

Credit Ratings and Investments*

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Abstract

We study experimental coordination games to examine how inflated credit ratings affect bond market investment decisions. 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 strongly impact investors' actions and capital allocation to firms. We show that, in the presence of feedback effects, the main channel through which the real effects materialize is a change in beliefs about other investors rather than firms' fundamentals. Our experimental results suggest that positive effects are likely to dominate, as inflated ratings act as a strong coordination device and lead to enhanced market outcomes.

JEL: D81; D82; D83; G24

Keywords: Credit ratings; Imperfect information; Investors 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 and helping investors to 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) (see [Ashcraft and Schuermann, 2008](#); [Alp, 2013](#); [Cornaggia and Cornaggia, 2013](#); [White, 2013](#); [Fulghieri *et al.*, 2014](#)).¹ This can result from various factors such as conflicts of interest (e.g., the desire to maintain a good relationship with an issuer), lax regulation, or the pressure to retain market share. The potential effects of such inflated credit ratings can be significant. They can lead to a misallocation of capital, a distortion of market prices, and a false sense of security for investors. 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. Yet, inflated ratings can also promote market liquidity and facilitate firms’ access to credit markets, which can benefit economic growth, particularly when improved financing conditions leads to more efficient investments. Understanding the role that inflated ratings play in shaping investors’ behavior and decision-making is, nevertheless, empirically challenging, as it is difficult to establish the causal impact of ratings on investors’ or firms’ decisions.²

In this paper, we provide experimental evidence on the informational role of inflated credit ratings and their impact on investment decisions and economic efficiency. We first present a parsimonious theoretical model based on [Goldstein and Huang’s \(2020\)](#) bond financing

¹During the Global Financial Crisis, initially AAA-rated securities were downgraded, suggesting that these securities had inflated credit ratings ([Benmelech and Dlugosz, 2009](#)). 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.

²While a large empirical literature documents 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](#)).

model, which features a feedback effect between credit ratings and firm investment decisions. In the model, a firm can invest in two types of risky projects: a low- 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 a 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.³ The inflated rating pools high- and low-risk firms together, but 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, this 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.⁴

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.⁵ Before making

³A 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 the firm’s decisions.

⁴The model allows for positive and negative effects of inflated ratings that depend on the parametrization.

⁵This experimental design allows us to focus on participants decision-making, while shutting down the possibility for firm’s strategic behavior.

their investment decision, participants receive a private signal about the firm’s fundamentals (i.e., internal funds), and we elicit their beliefs about fundamentals and the behavior 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 external financing provision 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 significantly more (less) external financing than firms in the Baseline treatment with similar fundamentals. Second, there is more investment in the CRA treatment conditional on the good (inflated) rating and less investment conditional on investors observing a bad rating. Finally, the increased availability of external financing in the CRA treatment leads to significantly more firm investment in the low-risk project compared to the Baseline treatment. At the same time, we observe significantly less firms investing in the high-risk project in the CRA treatment. These results suggest an overall positive effect of inflated ratings leading to a more efficient allocation of capital and an improved market outcome.

We then study individual investment behavior and evaluate the mechanisms that drive our results by analyzing the effect of credit ratings on investors’ actions and beliefs. Our results show that, on the one hand, ratings do not necessarily help investors form more accurate posterior beliefs about firm fundamentals. Investors tend to be more optimistic about a firm’s fundamentals for good ratings and more pessimistic for bad ones. On the other hand, we uncover a strong effect of ratings on investors’ beliefs about the behavior of other investors. Our experimental results show that investors are more optimistic (pessimistic) about the number of others investing for good (bad) ratings. This finding suggests that ratings affect investors’ confidence in the behavior of others and act as a strong coordination device. We

document that the main channel through which the real effects materialize in the presence of feedback effects between credit ratings and firm’s actions is not through the updating of investors’ beliefs about firm’s fundamentals, but rather through the updating of beliefs about other investors’ behaviour.

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](#), for a review), with several works focusing specifically 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](#); [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 in environments with multiple equilibria.

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 firm ratings that are unrelated to firm 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’ behavior can be driven by the same (unobserved) confounding factors (see [Kliger and Sarig, 2000](#); [Tang, 2009](#); [Sufi, 2009](#); [Almeida *et al.*, 2017](#); [Cornaggia *et al.*, 2018](#)). 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 effect investors decisions and economic efficiency.

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 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 behavior. 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 subjects' 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 subjects tend to overreact to public information and that public signals can act as focal points. The welfare implications of such public signals then depend on the optimal level of social coordination ([Cornand and Heinemann, 2014a](#)). For example, [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 real economy. We differ from these papers by studying the role of a discrete and biased public signal instead of continuous and unbiased signals.

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 to guide our experimental design based on the model of [Goldstein and Huang \(2020\)](#). 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 owed).

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 θ 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 $0 < q < p$ at date 2, and 0 with probability $1 - q$. We assume that the LR project is more efficient than the HR project: $pV > qH$. If the firm is insolvent, which may happen when the risky investment returns 0, then the firm defaults at $t = 2$ and its creditors receive nothing. The firm's investment choice is unobservable and unverifiable.⁶

To undertake a new project the firm needs a certain amount of funding. We assume that the LR-type of projects are in short supply and can be uncovered upon costly screening

⁶Note 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.

efforts. The LR project requires a higher initial investment (including screening costs), I , whereas the HR project can be undertaken with a smaller investment, $i < I$. 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, θ , 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 lose their investment.

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 $B = 1$ that mature at $t = 2$.⁷ If the firm does not default at date 1 and the new project is successful, then bondholders are fully repaid at date 2.⁸ 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 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 $B = 1$.

⁷Since 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 exogeneously given.

⁸This 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 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. 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 θ . However, before deciding whether to buy the bond, each investor i receives a private signal about θ : $x_i = \theta + \epsilon_i$, where the error terms ϵ_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 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 increases 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 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: $S^p > S^q > 0$.⁹ The cost C^R corresponds to (exogenous) reputation or legal costs in 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 to default 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 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 $x_i < \tilde{x}$.¹⁰

⁹See [Sangiorgi and Spatt \(2017\)](#) for an excellent review of these issues.

¹⁰This equilibrium strategy rests on the existence of *lower* and *upper dominance* regions below and above which an investor has a dominant strategy to either to not buy or buy the bond. The *lower dominance* region consists of values of fundamentals so low that even if all investors buy 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.

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 θ , by deriving the firm expected profits conditional on investors' strategies as shown in (3), and then establishing the firm profit-maximizing strategy. The firm always has incentives to choose the LR project over the HR project for $K(\theta) \geq I$ since $p[V - FW(\theta) + K(\theta) - I] > q[H - FW(\theta) + K(\theta)]$.¹¹ When the available funds are positive but not enough to allow for an investment in the LR project (i.e., $0 < K(\theta) < I$), choosing the HR project dominates the decision to default since $q[H - FW(\theta) + K(\theta)] > 0$.¹² Therefore, the firm's optimal investment strategy at date 1 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

(1) The firm's investment strategy is

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

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

¹¹One 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.

¹²The inequality holds since $H > F$.

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}

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

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: $R(\theta) = \{0, p\}$.

Lemma 1 If $S^p - S^q \geq (1 - q)(C^p - C^q)$, then 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 θ_1^* above which a θ -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 θ -firm is assigned a rating of p (i.e., implying it will undertake the LR project at date 1), while the firm undertakes project HR 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 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:

- (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 θ_1^* solves

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

and θ_2^* solves

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

Proof: See Appendix A3.

We show next that, for a given θ , the presence of the CRA can affect a firm's investment decision compared to the benchmark model without the CRA. We characterize how the equilibrium thresholds in the two models relate, which allows us to study the CRA's real effects. 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 real positive effect as a situation when a θ -firm invests in the LR project whereas it would have invested in the HR project without the credit rating. Credit ratings can also have a negative effect 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 real 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 have a positive real 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 real effect when $\theta_2^* \leq \theta < \tilde{\theta}_2$ and a negative real 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

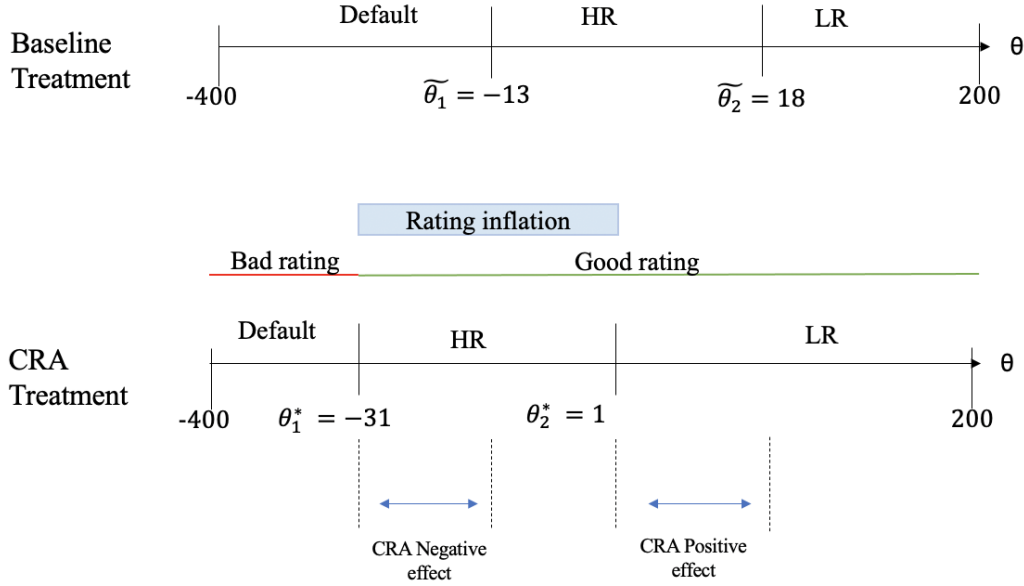
We adapt the theoretical model for a laboratory experiment and calibrate it in order to solve numerically for the equilibrium thresholds described in sections 2.1 and 2.2. To do so, we first compute the thresholds considering a finite number of players. Following Heinemann et al., (2004; 2009), we employ the binomial distribution to calculate the mass of investors who buy the bond (see also Peia and Vranceanu, 2019; Bayona and Peia, 2020). Specifically, we assume that the measure of creditors $W(\theta)$ from (2) is the probability that 0,1,2,...,n out of n subjects invests, when each player 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 players buying the bond in (5), (6), (10), and (11), is $E[W] = n \times m(\theta)$. We then calibrate the model using the parameters presented in Table 1.

Table 1: Experimental parametrization

Initial endowment	100
Range of fundamental 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	0
Signal noise (ϵ)	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 real effects.¹³

Figure 1: Equilibrium illustration of the investor, CRA and issuer actions.



From these theoretical predictions, we develop several testable hypotheses that relate to the

¹³Investors' 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.

effects of an inflated credit rating on investors' actions and firm's project choices.

Our first hypothesis concerns investor behavior.

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 leads some firms with relatively low fundamentals to gamble for resurrection and invest in the high-risk project. As such, our second hypothesis is:

H2 (*Real 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 HR 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 when a public credit rating is available. This 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, we expect that, unless the firm's fundamentals are very poor, the firm enjoys an increased supply of funds from investors when the rating is available. This, in turn, increases the probability that external funds 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 (*Real 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 LR project vs. the HR 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 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 that takes the optimal investment decisions as outlined in (4). Participants play the coordination game for 15 independent rounds in groups of 5 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, her 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 $300 \leq IF + EF$ then 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 observe a public credit rating about the firm's ability to repay its creditors in addition to their private signal.

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 IF are greater 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 IF are smaller than -31 . The CRA estimates that the B-rated firm will default and investors have a 0% probability of being repaid.¹⁴

¹⁴Note that -31 corresponds to the theoretical threshold θ_1^* from Proposition 2 under our parametrization from Table 1.

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.¹⁵ 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 Invest.¹⁶ 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.¹⁷ After all participants have made their decisions, they learn at the end of each round about the true level of the firm 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 experimental currency 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 behavior throughout the experiment (using Likert scales) and elicited selected socioeconomic characteristics through 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

¹⁵Appendix C shows the screenshots from the first part of the experiment. Beliefs were not incentivized.

¹⁶Appendix B presents the instructions for the CRA treatment.

¹⁷Figure 10 (from Appendix) presents the practice questions. These questions were not paid.

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).¹⁸ 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 behavior and firm outcomes at the group level, followed by an analysis of the predictors of individual investment behavior. We then investigate the channels that explain differences in investment behavior 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 behavior 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 threshold separating the two ratings in the CRA treatment.¹⁹ 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

¹⁸The experiment was programmed and run using Ztree software (Fischbacher, 2007). Table 14 (from Appendix) summarizes the sessions.

¹⁹The 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.

Table 2: Average number of investors and ratings

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 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.

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).²⁰ 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.²¹

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 behavior, we run a series of regression analyses on the group (firm)-level. Specifically, in Table 3, we investigate if the size of the investment 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 and 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

²⁰We report a non-parametric K-sample test on the equality of medians performed at the session level, but, in unreported results, we obtain similar statistical results using the non-parametric Mann-Whitney U test.

²¹Figure 6 (from Appendix) illustrates the impact of a credit rating on aggregate investment behavior.

Table 3: Size of investment across different ranges of fundamentals

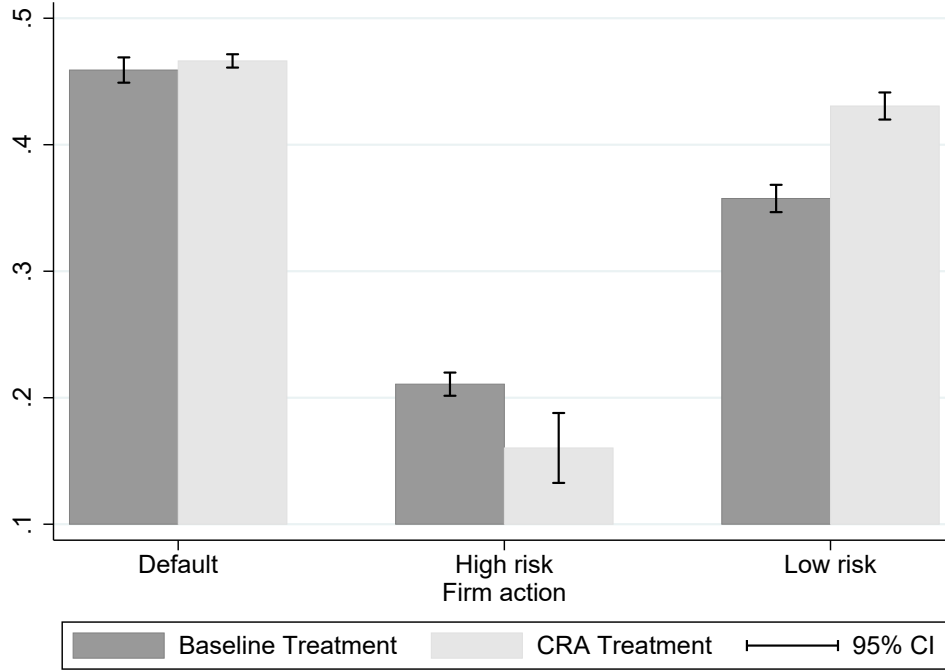
Dependent variable: Size of investment	(1) All	(2) Quartile 1	(3) Quartile 2	(4) Quartile 3	(5) Quartile 4	(6) Bad rating (B)	(7) Good rating (A)
Internal funds (IF)	0.006*** (0.000)	0.001 (0.003)	0.013*** (0.002)	0.014*** (0.002)	0.001** (0.000)	0.006*** (0.001)	0.002*** (0.000)
CRA treatment	0.048 (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 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.

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., 2nd 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., 3rd quartile).²² 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'll further test in Section 4.2, where we examine individual investment behavior.

²²We report in Appendix Table 10 the average number of investors across quartiles of fundamentals. Corroborating the results from Table 3, we observe significant differences in the 2nd and 3rd quartiles, corresponding to values of firm IF in the interval [-137, 20], which include 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 fundamental corresponding to the 1st and 4th quartiles.

Figure 2: Firm 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.

The observed variations in external funding across treatments result in significant differences in firm 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 than in the Baseline treatment (43% vs. 36%).²³ At the same time, the proportion of high-risk projects is lower in the CRA treatment (16% vs. 21%). Finally, 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 invest more (less) in the low (high) risk project than in the Baseline treatment. There is no significant difference in default rates across the two treatments.

²³Appendix Table 11 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.

These results are confirmed in Table 4 in a series of probit regressions that investigate differences in firm 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 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 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 real 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 real positive effects of inflated ratings.²⁴

²⁴In Table 12 (from Appendix) 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 3rd quartile of IF in the CRA treatment as compared to the Baseline treatment. For low (high) fundamentals values (i.e., in the 1st and 4th quartiles, respectively), there is no significant difference in the proportion of firms defaulting (or taking the risky projects) between the treatments.

Table 4: Ratings and firm 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 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.

Together, the results above point to a significant informational role of inflated credit ratings. Our findings suggest that the presence of the (biased) public signal can impact investors' behavior and firms' actions. While theoretically we show that inflated ratings can have negative and positive real 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), 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. Likewise, firms 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

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 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 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.

in investment behavior across treatments.

4.2 Individual investment behavior

We start by examining whether individual behavior is in line with the global games equilibrium selection criteria (i.e., subjects' investment decision is 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, first, that in all specifications, there is a positive and statistically significant correlation between the propensity to invest and the private signal. This result is consistent with Hypothesis 1(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., 2nd and 3rd quartiles, respectively) there is significantly lower (higher) probability of investing in the CRA than in the Baseline 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

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 when a bad rating is disclosed and the opposite effect for the 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 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 behavior 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 behavior of others is a stronger predictor of investment.

Result 4: The expected behavior of other investors is a strong predictor of investment decision, whereas the belief regarding 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 firm fundamentals. In the theoretical model presented in Section 2, inflated ratings have real effects because they provide useful information to creditors: 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 (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.

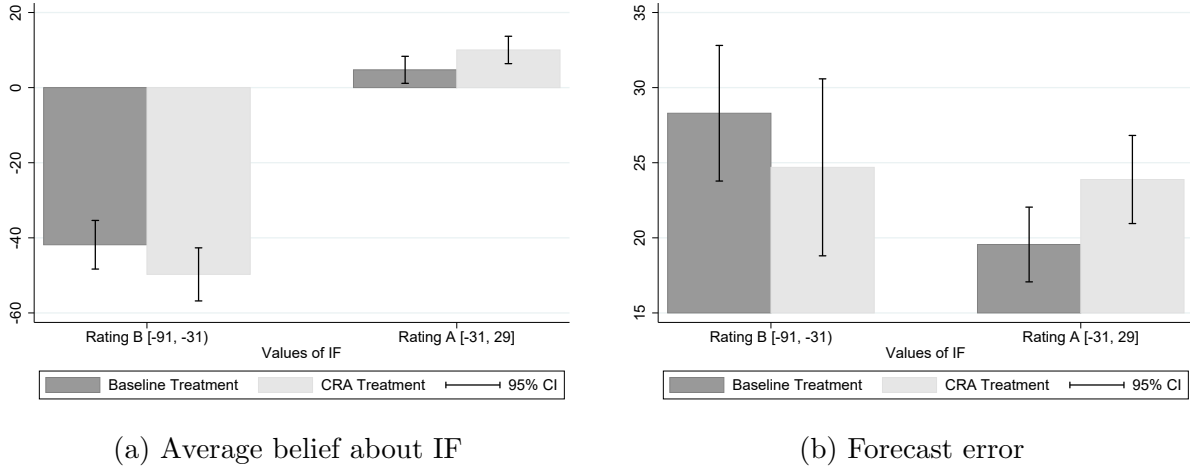
We, thus, start by investigating how the credit rating affects investors' posterior beliefs about firm fundamentals. In particular, for regions of IF that are close to the rating threshold, observing the rating should allow subjects to form more accurate posterior beliefs about the firm's IF.²⁵ Figure 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 the treatments. Overall, posterior beliefs about fundamentals are not significantly different across the two treatments (p-value=0.11; 0.5).²⁶ However, participants seem to be more optimistic about the value of IF for good ratings: they have a higher average belief about IF (panel (a)) and a higher forecast error (panel (b)). For the bad rating, average beliefs are more pessimistic and the forecast error is slightly lower.

Result 5: Investors are more optimistic (pessimistic) about a firm's fundamentals for a good (bad) rating in the CRA treatment than in the Baseline treatment. Still, they lack

²⁵Specifically, for fundamentals that are 2ϵ 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 θ over the maximum interval $[\theta_1^* - 2\epsilon, \theta_1^* + 2\epsilon]$.

²⁶The 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.

Figure 3: Beliefs about the firm's fundamentals



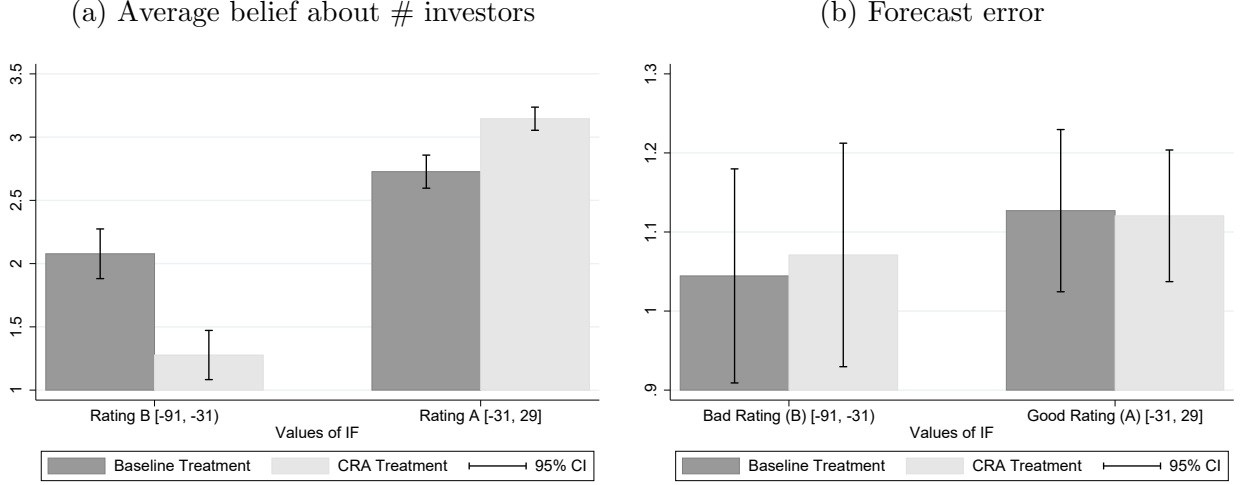
Notes: Panel (a) shows the average stated belief across individuals about the value of the firm's fundamentals around the rating threshold (-31). Panel (b) shows the forecast error measured as the absolute value of the difference between stated beliefs and actual fundamentals. Whiskers mark the 95% confidence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

accuracy in their posterior beliefs about fundamentals in both treatments.

A second channel 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 subjects that receive a bad rating. They hold significantly lower beliefs about the number of others investing ($p\text{-value} < 0.001; 0.02$) in the CRA treatment compared to the Baseline. However, the rating does not improve the accuracy of posterior beliefs about the behavior of others.

Result 6: Investors are more optimistic (pessimistic) about the investing behavior of others for a good (bad) rating in the CRA treatment than in the Baseline treatment. Still, they lack accuracy in their posterior beliefs about others actions in both treatments.

Figure 4: Beliefs about the investment behavior of others

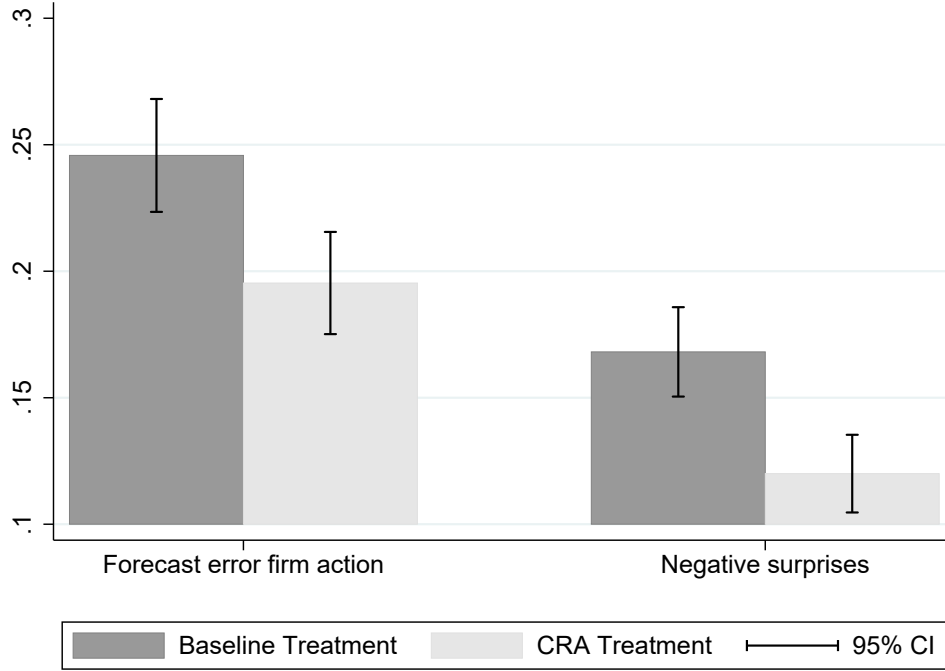


Notes: Panel (a) shows the average stated belief across individuals about the number of others investing around the rating threshold (-31). Panel (b) shows the forecast error measured as the absolute value of the difference between stated beliefs and actual number of other participants investing. Whiskers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

These results suggest that the rating acts as a focal point for participants' coordination problem and helps reduce participants' strategic uncertainty.²⁷ Our results align with the findings of other experimental studies that employ 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). A key result in this literature is that public information has a larger impact on equilibrium outcomes because public signals are more informative about the behavior of others. However, the welfare implications of this “overreaction” to public information depends on how socially optimal coordination is (Baeriswyl and Cornand, 2014). In our experiment, the public credit rating also acts as a strong coordination device, which has positive welfare implications in a setting with feedback effects between the financial and the real sector. As shown in the previous subsection, from an economic efficiency point of view, inflated ratings lead to a significantly higher number of low-risk projects and significantly lower high-risk projects undertaken by the firm.

²⁷We report in the Appendix the posterior beliefs about firm fundamentals and behavior of others across quartiles of fundamentals. Figure 7 illustrates the differences across the two treatments.

Figure 5: Expectations and realized firm action



Notes: 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. The expected firm action is computed based on the stated beliefs about firm fundamentals and behavior 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.

Additionally, investors' outcomes are also superior in the CRA treatment. To show this, we first compute the total ex-ante expected gains of subjects who invest in the two treatments. Specifically, we sum the anticipated gains from investing weighted by the proportion of firms undertaking the low/high-risk projects 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 investors have a significantly higher total expected return in the CRA treatment than in the Baseline (p-value=0.021).

Next, we show that investors are able to better forecast firms actions and are less likely to be negatively surprised by firms 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 firm action and the realized firm action. The expected firm action is computed based on the stated beliefs about firm fundamentals and behavior of others. We find that participants are better able to forecast the actual firm action in the CRA than in the Baseline treatment (p-value = 0.001; 0.25). Better forecast, in turn, leads to fewer negative surprises. In the right panel of Figure 5 we show the percentages of cases where the firm outcomes were less than expected based on participants' stated beliefs. Specifically, a negative surprise is recorded when the firm action turned out to be HR but the participant expected LR, or, similarly, the actual firm action was Default when HR or LR was expected). We find that participants have fewer negative surprises in the CRA treatment (p-value < 0.001; 0.25).

Finally, we confirm our 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) of 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 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 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 beliefs about fundamentals and the number of others investing are affected by the presence of the rating in the CRA treatment. On the one hand, the results in columns (3) and (4)

Table 7: 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 IF are above (below) -31 and 0 if the treatment is the Baseline and the firm IF are above (below) -31. Standard errors clustered at the subject level are reported in the parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

confirm that 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) for values of the fundamentals corresponding to a good (bad) rating in the CRA treatment compared to the Baseline treatment. We observe that the coefficient for *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: Good (bad) ratings have a significant positive (negative) impact on beliefs about the behavior of other investors. The effect of a bad rating is larger than that of a good rating. Beliefs about firm fundamentals are unaffected by ratings.

Overall, our results highlight the importance of ratings as a coordination device. While the ratings do not significantly affect the beliefs about the quality of the firm, they do influence the beliefs about the behavior of other investors. For good ratings, investors hold significantly

higher beliefs about the number of other 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. These patterns emphasize the role of credit ratings in reducing strategic uncertainty about the actions of others.

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. 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.²⁸ We control for selected socioeconomic characteristics of subjects: gender, 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. We define a negative surprise through a dummy variable equal to 1 if the firm outcome was worse than a subject expected based on its stated beliefs. Specifically, given the beliefs about fundamentals and number of other withdrawing, we compute the expected firm action. The dummy variable take the value 1 if the firm invests in the HR project or defaults when participants expect the firm action to be LR project or, similarly, the firm defaults when investment in the HR or LR projects was expected.

Our results from Table 7 are robust to additionally including these explanatory variables. We find evidence that loss averse individuals are less likely to invest (columns (1) and (2)), while

²⁸The risk aversion indicator equals 1 if a subject chooses one of the first three gambles depicted in Figure 8 from Appendix, corresponding to a risk-averse attitude in [Dave *et al.*'s \(2010\)](#) test. The loss aversion indicator equals 1 if a participant accepts at most two of the lotteries depicted in Figure 9 from Appendix, corresponding to an implied degree of loss aversion greater than 1.5 in the loss aversion test proposed in [Gächter *et al.* \(2022\)](#).

risk aversion has little explanatory power. At the same time, more negative past surprises appears positively correlated with the probability of investing (column (2)). Socioeconomic characteristics such as gender and financial experience, on the other hand, are not statistically significantly associated with the likelihood to invest or beliefs formation.²⁹

Finally, we use the information collected during the experiment’s second part, which included several questionnaires 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 behavior 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 sizable differences between the two treatments in the perceived ease of making choices or subjects confidence. The results of the post-experiment survey corroborates with findings previously discussed: on average, participants give more importance to estimating the behavior of others than the firm’s fundamentals.

5 Concluding remarks

We conduct a laboratory experiment to examine the interaction between inflated credit ratings, investors’ behavior, and firm investment and study potential channels through which ratings can affect economic efficiency. Credit ratings can have real economic effects as they not only reflect, but can also affect a debt issuer’s credit quality. However, the real effects of inflated credit ratings are less clear. The main argument for the detrimental role of inflated ratings is that they enable firms to fund risky investments and, as a result, have adverse real effects. Yet, inflated credit ratings can also increase economic efficiency by providing

²⁹Table 13 (from Appendix) 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 IF are above (below) -31 and 0 if the treatment is the Baseline and the firm 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 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. ***, **, * indicate significance at the 1, 5, and 10% levels, respectively.

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 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

informative (though potentially biased) signals that can affect a firm's financing costs and the types of projects undertaken, thereby justifying the initial rating ([Goldstein and Huang, 2020](#)). Whether the positive or negative effect dominates is an empirical question that has been understudied due to difficulties in first empirically observing which ratings are inflated and second, dealing with the endogeneity concern that ratings and investors' behavior are driven by the same (unobserved) confounding factors. Our experimental design allows us to overcome these obstacles and control for firm fundamentals and investors' information sets in order to understand the informational role of inflated credit ratings.

Our main finding is that positive effects are likely to dominate. Inflated credit ratings act as a coordination device and provide informative signals shaping investors' beliefs about other investors' investment behavior while having a modest impact on beliefs about firm fundamentals. Receiving a good (potentially inflated) rating makes investors more optimistic about the behavior of other investors. This improves a firm's access to external funding allowing the firm to undertake efficient-value-enhancing projects. Conversely, a bad rating makes investors more pessimistic about the behavior of others, reducing investors' incentive to provide funding. Limited access to external financing increases the likelihood that an unviable firm defaults instead of taking excessive risks. This result suggests that potential adverse real effects are muted. Overall, our findings indicate that even less precise ratings

can lead to a more efficient allocation of capital and improved market outcomes.

References

- ALLEN, F., MORRIS, S. and SHIN, H. S. (2006). Beauty Contests and Iterated Expectations in Asset Markets. *The Review of Financial Studies*, **19** (3), 719–752.
- ALMEIDA, H., CUNHA, I., FERREIRA, M. A. and RESTREPO, F. (2017). The real effects of credit ratings: The sovereign ceiling channel. *The Journal of Finance*, **72** (1), 249–290.
- ALP, A. (2013). Structural shifts in credit rating standards. *The Journal of Finance*, **68** (6), 2435–2470.
- ASHCRAFT, A. B. and SCHUERMANN, T. (2008). Understanding the securitization of subprime mortgage credit. *Foundations and Trends in Finance*, **2** (3), 191–309.
- BAERISWYL, R. and CORNAND, C. (2014). Reducing overreaction to central banks’ disclosures: theory and experiment. *Journal of the European Economic Association*, **12** (4), 1087–1126.
- and — (2016). The predominant role of signal precision in experimental beauty contests. *The BE Journal of Theoretical Economics*, **16** (1), 267–301.
- BAYONA, A. and PEIA, O. (2020). Financial contagion and the wealth effect: An experimental study. *Journal of Economic Behavior & Organization*.
- BENMELECH, E. and DLUGOSZ, J. (2009). The credit rating crisis. *NBER Working paper*, (15045).
- BLOOMFIELD, R. and ANDERSON, A. (2010). Experimental finance. *Behavioral Finance: Investors, Corporations, and Markets*, John Wiley & Sons, Inc, Hoboken, NJ, USA, pp. 113–130.
- BOND, P., EDMANS, A. and GOLDSTEIN, I. (2012). The real effects of financial markets. *Annu. Rev. Financ. Econ.*, **4** (1), 339–360.

- BOOT, A. W., MILBOURN, T. T. and SCHMEITS, A. (2006). Credit ratings as coordination mechanisms. *The Review of Financial Studies*, **19** (1), 81–118.
- BOSSAERTS, P. *et al.* (2009). The experimental study of asset pricing theory. *Foundations and Trends® in Finance*, **3** (4), 289–361.
- CABRALES, A., NAGEL, R. and ARMENTER, R. (2007). Equilibrium selection through incomplete information in coordination games: an experimental study. *Experimental Economics*, **10** (3), 221–234.
- CARLSSON, H. and VAN DAMME, E. (1993). Global games and equilibrium selection. *Econometrica*, **61** (5), 989–1018.
- CORNAGGIA, J. and CORNAGGIA, K. J. (2013). Estimating the Costs of Issuer-Paid Credit Ratings. *The Review of Financial Studies*, **26** (9), 2229–2269.
- , — and ISRAELEN, R. D. (2018). Credit ratings and the cost of municipal financing. *The Review of Financial Studies*, **31** (6), 2038–2079.
- CORNAND, C. and HEINEMANN, F. (2014a). Experiments on monetary policy and central banking. In *Experiments in macroeconomics*, Emerald Group Publishing Limited.
- and — (2014b). Measuring agents’ reaction to private and public information in games with strategic complementarities. *Experimental Economics*, **17** (1), 61–77.
- DALEY, B., GREEN, B. and VANASCO, V. (2020). Securitization, ratings, and credit supply. *The Journal of Finance*, **75** (2), 1037–1082.
- DAVE, C., ECKEL, C. C., JOHNSON, C. A. and ROJAS, C. (2010). Eliciting risk preferences: When is simple better? *Journal of Risk and Uncertainty*, **41** (3), 219–243.
- ECKEL, C. C. and GROSSMAN, P. J. (2008). Forecasting risk attitudes: An experimental study using actual and forecast gamble choices. *Journal of Economic Behavior & Organization*, **68** (1), 1–17.

- FISCHBACHER, U. (2007). z-tree: Zurich toolbox for ready-made economic experiments. *Experimental economics*, **10** (2), 171–178.
- FULGHIERI, P., STROBL, G. and XIA, H. (2014). The economics of solicited and unsolicited credit ratings. *The Review of Financial Studies*, **27** (2), 484–518.
- GÄCHTER, S., JOHNSON, E. J. and HERRMANN, A. (2022). Individual-level loss aversion in riskless and risky choices. *Theory and Decision*, **92** (3), 599–624.
- GAO, P. (2008). Keynesian beauty contest, accounting disclosure, and market efficiency. *Journal of Accounting Research*, **46** (4), 785–807.
- GOEL, A. M. and THAKOR, A. V. (2015). Information reliability and welfare: A theory of coarse credit ratings. *Journal of Financial Economics*, **115** (3), 541–557.
- GOLDSTEIN, I. and HUANG, C. (2020). Credit rating inflation and firms’ investments. *The Journal of Finance*, **75** (6), 2929–2972.
- HE, Z. and XIONG, W. (2012). Dynamic debt runs. *The Review of Financial Studies*, **25** (6), 1799–1843.
- HEINEMANN, F., NAGEL, R. and OCKENFELS, P. (2004). The theory of global games on test: Experimental analysis of coordination games with public and private information. *Econometrica*, **72** (5), 1583–1599.
- , — and — (2009). Measuring strategic uncertainty in coordination games. *The Review of Economic Studies*, **76** (1), 181–221.
- JEON, D.-S. and LOVO, S. (2013). Credit rating industry: A helicopter tour of stylized facts and recent theories. *International Journal of Industrial Organization*, **31**, 643–651.
- KESER, C., ÖZGÜMÜS, A., PETERLÉ, E. and SCHMIDT, M. (2017). An experimental investigation of rating-market regulation. *Journal of Economic Behavior & Organization*, **144**, 78–86.

- KLIGER, D. and SARIG, O. (2000). The information value of bond ratings. *The journal of finance*, **55** (6), 2879–2902.
- MANSO, G. (2013). Feedback effects of credit ratings. *Journal of Financial Economics*, **109**, 535–548.
- MORRIS, S. and SHIN, H. S. (1998). Unique equilibrium in a model of self-fulfilling currency attacks. *American Economic Review*, **88** (3), 587–597.
- and — (2004). Coordination risk and the price of debt. *European Economic Review*, **48** (1), 133–153.
- MY, K. B., CORNAND, C. and FERREIRA, R. D. S. (2021). Public information and the concern for coordination. *Journal of Behavioral and Experimental Economics*, **93**, 101710.
- PARLOUR, C. A. and RAJAN, U. (2020). Contracting on credit ratings: Adding value to public information. *The Review of Financial Studies*, **33** (4), 1412–1444.
- PEIA, O. and VRANCEANU, R. (2019). Experimental evidence on bank runs with uncertain deposit coverage. *Journal of Banking & Finance*, **106**, 214–226.
- RABANAL, J. P. and RUD, O. A. (2017). Does Competition Affect Truth Telling? An Experiment with Rating Agencies. *Review of Finance*, **22** (4), 1581–1604.
- SANGIORGI, F. and SPATT, C. (2017). The economics of credit rating agencies. *Foundations and Trends in Finance*, **12** (1), 1–116.
- SANJAY, B. and MAIER, M. (2016). Public information precision and coordination failure: An experiment. *Journal of Accounting Research*, **54** (4), 941–986.
- SHURCHKOV, O. (2016). Public announcements and coordination in dynamic global games: Experimental evidence. *Journal of Behavioral and Experimental Economics*, **61**, 20–30.
- SUFI, A. (2009). The real effects of debt certification: Evidence from the introduction of bank loan ratings. *The Review of Financial Studies*, **22** (4), 1659–1691.

- SUNDER, S. (2007). What have we learned from experimental finance? In *Developments on Experimental Economics*, Springer, pp. 91–100.
- TANG, T. T. (2009). Information asymmetry and firmsâ credit market access: Evidence from moody’s credit rating format refinement. *Journal of financial economics*, **93** (2), 325–351.
- TEROVITIS, S. (2020). Information disclosure and the feedback effect in capital markets. *Journal of Financial Intermediation*, p. 100897.
- WEBER, M., DUFFY, J. and SCHRAM, A. (2018). An experimental study of bond market pricing. *The Journal of Finance*, **73** (4), 1857–1892.
- WHITE, L. J. (2013). Credit rating agencies: An overview. *Annu. Rev. Financ. Econ.*, **5** (1), 93–122.

Appendix A

A1. Proof of Proposition 1

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

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

following from the fact that signals are uniformly distributed over $[\theta - \epsilon, \theta + \epsilon]$. A firm would choose 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 θ , 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 her 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 or not the bond. 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 cash flows when observing a signal \tilde{x} is uniformly distributed over $[\tilde{x} - \epsilon, \tilde{x} + \epsilon]$.

This is a linear system of equations in three unknowns $(\tilde{x}, \tilde{\theta}_1, \tilde{\theta}_2)$, which 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 $2\epsilon I > 0$, one can also easily check that $\tilde{\theta}_2 > \tilde{\theta}_1$, which completes the proof of equilibrium.

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 θ -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 first the case in which creditors believe that a rating p implies that the firm has better fundamentals than one with rating q . In that case, if the CRA deviates and assigns rating p , more creditors will invest, so if the firm does not default with a rating of q , it won't default if the CRA assigns a rating of p either. At the same time, the condition $\frac{S^p - S^q}{C^p - C^q} \geq 1 - q$ also 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 $S^p - (1 - q)C^p$. But from (13), we have that $S^p - (1 - q)C^p > S^q - (1 - q)C^q$, so the CRA finds it profitable to deviate and assign rating p even if the firm invests in project HR and default with probability $1 - q$. If, on the other hand, the firm invest in project LR, we have that $S^p - (1 - p)C^p > S^q - (1 - p)C^q$, which again implies that it is more profitable for the CRA to deviate and always assign rating p .

Consider now the case where creditors do not believe that a rating p implies that the firm has better fundamentals than one 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 $\theta \in (\theta_1, \theta_2)$ and $\theta_3 < \theta_4 < \theta_1 < \theta_2$. If now the CRA deviates and assigns a firm in interval (θ_1, θ_2) a rating of p instead of q , then creditors will believe that the fundamental is worse, i.e., in (θ_3, θ_4) . But firms in neither (θ_1, θ_2) nor (θ_3, θ_4) intervals will default early (as the CRA never assigns a rating different from zero to firms it believes it will default early). So firms in interval $\theta \in (\theta_1, \theta_2)$ will not default early even if assigned a rating p . And since condition (13), implies that the CRA has higher expected profits when assigning a rating p , then, in this case too, the CRA will deviate and prefer to assign a rating p .

This implies there is no equilibrium where the CRA will assign a rating q when (13) holds.

A3. Proof of Proposition 2

Similar to the proof in Proposition 1, we need to show that equations (10), (11) and (9) admit a unique solution. The system of equations can be re-written as:

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

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

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

It then straightforward to show $\tilde{\theta}_1 < \theta_1^*$ iff $\epsilon < \bar{\epsilon} \equiv \frac{(p-q)FI}{2(pF-1)} - \frac{1}{2}$.

Appendix B: Additional results

Table 10: Average number of investors and fundamentals

Fundamentals	Baseline	CRA	Test 1	Test 2
1 st quartile	0.43 (0.56)	0.24 (0.51)	0.0246	0.248
2 nd quartile	0.97 (1.12)	0.46 (0.68)	0.0005	0.021
3 rd quartile	2.80 (1.40)	3.44 (1.57)	0.0063	0.248
4 th 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 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 Firm action	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)
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

Table 12: Firm actions across quartiles of fundamentals

Quartile	Firm action	Baseline (1)	CRA (2)	Difference
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

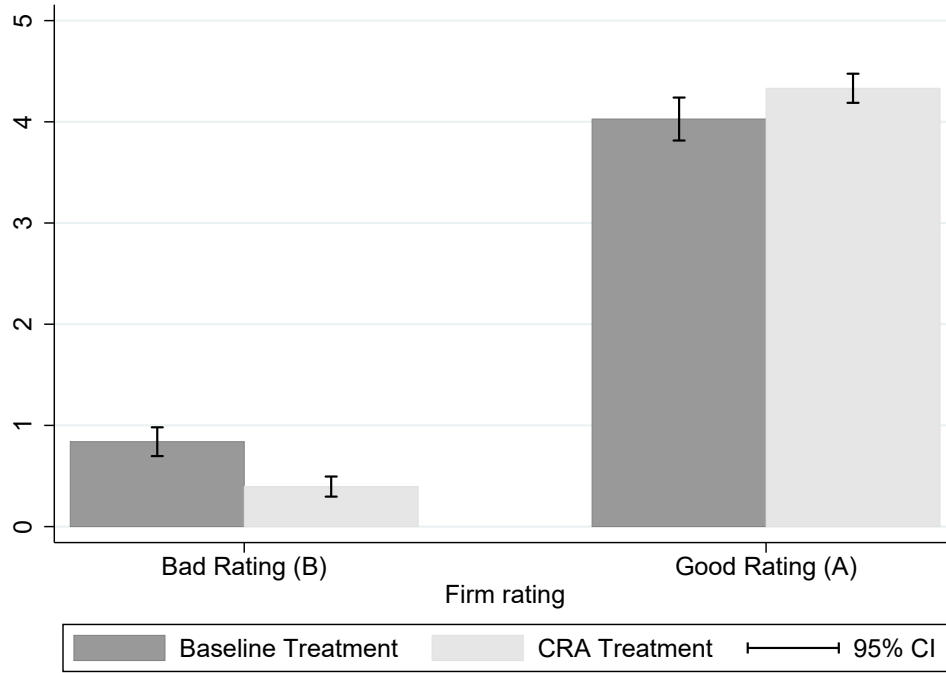
Notes: The table shows in columns (1)-(2) the mean percentage of firm actions across quartiles of firm fundamentals. The statistical significance of the difference in column (3) is based on a non-parametric K-sample test on the equality of medians performed at the session level.***, ** , and * indicate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

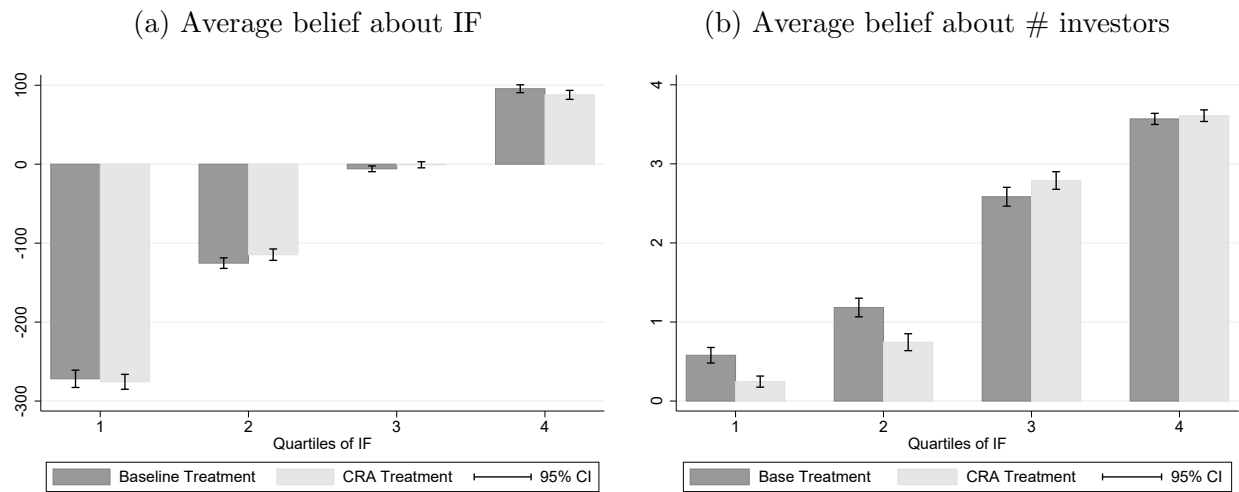
Notes: The table presents estimates from probit regressions where the dependent variable is an indicator equal to 1 if the participant invests. Columns (1)-(4) correspond to the Baseline treatment, while (5)-(8) to the CRA, respectively. *Hint about IF* captures the private information about firm fundamentals. *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 Euro 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, 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), high-risk project (HR), or 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.

Financing	Firm's action
$300 \leq IF + EF$	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.

	Internal funds of the firm													
	-400		-300		-200		-100		0		100		200	
Hypothetical number of players who invest	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 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:

$$[\text{True value of firm's IF}-30, \text{True value of firm's IF}+30].$$

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 only known 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 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 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 do you think is the true level of the firm's internal funds (IF)? (type a number)

(b) how many other investors do 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 E uro at the conversion rate 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 this 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 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% 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: 20 points are equivalent to 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%

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	Pompeo Fabra University
Baseline Treatment, Session 5	20	April 2022	Pompeo Fabra University
Baseline Treatment, Session 6	20	April 2022	Pompeo 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	Pompeo Fabra University
CRA Treatment, Session 5	20	April 2022	Pompeo Fabra University
CRA Treatment, Session 6	20	April 2022	Pompeo Fabra University

Appendix D: Experimental sessions and screens

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

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 beliefs
Your private hint about the firm's <u>internal funds</u> (IF) is: -300	What do you think is the actual level of the firm's <u>internal funds</u> (IF)? <input type="text"/>
The public credit rating of the firm's ability to repay is: Rating B	What is your estimate of the total number of <u>other</u> investors that choose to invest? <input type="text"/>
<div>Dialog The number of other investors can only be between 0 and 4 <input type="button" value="OK"/></div> <div><input type="button" value="CONFIRM BELIEFS"/></div>	

Figure 12: Decision screen 2

Information about the investment decision	Your beliefs
Your private hint about the firm's <u>internal funds</u> (IF) is: -300	What do you think is the actual level of the firm's <u>internal funds</u> (IF)? 100
The public credit rating of the firm's ability to repay is: Rating B	What is your estimate of the total number of <u>other</u> investors that choose to invest? 2
<div><input type="button" value="SIMULATOR"/></div> <div>Your decision <div><input type="button" value="NOT INVEST"/> <input type="button" value="INVEST"/></div></div>	