Advertisement-Financed Credit Ratings*

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Abstract

This paper investigates the incentives of a credit rating agency (CRA) to generate accurate ratings under an advertisement-based business model. We study a two-period endogenous reputation model in which the CRA can choose to provide private effort in evaluating financial products in each period. We show that the advertisement-based business model may provide sufficient incentives to improve the precision of signals when the CRA has an intermediate reputation. Furthermore, we identify conditions under which truthful reporting is incentive compatible.

JEL classification: D82, G24, L15.

Keywords: credit rating agencies, rating precision, information acquisition, advertisement, reputation.

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1 Introduction

Credit rating agencies (CRAs) act as intermediaries on financial markets between issuers of financial products and investors. They assess the creditworthiness of an issuer and publish the results of these assessments usually in the form of ratings to investors. In the past two decades, CRAs have widely been accused of publishing inaccurate ratings. In fact, the three major CRAs - Standard and Poor's Financial Services (S&P), Moody's Investors Service and Fitch Ratings - have published ratings considered to be investment grade for the American energy company Enron until shortly before Enron filed for bankruptcy in 2001.[1] Also, CRAs have been criticized for systematically failing to assess the high risk of structured assets like mortgage-backed securities and collateralized debt obligations issued during the U.S. housing boom, and thereby contributing to the financial crisis of 2008.[2]

There is a recent literature, trying to ascertain to what extent the CRA business model is responsible for inaccurate ratings. Until the early 1970s, most CRAs relied on the investor-pays model, under which fees for access to ratings are collected from investors. Today, most CRAs, including the three major ones, operate under the issuer-pays model where the revenue for ratings comes in the form of fees paid by the issuers of the securities. Comparing these two business models, Kashyap and Kovrijnykh (2016) and Bongaerts (2019), for instance, show that the investor-pays model generates more accurate ratings than the issuer-pays model when acquiring information about the default risk of a financial product is costly.

The present paper contributes to this literature by considering the accuracy of ratings under a different mechanism of CRA financing, namely, the use of online platforms to publish ratings and earn advertising revenue by attracting investors to these platforms. To our knowledge the idea of advertisement-financed credit rating, first raised in White (2013), has not been formally analyzed - a surprising fact, given that, in other industries, many intermediaries that were originally based on a subscriber-pays business model have switched to an advertisement-based business model, such as for example TV-stations and

[1]See, e.g., Berenson, A., New York Times, Nov. 29, 2001.

[2]See, e.g., White (2016).

newspapers (cf. Evans, 2008).[3]

The main objective of our paper is to investigate whether an advertisement-based business model may provide sufficient incentives to generate accurate ratings when information acquisition by the CRA is costly. To this end, we study a two-period model in which the CRA receives a noisy signal about the default risk of a financial product in each period. The precision of signals is costly and chosen by the CRA. This choice is unobservable by firms and investors, which creates a moral hazard problem. In the spirit of Kreps and Wilson (1982) and Milgrom and Roberts (1982), we assume that the CRA can be one of two possible types: committed to use the most accurate information technology or opportunistic, i.e., maximizing its continuation payoff. Types are drawn by nature and remain private information. Investors form subjective beliefs that the CRA is committed, measuring the CRA's reputation. If this reputation is high enough such that the CRA's ratings matter for the investment in risky projects, investors get attracted to the CRA's website and advertisement revenue is generated.

It is intuitive, and shown to be optimal, that the CRA will shirk, i.e., not improve the precision of the signals, if its reputation is either below a certain threshold level or above another threshold level. In the former case, future advertisement revenue is shown to be zero, irrespective of the CRA's information technology. In the latter case, future advertisement revenues will be positive, but constant even when highly-rated projects have failed. The key insight of our analysis is that, for a range of intermediate reputation levels, an opportunistic CRA will in fact publish more accurate ratings as the only equilibrium outcome. By improving the precision of signals, the CRA can reduce the probability that a highly-rated project fails which helps the CRA to maintain the reputation necessary to attract investors to its website. Furthermore, even when the reputation is not high enough initially, we show that the advertisement-based business model may provide sufficient incentives to improve the precision of signals in order to build a reputation over time.

Allowing the CRA to misreport the signal that it received about the quality of the financial product, we delineate the conditions for truthful reporting in every equilibrium involving maintaining or building a reputation. We show that increasing the precision

[3] Whereas the newspaper industry typically uses a mix between advertisement and subscription fees, TV-stations often use a pure advertisement model.

of signals and truth-telling can only be incentivized if the advertisement revenues are state-contingent and sufficiently rewarding relative to the cost of improving the precision of signals whenever a highly-rated project succeeds. The results also have implications for regulatory intervention, such as introducing special liability rules for CRAs (see, e.g., Pacces and Romano, 2015), in environments in which the accuracy of ratings cannot be incentivized.

Kashyap and Kovrijnykh (2016) characterize an incentive-compatible compensation scheme to induce the CRA to improve its signal precision and report the signals truthfully. The authors discuss, but in contrast to the present paper, do not formally analyze its implementation in a dynamic setting involving reputation concerns. Interestingly, the analysis of our two-period endogenous reputation model reveals that the incentive-compatible compensation structure can be implemented by an advertisement-financed business model with state-contingent revenues. Since the revenues are obtained from a third party, namely advertisers, we view our study as complementary to their work. Using a mechanism design approach, Chakraborty et al. (2019) characterize outcome-contingent payments to the CRA by a trust to induce the CRA to exert costly effort to increase the precision of signals and report the signals truthfully. The implementation of this mechanism requires that the trust is funded by issuers before it negotiates with the CRA, along with regulation ruling out any side payments to the CRA. By contrast, the mechanism considered in our paper does not depend upon a centralized authority specifying outcome-contingent payments and enforcing the rules. Instead, the advertisement-based business model considered here relies on the incentive structures created by the benefits of building and maintaining a reputation.

Our paper is also related to the recent work on costly information acquisition under the issuer-pays business model. For example, Bizzotto and Vigier (2019) examine the CRA's reputational incentives to acquire costly signals when the CRA is only paid for giving favorable ratings and when it is paid upfront, i.e., irrespective of the signals. The key difference is that the CRA is paid by the issuers of financial products, in contrast to the advertisement-financed mechanism considered in our paper. Moreover, the precision of signals is exogenously given in Bizzotto and Vigier (2019), whereas the CRA can exert costly effort to increase the signal precision in our setting. Charoontham and Amornpetchkul (2018) propose an alternative issuer-pays compensation mechanism under which the CRA obtains an upfront fee equal to the CRA's rating cost. In addition, the CRA obtains a share of the project return. In contrast to the present paper, the CRA and the investor are modeled as a single agent aiming at maximizing the expected projects return. Another key difference is that the precision of signals is a choice variable of the CRA in our paper, whereas it is contactable and set by the issuer in Charoontham and Amornpetchkul (2018). There are also no reputation concerns considered in their paper. Kartasheva and Yilmaz (2020) investigate the CRA's choice of signal precision in an issuer-pays model in which issuers are perfectly informed about their project's type. It is shown that in this setting the CRA may have an incentive to reduce the precision of its signals, even when more informative signals were costless. The reason is that noisy signals allow the CRA to equalize the willingness to pay for ratings across different issuer types and thereby extract all market surplus. Thus, in their paper, apart from considering a different business model, there is no problem of shirking in terms of signal precision which the focus of ours. Kovbasyuk (2018) shows that the CRA's incentives for costly information acquisition under the issuer-pays model may also depend on whether the payments to the CRA are publicly observable or not. Bongaerts (2014, 2019) explores an environment where a CRA's effort determines rating precision and is unobservable, similarly as in our model. The key difference is that his study focuses on the competition between issuer-pays and investor-pays CRAs. Opp et al. (2013) show that a rating-contingent regulation of institutional investors' capital requirements may increase or decrease the precision of signals chosen by the CRA. There are two major differences between our work and their contribution. First, the CRA is advertisement-financed in our paper. Second, we consider reputational incentives to acquire costly information.

Related are also some papers on the incentives for misreporting and rating inflation under the issuer-pays model. Mathis et al. (2009) analyze whether reputational concerns can incentivize CRAs to report truthfully under the issuer-pays model. Unlike us, they assume that the signal is perfectly informative. Mathis et al. (2009) show that reputation is only a good discipline device for CRAs when a sufficiently large fraction of the CRA income comes from other sources than rating complex products. They advocate to eliminate any direct commercial links between CRAs and issuers – a claim that is fulfilled under the advertisement-financed credit rating considered in our paper. Frenkel (2015) shows that, under the issuer-pays model, a CRA may also have an incentive to develop a reputation for lax rating standards among issuers. These reputational concerns can exacerbate the problem of rating inflation - an effect which is not present under advertisement financing. Moreover, in contrast to our paper, information acquisition is costless in his model. This rules out any reputational incentives for producing more informative signals, which are the focus of our analysis. Fulghieri et al. (2014) distinguish between solicited and unsolicited ratings and show that unsolicited ratings are lower because all favorable ratings are solicited. In our advertisement-financed model, all ratings are unsolicited.

At a broader level, our paper is related to the literature on certification, e.g. Bizzotto et al. (2016), Stahl and Strausz (2017), Bouvard and Levy (2018). These papers investigate markets on which the quality of the traded good is unobservable to buyers. Buyers and sellers may both pay for certification because they benefit from signaling their quality or respectively learning the quality of the offered good. In fact, a CRA is an example for a certifier that can be paid either by sellers (issuers), buyers (investors), or a third party such as advertisers.

The remainder of this paper is structured as follows. The next section describes the model of credit rating under the advertisement-based business model. The equilibrium analysis is provided in Section 3. Section 4 introduces and analyzes an extension in which misreporting is possible. Finally, Section 5 provides a summary of our findings and concludes. All proofs are placed in the Appendix.

2 The Model

We consider a financial market model, based on that of Mathis et al. (2009), with two periods, $t = 1, 2$.[4] At each period, a wealthless firm seeks financing to invest in a risky project of a size normalized to 1 that generates a return $X > 1$ in the event of success and 0 in the event of failure. The probability of success depends on the project's type τ_t, which can be good or bad, $\tau_t \in \{g, b\}$. A good project is successful with probability α

[4] Mathis et al. (2009) consider an infinite succession of periods.

and fails with probability $1-\alpha$, while a bad project always fails.[5] The project's type is unknown a priori: It can be the g-type with probability λ, and the b-type with probability $1-\lambda$. To facilitate the analysis, we restrict attention to the case of $0<\lambda<1/2$. That is, there is a larger proportion of type-b projects.

At each period, there is a number ($n \geq 2$) of identical investors.[6] Investors are risk neutral and competitive. They can invest either in the firm's project or in an outside option with a certain return, normalized to 1. Each firm promises to pay a return $R \in [0, X]$ to investors if the project is financed and successful. A project that is not financed cannot be carried out and is not available in future periods. Assume that

$$\lambda\alpha X < 1 < \alpha X \tag{A1}$$

The first part of (A1) implies that investors would not invest without any further information about the project's type. The second part implies that investment would take place when there is no uncertainty.

A credit rating agency (CRA) receives information about the project's type. Whereas firms and investors are short-lived (for one period), the CRA is a long-lived player (for two periods). The CRA obtains a private signal $\sigma_t \in \{L, H\}$, unfavorable (L) or favorable (H), about the firm's project type in period t. The signal may be noisy, which is in contrast to Mathis et al. (2009) who consider only the case of perfectly informative signals. We assume instead that the CRA can improve the precision of the signals, similar as in Kashyap and Kovrijnykh (2016). Let s_t be the CRA's effort exerted to increase the informativeness of the signal about the project's type in period t, and let probability that the signal is favorable, given that the project is good, be

$$\Pr(\sigma_t = H|\tau_t = g) = \Pr(\sigma_t = L|\tau_t = b) = \frac{1}{2} + s_t, \tag{1}$$

where $0 \leq s_t \leq 1/2$.[7] The effort s_t in the precision of the signal entails a cost of $c(s_t)$, with $c(0) = c'(0) = 0,\ c'(s_t) > 0$ for $s_t > 0$ and $c''(s_t) \geq 0$. We assume that the CRA's

[5]In the extended model of Mathis et al. (2009), the probability of success for the bad project is assumed to be less than the probability of success for the good project, but positive.

[6]In particular, all investors have the same prior beliefs and they face the same outside option.

[7]This is a special case of the information production technology considered in Kashyap and Kovrijnykh (2016). Note that higher effort makes the signal more informative in Blackwell's sense.

effort is unobserved by firms and investors and unverifiable. Thus, the CRA cannot be directly rewarded for exerting effort to acquire more precise signals. Our analysis rather focuses on the impact of reputational incentives. In the spirit of Kreps and Wilson (1982) and Milgrom and Roberts (1982), let the CRA be one of two types, $\theta \in \{C, O\}$, i.e., committed to receive a perfectly informative signal (C) or opportunistic (O) in which case it may obtain an imperfect of even completely uninformative signal.[8] The CRA's types are private information and randomly drawn with probability

$$\Pr(\theta = C) = \varphi_1 \quad \text{and} \quad \Pr(\theta = O) = 1 - \varphi_1, \quad \varphi_1 \in (0, 1)$$

We assume that the observed signal is truthfully reported to investors in the form of a rating, i.e., either "good" ($r_t = H$) or "bad" ($r_t = L$).[9] That is, the CRA disseminates only correct information. This assumption is made to capture, in a simple way, the fact that, otherwise, the CRA may face potential legal damage. By contrast, Mathis et al. (2009) treat the CRA's information production technology as exogenous and focus on the CRA's incentive of misreporting, i.e., giving a good rating when the CRA believes that the project is bad. We will extend our basic framework below to allow for both, shirking and misreporting, similar as in Kashyap and Kovrijnykh (2016) and Chakraborty et al. (2019).

A novel element is now introduced in such CRA models by assuming that the CRA earns a revenue through an advertising-financed business model.[10] More precisely, we consider a CRA who, in each period, publishes its rating on a website that investors can visit without any subscription fees. If the site attracts sufficient attention from investors, advertisers are willing to place ads on this site which generates a positive advertisement revenue $\pi > 0$ for the CRA in that period. Investors are willing to visit the website whenever they believe that the CRA's ratings will influence their investment decision.

[8]Note that one could alternatively assume that the 'committed type' faces zero costs of increasing the signal precision.

[9]It is obviously a simplification to allow only for two different rating scores. In the real world, finer partitions of ratings can be observed. Standard & Poor's, for instance, uses 24 rating grades, which span from AAA to D. Hereby, the best ten rating grades, from AAA to BBB-, are considered to be investment grade. The remaining 14 grades, from BB- to D, are considered to be speculative grade.

[10]For recent surveys of the literature on advertising-financed business models in other industries, see, e.g. Anderson (2012), Anderson and Jullien (2015).

We show that this occurs if and only if the CRA's reputation of publishing an accurate rating is high enough. Otherwise, the advertisement revenue will be 0. This happens when the observation of good and bad ratings would both lead to the same investment decision. Note that, despite its simplicity, the revenue structure incorporates one of the most important characteristics of the advertisement industry, namely, that expected revenue is increasing in the "attention" that a website attracts (cf. Ahmed and Kwon, 2012).

For period 1, the order of play is represented by the game trees depicted in Figure 1.

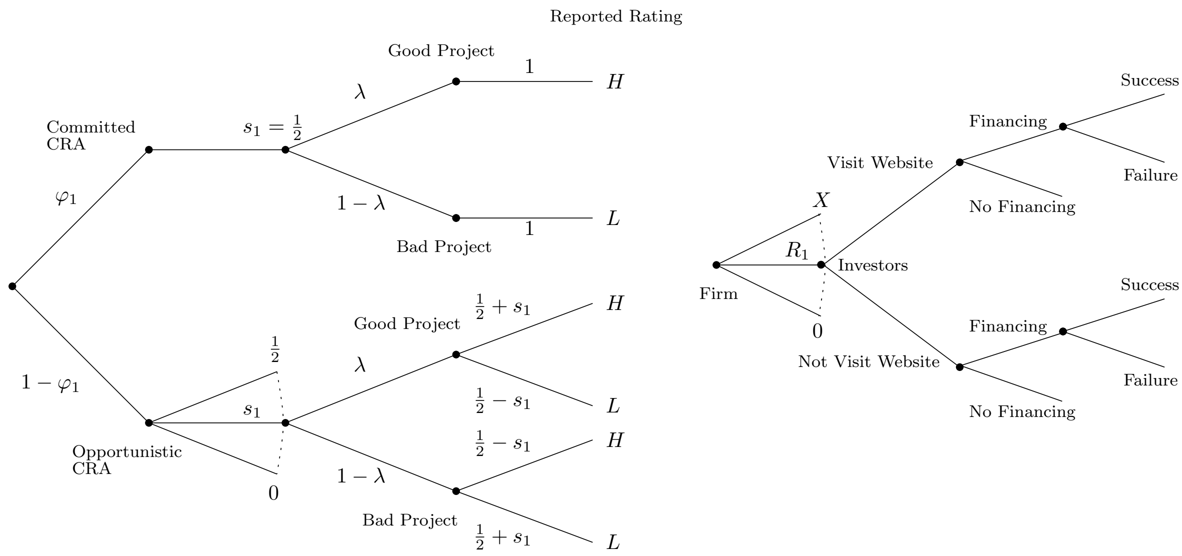

Figure 1: First Period Play

At the beginning of period 1, the committed CRA exerts effort $s_1 = 1/2$, whereas the opportunistic CRA type chooses an effort level of $s_1 \in [0, 1/2]$. Each CRA type then observes a signal and reports it truthfully to investors in the form of a rating, $r_1 \in \{L, H\}$. The firm sets $R_1 \in [0, X]$, i.e., the return to investors if the project is financed and successful. Investors then choose whether to visit the website or not. Their prior belief at the beginning of each period t that the CRA is committed to obtain perfectly informative signals is φ_1 (see left tree in Figure 1). This is the CRA's reputation for receiving precise signals at the beginning of period 1. When investors visit the website, they observe the reported rating and update their prior beliefs according to Bayes' rule. Based on these *interim beliefs,* they decide whether to invest in the project or not (see right tree in Figure

1). If the project is financed, investors' interim beliefs are updated according to Bayes' rule after the outcome of the firm's investment project is observed - resulting in final beliefs. If the project is not financed, investors' interim beliefs are not updated further. Investors' *final beliefs* at the end of period 1 become their prior belief at the beginning of period 2. This information structure ensures that all relevant information for the second-period decisions is summarized in the CRA's reputation parameter φ_2. Based on φ_2, all stages of period 1, except nature's initial choice of the CRA's type, are then repeated in period 2.

Let $\tilde{s}_t$ denote the investors' belief about the opportunistic CRA's effort choice in each period t. To ease the exposition, we make use of the following definitions:

$$\varphi_t^H \equiv \Pr(\theta = C | r_t = H) = \frac{\varphi_t \lambda}{\varphi_t \lambda + (1-\varphi_t)\left[\lambda\left(\frac{1}{2}+\tilde{s}_t\right) + (1-\lambda)\left(\frac{1}{2}-\tilde{s}_t\right)\right]} \tag{2}$$

$$\varphi_t^L \equiv \Pr(\theta = C | r_t = L) = \frac{\varphi_t (1-\lambda)}{\varphi_t (1-\lambda) + (1-\varphi_t)\left[\lambda\left(\frac{1}{2}-\tilde{s}_t\right) + (1-\lambda)\left(\frac{1}{2}+\tilde{s}_t\right)\right]} \tag{3}$$

That is, φ_t^H and φ_t^L are the investors' *interim beliefs* in period t that the CRA is committed to obtain perfectly informative signal, after it reports an H-rating and L-rating, respectively. The investors' updated beliefs in that period that the project is good are then, respectively,

$$\lambda_t^H \equiv \Pr(\tau_t = g | r_t = H) = \varphi_t^H + \frac{\left(1-\varphi_t^H\right)\lambda\left(\frac{1}{2}+\tilde{s}_t\right)}{\lambda\left(\frac{1}{2}+\tilde{s}_t\right) + (1-\lambda)\left(\frac{1}{2}-\tilde{s}_t\right)} \tag{4}$$

$$\lambda_t^L \equiv \Pr(\tau_t = g | r_t = L) = \frac{\left(1-\varphi_t^L\right)\lambda\left(\frac{1}{2}-\tilde{s}_t\right)}{\lambda\left(\frac{1}{2}-\tilde{s}_t\right) + (1-\lambda)\lambda\left(\frac{1}{2}+\tilde{s}_t\right)} \tag{5}$$

Furthermore, we define the investors' *final beliefs* that the CRA is committed to obtain accurate signals at the end of period 1, given an H-rating and project success (S) or failure (F), respectively,

$$\varphi_1^{HS} \equiv \Pr(\theta = C | r_1 = H, S) = \frac{\varphi_1}{\varphi_1 + (1-\varphi_1)(\frac{1}{2}+\tilde{s}_1)} \tag{6}$$

$$\begin{aligned}\varphi_1^{HF} &\equiv \Pr(\theta = C | r_1 = H, F) \\ &= \frac{(1-\alpha)\lambda\varphi_1}{(1-\alpha)\lambda\varphi_1 + (1-\varphi_1)\left((1-\alpha)\lambda\left(\frac{1}{2}+\tilde{s}_1\right) + (1-\lambda)\left(\frac{1}{2}-\tilde{s}_1\right)\right)},\end{aligned} \tag{7}$$

It is straightforward to verify that (A1) and $0 \leq \lambda \leq 1/2$ imply that

$$\varphi_1^{HF} \leq \varphi_1^H \leq \varphi_1 \leq \varphi_1^L \leq \varphi_1^{HS} \tag{8}$$

with equality signs at $\tilde{s}_1 = 1/2$. Notably, the CRA's final reputation of obtaining accurate signals rises when the CRA reports an L-rating, and is highest when an H-rated project turns out to be successful and lowest when it fails. The event that an H-rated project fails may occur in three different cases: First, when the CRA is committed to obtain an accurate signal and a good project fails; second, when the CRA is opportunistic and a good project fails;[11] and third, when the CRA is opportunistic and a bad project fails that has been rated high erroneously. Although financing in the two former cases is ex ante efficient, the project fails ex post due to bad luck. This is in contrast to the third case where the investment decision is also ex ante inefficient.

The equilibrium concept in our model is perfect Bayesian equilibrium.

3 Equilibrium Analysis

We first consider the decision problems of the firms and investors. Recall that both are short-lived players. Thus, they only care about actions of the actual period. Accordingly, it is not necessary to differentiate between first and second period agents. For given beliefs about the CRA's type φ_t and effort choice $\tilde{s}_t$ in period t, investors will find it optimal to finance the project after observing an H-rating whenever

$$\alpha\lambda_t^H(\tilde{s}_t) R_t \geq 1 \tag{9}$$

is satisfied. Proceeding backwards, the firm's optimal return choice is given by $R_t = \hat{R}_t$ such that $\alpha\lambda_t^H(\tilde{s}_t)\hat{R}_t = 1$, for $\hat{R}_t \leq X$, since its expected payoff is strictly decreasing in R_t. For $\hat{R}_t > X$, the firm cannot induce any investment, and we assume, without loss of generality, that $R_t = X$ in such a case. Furthermore, note that the firm cannot induce any investment when the investor observes an L-rating or when investors will not visit the website.

We now turn to the opportunistic CRA's effort choice. Define $\hat{\varphi}_t(\tilde{s}_t)$ by

$$\hat{\varphi}_t(\tilde{s}_t) \equiv \min\left\{\varphi_t(\tilde{s}_t) : \alpha\lambda_t^H(\tilde{s}_t) R_t \geq 1\right\} \tag{10}$$

where $\lambda_t^H(\tilde{s}_t)$ is defined by (4) and $R_t \leq X$. That is, $\hat{\varphi}_t(\tilde{s}_t)$ the lowest CRA's reputation at the beginning of period t such that (9) still holds.

[11] In contrast to the first case, the correctness of the rating could be mere coincidence.

In period 2, the CRA's problem is given by

$$\max_{\{s_2\}} \left[\mathbb{1}_{\{\varphi_2 \geq \hat{\varphi}_2(\tilde{s}_2)\}} \pi - c(s_2) \right] \tag{11}$$

where $\varphi_2 \in \left\{ \varphi_1^{HF}, \varphi_1, \varphi_1^L, \varphi_1^{HS} \right\}$ depending on the first-period outcome,[12] and $\mathbb{1}_{\{\varphi_2 \geq \hat{\varphi}_2(\tilde{s}_2)\}}$ is an indicator function that yields 1 if $\varphi_2 \geq \hat{\varphi}_2 (\tilde{s}_2)$ and 0 otherwise. It is straightforward to show that the maximum of (11) is attained at $s_2 = 0$. To understand this, note that whether advertisement revenue is generated or not is determined solely by the market conditions, as captured by α, λ, and X, and by the investors' beliefs φ_2 and $\tilde{s}_2$, which cannot be influenced by the CRA in that period, whereas the marginal cost are $c'(s_2) > 0$ for all $s_2 > 0$. The second-period equilibrium play is summarized in the next proposition. The proof is placed in the Appendix.

Proposition 1.
There is a unique equilibrium of the second-period play. In this equilibrium, the opportunistic CRA chooses $s_2 = 0$. Furthermore, investment takes place whenever the rating is good and $\varphi_2 \geq \hat{\varphi}_2 (0)$, where $\hat{\varphi}_2$ is defined above, and no investment takes place otherwise.

The proposition states that the opportunistic CRA has no incentive to improve the precision of the signals in the second period. Thus, firms and investors expect $\tilde{s}_2 = 0$, resulting in a completely uninformative signal. It is interesting to note that investment in the project may still occur: If the CRA's reputation for being committed to acquire perfectly informative signals is high enough, investors will nevertheless visit the website and follow the CRA's rating. Notice that this entails the risk that resources are allocated inefficiently since bad projects, rated high erroneously by an opportunistic CRA, may receive financing.

We turn now to the analysis of period 1. For simplicity, we normalize the CRA's discount factor to one. The opportunistic CRA's maximization problem is then given by

$$\max_{\{s_1\}} \left[\mathbb{1}_{\varphi_1 \geq \hat{\varphi}_1(\tilde{s}_1)} \pi + \mathbb{1}_{\varphi_2 \geq \hat{\varphi}_2(0)} \pi - c(s_1) \right] \tag{12}$$

[12] Note that we ignore the case of $\varphi_2 = \varphi_1^H$ since it lies off the equilibrium path. Note further that the final belief at the end of period 1 is φ_1^L when a bad rating is observed. To see this, suppose $r_1 = L$ and note that $\lambda_1^L \leq \lambda$. Then Assumption A1 implies that investors choose the outside option, and in turn, that the belief about the CRA's type remains at φ_1^L.

where $\varphi_2 \in \{\varphi_1^{HF}, \varphi_1, \varphi_1^L, \varphi_1^{HS}\}$. It is important to note that the CRA's effort choice in period 1 may influence the investors' prior beliefs in period 2, φ_2, measuring the CRA's reputation in that period. As a consequence, the opportunistic CRA may have an incentive to improve the precision of the signal in period 1. We start our analysis by identifying the opportunistic CRA's optimal effort choice in period 1 for arbitrary investors' beliefs $\tilde{s}_1$. For this, note that the marginal expected revenue of a slightly higher informativeness of the signal is zero in two cases: first, when the CRA's initial reputation φ_1 is so high such that $\varphi_2 \geq \hat{\varphi}_2(0)$, independent of the project success in period 1, the CRA obtains positive advertisement revenue $\pi > 0$ in period 2 for sure. Second, when the CRA's initial reputation φ_1 is so low that $\varphi_2 < \hat{\varphi}_2(0)$, independent of the project success in period 1, the advertisement revenue is 0 in period 2. In both cases the CRA gains from reducing the precision of the signal in period 1 whenever $c'(s_1) > 0$, which is the case for all $s_1 > 0$.

Nevertheless, we find that there is a range of reputation levels φ_1, such that the CRA's marginal expected revenue of increasing s_1 is positive, given arbitrary investors' beliefs. The reason is that ratings produced with higher signal precision reduce the probability that the CRA is revealed to be opportunistic. Our main finding is stated the following proposition. The proof is placed in the Appendix.

Proposition 2.
There exist unique values $0 < \underline{\varphi} \leq \hat{\varphi}_2(0) < \overline{\varphi} < 1$ *such that the game has four kinds of perfect Bayesian equilibria:*

1. *Resting on Laurels: For* $\overline{\varphi} \leq \varphi_1 \leq 1$, *there exists a unique perfect Bayesian equilibrium in which the opportunistic CRA chooses* $s_1^* = 0$.
2. *Reputation Maintenance: For* $\hat{\varphi}_2(0) \leq \varphi_1 < \overline{\varphi}$, *every perfect Bayesian equilibrium involves the opportunistic CRA choosing* $s_1^* > 0$.
3. *Reputation Building: For* $\underline{\varphi} \leq \varphi_1 < \hat{\varphi}_2(0)$, *there exist perfect Bayesian equilibria in which the opportunistic CRA chooses* $s_1^* > 0$.
4. *Everything Lost: For* $0 \leq \varphi_1 < \hat{\varphi}_2(0)$, *there exists a perfect Bayesian equilibrium in which the opportunistic CRA chooses* $s_1^* = 0$. *For* $\varphi_1 \leq \underline{\varphi}$, *this equilibrium is unique.*

The proposition shows that zero improvement of the signal precision may be an equilibrium outcome. Such equilibria arise whenever the first-period outcome does not affect investors' decision to visit the website in period 2. This happens in two polar cases: First, when investors are pessimistic about the CRA's improvement of the signal precision, i.e., $\tilde{s}_1 = 0$, and the CRA's initial reputation is too low to bring investors to the website in spite of their pessimistic beliefs, i.e., $\varphi_1 < \hat{\varphi}_1(0) = \hat{\varphi}_2(0)$, and second, when the reputation is so high such that investors always expect to benefit from the CRA's ratings, i.e., $\overline{\varphi} \leq \varphi_1 \leq 1$. We call the first equilibrium type Everything Lost because investment in the projects will not take place, and the second Resting on Laurels because the opportunistic CRA can exploit the high reputation and allow itself to be lazy in conducting an elaborate assessment of the projects.

Interestingly, at intermediate reputation levels, $\hat{\varphi}_2(0) \leq \varphi_1 < \overline{\varphi}$, zero improvement of the signal precision is no longer a possible equilibrium outcome. To see this note that, since $\hat{\varphi}_1(\tilde{s}_1) \leq \hat{\varphi}_1(0) = \hat{\varphi}_2(0) \leq \varphi_1$ for $\tilde{s}_1 \geq 0$, the CRA's reputation φ_1 is then high enough to make the website attractive for investors in period 1 for any $\tilde{s}_1$. Moreover, by (8), the updated reputation in period 2 is even higher whenever the CRA reports an L-rating or an H-rating followed by a successful project in period 1. Note that this increase in reputation occurs independently of the CRA's effort choice. Conversely, the CRA's updated reputation, φ_2, decreases below $\hat{\varphi}_2(0)$, turning investors away in period 2, when an H-rated project fails - which occurs again irrespectively of the CRA's effort s_1. However, the probability of this event does depend on the CRA's improvement of the signal precision: By exerting effort, the CRA can reduce the probability that a bad project is rated high erroneously. We show that, for reputation levels $\hat{\varphi}_2(0) \leq \varphi_1 < \overline{\varphi}$, an opportunistic CRA will in fact publish more accurate ratings as the only equilibrium outcome. We call this equilibrium type Reputation Maintenance because the CRA's effort exerted to improve the precision of signals helps the CRA to maintain its reputation above the critical level $\hat{\varphi}_2(0)$.

For lower reputations levels, $\underline{\varphi} \leq \varphi_1 < \hat{\varphi}_2(0)$, investors choose to visit the website in period 1 only if they expect the opportunistic CRA to sufficiently improve its signal precision. Given investors' beliefs, we show that the CRA may find it indeed attractive to increase the precision of the signals in equilibrium and thereby improve its reputation above the threshold $\hat{\varphi}_2(0)$. More precisely, a higher effort s_1 reduces the probability that an H-rated project fails in period 1 - an event that deters investors from visiting the website in period 2. In addition, it reduces the probability that an L-rating is reported incorrectly - an event that matters when L-ratings deter investors from visiting the website in period 2. We call this equilibrium type Reputation Building. Clearly, investors' beliefs play an important role for the existence of this equilibrium. As noted above, zero improvement of the signal precision is also always a possible equilibrium outcome in this range of reputation levels below $\hat{\varphi}_2(0)$ - the Everything Lost equilibrium arises when investors expect the CRA's effort to be zero.

4 Misreporting

In this section, we assume that the CRA has the choice between truthful reporting and misreporting, i.e., announcing a rating different from the obtained signal. Note that under truthful reporting, a good rating entails the risk of investment failure - an event that reduces the CRA's reputation of obtaining precise signals and deters investors from visiting the website in period 2. By contrast, a bad rating will not be followed by investment and thus not associated with the risk of failure. Rating deflation may therefore be a dominant strategy in our basic model when misreporting is possible. Thus, for a better understanding of the CRA's incentives to misreport under the advertisement-financed business model, it seems worth considering a richer setting, ruling out rating deflation as a dominant strategy.

One of the key features of online advertising is that expected revenue is increasing in the "attention" that a website attracts (Ahmed and Kwon, 2012). Thus far, we have assumed that the number of investors remains constant in each period. Yet, the success of highly-rated projects may help the CRA to attract additional users to its website. To capture this feature, we assume now that the CRA's advertisement revenue is state-contingent: the CRA obtains a revenue of $A\pi$, with $A \geq 1$, in period 2 when an H-rated project has been successful in period 1. Note that, for $A = 1$, the extended setting reduces to our basic model.

We continue to assume that the committed CRA never misreports and focus on the opportunistic CRA's incentives to improve the precision of signals and report the signals truthfully. Consider the Reputation Maintenance equilibria identified in Proposition 2. In these equilibria, investors turn away from the website in period 2 only when an H-rated project has failed in period 1. Therefore, the CRA will have an incentive to report the signals truthfully if and only if

$$\alpha\lambda\left(\frac{1}{2}+s_1^*\right)A\pi+\left[(1-\lambda)\left(\frac{1}{2}+s_1^*\right)+\lambda\left(\frac{1}{2}-s_1^*\right)\right]\pi-c(s_1^*)\geq\max\left\{\alpha\lambda A\pi,\pi\right\} \quad (13)$$

where $s_1^* > 0$ maximizes the LHS of (13). The first two terms on the LHS are the CRA's expected second-period payoff from exerting effort s_1^* and reporting the signal truthfully. The RHS of (13) represents the CRA's expected second-period payoff from not improving the precision of the signals and misreporting, i.e., reporting an H-rating when a bad signal is observed, $\alpha\lambda A\pi$, or an L-rating when a good signal is observed, π.

Next, consider the equilibrium of the Reputation Building type identified in Proposition 2. We know from the proof of the proposition that there are two cases to distinguish, depending on the investors' response to the ratings and project outcome: first, there may exist equilibria in which investors turn away from the website in period 2 only when an H-rated project has failed in period 1, similarly as in the equilibrium of the Reputation Maintenance type. The incentive compatibility constraint for truthful reporting is then also given by (13). Second, there may exist equilibria in which investors choose to visit the website in period 2 only when an H-rated project has been successful. For these equilibria, the incentive compatibility constraint is given by

$$\alpha\lambda\left(\frac{1}{2}+s_1^*\right)A\pi-c(s_1^*)\quad\geq\max\left\{\alpha\lambda A\pi,0\right\} \quad (14)$$

where $s_1^* > 0$ maximizes the LHS of (14).

Not surprisingly, we find that reporting signals truthfully is not always incentive compatible. Indeed, since $c(s_1) > 0$ for $s_1 > 0$, it is easy to see that constraint (14) cannot be fulfilled. Thus, in Reputation Building equilibria in which investors turn away whenever the CRA announces an L-rating,[13] the CRA always has an incentive to inflate ratings. Furthermore, constraint (13) implies that the cost of improving the signal precision $c\left(s_1^*\right)$ has to be sufficiently small. Assuming that this cost is close to zero at $s_1 = 1/2$, we

[13]For a more precise characterization, see the proof of Proposition 3 in the Appendix.

provide sufficient conditions for the existence of equilibria involving positive efforts and truth-telling under the advertisement-financed business model.

Proposition 3.
Suppose that revenues are state contingent with $\alpha A \geq 1$, and that the cost of improving the signal precision $c(1/2)$ is close to zero. Then reporting signals truthfully is incentive compatible in every equilibrium of the Reputation Maintenance type and in every equilibrium of the Reputation Building type in which investors turn away from the website in period 2 only when an H-rated project has failed in period 1.

Thus, truthful reporting can be induced if the increase in advertisement revenue associated with is the success of a highly-rated project, αA, is larger than revenue under the "safe option" of announcing an L-rating even though a good signal is received. As the probability of success of good projects, α, or the increase in advertisement revenue due to successful projects, A, get smaller, the CRA eventually has an incentive to deflate ratings, as in our basic model.

For an environment in which the CRA's costly effort determines the signal precision, similar to our model, Kashyap and Kovrijnykh (2016) derive an optimal compensation structure to provide incentives to the CRA to exert effort and report the signals truthfully. Their Proposition 1 states that the CRA should be rewarded in only two cases: if it announces the high rating and the project succeeds or if it announces the low rating. The CRA should never the paid for announcing the high rating if it is followed by the project's failure. While the optimal structure is not implementable under the issuer-pays or the investor-pays model, Kashyap and Kovrijnykh find that the investor-pays model generates a higher rating accuracy than the issuer-pays model. The reason is that issuers would not be willing to pay for low ratings. It is interesting to note that the optimal compensation structure identified in Kashyap and Kovrijnykh (2016) can be provided by an advertisement-financed business model with state-contingent revenues as considered in our paper. The crucial element of the advertisement-financed model is that investors are deterred when a highly-rated project fails, resulting in zero revenue for the CRA.

5 Conclusions

As Kashyap and Kovrijnykh (2016) have shown, traditional CRA business models - the investor-pays and the issuer-pays model - provide incentives to produce less informative signals than are socially optimal and to distort ratings in favor of issuers or investors, respectively. In this paper, we consider an alternative business model for CRAs which is free of charge for issuers and investors. The CRA earns revenue from advertisements displayed on the online platform where the ratings are published. Investors are attracted to this platform when they regard ratings as valuable information which turns out to be the case when the CRA has a sufficiently high reputation of being committed to provide effort and report truthfully. We investigate whether this advertisement-based business model provides sufficient reputational incentives to generate precise information and to report this information truthfully in the form of ratings. Our main findings are: first, CRAs will acquire more precise signals for a range of intermediate reputation levels than for very low or very high levels of reputation. Second, truthful reporting can be induced if advertisement revenues are state-contingent and sufficiently high.

Future research will investigate the role of competition under the advertisement-based business model. Compared to the issuer-pays model, competition might be more desirable because advertisement financing does not involve the problem of ratings shopping, which is exacerbated by competition under the issuer-pays model.[14] However, competition may reduce efficiency for other reasons than ratings shopping, for example, by growing pressure on the CRAs to further reduce their costs, and in turn, reduce the informativeness of the signals about the project's quality. Thus, whether competition between advertisement-financed CRAs is socially optimal remains an open question.

A Proofs

Proof of Proposition 1 Since $c'(s_2) > 0$ for all $s_2 > 0$, the maximum of (11) is attained at $s_2 = 0$. It is easy to see that this is the unique optimal action for the opportunistic CRA in $t = 2$. Recall that $\hat{\varphi}_2(\tilde{s}_2)$ denotes the lowest CRA reputation at the beginning

[14] See, e.g., Skreta and Veldkamp (2009) or Bolton et al. (2012).

of period 2 such that (9) still holds. The threshold is obtained by solving $\alpha\lambda_2^H R_2 = 1$ for φ_2, where λ_2^H is defined by (4), and then substituting R_2 by X. Inserting $\tilde{s}_2 = 0$, yields

$$\hat{\varphi}_2(0) = \frac{1-\alpha\lambda X}{1+\alpha\lambda X - 2\lambda}$$

with $0 < \hat{\varphi}_2(0) < 1$ by Assumption A1. Thus, if $\varphi_2 \geq \hat{\varphi}_2(0)$, investors will visit the website and invest upon observing a good rating. □

Proof of Proposition 2 We make use of the following definitions:

$$\hat{\varphi}_1^{\omega}(\tilde{s}_1) \equiv \min\{\varphi_1 : \varphi_1^{\omega}(\varphi_1, \tilde{s}_1) \geq \hat{\varphi}_2(0)\} \text{ for } \omega \in \{HF, L, HS\} \tag{15}$$

That is, given investors' belief in period 1 of $\tilde{s}_1$ and a first-period history of $\omega \in \{HF, L, HS\}$, $\hat{\varphi}_1^{\omega}(\tilde{s}_1)$ denotes the threshold that φ_1 has to exceed so that advertisement revenue will be generated in period 2. It is easy to verify that

$$\hat{\varphi}_1^{HS}(\tilde{s}_1) \leq \hat{\varphi}_1^{L}(\tilde{s}_1) \leq \hat{\varphi}_1(0) \leq \hat{\varphi}_1^{HF}(\tilde{s}_1) \tag{16}$$

for all $\tilde{s}_1 \geq 0$. Furthermore,

$$\begin{aligned} \overline{\varphi} &\equiv \hat{\varphi}_1^{HF}(0) \\ \underline{\varphi} &\equiv \min\left\{\varphi_1 : \hat{\varphi}_1^{HS}(\tilde{s}_1) = \hat{\varphi}_1(\tilde{s}_1)\right\} \text{ for } \tilde{s}_1 \geq 0, \end{aligned}$$

where $\hat{\varphi}_1^{HS}(\tilde{s}_1)$ and $\hat{\varphi}_1(\tilde{s}_1)$ are defined by (15) and (10), respectively. Note that $\hat{\varphi}_1(0) = \hat{\varphi}_2(0)$.

We are now able prove the existence of the four equilibrium types. See Figure 2 for an illustration of the different regions in the $\tilde{s}_1 \times \varphi_1$ space.

(i) Resting on Laurels: Suppose that $\tilde{s}_1 = 0$ and $\varphi_1 \geq \overline{\varphi}$. The CRA's payoff function is then $2\pi - c(s_1)$, which is maximized at $s_1^* = 0$. This is consistent with $\tilde{s}_1 = 0$ and, therefore, constitutes a perfect Bayesian equilibrium. To prove uniqueness, assume towards a contradiction that there exists another equilibrium with $s_1 = \tilde{s}_1 > 0$. It is easily verified that $\hat{\varphi}_1^{HF}(\tilde{s}_1) < \overline{\varphi} \leq \varphi_1$ for $\tilde{s}_1 > 0$. Since the CRA's payoff function is still $2\pi - c(s_1)$, the CRA has a strictly profitable deviation, namely, $s_1 = 0$.

(ii) Everything Lost: Suppose that $\varphi_1 < \hat{\varphi}_2(0)$ and $\tilde{s}_1 = 0$. Since $\hat{\varphi}_1(0) = \hat{\varphi}_2(0)$, investors will not pay attention to first-period credit ratings. Accordingly, the CRA does

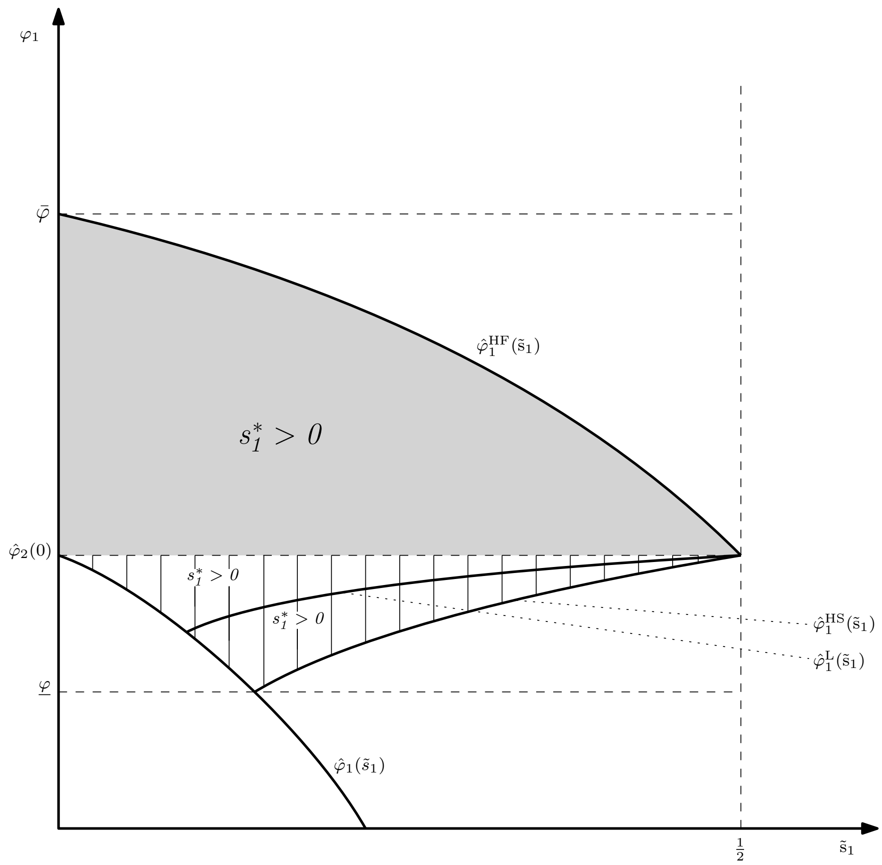

Figure 2: Regions in the $\tilde{s}_1 \times \varphi_1$ space

not generate revenue in the first period and there is no belief update. This implies that the second-period revenue is also zero. Thus, the CRA's payoff function is given by $-c(s_1)$, which is maximized by $s_1^* = 0$. This is consistent with $\tilde{s}_1 = 0$ and, therefore, constitutes a perfect Bayesian equilibrium. We now prove uniqueness. Suppose that $\varphi_1 < \underline{\varphi}$. Then the opportunistic CRA's payoff is $-c(s_1)$ if $(\tilde{s}_1, \varphi_1)$ fulfills $\varphi_1 < \hat{\varphi}_1(\tilde{s}_1)$, and $\pi - c(s_1)$ otherwise. In both cases, $s_1^* = 0$ is the unique optimal technology choice.

(iii) Reputation Maintenance: Suppose that $\hat{\varphi}_1(0) < \varphi_1 < \overline{\varphi}$. This implies that $\varphi_1 > \hat{\varphi}_1^L(\tilde{s}_1)$, as defined by (15). That is, φ_1 is high enough to generate a positive advertisement revenue in period 2 after the report of an L-rating in period 1. For $\tilde{s}_1 > 0$, there two cases to consider: First, suppose that $\hat{\varphi}_1(0) < \varphi_1 < \hat{\varphi}_1^{HF}(\tilde{s}_1)$. In this case, the CRA's second-period revenue is zero only when a highly-rated project fails at the end of period 1. The CRA's payoff is then given by $\left[2 - (1-\alpha)\lambda\left(\frac{1}{2} + s_1\right) - (1-\lambda)\left(\frac{1}{2} - s_1\right)\right]\pi - c(s_1)$. It is easily verified that this payoff is maximized at $s_1^* > 0$. Second, suppose that $\hat{\varphi}_1^{HF}(\tilde{s}_1) \leq \varphi_1 < \overline{\varphi}$. The CRA's payoff in this case is $2\pi - c(s_1)$, which is maximized by $s_1 = 0$.

However, for $\tilde{s}_1 = 0$, we have that $\varphi_1 < \hat{\varphi}_1^{HF}(\tilde{s}_1) = \overline{\varphi}$, a contradiction. Hence, there cannot exist an equilibrium with $s_1^* = 0$ in this case.

(iv) Reputation Building: Suppose that $\underline{\varphi} \leq \varphi_1 \leq \hat{\varphi}_2(0)$ and $\tilde{s}_1 > 0$.

For $\varphi_1 < \hat{\varphi}_1(\tilde{s}_1)$, investors will not pay attention to first-period credit ratings. Accordingly, the CRA does not generate revenue in the first period and there is no belief update. This implies that the second-period revenue is also zero. Thus, the CRA's payoff function is given by $-c(s_1)$, which is maximized by $s_1^* = 0$. This is not consistent with $\tilde{s}_1 > 0$ and, hence, does not constitute a perfect Bayesian equilibrium.

For $\varphi_1 \geq \hat{\varphi}_1(\tilde{s}_1)$, we distinguish three subcases: First, we consider pairs of $(\varphi_1, \tilde{s}_1)$ such that $\varphi_1 \geq \hat{\varphi}_1^L(\tilde{s}_1)$. The CRA's second-period revenue is then zero only when a highly-rated project fails at the end of period 1. The CRA's payoff is then given by $\left[2 - (1-\alpha)\lambda\left(\frac{1}{2} + s_1\right) - (1-\lambda)\left(\frac{1}{2} - s_1\right)\right]\pi - c(s_1)$, which is maximized at $s_1^* > 0$. Together with consistent beliefs $\tilde{s}_1 = s_1^*$, this constitutes a perfect Bayesian equilibrium of the Reputation Building type. Second, we consider pairs of $(\varphi_1, \tilde{s}_1)$ such that $\hat{\varphi}_1^{HS}(\tilde{s}_1) \leq \varphi_1 < \hat{\varphi}_1^L(\tilde{s}_1)$. The CRA's second-period revenue is then positive only when a highly-rated project succeeds at the end of period 1. The CRA's payoff is then given by $\pi + \alpha\lambda\left(\frac{1}{2} + s_1\right)\pi - c(s_1)$. It is easily verified that this payoff is maximized at $s_1^* > 0$. Together with consistent beliefs $\tilde{s}_1 = s_1^*$, this constitutes a perfect Bayesian equilibrium of the Reputation Building type. Third, consider pairs of $(\varphi_1, \tilde{s}_1)$ such that $\varphi_1 < \hat{\varphi}_1^{HS}(\tilde{s}_1)$. The CRA's second-period revenue is then zero for all ratings. The CRA's payoff is then given by $\pi - c(s_1)$, which is maximized by $s_1^* = 0$. This is not consistent with $\tilde{s}_1 > 0$ and, hence, does not constitute a perfect Bayesian equilibrium. $\square$

Proof of Proposition 3 By Proposition 2, equilibria of the Reputation Maintenance type exist for $\hat{\varphi}_2(0) \leq \varphi_1 < \overline{\varphi}$. These thresholds stay the same under the state-contingent revenue structure. Checking constraint (13) for $s_1^* = \frac{1}{2}$ reveals that it is satisfied if $A \geq \frac{1}{\alpha}$. By continuity, there exists a $\hat{s}_1$ such that the constraint is also satisfied for a range of effort levels $\hat{s}_1 < s_1^* < \frac{1}{2}$. By Proposition 2, equilibria of the Reputation Building type exist for $\underline{\varphi} \leq \varphi_1 < \hat{\varphi}_2(0)$. These thresholds stay the same under the state-contingent revenue structure. From the proof of Proposition 2, we know that for pairs of $(\varphi_1, \tilde{s}_1)$ such that $\varphi_1 \geq \hat{\varphi}_1^L(\tilde{s}_1)$, the CRA's second-period revenue is then zero only when a highly-rated project fails at the end of period 1. The incentive compatibility constraint for truth-telling is then also given by (13). For pairs of $(\varphi_1, \tilde{s}_1)$ such that $\hat{\varphi}_1^{HS}(\tilde{s}_1) \leq \varphi_1 < \hat{\varphi}_1^{L}(\tilde{s}_1)$, the CRA's second-period revenue is then positive only when a highly-rated project succeeds at the end of period 1. The incentive compatibility constraint for truth-telling is then given by (14), which cannot be satisfied. □

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