Simultaneous Reporting of Credit Ratings May Discipline Rating Agencies*

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Abstract

Rating inflation has been a major concern in the credit rating industry. We show that requiring a credit rating agency to report many ratings at once may discipline it against rating inflation. When the rating agency has to report ratings simultaneously, it faces a trade-off in the choice of the number of good ratings to report. While reporting one more good rating earns the agency one more fee, it also lowers the credibility of the good ratings the agency gives, thus diminishing borrowers' willingness to pay for a good rating (and consequently the rating fee). In the case of a large number of borrowers, this mechanism ensures an allocation that asymptotically approaches the first best. In the functioning of this mechanism, interestingly, the fact that borrowers pay for the ratings plays a necessary role. This paper suggests an extra benefit to synchronizing the issuance of corporate bonds.

Keywords: Credit Rating Agencies, Simultaneous Rating, Synchronization of Debt Issuance.

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1 Introduction

Credit rating agencies play an important role in the functioning of financial markets and allocation of capital. However, there is growing concern (and evidence) that they have inflated the ratings of bonds and other related financial products. Take for example the case of Alt-A mortgage-backed securities (MBS). About 10% of the tranches issued in the period 2005-2007 rated most safe –triple AAA–were either downgraded to junk status or lost their principal by 2009. The case of CDO bonds was not better. More than 71.3% of such bonds had the same fate despite being initially rated as Aaa.[1] Credit rating agencies have also been involved in lawsuits because of inflation of ratings. In 2008 a group of investors initiated a lawsuit against the investment bank Morgan Stanley and the two rating agencies: Moody's and Standard and Poor's. The investors accused the ratings agencies of collaborating with the bank in arranging for some of its financial products to receive ratings as high as triple-A, even though much of the underlying collateral was low-quality or subprime mortgage debt.[2] More recently, in February 2013, the U.S. Department of Justice filled a lawsuit against Standard & Poor's accusing the rating agency of inflating ratings and understating risks associated with mortgage securities with the purpose of gaining more market shares.[3]

Inflation of credit ratings may cause huge losses to investors, as was evident in the recent crisis. The $5 billion compensation which the U.S. government seeks from Standard & Poor's is just one signal of the magnitude of such losses. However, this is not the only cost of credit ratings inflation. The inflation of credit ratings also hinders the credibility of rating agencies and with the credibility of credit rating agencies shattering, investors face greater difficulty discerning good projects from bad ones. As a result, it is the functioning of the financial markets and the efficiency of capital allocation that are at stake. This begs the question: how to discipline the credit rating agencies against rating inflation? The economics and finance literatures, which we review in more detail below, pays considerable attention to the reputation mechanism: if a credit rating agency gives a good rating to a bad project, which is likely to perform poorly, then this bad performance will damage the agency's reputation for issuing credible ratings. The mechanism relies on repeated interaction

[1] See the "Final Report of the National Commission on the Causes of the Financial and Economics Crisis in the United States", pages 228-229. This report is authenticated U.S. government information.

[2] The case is Abu Dhabi Commercial Bank et al v. Morgan Stanley & Co et al, U.S. District Court, Southern District of New York, No. 08-07508. The parties reached a settlement agreement in April 2013. The settlement amount was almost 9.5 million dollars.

[3] The case is United States of America v. McGraw-Hill Companies, Inc and Standard and Poor's Financial Services LLC, U.S. District Court, General District of California, No. CV13-00779.

and on the comparison between the ratings obtained by projects and their ex-post performance.

This paper studies a different disciplinary mechanism, which relies neither on repeated interaction nor on the comparison between projects' ratings and their ex-post performance. It simply requires a credit rating agency to simultaneously report the ratings of many issuers. The simultaneity in the reporting of ratings means here that investors make their investment decisions *only* after observing the ratings given by the rating agency to *all* the issuers. This situation is opposed to that where the rating agency reports ratings sequentially (over time) and investors decide to invest or not in each issuer immediately after the release of its rating. We show that simultaneous rating engenders disincentives for a credit rating agency to inflate ratings. This is underpinned by two economic effects.

First, simultaneous rating generates a negative link between the value of a good rating and the number of such ratings reported. An intuition for this negative link can be obtained through the analogy to a professor writing references for her undergraduate students to apply for jobs (or graduate programmes). If she refers only one student to a potential employer, she may credibly rate the student as top one percent. If she refers twenty students to the same employer, the more students she rates as top one percent, the less credible this rating becomes to the employer. The negative link between the value of a good rating and the number of such ratings forces the credit rating agency to face a trade-off in the choice of the number of good ratings it reports. By reporting one more good rating it earns one more fee but it also lowers the credibility of a good rating, which then lowers borrowers' willingness to pay for the agency's ratings (and consequently the rating fee). Because of this trade-off, the credit rating agency self-imposes a quota as for the number of good ratings to report; it may even optimally refrain from giving a good rating to a high-quality issuer.

Second, it is always optimal for a rating agency to fill the quota with issuers that have a high-quality project first and only then with issuers that have low-quality projects. This is because given the cost of finance, high-quality projects create a greater value than low-quality projects, and therefore, the issuers of the former can (and are willing to) pay more for a good rating than those of the latter. Put differently, high-quality issuers can always outbid low-quality issuers when competing for good ratings.

The conjugation of these two effects implies that in equilibrium, rating agencies will not give a good rating to all issuers and will give a good rating to a high-quality issuer before they give it to a low-quality issuer. Hence, an issuer with a good rating is more likely to be of higher quality than an issuer without a good rating. This is why ratings will be credible and convey information about issuers' qualities.

This paper highlights that simultaneous reporting of ratings generates a mechanism to discipline credit rating agencies against rating inflation and to improve the credibility of the ratings they give. Other mechanisms have been studied in the literature. Perhaps the most notable of them is the reputation mechanism – see, among others, Kunher, 2001; Mathis, McAndrews and Rochet (2009); Bolton, Freixas and Shapiro (2012); Mariano (2012); and Frenkel (2013). This mechanism highlights that a rating agency with reputation concerns will refrain from giving a good rating to a bad issuer because of the concern that its reputation (and future credibility and revenues) will be damaged later on following the (likely) default by the issuer.[4] Unlike the reputation mechanism, the mechanism studied in this paper depends neither on repeated interaction nor on the comparison between projects' rating with their ex-post performance. Instead, it puts into more effective use the information about the distribution of issuers' qualities. As the two mechanisms rely on different economic effects, they can actually complement one another in disciplining rating agencies.

The literature has also highlighted that the credibility of credit ratings could be improved by addressing, in the first place, the conflicts of interest that may generate the bias in the ratings. One source of such conflicts of interest is the fact that credit rating agencies are paid by issuers – precisely those who they rate – and such payment usually occurs only if the issuer agrees with the disclosure of the rating.[5] Mathis, McAndrews and Rochet (2009), for example, advocate a new business model in which the platforms where the securities are traded pay for the ratings of the securities. In the present paper, we assume that issuers pay the credit rating agency to rate them. Hence, the mechanism we highlight in this paper is effective even when borrowers pay rating agencies for their rating. Actually, the fact that issuers pay for the rating is a necessary part for the mechanism to work. It is this fact that allows the issuers of high-quality projects to beat the issuers of low-quality projects when competing for good ratings, rendering good ratings credible.

[4]Interestingly, Frenkel (2013) shows that when a rating agency has two reputations–one with investors and another with issuers–reputation concerns may actually lead to the inflation of ratings by the rating agency.

[5]Griffin and Tang (2011) provide empirical evidence of ratings inflation due to conflict of interest by comparing the CDO assumptions made by the ratings department and by the surveillance department within the same rating agency. Xia and Strobl (2012) provide empirical evidence of rating inflation due to the issuer-pay model by comparing the ratings issued by Standard & Poor's which follows the issuer-pay model to those issued by the Egan-Jones Rating Company which adopts the investor-pay model.

Several articles have studied the impact of competition on the credibility and informativeness of ratings provided by a credit rating agency or more generally by a certifier (e.g., Lizzeri, 1999; Miao, 2009; Skreta and Veldkamp, 2009; Camanho, Deb and Liu, 2012; Bolton, Freixas and Shapiro, 2012). While Lizzeri (1999) shows that competition between certifiers can lead to full information revelation, Skreta and Veldkamp (2009), Camanho, Deb and Liu (2012) and Bolton, Freixas and Shapiro (2012) show that competition between credit rating agencies can in fact decrease the informativeness of credit ratings and the reputation of the rating agencies.[6] In Skreta and Veldkamp (2009) and Bolton, Freixas and Shapiro (2012), this is because competition allows for credit rating shopping. In Camanho, Deb and Liu (2012) it is because it hinders rating agencies' ability to sustain a high reputation. An important difference amongst these papers, including ours, is that Lizzeri (1999) assumes that the certifier can commit to a disclosure rule and the other articles assume that it cannot.[7] While we address the issue of competition between rating agencies only lightly, we share a result with Skreta and Veldkamp (2009), Camanho, Deb and Liu (2012), and Bolton, Freixas and Shapiro (2012), namely that competition may reduce the quality and efficiency of credit rating agencies' service. This adverse effect, in our paper, is due to different reasons from those papers.

Finally, the results we obtain in this paper are reminiscent of those in Damiano, Li and Suen (2008). The authors compare a rating agency that rates several clients separately (individual rating) with a rating agency that rates all clients together (centralized rating) and show that centralization of rating may enhance the credibility of the ratings. They consider a costly signaling model as in Spence (1973), where producing a rating affects the agency's payoff in itself, like obtaining a different educational degree incurs a different cost per see. Instead, we consider a model of cheap-talk, where the reporting a rating affects the credit rating agency nothing in itself but only through equilibrium interaction. This difference in modeling leads two further differences. First, our paper focuses on credit rating, which their paper does not directly cover (though it might be interpreted in some way to be relevant to). Second, in our paper the improvement in rating credibility is driven by the two economic effects aforementioned (i.e., the negative link and the fact that high-quality issuers can pay

[6] Becker and Milbourne (2010) provide evidence that increased competition due to Fitch's entry in the credit ratings market in 1997 coincides with lower quality ratings from the incumbents. While Fitch was founded in 1913, the authors argue that only in 1997, following a merger with IBCA Limited, Fitch became an alternative global, full-service ratings agency capable of successfully competing with Moody's and S&P.

[7] Another important difference is that Lizzeri (1999) takes a mechanism design approach to the modelling of the certifier. Faure-Grimaud, Peyrache and Quesada (2009) is another example of an article that follows this line of modelling certifiers. They also use a mechanism design approach to model the certifier and assume that the certifier can commit to a disclosure rule.

more for a rating than low-quality issuers), which do not appear in their paper.

The rest of the paper is organized as follows. Section 2 elaborates on the baseline model. The model consists of a simple setting where two firms seek funds from investors to implement their projects and can ask a credit rating agency to rate their credit. The credit rating agency evaluates the quality of the credit of both firms simultaneous, i.e. before investors make their decisions. Section 3 highlights the importance of the simultaneity in the reporting of credit ratings by showing the existence of equilibria where credit ratings are informative about credit quality and where firms pay for such credit ratings. This section also contrasts these outcomes with those obtained when credit ratings are disclosed sequentially. Section 4 extends the analysis to the case where the number of issuers is large and shows that in (some sequences of the) equilibrium the total surplus asymptotically approaches the first-best total surplus. Section 5 discusses some robustness issues related to our key findings. Section 6 draws a conclusion. All proofs are given in the Appendix.

2 Model

There are two cashless firms, a pool of competitive investors, and one credit rating agency (CRA hereafter).[8] All agents are risk neutral and the risk free interest-rate is normalized to zero. Each firm (issuer) has one investment project and seeks funds from investors to implement it. A project requires an initial investment of one unit of capital and is characterized by its probability of success (not defaulting). There are two types of projects, *good* projects and *bad* projects. A good project is a success with probability q_g, whereas a bad project is a success with probability q_b. Either type of project yields the same return R when it is a success, and zero in case of failure (default). We assume that a good project has a positive net present value, while a bad project destroys value, i.e.,

$$q_b R - 1 < 0 < q_g R - 1. \tag{1}$$

In what follows, we denote by V_i the value created by a project of type i, i.e., $V_i \equiv q_i R - 1$ for $i = b, g$. Hence, (1) can be written as $V_b < 0 < V_g$. We also assume that $-V_b < V_g$, which means that a good project creates more value than a bad project destroys. Observe that the conditions in (1) imply

[8] We consider here the case of a monopolist CRA because it allows us to highlight the importance of the simultaneity in the reporting of credit ratings in the simplest possible way. In Section 5 we discuss the implications of competition between CRAs for our mechanism.

that $q_g > q_b$. They also imply that investors are willing to invest in good projects, but not in bad projects. It is common knowledge that ex-ante a project is good with probability p and projects' qualities are independent. We assume throughout the paper that

$$[pq_g + (1-p)q_b]R < 1. \tag{2}$$

A randomly drawn project cannot be financed. As we will see below, this condition also means that without any additional information on project quality, investors will finance no project.

The quality of a project is known to its issuer, but not to the investors. To overcome this informational problem, firms can ask the CRA to rate their projects before they seek funds from investors. Firms decide simultaneously whether to do so. The CRA has a technology that allows it to perfectly observe the quality of a project at no cost and evaluates a project only if solicited to do so by the firm that owns the project.[9] After observing the qualities of all the projects for which a rating was solicited, the CRA simultaneously proposes a contract to each firm specifying a rating $r \in \{\text{good, bad}\}$ for its project and a fee f to be paid by the firm to the CRA. Each firm then accepts the contract proposed by the CRA or rejects it. If a firm rejects the contract, its project remains unrated and the firm pays nothing to the CRA. If a firm accepts the contract, the rating is publicly disclosed and the firm commits to pay f to the CRA. The value of this fee is not observable by the investors and can be paid after the project has been implemented. The ratings given by the CRA are not verifiable, which means that the CRA can give a good rating to a bad project or a bad rating to a good project. Investors do not observe whether an issuer asked the CRA to evaluate its project, unless a rating is given to the issuer. We assume that issuers never ask the CRA to publicly disclose a bad rating.

Investors observe the rating given to each project (if any) and decide which projects to fund (if any). If investors decide to fund a project, they demand a compensation C. This compensation is paid only if the project succeeds. If the project fails, the issuer defaults. The compensation demanded by investors depends on their beliefs about the quality of the project. Observe that while we assume that firms decide simultaneously whether to request a rating to the CRA and the CRA offers contracts to firms simultaneously, none of these assumptions are essential to our results. The

[9] The assumption that CRA can observe the quality of project at no cost is made for simplicity of exposition. The assumption that the CRA evaluates a project only when requested to do it rules out the possibility of unsolicited reporting of credit ratings.

key assumption that captures the simultaneity in the reporting of credit ratings is that investors make their investment decisions after observing the ratings (or absence of a rating) of all the projects.

Finally, the outcome of the implemented projects is realized. In the case of successful projects, the issuer pays first the investors and then the CRA the agreed compensation and fee, respectively, and keeps the remainder as profit. In the case of unsuccessful projects all agents obtain zero.

The agent's strategies consists of the following. Given the quality of its project, a firm decides whether to request a rating to its project and then to accept or reject the contract proposed by the CRA. Given the qualities of the projects it evaluates, the CRA decides the rating offered to each project and the fee for the rating. Investors decide whether to fund each of the projects given its rating (if any). We use Perfect Bayesian Equilibrium as the equilibrium concept. We focus on equilibria where investors' belief that an unrated project is of good quality is no higher than the prior p. Since firms loose nothing by asking a CRA to evaluate their projects, we assume that all firms do so. Finally, we assume the following tie-braking rules: a firm always accepts the CRA's proposal of a good rating when indifferent between accepting and rejecting it; and a CRA always gives a good rating to a good project when indifferent between giving it an not giving it. While these assumptions simplify the analysis and exposition considerably, they have no impact on the (qualitative) results obtained in the paper.

3 The Role of Credit Ratings

In this section, we characterize the equilibrium of the credit ratings game. We first analyze whether the ratings issued by the CRA can be credible enough to improve the allocation of capital and create value relative to the case where no CRA exists. We then compare the outcomes obtained with those when ratings are reported sequentially.

It is instructive to begin with the analysis of the investors' decisions. These decisions crucially depend on the beliefs investors hold about projects' qualities. Let ϕ denote the investors' belief that a project is good. Because investors' opportunity cost of investment is zero and they act competitively, they require a compensation C to invest in the project such that their expected return is zero, i.e., they require C such that

$$[\phi q_g + (1-\phi)q_b]C - 1 = 0. \tag{3}$$

The lower the belief that the project is good, the higher the compensation they demand from the project. In particular, for sufficiently low values of ϕ, that compensation may exceed R, in which case they refrain from investing in the project.

Consider for example the case where no CRA exists. In the absence of a CRA, it is impossible for investors to obtain additional information about the quality of a project before they invest in it. Their belief that a project is of good quality is therefore p. Even if investors require the maximum feasible compensation from a project, i.e. if they require $C = R$, the expected rate of return to an investor is

$$[pq_g + (1-p)q_b]R - 1,$$

which by condition (2) is negative. Hence, no project is implemented. In particular, good projects (which may exist) are not implemented and no value is created. When firms can ask a CRA to rate their projects, credit ratings may be important because they may affect investors' beliefs about the quality of a given project. The question that arises is whether and to what extent they can be credible and informative in equilibrium.

Our first observation is that there is no equilibrium in which ratings are fully credible and informative in the sense that they truthfully reveal the quality of all projects. To see this let ϕ_k denote investors belief that a project with a good rating is good when k projects receive a good rating. Observe that in such an equilibrium, the CRA would give no good rating if no project is good and k good ratings in the event k projects are good, $k = 1, 2$. Moreover, because in equilibrium investors' beliefs must be consistent with the CRA's rating strategy, $\phi_k = 1$ for $k = 1, 2$ necessarily. This means that investors require $C = 1/q_g < R$ to invest in a project with a good rating. However, this implies that in the event that zero projects are good, the CRA would have an incentive to deviate and offer a good rating to both projects. Specifically, the CRA could charge a fee $f = R - 1/q_g$ for each good rating and obtain an expected profit of $2q_b(R - 1/q_g) > 0$ instead of zero.

Even though no equilibrium where ratings are fully informative about projects' qualities exists, we will see that the presence of a CRA can alleviate the informational problem that generates the market failure. That is, in some cases, the CRA issues ratings that are credible (to some extent) and convey information about the quality of a project. Let $\Delta \equiv q_g - q_b$. Observe that we can write (2) as $p < -V_b/\Delta R$. Observe also that the probability that at least one project is good is $p\,(2-p)$. Of course, this probability is greater than p. We can claim the following.

Proposition 1 *If $p\,(2-p) < -V_b/\Delta R$, then in no equilibrium the CRA can create value. If $p\,(2-p) \geq -V_b/\Delta R$, then there exists a pooling equilibrium where the CRA issues only one rating (to the good project if it exists) regardless of the number of good projects. In this equilibrium, the good rating creates value and issuers pay the CRA for it. This is the unique equilibrium in pure strategies in which a good rating creates value and the profit of the CRA is strictly positive.*

We know that no project is implemented in the absence of a credit rating agency. Proposition 1 highlights that when the probability that at least one project is good is sufficiently small, a CRA cannot create value. While projects with a good rating can still be implemented, their implementation does not create any value. In other words, the expected return of a project with a good rating is no higher than zero, the opportunity cost of investment to investors. In this case, not only the ex-ante probability that a project is good is low, but also any good rating given by CRA will not be credible enough to create value. Hence, a good rating is worthless and the maximum the CRA can charge for it is zero.

However, for $p(2-p) \geq -V_b/\Delta R$, there is an equilibrium where the CRA issues one good rating only and this rating is credible enough to increase the expected return of the project with a good rating above zero. The CRA gives at least one good rating because it can charge a positive fee only for a good rating; and the CRA refrains from giving two good ratings because doing so would render its ratings non-credible, meaning that investors would not invest in any of the projects and ratings would be worthless. At this point, it is important to highlight the reason why the good rating given the CRA in the equilibrium mentioned in the proposition is valued by investors. This rating is valuable because the CRA gives the good rating to the good project when there is only one good project ($n = 1$). That is, while the fact that the CRA gives one good rating is uninformative about the number of good projects, it reveals the identity of the good project when there is only one. This means that conditional on the event that there is only one good project ($n = 1$), the probability that the project with the good rating is in fact good is one. In the absence of a CRA, conditional on the event that there is only one good project ($n = 1$), the probability that a randomly chosen project is good is only one half. Observe that the motive for the CRA to give the good rating to the good project when only one project is good is profit maximization. Indeed, because a good project generates more value than a bad project, a good project can pay more for the good rating than a bad project. Hence, it is the simple force of profit maximization by the CRA that leads good projects to beat bad projects when projects "compete" for good ratings.

It is easy to obtain that the presence of a CRA enhances efficiency, from an ex-ante perspective, when $p(2-p) \geq -V_b/\Delta R$. The total expected surplus without a CRA is zero, whereas total expected surplus with a CRA under the identified pooling equilibrium is $(1-p)^2 V_L + p(2-p)V_H$. Observe, however, that the outcome is fully efficient only when the realized number of good project is one ($n = 1$). Relative to the efficient outcome, there is overimplemention of projects when no project is good ($n = 0$), and underimplementation of projects when all projects are good ($n = 2$). This is because the CRA inflates the ratings when no project is good and deflates them when all projects are good. Once concern with CRAs is that they may inflates the ratings they give, especially when issuers pay for such ratings. In our framework, that is not always the case. Actually, the opposite may happen. There is trade-off for the CRA when giving one more good rating: the CRA can collect the fee associated with the good rating, but its good ratings may become less credible (given the ex-ante expectations of product quality) which means the CRA will have charge lower fees for them. Interestingly, this trade-off effect is similar to that of a firm facing a demand with a negative slope. To sell a higher quantity, the firm has to lower the price. As in that case, lowering the price to sell one more unit may not enhance the firm's profit.

We have seen that the CRA can charge a positive fee for one good rating and that such good rating is credible. One may ask whether the CRA can also charge a positive fee for a good rating when it issues two good ratings. This would correspond to a situation where investors trust a good rating even when the CRA gives a good rating to all projects. The following proposition answers this question.

Proposition 2 *Suppose $p(2-p) \geq -V_b/\Delta R$. Then there exists an equilibrium where the CRA randomizes between giving one and two good ratings when no project is good, gives one good rating to the good project if only one project is good, and gives two good ratings if the two projects are good. Moreover, all projects with a good rating are financed.*

In the equilibrium described in Proposition 2, a good rating is informative about the quality of a project even if all projects obtain a good rating. Moreover, such a good rating generates value and firms are willing to pay for it. However, the value of a good rating when two good ratings are issued is lower than the value of a good rating when only one good rating is issued. This is precisely what refrains the CRA from always giving a good rating to all projects. Interestingly, there is rating inflation only when no project is good. In all the other cases, the CRA issues a good rating if and only if the project is good. Clearly, the outcome in this equilibrium is more efficient than that in the absence of a CRA. The equilibrium identified in Proposition 2 and that identified in Proposition 1 are the only equilibria in which a good rating generates value and the CRA has a (strictly) positive profit.

We have seen that when the ratings of all projects are disclosed before investors decide on which projects to invest, credit ratings carry information about the quality of the projects and the presence of a CRA improves efficiency. The fact that the ratings of all projects are disclosed simultaneously is key to the result. To highlight this, consider the alternative case where the decisions across the two projects are taken sequentially. Specifically, suppose that there are two periods and one project per period. In period one, the respective project receives a rating (or not) and then investors decide to invest in it or not. The same happens in period two with that period's project. Although it is unimportant to our argument, assume the performance of the two projects is not observed until the end of period two. This means that in both cases, the only potential source of information about the quality of the projects are their ratings.

In this sequential setting, there is no equilibrium where the ratings of the CRA are credible enough that firms are willing to pay for them. That is, there is no equilibrium where a good rating can generate value. In the second period, a good rating cannot be credible enough to generate value. If that was the case, the CRA would issue the good rating irrespective of the quality of the project. But then investors would anticipate this and would not finance a project with a good rating, rendering the rating worthless. Regarding the period one project, any decision about this project will not affect the outcome of the project in period two. So the same applies. In equilibrium, ratings cannot generate value and are, therefore, worthless. The difference between the case of simultaneously reporting of ratings and the case of sequential reporting of ratings is stark.

This discussion suggests that one of the problems of the CRA in the sequential case is that it has no incentive not to inflate the rating of each project. In other words, it cannot discipline itself when selling ratings. This begs the question: Would commitment by the CRA to give at most one good rating solve the problem? The answer is no. Observe that if the CRA does not give a good rating to the project in period one, it will have the incentive to give a good rating to the project in period two regardless of the project's quality as long as it can charge a positive fee for it. Anticipating this, the investors will not finance the project in period two even if it has a good rating. This means that a good rating in period two must be worthless. Thus, the CRA can make a profit only by selling the good rating in period one. But, by the same reasoning, we can conclude that a good rating must also be worthless in period one. Hence, commitment by the CRA to issue at most a given number of good ratings is not sufficient to ensure the credibility of such good ratings. One additional ingredient is needed. The CRA also needs to have the incentive to give those good ratings to the good projects when such projects exist. This incentive is not present in this case. This contrasts with the case when credit ratings are reported simultaneously, where the two effects are present: the CRA has an incentive to limit the number of the good ratings it issues to keep their value high and also has the incentive to give the good rating to the good project because good projects can pay more for the good rating than bad projects.

4 Efficiency When the Number of Projects is Large

We have seen in the previous section that the presence of a CRA can improve efficiency even in a simple setting with two investment projects. In this section, we consider the case of a large number of projects. We focus on a particular type of equilibrium: pooling equilibrium where the CRA gives the same number of good ratings regardless of the number of realized good projects. We show that the efficiency level under this equilibrium asymptotically approaches that in the first best. More precisely, we show that the expected total surplus in equilibrium asymptotically approaches the expected total surplus under the first best allocation where all good projects (and only these) are implemented.

Suppose there are N firms, each with an investment project. As before, firms' projects are independent and each project has a probability p of being good. We focus on the following type of equilibrium: the CRA gives the same number of good ratings, say k, irrespective of the number of realized good projects; all projects with a good rating (and only these) are implemented; and no project is implemented if the number of good ratings given by CRA differs from k. For N sufficiently large, an equilibrium of this type always exists.[10] Moreover, for the same total number of projects, N, equilibria with a different number of good ratings k may coexist. However, there is a trade-off for efficiency with the value of k. If k is too low relative to the expected number of good projects, too few good projects are implemented. If instead k is too large relative to the expected number of

[10] For the derivation of such an equilibrium, please see the proof of Proposition 3.

good projects, too many bad projects are implemented. In the most efficient equilibrium, the value of k balances these two effects. Because the number of good ratings in this type of equilibrium is unresponsive to the number of good projects, the equilibrium outcome will never be fully efficient. However, we can state the following when the number of borrowers is sufficiently large.

Proposition 3 *Consider the case where the number of borrowers N is large. In the asymptotically optimal pooling equilibrium, the number of projects that receive a good rating (and are implemented) is $k = Np + \lambda\sqrt{Np(1-p)}$, where λ is implicitly defined by $\Phi(\lambda) = V_g/(V_g - V_b)$. Furthermore, the expected total surplus evaluated at this equilibrium asymptotically approaches the first-best expected total surplus, and the probability that a project with a good rating is good asymptotically approaches one. In both cases, the asymptotic approximation is in the order of $N^{-1/2}$.*

At the optimal pooling equilibrium, the number of projects that receive a good rating is equal to the unconditional expected number of good projects Np adjusted by λ times the standard deviation of the distribution of the number of good projects. The magnitude of this adjustment depends on the value created by a good project and the value destroyed by a bad project. More specifically, as the value created by a good project V_g increases relative to the value destroyed by a bad project $-V_b$, λ increases, meaning that more projects receive a good rating and are implemented. The intuition for this result is simple. In this case, the cost of not implementing a good project increases relative to the cost of implementing a bad project and it becomes optimal to increase the number of implemented projects. In the limit case in which a good project creates as much value as a bad project destroys, i.e. when $V_g = -V_b$, the optimal equilibrium prescribes that the number of projects that receive a good rating and are implemented is precisely the expected number of good projects Np.

Proposition 3 highlights the importance of credit ratings in this type of market. While the first-best outcome is not attainable in equilibrium, the surplus loss becomes negligible relative to the total surplus, when the number of projects is very large. Observe that this contrasts sharply with the case where borrowers cannot obtain a credit rating because no CRA exists. Without a CRA, no project is implemented and the total surplus created is zero. This is independent of the total number of projects.

5 Discussion and Extensions

The analysis above highlights the importance of simultaneous reporting of credit ratings for ratings credibility. In this section, we explore the robustness of our key findings to a set of alternative modeling assumptions and explore some possible generalizations of our environment.

Projects with correlated qualities We have assumed so far that projects' qualities are independent. In some cases, this assumption may be unrealistic. Some exogenous factors may affect simultaneously the intrinsic quality of all projects. For example, during a period of fast economic growth all projects may be more likely to succeed. Similarly, during a recession, all projects are less likely to succeed and their probability of default may increase. It turns out that it is possible to extend the analysis in Section 3 to allow for intrinsic correlation between projects' qualities. Let P_n denote the probability that exactly $n \in \{0, 1, 2\}$ projects are of good quality. Clearly, $\sum_{n=0}^{2} P_n = 1$. We continue to assume that projects are identical so that the probability that one given project is of good quality is $P_1/2 + P_2$, and that this probability is low enough to discourage investors from financing a project without a credit rating, i.e. $[(P_1/2+P_2)(q_g - q_b)+q_b]R < 1$. This condition, which can be written as $P_1/2 + P_2 < -V_b/\Delta R$, is the counterpart of (2). Observe that this formulation allows for any correlation between the qualities's of the two projects. Following the steps in Section 3, we can obtain a generalized version of Proposition 1.[11] Specifically, if $P_1 + P_2 < -V_b/\Delta R$, then no project (even with a good rating) is implemented. However, if $P_1 + P_2 \geq -V_b/\Delta R$, then there exists a pooling equilibrium where the CRA gives a good rating to only one project and this project is implemented. Moreover, this is the unique equilibrium (in pure strategies) in which at least one project is implemented with positive probability. This result confirms that as long as the probability that at least one project is of good quality $P_1 + P_2$ is not too low, credit ratings can be informative and valuable in equilibrium even when projects' qualities are correlated.

Interestingly, when projects are negatively correlated the gain from simultaneous reporting of credit ratings (relative to sequential reporting) does not disappear. This is because credit ratings do not become informative under sequential reporting of ratings even when projects' qualities are correlated. To illustrate this point, take the case where projects qualities' are perfectly and negatively correlated. This corresponds to the case in which when one project is good and the other is bad.

[11] The proof of this general version of the Proposition 1 follows the same steps as the proof of Proposition 1 and is omitted.

So, all agents know ex-ante that one of the two projects is good. The problem is that they do not know which. One could think that a CRA could refrain from giving a good rating in period one to a bad project and then credibly issue a good rating in period two. The problem is that it cannot charge any money for the good rating in period two. Because of the negative correlation, investors know that the absence of a good rating in period one means that the period two project is good. So a good rating in period two becomes worthless. It is easy to show that there is no equilibrium where ratings are informative even with correlated qualities when projects are rated sequentially.

Commitment by investors We argued above that commitment by the CRA (to give only good rating) will not ensure informativeness of the credit ratings when they are reported sequentially. This means that the outcome under simultaneous reporting of ratings (where one project receives a good rating and is implemented) cannot be replicated by a combination of sequential reporting of ratings and commitment by the CRA. While commitment by the CRA (partially) solves the problem of rating inflation, it does not provide the CRA with enough incentives to give the good rating to the good projects. We argue here that commitment by the investors to finance one (and only one) project, provided it has a good rating, would provide the CRA (in the sequential setting) with the same incentives it has under simultaneous reporting of ratings. More specifically, the outcome achieved under simultaneous reporting of ratings (where one project receives a good rating and is implemented) can be achieved.

To see this, observe that given that one project will be financed, the CRA has no incentive to give more that one good rating. This refrains the CRA from inflating the ratings to the point where they become uninformative and worthless. Moreover, when faced with this situation, the CRA has the incentive to give the good rating to the good project if such a project exists, as the good project creates more value and can, therefore, pay a higher fee for the rating. Hence, commitment by investors, but not commitment by the CRA, can be a substitute to simultaneous reporting of ratings. One may wonder, however, whether such commitment by investors is feasible and easy to implement in reality. While investors are ex-ante better off under the commitment, they would prefer not to finance the project in period two in the event the project in period one receives no rating. This is because they know that in such situation, the period two project will receive a good rating regardless of its quality. (This is precisely why commitment by the investors is needed.) Obviously, in expectation this loss is recovered because in the situations in which the project in period one receives a good rating, investors are sure to finance a good project.[12]

Competition between CRAs Thus far we have consider the case of a monopolist CRA. We discuss here some possible effects of competition between CRAs. The first point to highlight is that even in the case of competition the mechanism considered in this paper continues to work. This mechanism is underpinned by two economic effects: the negative link between the value of a good rating and the total number of such ratings, and the fact that good issuers can outbid bad issuers when competing for good ratings. None of these effects disappear if we allow for competition between CRAs. However, they may became weaker and this may have implications for the value that CRAs can create. There might be two reasons for it.

First, when there are many CRAs and investors cannot observe which issuers request which CRAs to rate their projects, a negative link between the value of a CRA's good rating and the total number of good ratings reported by *all* the CRAs may emerge. If this is case, the issuing of one more good rating by one CRA lowers the value of good ratings issued by all the CRAs. In other words, a CRA generates a negative externality on the other CRAs when it issues an additional good rating. The existence of this externality may lead CRAs to issue more good ratings than a monopolist CRA would do, leading to a loss in the ratings' credibility. This effect is similar to that in Cournot quantity competition. By selling one more unit, a Cournot competitor causes a price decrease and this affects negatively the profits of all the other firms. It is well known that because of this externality Cournot oligopolists produce in total a quantity higher than that a monopolist would produce (which is the quantity that maximizes the industry's profit).

Second, in the case of a large number of issuers, say N, dividing the market between several CRAs means that the number of issuers served by each CRA is not as large as the total number of issuers. This diminishes the power of the Law of Large Numbers. If a CRA is rating N issuers, by Proposition 3, the loss of efficiency, compared to the first best is in the order of $\sqrt{N}$. Therefore, the loss in the case of a monopolist CRA is $c\sqrt{N}$, while the loss in the case of two CRAs (for example) whose market shares are respectively α and $1-\alpha$ is $c\sqrt{\alpha N} + c\sqrt{(1-\alpha)N}$. Since

$$\sqrt{N} < \sqrt{\alpha N} + \sqrt{(1-\alpha)N},$$

[12] This depends, of course, on the amount investors demand from the project they finance. We assume here they commit to charge precisely the same as the amount charged from the project they finance in the pooling equilibrium when ratings are reported simultaneously, $1/(q_b + p(2-p)\Delta)$.

it is clear that the loss is greater in the case of two CRAs than it is in the case of a monopolist CRA.

6 Conclusion

Concerns that credit rating agencies have inflated the ratings of some financial products have increased in recent years. This is in part because during the recent financial crisis, highly rated projects performed very poorly and their ratings had to be significantly downgraded. We show in this paper that requiring a rating agency to report the ratings of many borrowers at once provides a mechanism to discipline it against rating inflation and to increase the credibility of its ratings. The simultaneity in the reporting of credit ratings disciplines rating agencies because it links the CRA's decisions regarding the ratings of different borrowers: by giving more good ratings, the rating agency lowers the credibility of its ratings and the fee it can charge for a good rating. Moreover, it provides the rating agency with incentives to give good ratings to good projects, as these are the projects that can pay more for a good rating. We also show that our mechanism is asymptotically efficient. That is, when the number of borrowers is sufficiently large, the surplus generated in equilibrium (asymptotically) approaches the efficient total surplus.

The findings in the paper suggest that the efficiency in the market for credit ratings could be improved by restricting rating agencies to report ratings only at certain points in time. This way rating agencies would report simultaneously the credit ratings of the borrowers who request such ratings during the reporting moments. There are, however, potential costs with the implementation of such mechanism. One is that this could generate delays in the implementation of projects. Since borrowers would have to wait more for a credit rating, it would take them more time to raise the funds necessary to implement their projects. Another cost is that imposing such a restriction on rating agencies may interfere with other mechanisms, such as the typical reputation mechanism, that discipline rating agency against rating inflation. We abstract from those effects in the present paper. The goal of the paper is to highlight a mechanism that may help discipline rating agencies. Its implementation in practice may require a more comprehensive analysis of all its effects.

7 Appendix

Proof of Proposition 1. We focus on equilibrium where the investors' belief that a non-rated project is of good quality is no higher than the prior p. Hence, in equilibrium a non-rated project is not implemented, as it is not funded by investors. This means that a firm's payoff in case it rejects the rating proposal of the CRA is zero. Hence, since firms are protected by limited liability, the strategy of accepting the CRA's rating and fee proposal (r, f) if and only if $r = g$ is optimal for the firm. Given this strategy by the firms, we can obtain the expected profit of the CRA if it proposes (a total of) k good ratings given that n projects are good. Let π_n^k denote this profit. If $k = 0$, all the rating offers made by the CRA are rejected. Hence, $\pi_n^0 = 0$ for all $n = 0, 1, 2$. If $k = 1$, one offer is accepted and one good rating is reported. The maximum fee the CRA can collect in this case is $f = \max\{R - C_1, 0\}$. If $n = 0$, the good rating will be given to a bad project. The probability that the fee is collected is then q_b. If $n = 1$ or $n = 2$, the good rating is given to a good project. The probability that the fee is collected is q_g. (Observe that it is optimal for the CRA to give the good rating to the firm with the good project when $n = 1$.) Hence, $\pi_0^1 = q_b \times \max\{R - C_1, 0\}$, and $\pi_1^1 = \pi_2^1 = q_g \times \max\{R - C_1, 0\}$. If $k = 2$, both offers are accepted and two good ratings are reported. The maximum fee that the CRA can collect from each firm is $f = \max\{R - C_2, 0\}$. Applying the same reasoning as above we obtain $\pi_0^2 = 2q_b \times \max\{R - C_2, 0\}$, $\pi_1^2 = (q_b + q_g) \times \max\{R - C_2, 0\}$, and $\pi_2^2 = 2q_g(R - C_2)$. We can now analyze the choice by the CRA of the number of good ratings it proposes to firms. It is clear from direct inspection of the values of π_n^k that choosing $k = 0$ is dominated for the CRA. Hence, we can restrict attention to the choice by the CRA between $k = 1$ and $k = 2$, for each value n. Next, observe that $\pi_0^1 > \pi_0^2$ and $\pi_2^1 > \pi_2^2$ are equivalent, and that these conditions imply $\pi_1^1 > \pi_1^2$. This implies that depending on the profit values, at most three types of equilibrium where $C_1 < R$ or $C_2 < R$ (i.e., where project are implemented) can exist. We consider each case in turn. In what follows let P_j denote the ex-ante probability that j projects are of quality q_g, i.e. $P_0 = (1 - p)^2$, $P_1 = 2p(1 - p)$ and $P_2 = p^2$.

Case 1: $\pi_1^1 \le \pi_1^2$. This implies that $\pi_0^1 \le \pi_0^2$ and $\pi_2^1 \le \pi_2^2$. In such an equilibrium (if exists), the CRA chooses $k = 2$ regardless of n. Given this strategy by the CRA, it follows from Bayesian updating that the investors' belief that a project with a good rating is good is $\phi_2 = p$. This implies that

$$C_2 = \frac{1}{\phi_2 q_g + (1-\phi_2) q_b} = \frac{1}{q_b + \phi_2 \Delta} = \frac{1}{q_b + p\Delta},$$

which is greater than R when $p < -V_b/\Delta R$. Hence, $\pi_n^2 = 0$, for $n = 0, 1, 2$. Since by assumption $\pi_n^1 \leq \pi_n^2$, then $\pi_n^1 = 0$, for $n = 0, 1, 2$. But if $\pi_n^1 = \pi_n^2 = 0$ for $n = 1, 2, 3$ then it cannot be an equilibrium in which $C_1 < R$ or $C_2 < R$.

Case 2: $\pi_0^1 \leq \pi_0^2$ and $\pi_1^1 > \pi_1^2$. Since, $\pi_0^1 \leq \pi_0^2$, then $\pi_2^1 \leq \pi_2^2$. In such an equilibrium, (if exists), the CRA chooses $k = 2$ when $n = 0$ or $n = 2$, and $k = 1$ (given to the good project) when $n = 1$. Given this strategy by the CRA, the investors' beliefs are $\phi_1 = 1$ and $\phi_2 = P_2/(P_0+P_2) = P_2/(1-P_1)$. This means that investors demand

$$C_1 = \frac{1}{q_g}$$

and

$$C_2 = \frac{1}{\phi_2 q_g + (1-\phi_2) q_b} = \frac{1}{q_b + \phi_2 \Delta} = \frac{1}{q_b + (P_2/(1-P_1))\Delta}.$$

This situation is an equilibrium if for these values of C_1 and C_2, conditions $\pi_0^1 \leq \pi_0^2$ and $\pi_1^1 > \pi_1^2$ are satisfied. It is routine to show these conditions are equivalent to

$$P_2 \geq \frac{\Delta - q_g V_b}{\Delta + q_g \Delta R}(1 - P_1) \tag{4}$$

and

$$P_2 < \frac{(\Delta - q_b V_b)}{(\Delta + q_b \Delta R)}(1 - P_1),$$

respectively. It also routine to show that (4) is not satisfied when $p < -V_b/\Delta R$. Hence, such an equilibrium does not exist.

Case 3: $\pi_0^1 > \pi_0^2$. Since $\pi_0^1 > \pi_0^2$ implies $\pi_1^1 > \pi_1^2$ and $\pi_2^1 > \pi_2^2$, in such an equilibrium the CRA must to choose $k = 1$ regardless of n. Given this strategy by the CRA, the investors' belief that the project with the good rating is good is obtained by Bayes rule and is given by $\phi_1 = P_1 + P_2 = p(2-p)$. Hence, investors demand from such project

$$C_1 = \frac{1}{\phi_1 q_g + (1-\phi_1) q_b} = \frac{1}{q_b + \phi_1 \Delta} = \frac{1}{q_b + p(2-p)\Delta}.$$

Since in this type of equilibrium, a choice of $k \neq 1$ by the CRA is off-the-equilibrium path, we are free to choose ϕ_2. Let $\phi_2 = 0$. Hence, $C_2 = 1/q_b > R$ and, consequently, $\pi_n^2 = 0$ for all n. Hence, such an equilibrium exist if and only if $C_1 \leq R$, which is equivalent to

$$p(2-p) \geq \frac{-V_b}{\Delta R}.$$

This concludes the proof. ■

Proof of Proposition 2. Let π_n^k denote expected profit of the CRA if it proposes (a total of) k good ratings given that n projects are good. We know (from the proof of Proposition 1) that $\pi_n^0 = 0$ for all $n = 0, 1, 2$; $\pi_0^1 = q_b \times \max\{R - C_1, 0\}$, $\pi_1^1 = \pi_2^1 = q_g \times \max\{R - C_1, 0\}$; and $\pi_0^2 = 2q_b \times \max\{R - C_2, 0\}$, $\pi_1^2 = (q_b + q_g) \times \max\{R - C_2, 0\}$, and $\pi_2^2 = 2q_g(R - C_2)$. The equilibrium described in the proposition exists if $C_1 < R$ and $C_2 < R$ are such that $\pi_0^1 = \pi_0^2$, $\pi_1^1 \geq \pi_0^2$, $\pi_2^1 \leq \pi_2^1$ and are consistent with investors beliefs about the quality of a project in equilibrium. Let us assume for the moment that $C_1 < R$ and $C_2 < R$. We show later that these conditions are satisfied. Observe that conditions $\pi_0^1 = \pi_0^2$ and $\pi_2^1 = \pi_2^2$ are equivalent, they imply that $\pi_1^1 \geq \pi_0^2$, and they can written

$$2C_2 = R + C_1. \tag{5}$$

Hence, all the conditions $\pi_0^1 = \pi_0^2$, $\pi_1^1 \geq \pi_0^2$, and $\pi_2^1 \leq \pi_2^1$ are satisfied as long as (5) holds. We next obtain C_1 and C_2 that are consistent with investors' beliefs in equilibrium.

Let r_k denote the probability that the CRA issues k good ratings when the number of good projects is zero. Let also ϕ_k denote the probability (investors' belief) that a project with a good a rating is good when k project receive a good rating. From Bayes rule and the CRA's strategy, it follows that

$$\phi_1 = \frac{\Pr(n=1)}{\Pr(n=1) + r_1 \Pr(n=0)} = \frac{2p(1-p)}{2p(1-p) + r_1(1-p)^2} = \frac{2p}{2p + r_1(1-p)} \tag{6}$$

and

$$\phi_2 = \frac{\Pr(n=2)}{\Pr(n=2) + r_2 \Pr(n=0)} = \frac{p^2}{p^2 + r_2(1-p)^2}. \tag{7}$$

Because investors' demand a zero rate of return to invest in a project,

$$C_k = \frac{1}{q_b + \phi_k \Delta},\ k = 1, 2. \tag{8}$$

Hence, the equilibrium described in the proposition exists if and only if there exist $r_1, r_2 \geq 0$ with $r_1 + r_2 = 1$, such that (5) is satisfied when C_k is given by (8) and ϕ_1 and ϕ_2 are given, respectively by (6) and (7). It is routine to show that there exists $r_1 \in [0,1]$ such that

$$\frac{2}{q_b + \frac{p^2}{p^2+(1-r_1)(1-p)^2}\Delta} = R + \frac{1}{q_b + \frac{2p}{2p+r_1(1-p)}\Delta}$$

when $p\,(2-p) \geq -V_b/\Delta R$ and that the resulting $C_k < R$, $k = 1, 2$. ■

Proof of Proposition 3. Take the total number of projects N as fixed for the moment. Consider the pooling equilibrium where k projects receive a good rating regardless of the true number good projects $n \in \{0, 1, .., N\}$, and all projects with a good rating are implemented. Given the number of good projects n, the total surplus is kV_g if $n \geq k$ and $nV_g + (k-n)V_b$. The expected total surplus (before n is realized) is given by

$$\begin{aligned} V(k) &= \Pr(n \geq k) \times kV_g + \sum\nolimits_{n=0}^{k-1} p_n(nV_g + (k-n)V_b) \\ &= \Pr(n \geq k) \times kV_g + \Pr(n < k) \times kV_b + (V_g - V_b) \times \sum\nolimits_{n=0}^{k-1} p_n n \\ &= \Pr(n \geq k) \times kV_g + \Pr(n < k) \times kV_b + (V_g - V_b) \times \sum\nolimits_{n=0}^{k-1} p_n n \\ &= kV_g - \Pr(n < k)k \times (V_g - V_b) + (V_g - V_b) \times \sum\nolimits_{n=0}^{k-1} p_n n \\ &= kV_g - (V_g - V_b)[\Pr(n < k)k - \sum\nolimits_{n=0}^{k-1} p_n n], \end{aligned}$$

where p_n is the probability that the number of good projects is n. The optimal k maximizes $V(k)$. It turns out that this is not a trivial problem. Therefore, we next obtain an asymptotic approximation to $V(k)$.

Observe that

$$\frac{V(k)}{N} = \frac{k}{N}V_g - (V_g - V_b)\frac{\Pr(n < k)k - \sum\nolimits_{n=0}^{k-1} p_n n}{N}. \tag{9}$$

In what follows, it is convenient to write k and n as:

$$k = Np + \lambda_N \sqrt{Np(1-p)}$$

and

$$n = Np + t\sqrt{Np(1-p)}$$

where $\lambda_N, t \in R$. These are just variable transformations. Hence, we can write

$$\frac{K}{N} = p + \lambda_N \sqrt{\frac{p(1-p)}{N}}. \tag{10}$$

By the Central Limit Theorem, asymptotically, $t \sim N(0,1)$ with density $\phi(t) = (\sqrt{2\pi})^{-1} e^{\frac{-t^2}{2}}$ and c.d.f. $\Phi(t) = \int_{-\infty}^{t} \phi(s)ds$. By the Barry- Esseen theorem, for N large,

$$\Pr(n < k) = \Phi(\lambda_N) + O(\frac{1}{\sqrt{N}}). \tag{11}$$

Observe also that

$$\begin{aligned}
\sum\nolimits_{n=0}^{k-1} p_n \frac{n}{N} &= \Pr(n < k) E[\frac{n}{N} \mid n < k] \\
&= \Pr(n < k) E[\frac{Np + t\sqrt{Np(1-p)}}{N} \mid n < k] \\
&= \Pr(n < k) E[p + t\sqrt{\frac{p(1-p)}{N}} \mid n < k] \\
&= \Pr(n < k)p + \sqrt{\frac{p(1-p)}{N}} \times \Pr(n < k) E[t \mid n < k] \\
&= \Pr(n < k)p + \sqrt{\frac{p(1-p)}{N}} \int_{-\infty}^{\lambda_N} t\phi(t)dt + o(\frac{1}{\sqrt{N}}).
\end{aligned}$$

Using the fact that $\int_{-\infty}^{\lambda_N} \phi(t)tdt = \int_{-\infty}^{\lambda_N} \frac{1}{\sqrt{2\pi}} e^{\frac{-t^2}{2}} tdt = -\phi(\lambda_N)$, we can write

$$\sum\nolimits_{n=0}^{k-1} p_n \frac{n}{N} = \Pr(n < k)p - \sqrt{\frac{p(1-p)}{N}} \phi(\lambda_N) + o(\frac{1}{\sqrt{N}}). \tag{12}$$

Using (10), (11) and (12) into (9), we obtain

$$\begin{aligned}
\frac{V(k)}{N} &= V_g \times (p + \lambda_N \sqrt{\frac{p(1-p)}{N}}) \\
&\quad -(V_g - V_b) \times \{[\Pr(n < k) \times (p + \lambda_N \sqrt{\frac{p(1-p)}{N}})] - [\Pr(n < k) \times p - \sqrt{\frac{p(1-p)}{N}}\phi(\lambda_N) + o(\frac{1}{\sqrt{N}})]\} \\
&= pV_g + \sqrt{\frac{p(1-p)}{N}}\lambda_N V_g - \sqrt{\frac{p(1-p)}{N}}(V_g - V_b)[\Phi(\lambda_N)\lambda_N + \phi(\lambda_N)] + o(\frac{1}{\sqrt{N}}) \\
&= pV_g + \sqrt{\frac{p(1-p)}{N}}\{\lambda_N V_g - (V_g - V_b)[\Phi(\lambda_N)\lambda_N + \phi(\lambda_N)]\} + o(\frac{1}{\sqrt{N}}).
\end{aligned}$$

Hence, asymptotically, the optimal k for each N can be obtained by solving:

$$\max_{\lambda_N} \lambda_N V_g - (V_g - V_b)[\Phi(\lambda_N)\lambda_N + \phi(\lambda_N)].$$

Observe that $\Phi'(\lambda_N) = \phi(\lambda_N)$ and $\phi'(\lambda_N) = -\lambda_N\phi(\lambda_N)$. The first-order condition associated with this maximization problem is

$$V_g - (V_g - V_b)\Phi(\lambda_N) = 0,$$

from which it follows that the optimal λ_N does not depend on N and is implicitly defined by the condition

$$\Phi(\lambda^*) = \frac{V_g}{V_g - V_b}.$$

Hence, asymptotically, the optimal k is $k^* = Np + \lambda^*\sqrt{Np(1-p)}$ and the expected total surplus evaluated at the optimal pooling equilibrium is

$$V(k^*) = N(pV_g - \sqrt{\frac{p(1-p)}{N}}(V_g - V_b)\phi(\lambda^*).$$

Since the first-best expected total surplus is $V^{FB} = NpV_g$, we obtain that

$$\frac{V^{FB} - V(K^*)}{V^{FB}} = \sqrt{\frac{1-p}{Np}}(V_g - V_b)\phi(\lambda^*),$$

which means that $V(K^*)$ asymptotically approaches V^{FB} in the order of $N^{-1/2}$. Finally, observe that under the optimal k, the probability that a project with a good rating is indeed good when N

is sufficiently large is given by

$$
\begin{aligned}
\phi_{k^*}^N &= \Pr(n \geq k^*) \times 1 + \sum\nolimits_{n=0}^{k^*-1} p_n \frac{n}{k^*} \\
&= 1 - \Phi(\lambda^*) + \frac{N}{k^*} \times \sum\nolimits_{n=0}^{k^*-1} p_n \frac{n}{N} + O(\frac{1}{\sqrt{N}}) \\
&= 1 - \Phi(\lambda^*) + \frac{1}{p + \lambda^* \sqrt{\frac{p(1-p)}{N}}} \times [p\Phi(\lambda^*) - \sqrt{\frac{p(1-p)}{N}} \phi(\lambda^*)] + O(\frac{1}{\sqrt{N}}) \\
&= 1 - \Phi(\lambda^*) + \frac{1}{p} \times (1 - \lambda^* \sqrt{\frac{1-p}{Np}}) \times [p\Phi(\lambda^*) - \sqrt{\frac{p(1-p)}{N}} \phi(\lambda^*)] + O(\frac{1}{\sqrt{N}}) \\
&= 1 - \Phi(\lambda^*) + (1 - \lambda^* \sqrt{\frac{1-p}{Np}}) \times [\Phi(\lambda^*) - \sqrt{\frac{(1-p)}{Np}} \phi(\lambda^*)] + O(\frac{1}{\sqrt{N}}) \\
&= 1 - \Phi(\lambda^*) + \Phi(\lambda^*) + O(\frac{1}{\sqrt{N}}) \\
&= 1 + O(\frac{1}{\sqrt{N}}).
\end{aligned}
$$

It converges to one in the order of $N^{-1/2}$. Finally, the fact that this probability converges to one ensures that all projects with a good rating are implemented in equilibrium, justifying the initial assumption about the equilibrium considered. ■

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