeconomic characteristics of subjects: gender, and whether the subject has more than one bank account or invests in capital markets. Finally, we control for past outcomes in the experiment by including a variable that captures the average number of negative surprises in previous rounds.

Our results from [Table 7](#) are robust to including these additional explanatory variables. We find evidence that loss-averse individuals are less likely to invest (columns (1) and (2)) and hold more pessimistic beliefs about the behaviour of other investors (column (6)), while risk aversion has little explanatory power. At the same time, more negative past surprises appear positively correlated with the probability of investing (column (2)) and have a strong impact on investors' beliefs (columns (4) and (6)), but only when a bad rating is observed. Socioeconomic characteristics such as gender and financial experience are not significantly correlated with the likelihood of investing or belief formation.<sup>36</sup>

Finally, we analyze the information collected during the experiment's second part, which included several questions aimed at understanding subjects' experience and attitudes in the investment game. Specifically, we inquired about the ease of making choices in the experiment, the level of confidence in making the investment decisions, and the importance of estimating the behaviour of others or the actual level of the firm's fundamentals. The questions were presented on a Likert scale from 1 to 5, with 1 representing "Strongly Disagree" and 5 representing "Strongly Agree", respectively. [Table 9](#) presents the questions and summary statistics for participants' responses across the two treatments. There is minimal variation across the treatments and all responses average between 3 and 4. Notably, there are no statistically significant differences between the two treatments in the perceived ease of making choices or subjects' confidence. The results of the post-experiment survey corrob-

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<sup>35</sup>The risk aversion indicator equals 1 if a subject chooses one of the first three gambles depicted in [Figure 8](#) from [Appendix C](#), corresponding to a risk-averse attitude in [Dave \*et al.\*'s \(2010\)](#) test. The loss aversion indicator equals one if a participant accepts at most two of the lotteries depicted in [Figure 9](#) from [Appendix C](#), corresponding to an implied degree of loss aversion greater than 1.5 in the loss aversion test proposed in [Gächter \*et al.\* \(2022\)](#).

<sup>36</sup>[Table 13](#) (from [Appendix B](#)) shows the robustness of the results from [Table 6](#) to the inclusion of additional controls.

Table 8: Investment behavior - Robustness tests

Dependent variable	$\mathbb{1}\{\text{Invest} = 1\}$		Belief fundamentals		Belief number investors	
	(1)	(2)	(3)	(4)	(5)	(6)
Hint about IF	0.014*** (0.002)	0.006*** (0.001)	0.013*** (0.002)	-0.003* (0.002)	0.014*** (0.005)	0.008*** (0.000)
Good rating (A)	0.614*** (0.167)		0.127 (0.175)		0.517** (0.246)	
Bad rating (B)		-0.395*** (0.128)		-0.765 (0.569)		-0.540*** (0.132)
Period	0.057*** (0.014)	-0.008 (0.017)	0.008 (0.019)	0.058 (0.051)	0.068*** (0.018)	-0.028** (0.012)
Risk aversion	-0.276 (0.208)	-0.072 (0.145)	0.024 (0.159)	-0.543 (0.401)	-0.400** (0.179)	0.070 (0.106)
Loss aversion	-0.270* (0.138)	-0.365** (0.150)	-0.051 (0.137)	0.504 (0.442)	0.096 (0.201)	-0.398*** (0.100)
Negative past experiences	0.447 (0.334)	2.799*** (0.239)	0.492 (0.466)	-2.145*** (0.721)	0.489 (0.424)	2.985*** (0.442)
Capital market	0.225 (0.797)	-2.204*** (0.639)	-0.854* (0.499)		-0.350 (0.731)	-0.258 (0.440)
Bank accounts	0.390 (0.475)	-0.318 (0.525)	0.551* (0.290)	0.456 (0.645)	-0.284 (0.453)	-0.498 (0.637)
Gender	-0.151 (0.432)	0.845 (0.565)	0.463* (0.250)	0.023 (0.844)	-0.371 (0.415)	0.711 (0.600)
Observations	1,545	1,905	1,545	1,882	1,545	1,905

*Notes:* Columns (1)-(2) report estimates from probit regressions where the dependent variable is an indicator equal to 1 if a participant invests. Columns (3)-(4) present estimates from OLS regressions where the dependent variable is the stated belief about the value of the firm's internal funds (IF). Columns (5)-(6) report estimates from ordered logit regressions where the dependent variable is the stated belief about the number of participants that buy the bond. *Hint about IF* captures the private information about firm fundamentals. *Good (Bad) rating A (B)* is an indicator variable equal to 1 if the treatment is CRA and the firm's IF are above (below) -31 and 0 if the treatment is the Baseline and the firm's IF are above (below) -31. *Risk/Loss aversion* are dummy variables equal to 1 if the participant was classified as risk/loss averse in the post experiment questionnaire. *Negative past experiences* captures the average number of negative surprises from previous periods. *Capital market* is a dummy that equals 1 for subjects who report investing in capital markets. *Bank accounts* is a dummy that equals 1 for subjects with more than one bank account. *Gender* is a dummy that equals 1 for male participants. Standard errors clustered at the subject level are reported in parentheses. \*\*\*, \*\*, \* indicate significance at the 1, 5, and 10% levels, respectively.

orate with the findings previously discussed: on average, participants give more importance to estimating the behaviour of others as compared to the firm's fundamentals.

Table 9: Post-experiment survey

	N	Baseline Mean	Treatment St. Dev.	CRA Mean	Treatment St. Dev.
Making the choices in Part I of the experiment was easy	115	3.696	0.929	3.678	0.969
I was confident in taking the decisions in Part I of the experiment.	115	3.922	0.919	3.93	0.934
In Part I of the experiment, the most important element was estimating the level of the firm's internal funds	115	3.165	1.051	3.104	1.18
In Part I of the experiment, the most important element was estimating how many other investors invest.	115	3.852	0.891	3.817	0.904

## 5 Concluding remarks

We conduct a laboratory experiment designed to investigate the relationship between inflated credit ratings, investor behavior, and firm investment. Our study brings new empirical evidence on the potential mechanisms through which ratings can influence economic efficiency. While credit ratings can have significant economic consequences (as they not only reflect but also affect a debt issuer's credit quality), the impact of inflated credit ratings remains uncertain. On the one hand, inflated ratings may facilitate firms' excessive risk-taking, resulting in adverse economic outcomes. On the other hand, inflated credit ratings may also enhance economic efficiency by providing informative (though potentially biased) signals that can influence a firm's financing costs and investment choices, thus justifying the original rating. The net effect of inflated credit ratings remains an empirical question that has been difficult to address due to the challenge of identifying inflated ratings and dealing with endogeneity concerns arising from the potential influence of unobserved confounding factors on both ratings and investors' behaviour.

Our experimental design overcomes these challenges by controlling for firms' fundamentals and investors' information sets to isolate the informational role of inflated credit ratings. Our main finding suggests that the positive effects of inflated credit ratings are more likely



to dominate. Specifically, inflated credit ratings serve as a coordination mechanism that provides informative signals, shaping investors' beliefs about the investment behaviour of other investors while having a modest impact on their beliefs about firm fundamentals. Receiving a good, potentially inflated, rating makes investors more optimistic about the behaviour of other investors, which enhances a firm's access to external funding and enables it to undertake value-enhancing projects. Conversely, a bad rating makes investors more pessimistic about others' behaviour, reducing their incentive to provide funding. As a result, firms with limited access to external financing are less likely to take excessive risks. Our findings suggest that the potential adverse real effects of inflated credit ratings are muted, indicating that inflated credit ratings may have positive effects beyond the laboratory in terms of efficient capital allocation and improved market outcomes.

Our findings imply that, from a policy standpoint, the interdependence between credit ratings and the actions of investors and firms is paramount. Inflated credit ratings can lead to greater economic efficiency if this feedback loop is present. In a market with credit rating agencies, even if ratings are potentially inflated, they provide valuable information that enhances the allocation of resources compared to markets without public ratings. Future research may explore whether accurate credit ratings (that reflect a firm's credit risk as closely as possible) impact economic efficiency more than inflated ratings.

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# Appendix A

## A1. Proof of Proposition 1

To prove Proposition 1 we need to show that there is a unique solution to equations (5), (6), and (7). The intuition for the solution is as follows: given the realization of fundamentals  $\theta$  and the investors' threshold strategies, the measure of investors who buy the bond is:

$$W(\theta) = \Pr(x \geq \tilde{x}|\theta) = 1 - \Pr(x < \tilde{x}|\theta) = 1 - \frac{\tilde{x} - \theta + \epsilon}{2\epsilon} = \frac{\theta - \tilde{x} + \epsilon}{2\epsilon}, \quad (12)$$

which follows from the fact that signals are uniformly distributed over  $[\theta - \epsilon, \theta + \epsilon]$ . A firm chooses to default when the payoff from the ongoing project is low enough. This happens if and only if  $\theta < \tilde{\theta}_1$ , where  $\tilde{\theta}_1$  solves equation (5). As  $K(\theta)$  is strictly increasing in  $\theta$ , for any  $\theta < \tilde{\theta}_1$  the firm's external funding is insufficient to cover the losses from the ongoing project. However, when  $\theta > \tilde{\theta}_1$ , the firm has incentives to invest in a new project. The firm chooses the LR project over the HR project for  $\theta \geq \tilde{\theta}_2$ , where  $\tilde{\theta}_2$  solves equation (6). Note that an investor has a dominant strategy to invest when the expected payoff of doing so, conditional on the available information, is higher than the expected payoff of not investing. Any investor  $i$  receiving a signal  $x_i$  invests as long as their signal is higher than the threshold signal,  $\tilde{x}$ . As such, there must be a marginal investor who receives exactly the signal  $\tilde{x}$  and is indifferent between buying the bond or not. The indifference condition is given by equation (7). Equations (5), (6), and (7) can be re-written as follows:

$$\begin{cases} \tilde{\theta}_1 + \frac{\tilde{\theta}_1 - \tilde{x} + \epsilon}{2\epsilon} = 0 \\ \tilde{\theta}_2 + \frac{\tilde{\theta}_2 - \tilde{x} + \epsilon}{2\epsilon} = I \\ \frac{\tilde{x} - \tilde{\theta}_1 + \epsilon}{2\epsilon} \times pF + \left( \frac{\tilde{\theta}_2 - \tilde{x} + \epsilon}{2\epsilon} - \frac{\tilde{\theta}_1 - \tilde{x} + \epsilon}{2\epsilon} \right) \times qF = 1, \end{cases}$$

where we have used the fact that the posterior belief over the firm fundamentals when observing a signal  $\tilde{x}$  is uniformly distributed over  $[\tilde{x} - \epsilon, \tilde{x} + \epsilon]$ .

The linear system of equations with three unknowns (i.e.,  $\tilde{x}, \tilde{\theta}_1, \tilde{\theta}_2$ ) has an analytical solution of the form:

$$\begin{cases} \tilde{x} = \frac{2\epsilon+1}{p^F} + \frac{(p-q)I}{p} - \epsilon - 1 \\ \tilde{\theta}_1 = \frac{\tilde{x}-\epsilon}{2\epsilon+1} \\ \tilde{\theta}_2 = \frac{\tilde{x}-\epsilon+2\epsilon I}{2\epsilon+1} \end{cases}$$

As  $2\epsilon I > 0$ , we obtain that  $\tilde{\theta}_2 > \tilde{\theta}_1$ . *QED*

## A2. Proof of Lemma 1

To prove Lemma 1 we need to show that the CRA will not assign a rating  $q$  in equilibrium, whenever  $\frac{S^p - S^q}{C^p - C^q} \geq 1 - q$  holds. Suppose the CRA assigns a rating  $q$  to a  $\theta$ -firm when  $\theta \in (\theta_1, \theta_2)$ . We will show that it is always profitable for the CRA to deviate and assign a rating  $p$ .

Consider the case in which investors believe that a rating  $p$  implies that the firm has better fundamentals than a firm with rating  $q$ . In that case, if the CRA deviates and assigns rating  $p$ , more investors will buy the firm's bonds. This implies that if the firm does not default with a rating of  $q$ , it won't default when the CRA assigns a rating of  $p$  either. At the same time, the condition  $\frac{S^p - S^q}{C^p - C^q} \geq 1 - q$  implies that:

$$\frac{S^p - S^q}{C^p - C^q} \geq 1 - q \geq 1 - p, \text{ since } p > q. \quad (13)$$

If the firm invests in the HR project when assigned a rating  $p$ , the CRA obtains a profit of  $S^p - (1 - q)C^p$ . From (13) we obtain that  $S^p - (1 - q)C^p > S^q - (1 - q)C^q$ , implying that the CRA is better off by deviating and assigning a rating  $p$  even if the firm invests in an HR project and defaults with probability  $1 - q$ . Likewise, if the firm invests in an LR project, the CRA's profit is  $S^p - (1 - p)C^p$  and using (13) we obtain that  $S^p - (1 - p)C^p > S^q - (1 - p)C^q$ , implying that it is more profitable for the CRA to deviate and assign rating  $p$ .

Consider now the case in which investors do not believe that a rating  $p$  implies that the firm has better fundamentals than a firm with rating  $q$ . Then there are some intervals of fundamentals where the rating is  $p$  for  $\theta \in (\theta_3, \theta_4)$  and  $q$  for  $\theta \in (\theta_1, \theta_2)$ , with  $\theta_3 < \theta_4 < \theta_1 < \theta_2$ . If the CRA deviates and assigns a firm with fundamentals in interval  $(\theta_1, \theta_2)$  a rating of  $p$  instead of  $q$ , investors will believe that the fundamentals are worse, i.e., in interval  $(\theta_3, \theta_4)$ . However, firms in neither  $(\theta_1, \theta_2)$  nor  $(\theta_3, \theta_4)$  intervals will default early (as the CRA never assigns a rating different from zero to firms that it believes will default early). So firms with fundamentals in interval  $(\theta_1, \theta_2)$  will not default early even if they receive a rating  $p$ . Given that from (13) the CRA has higher expected profits when assigning a rating  $p$ , the CRA will then deviate and prefer to assign a rating  $p$ .

Summing up the two cases, there is no equilibrium in which the CRA assigns a rating  $q$  when (13) holds. *QED*

### A3. Proof of Proposition 2

Similar to the proof of Proposition 1, we show that equations (9), (10), and (11) admit a unique solution. From Lemma 1, the CRA assigns only ratings  $R = 0$  and  $R = p$  in this equilibrium. Moreover, a rating of  $R = 0$  is assigned when the CRA knows that the firm will default at  $t = 1$  even with a rating of  $p$ . As such, the rating  $R = 0$  is assigned for  $\theta < \theta_1^*$ , where  $\theta_1^*$  is the threshold at which the firm is indifferent between defaulting early or investing in the HR project:  $K(\theta_1^*) = \theta_1^* + W(\theta_1^*) = 0$ .

Similarly, given that the firm's payoff is increasing in  $\theta$ , there must be a threshold  $\theta_2^* > \theta_1^*$ , such that the firm invests in the LR project for  $\theta \geq \theta_2^*$  and in the HR for  $\theta \in [\theta_1^*, \theta_2^*]$ , where  $\theta_2^*$  solves:  $K(\theta_2^*) = \theta_2^* + W(\theta_2^*) = I$ .

Finally, given the CRA's strategy, investors observing a rating of  $R = p$  believe that the firm's true fundamentals are above  $\theta_1^*$ , which means that for any private signal  $x_i$  their posterior distribution for  $\theta$  is truncated from below by  $\theta_1^*$ . The indifference condition for the

marginal investor becomes:

$$\frac{\text{Prob}[\theta \geq \theta_2^* \mid x^*]}{\text{Prob}[\theta \geq \theta_1^* \mid x^*]} \times pF + \frac{\text{Prob}[\theta < \theta_2^* \mid x^*] - \text{Prob}[\theta < \theta_1^* \mid x^*]}{\text{Prob}[\theta \geq \theta_1^* \mid x^*]} \times qF = 1. \quad (14)$$

Using the fact that  $W(\theta) = \frac{\theta - \tilde{x} + \epsilon}{2\epsilon}$ , equations (9), (10), and (11) in Proposition 2 become:

$$\begin{cases} \theta_1^* + \frac{\theta_1^* - \tilde{x} + \epsilon}{2\epsilon} = 0 \\ \theta_2^* + \frac{\theta_2^* - \tilde{x} + \epsilon}{2\epsilon} = I \\ \frac{(x^* - \theta_2^* + \epsilon) \times pF + (\theta_2^* - \theta_1^*) \times qF}{x^* - \theta_1^* + \epsilon} = 1. \end{cases}$$

The unique solution  $(x^*, \theta_1^*, \theta_2^*)$  to the system of equations above is:

$$\begin{cases} x^* = \frac{(p-q)IF}{pF-1} - \epsilon - 1 \\ \theta_1^* = \frac{x^* - \epsilon}{2\epsilon + 1} \\ \theta_2^* = \frac{x^* - \epsilon + 2\epsilon I}{2\epsilon + 1}. \end{cases}$$

*QED.*

#### A4. Proof of Lemma 2

Given the equilibria  $(\tilde{x}, \tilde{\theta}_1, \tilde{\theta}_2)$  in Proposition 1 and  $(x^*, \theta_1^*, \theta_2^*)$  in Proposition 2, we can show that  $\tilde{\theta}_1 < \theta_1^*$  and  $\tilde{\theta}_2 < \theta_2^*$  if  $\tilde{x} < x^*$ , which occurs whenever the noise of the signal is not too large, specifically  $\epsilon < \bar{\epsilon} \equiv \frac{(p-q)FI}{2(pF-1)} - \frac{1}{2}$ . *QED*

## Appendix B: Additional results

Table 10: Average number of investors and fundamentals

Fundamentals	Baseline (1)	CRA (2)	Test 1 (3)	Test 2 (4)
1 <sup>st</sup> quartile	0.43 (0.56)	0.24 (0.51)	0.0246	0.248
2 <sup>nd</sup> quartile	0.97 (1.12)	0.46 (0.68)	0.0005	0.021
3 <sup>rd</sup> quartile	2.80 (1.40)	3.44 (1.57)	0.0063	0.248
4 <sup>th</sup> quartile	4.66 (0.62)	4.71 (0.51)	0.5814	1

*Notes:* Columns (1)-(2) present the mean (standard deviation) of the number of subjects (per group) investing conditional on the treatment and quartiles of firm fundamentals. Test 1 in column (3) is a t-test of equality of means performed at the group level. Test 2 in column (4) is a non-parametric K-sample test on the equality of medians performed at the session level.

Table 11: Firm actions

Treatment	Baseline			CRA			Non-parametric test (p-values)		
	(1) Default	(2) HR	(3) LR	(4) Default	(5) HR	(6) LR	(1) vs (4)	(2) vs. (5)	(3) vs. (6)
Firm action									
Proportion of firms	0.46 (0.06)	0.21 (0.04)	0.36 (0.06)	0.47 (0.03)	0.16 (0.09)	0.43 (0.07)	1	0.02	0.02
Observations	155	70	120	160	41	144	6	6	6

*Notes:* Non-parametric test is a K-sample test on the equality of medians performed at the session level that compares the proportion of firms with specific actions across the two treatments.

Table 12: Firm actions across quartiles of fundamentals

Quartile	Firm action	Baseline (1)	CRA (2)	Difference (3)
1	Default	100	100	0
2	Default	73	83	9
	High risk	35	20	-15
	Low risk	11	0	-11
3	Default	11	11	0
	High risk	58	43	-15**
	Low risk	43	72	29**
4	High risk	6	0	-6
	Low risk	99	100	1

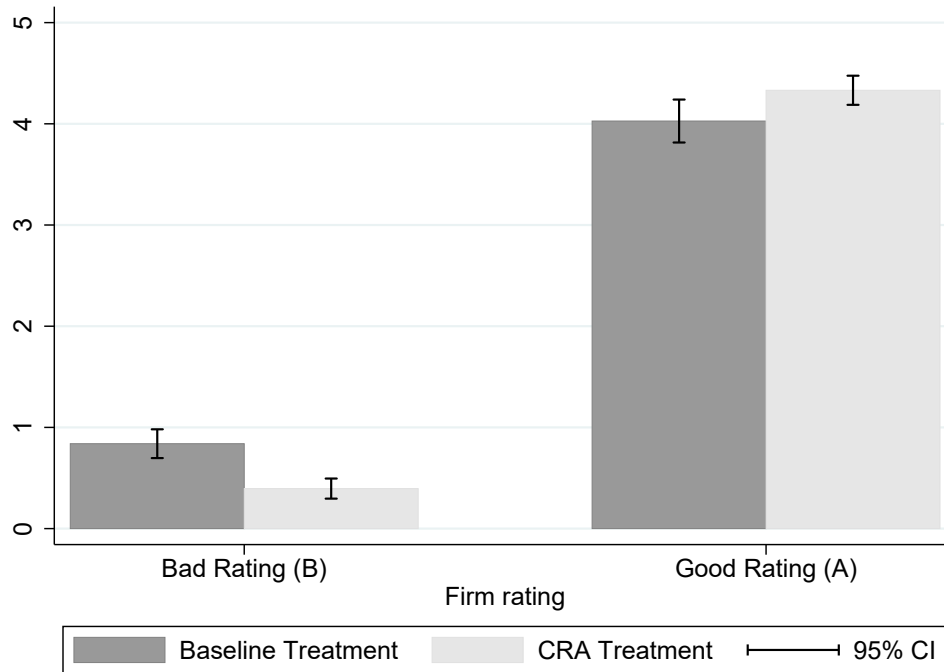
*Notes:* The table shows in columns (1)-(2) the mean percentage of firm actions across quartiles of firm fundamentals. The statistical significance of the difference in column (3) is based on a non-parametric K-sample test on the equality of medians performed at the session level.\*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 13: Individual behavior - Additional robustness tests

	Baseline				CRA			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Hint about IF	0.010*** (0.001)	0.008*** (0.001)	0.004*** (0.001)	0.004*** (0.001)	0.012*** (0.001)	0.006*** (0.001)	0.004*** (0.001)	0.001 (0.001)
Belief IF		0.002 (0.001)		0.000 (0.001)		0.008*** (0.001)		0.005*** (0.001)
Belief # investors			1.131*** (0.104)	1.131*** (0.105)			1.047*** (0.100)	1.015*** (0.095)
Period	0.002 (0.009)	0.003 (0.009)	0.003 (0.015)	0.003 (0.015)	0.014 (0.010)	0.022** (0.010)	0.002 (0.012)	0.007 (0.012)
Risk aversion	-0.239** (0.111)	-0.231** (0.114)	-0.086 (0.148)	-0.085 (0.148)	0.028 (0.182)	-0.090 (0.167)	-0.014 (0.248)	-0.060 (0.237)
Loss aversion	-0.207* (0.119)	-0.203 (0.125)	-0.212 (0.130)	-0.212 (0.131)	-0.340 (0.274)	-0.248 (0.227)	-0.313 (0.350)	-0.285 (0.337)
Negative past experiences	1.881*** (0.355)	1.674*** (0.393)	0.135 (0.375)	0.130 (0.383)	1.400*** (0.317)	0.455* (0.256)	-0.217 (0.343)	-0.607** (0.251)
Capital market	-1.165** (0.590)	-1.142* (0.588)	-0.785* (0.475)	-0.788 (0.488)	-0.077 (0.560)	0.160 (0.457)	0.019 (0.550)	0.001 (0.443)
Bank accounts	0.218 (0.406)	0.154 (0.408)	0.689** (0.314)	0.687** (0.313)	-0.013 (0.385)	-0.021 (0.291)	0.349 (0.498)	0.300 (0.449)
Gender	0.828* (0.451)	0.836* (0.471)	0.676* (0.372)	0.678* (0.373)	0.620 (0.572)	0.205 (0.564)	0.309 (0.380)	0.156 (0.378)
Observations	1,725	1,725	1,725	1,725	1,725	1,725	1,725	1,725

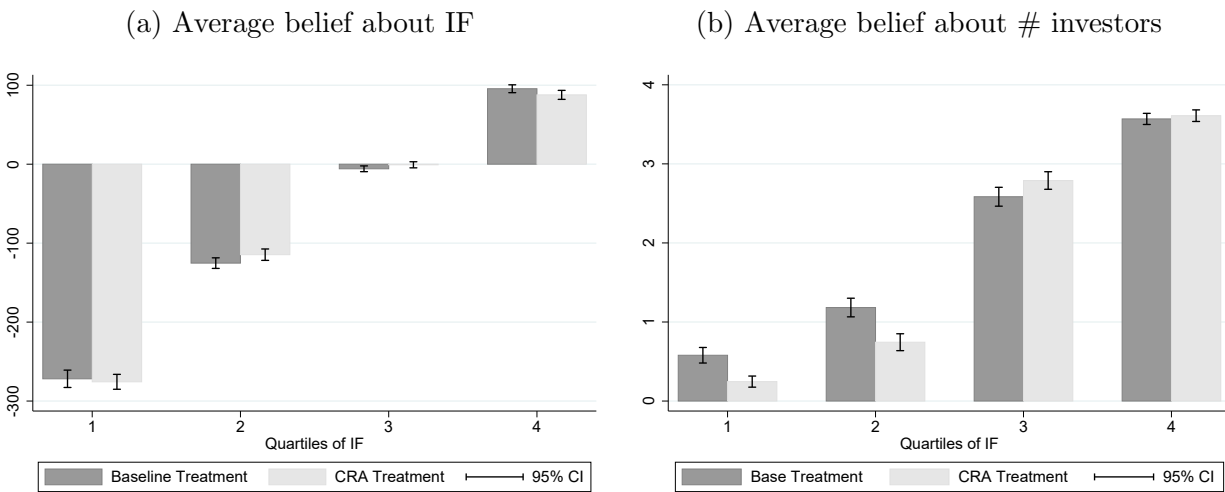
*Notes:* The table presents estimates from probit regressions where the dependent variable is an indicator equal to 1 if the participant invests. Columns (1)-(4) correspond to the Baseline treatment, while (5)-(8) correspond to the CRA, respectively. *Hint about IF* captures the private information about firm fundamentals. *Belief about IF* and *Belief # investors* capture the stated beliefs (as a number) about firm fundamentals and the other participants investing, respectively. *Risk/Loss aversion* are dummy variables equal to 1 if the participant was classified as risk/loss averse in the post experiment questionnaire. *Negative past experiences* captures the average number of negative surprises in previous periods. *Capital market* is a dummy that equals 1 for subjects that report investing in capital markets. *Bank accounts* is a dummy that equals 1 for subjects with more than one bank account. *Gender* is a dummy that equals 1 for male participants. Standard errors clustered at the subject level are reported in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Figure 6: Average number of investors and ratings



Notes: The figure shows the average number of investors for values of the fundamentals below (above) -31, which correspond to Bad rating B (Good rating A) in the CRA treatment. The sample size is 690 groups across the two treatments. Whiskers mark the 95% confidence interval.

Figure 7: Beliefs about firm fundamentals and behavior of others



Notes: Panel (a) shows the average stated belief across individuals about the value of the firm's fundamentals for quartiles of IF. Panel (b) shows the average stated belief across individuals about the number of others investing for quartiles of IF. Whiskers mark the 95% confidence interval.



## Appendix C: Experimental instructions

We present the experimental instructions for the CRA treatment. The instructions for the Baseline treatment are identical, except that any information concerning the credit rating is omitted.

### General instructions

This is an experiment on financial decision-making. If you follow these instructions carefully, you can earn a considerable amount of money, which we will pay you at the end of this experiment. Please read the instructions carefully. Please do not talk or communicate with other participants. The use of mobile phones is not allowed. The rules are the same for all the participants. All your decisions and answers to questions remain anonymous.

The experiment consists of two parts: in Part 1, you will play a financial game with other participants. In Part 2, you will be asked to fill out several individual questionnaires. We will convert your experimental gains from Parts 1 and 2 into Euros at the end of the experiment and add a 7 Euro show-up fee to that amount.

If you have any questions during the experiment or difficulties in understanding these instructions, please raise your hand and wait for the experimenter to come to your cubicle and answer your questions privately.

Thank you for your participation!

### Part 1. An investment game

**Background** In this part of the experiment, all participants will play the role of investors who must decide whether to invest in a firm or not. There are 15 rounds and you will make an investment decision in each of them. Each round is independent of the others. In each round, 5 participants are potential investors in the same firm (you and four others). The computer plays the role of the firm. Investors in your group will change randomly from round to round. You will not know which of the other participants belong to your group in a given round. Your payoff will depend on your own decision and on that of the other four

investors in your group, as well as on the firm's action.

**Your decision** In each round, each investor is endowed with 100 Experimental Currency (EC) and will choose one of the following two decisions:

- NOT INVEST and you keep your initial 100 EC.
- INVEST and finance the firm with 100 EC. If you invest, your payoff depends on the firm's action. The firm can undertake one of the following three actions:
  - The firm can invest in a low-risk (LR) project, in which case you will obtain 200 EC with a probability of 90% and 0 with a probability of 10%.
  - The firm can invest in a high-risk (HR) project, in which case you will obtain 200 EC with a probability of 20% and 0 with a probability of 80%.
  - The firm can also default, in which case you will obtain 0 EC with 100% probability.

These payoffs are the same for all investors in your group. Now, we will explain how the firm's action is affected by your investment decision and that of the other members of your group.

### **The firm's action**

In each round, the computer plays the firm's role and chooses automatically between the low-risk project (LR), the high-risk project (HR), and default, depending on how much financing the firm has available. The firm has two funding sources: its own funds (internal funds, denoted IF) and the external funds (denoted EF) provided by you and the other four investors. Details about the firm's IF are provided below (*Information section*). The firm's automatic decision is as follows:

- If the firm obtains 300 EC or more from both IF and EF (provided by all five investors), it undertakes the LR project.
- If the firm has less than 300 EC (but at least zero) financing from both IF and EF

(provided by all five investors), it undertakes the HR project.

- If the firm has losses (i.e., IF are less than 0) and EF are lower than the losses, it defaults.

We summarize the firm's actions in the following table.

<b>Financing</b>	<b>Firm's action</b>
$300 \leq IF + EF$	LR project
$0 \leq IF + EF < 300$	HR project
$IF + EF < 0$	Default

### Example:

The table below provides an example of the different actions of the firm for hypothetical values of the internal and external funds available.

Hypothetical number of players who invest	Internal funds of the firm													
	-400		-300		-200		-100		0		100		200	
	Total Funds available to the firm	Firm's action	Total Funds available to the firm	Firm's action	Total Funds available to the firm	Firm's action	Total Funds available to the firm	Firm's action	Total Funds available to the firm	Firm's action	Total Funds available to the firm	Firm's action	Total Funds available to the firm	Firm's action
0	-400	Default	-300	Default	-200	Default	-100	Default	0	HR	100	HR	200	HR
1	-300	Default	-200	Default	-100	Default	0	HR	100	HR	200	HR	300	LR
2	-200	Default	-100	Default	0	HR	100	HR	200	HR	300	LR	400	LR
3	-100	Default	0	HR	100	HR	200	HR	300	LR	400	LR	500	LR
4	0	HR	100	HR	200	HR	300	LR	400	LR	500	LR	600	LR
5	100	HR	200	HR	300	LR	400	LR	500	LR	600	LR	700	LR

### The credit rating agency

Before your decision and the firm's action, a *credit rating agency* assigns a rating to the firm. A credit rating is a grade that indicates the firm's ability to repay its investors. We will provide details below on how this rating is assigned.

### Information

The firm's IF consist of profits (or losses) from ongoing activities. These funds are known by the firm and the credit rating agency and unknown to any investor. In each round, the firm's IF are randomly selected from the interval [-400, 200]. Each number in this interval

has the same probability of being drawn. The number is the same for all investors in your group. When you make your investment decision, you do not know the exact value of the firm's profits (or losses). However, before investing, you and all the other investors from your group receive information about the firm's IF from two sources:

1. A private hint about the firm's IF. The hint number is randomly selected from the interval:

[True value of firm's IF-30, True value of firm's IF+30].

All numbers in the interval have the same probability of being drawn. Hint numbers of different investors are drawn independently from the same interval. Note that each of the investors in your group receives a different hint, which is known only by the participant who receives it.

2. A public credit rating from the credit rating agency about the firm's ability to repay its creditors. The rating can be either A or B. All investors in your group observe the same rating. In each round, the rating agency uses a theoretical scoring model to predict the ability of the firm to repay. The model considers the firm's IF (which it knows perfectly) and how the rating might affect a hypothetical investor's decision and thus the total amount of funds available to the firm and its corresponding action. The rating agency decides on a rating as follows:

- Rating A is assigned if the firm's IF are greater than or equal to -31. By giving this rating, the rating agency estimates that the firm will invest in the LR project, and investors have a 90% probability of being repaid.
- Rating B is assigned if the firm's IF are lower than -31. By giving this rating, the rating agency estimates that the firm will default, and investors have a 0% probability of being repaid.

Example:

Suppose that the firm's IF are 0. This amount is known to the firm and the rating agency

but not to investors. The hints the five investors receive are in the range  $[-30, 30]$  and are equal to  $-30, 27, 19, -15, 1$ . The participant who receives hint  $-30$  knows that the firm's IF must be between  $-60$  and  $0$ . The participant who receives hint  $19$  knows that the firm's IF must be between  $-11$  and  $49$ , etc.

All investors observe that the public credit rating of the firm is A, which implies that the firm's IF are greater than or equal to  $-31$  and the rating agency estimates a probability of repayment of 90%. As explained above, this probability is only an estimation based on the theoretical scoring model used by the rating agency. The actual probability of repayment depends on how many investors finance the firm and the project that the firm undertakes.

Suppose that you receive a private hint of  $-15$ . This implies that the firm's IF must lie between  $[-45, 15]$ . You also observe the public rating A, which means that the firm's IF must be greater than or equal to  $-31$ . Therefore, using these two pieces of information, the possible range of the firm's IF must lie between  $[-31, 15]$ . Suppose you think, based on this information, that the firm's IF =  $-2$ . Given your beliefs about the firm's IF, the table below illustrates your payoff and probabilities from choosing between investing and not investing (conditional on the hypothetical number of other investors that decide to invest). (During the experiment, you will have access to a simulator similar to the table below).

Hypothetical number of other players who invest	Do not invest		Invest				
	Probability of 100 EC payoff	Expected payoff (EC)	Total funds available to the firm	Firm's action	Probability of 200 EC payoff	Probability of 0 EC payoff	Expected payoff (EC)
0	100%	100	$-2+100=98$	HR	20%	80%	40
1	100%	100	$-2+200=198$	HR	20%	80%	40
2	100%	100	$-2+300=298$	HR	20%	80%	40
3	100%	100	$-2+400=398$	LR	90%	10%	180
4	100%	100	$-2+500=498$	LR	90%	10%	180

### Your beliefs

Before making your investment decision, you will also be asked to indicate:

- (a) what you think the true level of the firm's internal funds (IF) is (type a number)

(b) how many other investors you expect to invest and finance the firm (0, 1, 2, 3, or 4)

### **Feedback**

After all participants in a given round take their decisions, you will learn the true level of the firm's IF, how many other players invested in the firm, the firm's action, and your potential payoff in ECs for this round.

### **Your earnings**

One of the 15 rounds will be randomly chosen to determine your payoffs for Part 1 of the experiment. Therefore, you should carefully consider each decision, as it could be the one that is relevant for your total earnings from this part of the experiment. At the end of the entire experiment, you will learn which round has been selected to determine your payoff. Your earnings will be converted into Euros at the conversion rate of 15 EC= 1 Euro.

### **Comprehension quiz**

Before starting Part I of the experiment, there will be a short comprehension quiz to check that you understood these instructions. The quiz is not incentivized.

### **Part 2. Two individual tasks**

You will be asked to make several other decisions, which are answered individually and do not depend on the choices of other participants.

At the end of the second part, we will ask you for some personal information. The data is treated confidentially and will be used only for research purposes.

### **Risk aversion**

You have to select ONE gamble that you would like to play from the gambles below (see Figure 8). Each gamble has two possible outcomes (Event A or Event B), each with 50% chance of occurring. For example, if you select gamble 4 and Event A occurs, you will gain 21 points. If event B occurs, you will get 57 points. Your gains in points will be converted

into Euros according to the following conversion rate: 20 points are equivalent to 1 Euro.

Figure 8: Risk aversion test

Gamble	Event	Payoff in Points	Probabilities
1	A	33	50%
	B	33	50%
2	A	29	50%
	B	41	50%
3	A	25	50%
	B	49	50%
4	A	21	50%
	B	57	50%
5	A	17	50%
	B	65	50%
6	A	7	50%
	B	75	50%

### Loss aversion

For EACH gamble below, you have to choose whether you want to Accept or Reject it (see Figure 9). If you reject a gamble, your payoff is zero. Each gamble has two possible outcomes (Event A or Event B), each with a 50% probability of occurring. After you have made your choice, one of the gambles you accepted will be picked at random and you will be paid the outcome of that gamble. Your gains in points will be converted into Euros according to the conversion rate of 20 points for 1 Euro.

Figure 9: Loss aversion test

Gamble	Event	Payoff in Points	Probabilities
1	A	6	50%
	B	-2	50%
2	A	6	50%
	B	-3	50%
3	A	6	50%
	B	-4	50%
4	A	6	50%
	B	-5	50%
5	A	6	50%
	B	-6	50%
6	A	6	50%
	B	-7	50%



# Appendix D: Experimental sessions and screens

We summarize the experimental sessions and present several screenshots from Part I of the experiment.

Table 14: Experimental sessions

Treatments	Number of Students	Date	Location
Baseline Treatment, Session 1	20	March 2022	ESADE
Baseline Treatment, Session 2	15	March 2022	ESADE
Baseline Treatment, Session 3	20	March 2022	ESADE
Baseline Treatment, Session 4	20	April 2022	Pompeu Fabra University
Baseline Treatment, Session 5	20	April 2022	Pompeu Fabra University
Baseline Treatment, Session 6	20	April 2022	Pompeu Fabra University
CRA Treatment, Session 1	20	March 2022	ESADE
CRA Treatment, Session 2	15	March 2022	ESADE
CRA Treatment, Session 3	20	March 2022	ESADE
CRA Treatment, Session 4	20	April 2022	Pompeu Fabra University
CRA Treatment, Session 5	20	April 2022	Pompeu Fabra University
CRA Treatment, Session 6	20	April 2022	Pompeu Fabra University

Figure 10: Practice questions

**Review questions**

Before starting the experiment, you will need to answer five questions to test your understanding of the investment game that you will play for 15 rounds.  
You have to answer all the questions below correctly to move to the first part of the experiment. There is only one correct answer per question.

1. If you receive a private hint about the firm's internal funds (IF) equal to **-25**, then you know that the true value of the firm's internal funds is:

- 25
- Any number between -30 and 30.
- Any number between -55 and 5.
- The true value can be any number.

Correct! The true value of the internal funds is between hint -30 and hint +30.

4. Suppose that based on the information you receive, you believe the firm's internal funds (IF) are **-10**. Suppose you and 2 other participants invest (a total of 3). Your payoff is:

- 100.
- 200 with 90% probability and 0 with 10% probability.
- 200 with 10% probability and 0 with 90% probability.
- 200 with 20% probability and 0 with 80% probability.

Correct! If 3 participants invest the fund has total fund of 300-10=290. As this is lower than 300, the firm will invest in the high-risk project which has a 20% probability of paying 200 and a 80% probability of paying 0.

2. If you receive a private hint about the firm's internal funds (IF) equal to **-25** and the credit rating agency announces a rating of **A**, then you know that the true value of the firm's internal funds is:

- 31
- Any number between -31 and 5.
- Any number higher than -31.
- Any number between -55 and 5.

Correct! A rating of A means IF are higher than -31.

5. Suppose that based on the information you receive, you believe the firm's internal funds (IF) are **-10**. Suppose you and 4 other participants invest (a total of 5). Your payoff is:

- 100.
- 200 with 90% probability and 0 with 10% probability.
- 200 with 10% probability and 0 with 90% probability.
- 200 with 20% probability and 0 with 80% probability.

Correct! If 5 participants invest the fund has total fund of 500-10=490. As this is higher than 300, the firm will invest in the low-risk project which has a 90% probability of paying 200 and a 10% probability of paying 0.

3. If you receive a private hint about the firm's internal funds (IF) equal to **-25** and the credit rating agency announces a rating of **B**, then you know that the true value of the firm's internal funds is:

- 31
- Any number between -55 and 5.
- Any number lower than -31.
- Any number between -55 and -31.

Correct! A rating of B means IF are lower than -31.

**CONTINUE**

Figure 11: Decision screen 1

**Information about the investment decision**

Your private hint about the firm's internal funds (IF) is: -300

The public credit rating of the firm's ability to repay is: Rating B

**Your beliefs**

What do you think is the actual level of the firm's internal funds (IF)?

What is your estimate of the total number of other investors that choose to invest?

**Dialog**

The number of other investors can only be between 0 and 4

Figure 12: Decision screen 2

**Information about the investment decision**

Your private hint about the firm's internal funds (IF) is: -300

The public credit rating of the firm's ability to repay is: Rating B

**Your beliefs**

What do you think is the actual level of the firm's internal funds (IF)? 100

What is your estimate of the total number of other investors that choose to invest? 2

**Your decision**

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