Natural Barrier to Entry in the Credit Rating Industry*

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February 25, 2010

Abstract

This paper examines whether there is a natural barrier to entry in the credit rating industry. We consider an infinite horizon model in which each period, an original incumbent faces competition from an entrant randomly selected from a pool of ex ante identical potential entrants. The incumbent's accuracy is imperfect, constant and known while each entrant's true accuracy is unknown and can be perfect or completely noisy.

In the benchmark in which the signal that a CRA receives is public information, we find that the market provides either a right or a socially excessive incentive to experiment with entrants. On the contrary, when the signal is private information, the experimentation never occurs. Our result suggests that a rather incompetent CRA can dominate the market without being worried about entry of potentially more competent entrants and can explain the current failure of the credit rating industry. We derive policy implications.

Key Words: Credit Rating, Entry Barrier, Market Structure, Reputation, Private Information

JEL Codes: D82, G29, L11, L13, L15

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*We thank the participants of the seminar in Toulouse School of Economics. We thank Bruno Biais, Alexander Grumbel, Augistin Landier, Jerome Mathis for useful comments.

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1 Introduction

Credit Rating Agencies (CRAs) are considered a central culprit in the current financial turmoil. By giving safe investment ratings to subprime mortgages, they significantly contributed to create mortgage bust. In this paper, we show that the questionable accuracy in current ratings can be due to natural barrier[1] that hinders potentially more accurate CRAs from entering the credit rating business and replacing less efficient incumbents. We present an infinite horizon model that studies the competition between a relatively ineffective incumbent CRA and a sequence of entrant CRAs that are potentially more effective but whose ability in apprising default risk is unproven at the time they enter the market. We show that when CRAs' private information cannot be credibly disclosed, market fails in selecting the most competent CRA among the incumbent and the pool of entrants. In other words, a rather incompetent CRA can dominate the market without being worried about potentially more competent entrants.

Understanding how competition between an incumbent and an entrant works in the credit rating industry is a prerequisite for any reform of the industry. A striking fact about the credit rating industry is its persistent fewness of incumbents (White, 2002). According to Coffee (2006)

"Since early in the 20th century, credit ratings have been dominated by a duopoly - Moody's Investors Services, Inc. (Moody's) and Standard & Poor's Ratings Services (Standard & Poor's)." (Coffee, p.284).

Even though one admits that the SEC's awarding, since 1973, of "Nationally Recognized Statistical Ratings Organizations" (NRSROs) status only to a small number of CRAs created an *artificial barrier to entry*, the persistent level of concentration before the promulgation of NRSRO status suggests that there might be some *natural barrier to entry* into this market even in the absence of this artificial barrier to entry. Furthermore, the SEC attributes paucity of NRSROs to natural barrier to entry, which reduces the number of applications.[2] Scarcity of applications to the status of NRSRO is also at odds with the high profitability of the credit rating business.[3] Our paper identifies a mechanism that

[1]The meaning of natural barrier is explained later on in the introduction.

[2]In a hearing held on April 2, 2003 on rating agencies before the Capital Markets Subcommittee of the House of Financial Services Committee, Annette Nazareth (director of the division of market regulation for the SEC) said, "Again, we think that there are some natural barriers to entry here. There have not been that many applications." See page 20 at http://financialservices.house.gov/media/pdf/108-18.pdf

[3]On avergae, between 1995 and 2000, Moody's annual net income amounted to 41.1% of its total assets (White, 2002).

generates such a natural entry barrier.

For this purpose, we consider a stylized model of infinite horizon in which each period an incumbent CRA faces competition from an entrant randomly selected from a pool of potential entrants. All CRAs are, potentially, long-term players. Each period, there is a short-lived firm who needs to obtain the rating of its security issued to finance a risky project. A rating is an assessment of the quality of the project and hence of the security's default risk. When choosing between hiring the entrant or the incumbent CRA, the issuer takes into account both the difference in their rating fees and in the reliability of their ratings. In fact, the reduction in the issuer's cost of capital resulting from a good rating increases with the reliability of the rater.

If requested to rate a project, a CRA receives a private signal regarding the quality of the project. We assume that the original incumbent CRA's signal is imperfectly correlated with the project quality. The precision of this signal (hence the reputation of the original incumbent) is imperfect, constant and known to everybody. An entrant CRA can be either perfectly accurate (i.e. it receives a perfect signal) or inaccurate (i.e. it receives a completely noisy signal) and its actual accuracy is unknown to everybody (including the entrant itself). All potential entrants are ex ante identical. What we have in mind is that the incumbent such as Moody's and S & P's has been in the market for long time and therefore an extra correct (or incorrect) rating does not change much its reputation. On the other hand, an entrant has not yet been given opportunities to make ratings and therefore its reputation is more sensitive to new information. It is assumed that an entrant's initial reputation (i.e. the probability to be accurate) is lower than the original incumbent's known imperfect accuracy. However, conditionally on truthfully reporting its signal, by correctly evaluating a project, the entrant's reputation becomes higher than that of the original incumbent.

In each period the current entrant and the current incumbent compete in fees to attract an issuer. In most part of the paper (except for the section on policy implications), we consider that each CRA charges a constant fee that does not depend on its rating as in the fee structure proposed in the Cuomo plan. While we allow CRAs to charge a negative fee to attract issuer, we assume that CRAs cannot stay indefinitely in business without generating a strictly positive profit. More precisely, a period t entrant that fails to build up reputation by the end of the period has to leave the market and is replaced by a new entrant from the pool. If on the contrary, the current entrant builds a reputation of being more accurate than the incumbent, then the latter exits the business and is replaced by a new entrant in the following period.

We focus on whether the market provides a right incentive to experiment with entrants and select the most accurate CRA. For this purpose we first characterize the socially optimal experimentation policy when the signal of each CRA is public information and find that it is preferable to always hire the original incumbent instead of optimally experimenting with the entrants if and only if the incumbent's accuracy is sufficiently larger than the entrants' ex ante reputation. Secondly, we compare this policy with the one induced by competition. To identify the causes of entry barrier, we distinguish two cases depending on whether a CRA's signal is public information or private information.

When the signal is public information, we find that the market provides issuers with an excessive incentive to experiment with entrants. In the market equilibrium, the original incumbent maintains its monopoly position only if its accuracy is substantially larger than the entrant's reputation. However the incumbent loses competition against an entrant also for some levels of its accuracy for which it would be socially optimal not to hire entrants. This excessive experimentation is due to the fact that an identical entrant is more aggressive with respect to the original incumbent than with respect to an incumbent who once was an entrant in the pool. When competing against the original incumbent, an entrant pledges its future profit that it can generate by making a successful prediction that allows it to replace the original incumbent. On the contrary, when competing against an incumbent who started as entrant, it does not pledge its future profit since even if it improves its reputation by making one successful prediction, its reputation cannot be superior to that of the incumbent and hence must exit the market before the next period. This fact implies that the competition from a sequence of identical entrants reduces more the continuation payoff of the original incumbent than that of an incumbent who started as an entrant and eventually induces the entrant wins too often the competition against the original incumbent. However, the market provides the right incentive to experiment with entrants if the initial reputation of an entrant is close enough to the reputation of the original incumbent. Then, it is socially optimal to experiment with entrants and in equilibrium any entrant wins the competition against the original incumbent and the market eventually reaches a steady state in which an accurate type CRA provides ratings forever.

By contrast, when the signal is private information, in equilibrium there never is any experimentation of entrants and hence the original incumbent always stays in the market as the dominant CRA. The driving force of the result is the reputational conflict of interest: an entrant cannot credibly commit to truthful reporting of its private signal when requested to give a rating. In particular, conditional on receiving a bad signal, it has a strong incentive to give a good rating. To be precise, consider a candidate equilibrium of truth-telling and suppose that an entrant receives a bad signal. Then, if it gives a bad rating, the project will not be implemented and hence it will be replaced by a new entrant. If it gives a good rating, the project will be implemented and with some luck (since, in expectation, the entrant's signal is imperfect) the project will succeed. Then, the entrant's reputation increases and can replace the original incumbent. Hence the entrant would have an incentive to always report a good rating, implying that in equilibrium one cannot rely on its rating. The result that an entrant faces a strong temptation to inflate ratings is consistent with empirical findings that less established competitors, such as Fitch, have at times been perceived as more generous in their ratings than S&P or Moody's. (Coffee, 2006, p. 300).

Our results generate interesting policy implications. First, the policies that are effective in eliminating rating inflation, namely the Cuomo plan and no rating shopping, may not be useful in eliminating natural barriers of entry. Even though, in our model, we incorporated the Cuomo plan (an issuer should pay a fixed fee regardless of the rating it receives) and assumed away rating shopping (a rating is always disclosed), the natural barrier to entry exists. Furthermore, it is clear that the reputational conflict of interest that an entrant faces remains even if we switch from issuer-pays pricing to investor-pays pricing. The remedy we propose is to allow each CRA to use complete contracts that allow to charge fees contingent on ratings: in particular, an entrant CRA should be able to commit to charge a fee contingent on bad rating much higher than a fee contingent on good rating.

Some recent papers have offered explanations of the CRAs' failures. Mathis et al. (2009) study how an opportunistic CRA can build reputation for being fully committed to always truthfully revealing its private signal regarding the quality of an issuer's project.. They show that when a large fraction of the CRA's income comes from rating complex projects, as soon as the CRA's reputation for being committed is strong enough, it is optimal for an opportunistic CRA to be too lax in its rating. Their model is a model of reputation à la Benabou and Laroque (1992) who consider a monopoly CRA that faces no competition from other CRAs. Skreta and Veldkamp (2009) consider a static model where an issuer can buy and make public one or more signals regarding the quality of the project it wants to finance. They assume CRAs are committed to truthfully report their signal. CRA's signals are conditionally independently distributed and their accuracy decrease with the complexity of the project to assess. They show that since an issuer can choose which signal to make public, only best ratings are published and this biases published rating to be good even if CRAs truthfully report their signals to the issuer. Bolton et al. (2009) consider a static model where CRAs receive private signals regarding the quality of an issuer's project. As in Mathis et al. (2009), CRAs can manipulate their ratings but suffer an exogenous cost for misreporting. In their model a fraction of investors are naive and take ratings at face value. They show that CRAs may inflate their ratings when the fraction of naive investors is large enough and/or when CRAs' misreporting costs are low enough. Boot et al. (2006) take a different approach and study the role that a rating agency can have as a coordination device in the presence of multiple equilibria. None of these papers study the entry problem in the credit rating business. In the first three papers, rating inflation of incumbent CRA(s) is due to the fact that CRAs deliberately decide to issue overoptimistic ratings, and/or issuers choose to publish only good ratings. Our paper is the first studying the entry game in the credit rating business and explains how a non-accurate CRAs can maintain a monopolistic position even when potentially accurate CRA can enter the market. In our model, an entrant has an incentive to inflate rating because of its imperfect accuracy and the fact that securities with bad rating are not issued.

On the theoretical literature on certification agency, a number of papers have analyzed the endogenous disclosure policy of a certification agency in a static set up. This was done by Lizzeri (1999) for the case of a monopolistic certification agency and further extended in Doherty et al. (2009) for the case of static competitions among rating agencies. In Faure-Grimaud et al. (2009), the optimal contract regarding the ownership of the rating is analyzed when the decision to obtain a rating is endogenous.

The paper is organized as follows. Section 2 presents the model. Section 3 discusses the case of publicly observable CRAs' signals analyzing both the socially optimal experimentation policy and the market equilibrium. Section 4 studies the market equilibrium when CRAs' signals are private information. In Section 5, we analyze the equilibrium when CRAs' signals are private but contingent rating fees are allowed. Section 6 contains some policy implications. Conclusions are in Section 7. All the proofs are in the Appendix.

2 The model

2.1 Issuers and Investors

We consider a model of infinite periods. In each period $t = 1, ...,$ there is a short-lived cashless firm, named issuer t, who wants to issue a security for financing an investment project. We normalize the cost of the project to 1. Let $\widetilde{X}_t \in \{X, 0\}$ denote the return from the project of issuer t. With probability $\mu := 1/2$, the project is of good quality and $\widetilde{X}_t = X > 1$. With probability $1-\mu$ the project is of bad quality and $\widetilde{X}_t = 0$. The project's quality is unknown to everybody including to the issuer himself. Returns of issuers' projects are independently and identically distributed.

Investors are risk neutral and competitive. We normalize the market interest rate of a risk-free bond to zero. In the absence of any additional information about the project, if $\mu X - 1 \geq 0$, the project will be financed. Then investors' required interest rate on the corporate bond is $y := (1-\mu)/\mu$ leaving $X - 1/\mu$ to the issuer's shareholders if the project is successful and 0 otherwise. If $\mu X - 1 < 0$, then no investment takes place. We shall consider both cases $X \geq 1/\mu$ and $X < 1/\mu$.

2.2 Credit Rating Agencies (CRAs)

Issuer t can hire a CRA to rate its bonds. In order to provide a rating the CRA has to gather information about the issuer t by auditing the firm, meeting its executives and analyzing the firm's investment project. These activities have a cost $c \geq 0$ that a CRA must pay to receive a private signal regarding the quality of the project. Upon accepting to rate an issuer, a CRA is assumed to spend c: there is no moral hazard on c since the issuer can check it.[4] Let $s_{it} \in \{G, B\}$ represent the private signal received by CRA i regarding issuer t. We assume that CRA i's rating, denoted by r_{it}, belongs to $\{G, B\}$. We assume that c is large enough that the issuer buys only one rating.

2.2.1 Accuracy and Reputation

There are two kinds of rating agencies: the original incumbent and a pool of infinite number of ex ante identical potential entrants.

Let $i = I$ represent the original incumbent CRA. We assume that the original incumbent's signal is informative but not perfect. We will denote with $q = \Pr\left(s_{It} = G | \widetilde{X}_t = X \right) = \Pr\left(s_{It} = B | \widetilde{X}_t = 0 \right)$ the probability that the incumbent's signal reflects the true quality of the project and we assume $1/2 < q < 1$. Let $\lambda_I = 2q - 1 \in (0, 1)$ denote *the original incumbent's accuracy or reputation.*

Let $i = Et$ represent the potential entrant CRA entering the credit rating market at period t. Any potential entrant CRA can be of two types: it can be accurate or inaccurate. An accurate type receives the signal G (B) whenever the project is good (bad). An inaccurate CRA's signal is not informative about the project's quality and equals G or B with probability $1/2$ regardless of the realization of $\widetilde{X}_t$. Thus, an accurate (inaccurate) entrant receives a signal that is always more (less) precise than the original incumbent's signal. Conditional on the project being good (or bad), the signals that competing CRAs receive are independently distributed. The type of an entrant CRA is unknown to everybody including to the entrant itself. Let $\lambda_{Et} = \lambda_E$ be the initial belief that an entrant is accurate. The parameter λ_E can be interpreted either as *the entrant's initial expected accuracy* or *its initial reputation.* All potential entrants in the pool have the same initial reputation.

[4] This assumption is common in Bolton-Freixas-Shapiro (2009), Mathis-McAndrews-Rochet (2009), Skreta and Veldkamp (2009).

Let λ_{it} be CRAi's reputation at *the beginning of period* t and suppose that CRAi received the signal G at t. Then, we have

$$\begin{aligned}\mu_G(\lambda_{it}) \quad &: \quad = \Pr\left(\widetilde{X}_t = X \mid s_{it} = G\right) \\ &= \frac{\mu\left[\lambda_{it} + (1-\lambda_{it})/2\right]}{\mu\left[\lambda_{it} + (1-\lambda_{it})/2\right] + (1-\mu)(1-\lambda_{it})/2} = \\ &= \lambda_{it} + (1-\lambda_{it})/2 = (1+\lambda_{it})/2.\end{aligned}$$

Thus $\mu_G(\lambda_{it}) \geq \mu$ is the belief that period-t project is of good quality given CRAi with reputation λ_{it} received signal $s_{it} = G$. This is an increasing function of λ_{it} with $\mu_G(0) = \mu$. In a similar way,

$$\begin{aligned}\mu_B(\lambda_{it}) \quad &: \quad = \Pr\left(\widetilde{X}_t = X \mid s_{it} = B\right) = \\ &= \frac{\mu(1-\lambda_{it})/2}{\mu(1-\lambda_{it})/2 + (1-\mu)\left[\lambda_{it} + (1-\lambda_{it})/2\right]} = (1-\lambda_{it})/2.\end{aligned}$$

That is, $\mu_B(\lambda_{it}) \leq \mu$ represents the belief period-t project is good given signal $s_{it} = B$ from a CRA with reputation λ_{it}.

In the absence of CRAs, the social surplus in period t is $\max\{0, \mu X - 1\}$. If a CRA is hired and the project is implemented only if its signal is G, the social surplus is $\frac{1}{2}(\mu_G(\lambda_{it})X - 1) - c$. Let $\lambda_{\min}$ be defined such that

$$\frac{1}{2}(\mu_G(\lambda_{\min})X - 1) - c \equiv \max\{0, \mu X - 1\}$$

We assume:

A1: $\lambda_I \geq \lambda_E > \lambda_{\min}$

The first inequality in A1 says that the reputation of the original incumbent is not smaller than the initial reputation of an entrant. The second inequality implies that any CRA's initial reputation is above the minimum necessary to justify, from a social planner's perspective, the investment of c to generate the CRA's private signal. Beside, this implies that each CRA's reputation is large enough to convince investors to finance (to dissuade investors from financing) the project when the CRA's signal is good (bad).

2.2.2 Evolution of reputation

We assume that the original incumbent's reputation λ_I is fixed and commonly known. This assumption is not crucial as long as long as the incumbent's reputation is not too sensitive to an additional news regarding its rating performance. This happens when the incumbent has been in the business for a long time and its long record of rating performance leaves little uncertainty regarding its rating accuracy. On the contrary, an entrant has not yet given many opportunities to make rating to demonstrate its rating accuracy. As a consequence, the entrant's reputation can vary sharply as new information about its accuracy is revealed by its rating performance.

Formally, in period t, consider a CRA $i \neq I$ with reputation λ_i and suppose that it received private signal $s_{it} \in \{G, B\}$ regarding the period t project. Let ω_t denote the event realized at the end of period t. When s_{it} is observable, there are five possible events:

- $\omega_t = S^G$ meaning that the project was financed with a CRA i's good signal and it succeeded.
- $\omega_t = F^G$ meaning that the project was financed with a CRA i's good signal and it failed.
- $\omega_t = S^B$ meaning that the project was financed with a CRA i's bad signal and it succeeded.
- $\omega_t = F^B$ meaning that the project was financed with a CRA i's bad signal and it failed.
- $\omega_t = N$ meaning that the project was not financed.

Thus it is possible to update belief regarding CRA i's true accuracy by observing ω_t, i.e., by comparing the outcome of the project $\widetilde{X}_t$ with the CRA's signal s_i. Namely,

$$\begin{aligned} \lambda_i^+ \quad &: \quad = \Pr\left(\text{CRA}i \text{ is accurate}|\, S^G\right) = \\ &= \quad \Pr\left(\text{CRA}i \text{ is accurate}|\ \ F^B\right) = \frac{2\lambda_i}{\lambda_i + 1} > \lambda_i, \end{aligned}$$

$$\Pr\left(\text{CRA}i \text{ is accurate}|\, F^G\right) = \Pr\left(\text{CRA}i \text{ is accurate}|\, S^B\right) = 0$$

and

$$\Pr\left(\text{CRA}i \text{ is accurate}|\, N\right) = \lambda_i.$$

where the last equality follows from the fact that if the project is not implemented, nothing can be learned about the entrant's accuracy. When $\lambda_i = \lambda_E$, let $\lambda_E^+ \equiv \frac{2\lambda_E}{\lambda_E + 1}$. We assume:

A2: $\lambda_E^+ > \lambda_I$

A2 says that if an entrant is given a chance to rate an issuer and if its truthful revelation of signal turns out to be correct, then this boosts its reputation such that it becomes superior to that of the original incumbent. Since $\lambda_E^+ > \lambda_E$, A2 is equivalent to $\lambda_E > \lambda_I/(2-\lambda_I)$ and A1 and A2 are satisfied if and only if $max\,\{\lambda_{\min}, \lambda_I/(2-\lambda_I)\} < \lambda_E \leq \lambda_I$.

2.3 CRAs' survival dynamics

We design the survival dynamics of active CRAs to gather the idea that no CRAs can stay in the business for too long without generating positive profits. In our model, the length of one period shall be interpreted as the time elapsed between the issuance of the rating and the observation of the outcome of a project, i.e. the maturity of an issuer's debt. Formally,

A3(i) An active CRA that does not generate a positive profit over two consecutive periods exits the market by the end of the second of the two periods. When this happens, the exit is definitive and the surviving CRA, if any, becomes the next period incumbent CRA. An exiting CRA is replaced by a new active entrant from the pool of potential entrants.

Assumption A3(i) means that a CRA is liquidated when it is not able to generate any positive profit over two consecutive periods. In order to capture the idea that in the real world, a CRA has to sustain some fixed annual cost to be present in the market we make this additional simplifying assumption:

A3(ii): If a CRA active in period t expects to generate no profit in the future or has generated no positive profit in period t and anticipates no positive profit from staying in the market in period $t+1$, it will exit the market at the end of period t.

Given that the length of one period should be interpreted as the US corporate bond average maturity of 10 years [5], the survival rule implied by Assumptions A3(i) (respectively, A3(ii)) is intentionally lenient toward entrant CRAs, as it implies that a CRA can stay in business two decades (respectively, one decade) without generating any positive profit. Note also that a CRA that realizes a reputation $\lambda_t = 0$ cannot improve it and hence cannot hope to compete with other CRA in the future. Hence according to Assumption A3(ii), it will exit the market at the end of t. Finally, we introduce a tie-breaking rule that will be applied only to an off-the equilibrium event.

[5] Between 1996 and 2009, the U.S. corporate bond average maturity was of 9.6 years (Source: Thomson Reuters).

A3(iii): If period-t issuer is indifferent between hiring the entrant or the incumbent it will opt for the latter.

In each period an active entrant CRA is randomly chosen from the pool of infinitely many potential entrant CRAs. Period-t active entrant and period t incumbent approach period t issuer and compete to be hired by the issuer. Thus while in period 1, the original incumbent I competes with period 1 entrant, in a generic period t, the period t incumbent is either the original incumbent I or a past entrant (in the case the original incumbent I has already been forced out of business) and will compete with period t entrant.

2.4 Contracts

We assume that each period, each CRA simultaneously offers a short-term contract, which is a fixed fee f_{it} that an issuer must pay regardless of the rating that the CRA gives. This case of a fixed fee corresponds to the fee scheme under the Cuomo plan. Our results are robust if we allow a CRA to charge a positive fee contingent on the good rating in addition to the fixed fee, which corresponds to the situation before the Cuomo plan. Given that investors are risk-neutral and competitive and that each CRA's reputation is higher than $\lambda_{\min}$, an issuer can get financing to pay for the fee to a CRA.

2.5 One period benchmark

Consider as a benchmark a single period competition between two CRAs. Then, it is optimal for each CRA to offer a contract based only on a fixed fee since this gives it the incentive to truthfully reveal its signal. If the two CRAs charge the same fee, then the issuer will prefer to be rated by the CRA with the higher reputation, as this maximizes the expected profit from implementing a project with good rating. Consider $\lambda_{it} \geq \lambda_{jt}$. Then, in equilibrium, CRA j charges the fee $f_{jt} = c$. CRA i charges the fee such that the issuer is indifferent between the two CRAs.

Lemma 1 *In a single period model, if $\lambda_{it} \geq \lambda_{jt}$, then,*

$$f_{it} = (\lambda_{it} - \lambda_{jt}) \frac{X}{4} + c, \;\; f_{jt} = c.$$

CRA i rates the project and realizes a profit of $(\lambda_{it} - \lambda_{jt}) \frac{X}{4}$.

3 Public information

In this section we consider the benchmark in which the signal of each CRA is public information. Since each CRA's reputation is above $\lambda_{\min}$ and signals are publicly observable, only a project that receives a good rating will be implemented. This implies that only events S^G, F^G and N can happen.

3.1 Social welfare

We first study as a benchmark the case in which a social planner can decide which CRAs to hire to maximize social welfare. In period one, there are two possibilities: either it is socially optimal to hire an entrant CRA or the original incumbent. Suppose first that it is socially optimal to hire an entrant CRA in $t = 1$. Then, in the event of N, and a fortiori in the event of S^G, it is optimal to continue to hire the same CRA in $t = 2$. In the event of F^G, it is optimal to hire a new entrant (different from the entrant who realized the F^G event). Thus, when it is optimal to hire an entrant CRA in $t = 1$, the optimal experimentation policy consists in (i) continuing to have projects rated by the entrant CRA of $t = 1$ as long as he does not realize an F^G event (ii) if the CRA realizes an F^G event, replacing him with a new entrant with fresh reputation λ_E who should rate projects until an event F^G happens. Under this optimal experimentation, eventually an entrant of accurate type will be recruited and will rate all following projects. The alternative to this experimentation policy is never to experiment and have all projects rated by the original incumbent. In fact, if it is socially optimal to hire the original incumbent at $t = 1$, it would be also optimal to do so for any $t > 1$. In the following we compare the social welfare of the following two policies: "to hire always the original incumbent" and "to optimally experiment with entrants without hiring the original incumbent".

Let W_I denote the expected per-period social welfare (gross of a CRA's cost of obtaining a signal) from having the original incumbent I with known accuracy λ_I rate the infinite sequence of projects. From A1 we know that only projects that receive a good rating will be implemented. The ex ante probability that in any given period t the CRA I's signal is G is 1/2. The probability that a project is good given CRA I received a good signal is $\mu_G(\lambda_I) = \frac{1+\lambda_I}{2}$. Hence,

$$W_I = \frac{1}{2}\left(\frac{1+\lambda_I}{2}X - 1\right)$$

Let W_E denote the average per-period social welfare (gross of a CRA's cost of obtaining a signal) obtained by optimally experimenting with entrants. When the reputation of the currently active CRA is $\lambda \geq \lambda_E$, we have that in any given period t, $\Pr(\omega_t = S^G) = \frac{1+\lambda}{4}$,

$\Pr(\omega_t = N) = 1/2$ and $\Pr(\omega_t = F^G) = \frac{1-\lambda}{4}$. In this instance the average social welfare should satisfy the following recursive equation:

$$W_E(\lambda) = (1-\delta)\frac{1}{2}\left(\frac{1+\lambda}{2}X - 1\right) + \delta\left(\frac{1+\lambda}{4}W_E(\lambda^+) + \frac{1}{2}W_E(\lambda) + \frac{1-\lambda}{4}W(\lambda_E)\right)$$

Solving this functional equation in $W_E(.)$, we obtain

$$W_E(\lambda) = \frac{1}{2}\left(\frac{2(1-\delta)(1+\lambda)+\delta\lambda_E}{4(1-\delta)+\delta\lambda_E}X - 1\right).$$

As expected, $W_E(\cdot)$ strictly increases with λ. Note that because of A1, W_I and $W_E(\lambda_E)$ are always greater than the social welfare obtained in the absence of CRAs.

Experimenting with entrants is socially preferred to consistently hiring the original incumbent if $W_E(\lambda_E) > W_I$. We have:

Proposition 1 *Experimenting with the entrants is socially optimal if and only if*

$$\lambda_I < \lambda_E + \frac{\delta\lambda_E(1-\lambda_E)}{4(1-\delta)+\delta\lambda_E} := \lambda_I^*(\lambda_E) \tag{1}$$

Note that as δ goes to 1, condition (1) becomes $\lambda_I < 1$ for $\lambda_E > 0$ implying that if agents are patient enough it is always socially optimal to experiment with entrants even if each entrant has an arbitrarily small probability of being accurate. This is not surprising since experimenting with entrants allows to identify an entrant with perfect accuracy in a number of periods that is finite in expectation. The social welfare generated by a CRA with perfect accuracy is larger than the social welfare from the initial incumbent. Thus when the social planner is patient enough, experimenting is socially optimal.

3.2 Competition

We consider now the dynamic competitive interactions among CRAs. At the beginning of each period t, two CRAs compete in price to rate period t issuer. Charging a fixed fee $f_{i,t}$ is equivalent to making a bid of $b_{i,t} = -f_{i,t}$ to the issuer t. If $b_{i,t}$ and $b_{j,t}$ are the CRAs' bids, then the issuer profit maximization leads to select the CRA that solves[6]

$$\arg\max_{h\in\{i,j\}} b_{h,t} + \frac{1}{2}\left(\mu_G(\lambda_{h,t})X - 1\right)$$

Then the winning CRA invests c and discloses its signal. Let λ_i, λ_j, with $\lambda_i \geq \lambda_j$, be the reputation of the two CRAs at the beginning of period t. Then, CRA j, i.e., the CRA with the lowest reputation, cannot generate a positive profit in t.

[6] According to A3(iii) in case of perfect indifference the issuer will hire the period t incumbent CRA.

Lemma 2 *If at period t the CRA i's reputation is not strictly larger than its competitor's reputation, then CRA i's profit of period t cannot be strictly positive.*

The issuer's project is implemented if and only if the CRA's signal is G. At the end of period t, event S^G, F^G or N realizes and the CRA's reputation is updated accordingly.

In what follows, in order to describe the competition among rating agencies we distinguish three phases:

1) Phase with no incumbent: The CRAs active at period t are two new entrants since no CRA survived from the previous period.

2) Phase with a varying reputation incumbent: The CRAs active at period t are a new entrant and an incumbent with unknown accuracy and reputation $\lambda_{I,t} \geq \lambda_E^+$.

3) Phase with the original incumbent: The CRAs active at period t are a new entrant with reputation λ_E and the original incumbent with known and fixed reputation λ_I.

3.2.1 Phase with no incumbent

When the only active CRAs are two entrants with identical reputation λ_E, both CRAs will compete to attract the issuer. Since the two CRAs are identical, their expected equilibrium payoff will be 0 by Bertrand competition. The issuer will randomly select one of the CRAs. If the selected CRA's signal is good and the project is successful, then in $t+1$ its reputation will move to λ_E^+, which starts the phase with a varying reputation incumbent. Otherwise, both the selected CRA and the other CRA exit the market at the end of t according to A3(ii) and the phase with no incumbent continues.

3.2.2 Phase with a varying reputation incumbent

This phase with a varying reputation incumbent starts after the original incumbent has been replaced by an entrant who realized an S^G event. In this phase, we have:

Lemma 3 *Suppose that CRAs' signals are publicly observable. If at period t the incumbent's true accuracy is unknown and its reputation is $\lambda_{I,t} \geq \lambda_E^+$, then:*

(i) The equilibrium payoff of period t entrant is 0.

(ii) The equilibrium payoff of the incumbent is

$$\widehat{V}(\lambda_{I,t}) = \frac{X}{4-3\delta}\left(\frac{4-3\delta-\delta\lambda_E}{4}\lambda_{I,t} - (1-\delta)\lambda_E\right).$$

(iii) If, in period t, the incumbent's signal is good but the project reveals to be bad (event F^G), the incumbent leaves the market at the end of period t and the phase with no incumbent

starts at $t+1$. Otherwise, $\lambda_{I,t+1} \geq \lambda_{I,t}$ and the phase of a varying reputation incumbent continues in $t+1$. This dynamics eventually leads to the selection of an accurate CRA that survives all periods' competition.

As is expected, in the phase with a varying reputation incumbent, the incumbent wins the competition against an entrant and stays in the market unless event F^G is observed. Even if the entrant of period t wins the competition (with a negative profit), rates the issuer t and realizes an event of S^G, its reputation cannot be higher than that of the incumbent and hence, according to A3(ii), it will exit the market at the end of period t. This implies that the entrant cannot pledge any future profit to win the competition and hence will charge a fee of c. The incumbent can match the entrant's offer with a fee of $c + \frac{1}{2}\left[\mu_G(\lambda_{I,t}) - \frac{1}{2}\mu_G(\lambda_E)\right] X - 1$ and win the competition, realizing a profit of $(\lambda_{I,t} - \lambda_E) X/4$. its reputation will move to $\lambda_{I,t}^{+}$ $\lambda_{I,t}$ and 0 in event S^G, N and F^G respectively. Considering that the ex ante probability of these events are $\Pr(S^G) = \frac{\lambda_{I,t}+1}{4}$, $\Pr(N) = 1/2$ and $\Pr(F^G) = \frac{1-\lambda_{I,t}}{4}$, the incumbent equilibrium payoff $\widehat{V}(\lambda_{I,t})$ must satisfy the following functional equation

$$\widehat{V}(\lambda_{I,t}) = (1-\delta)(\lambda_{I,t} - \lambda_E)\frac{X}{4} + \delta\left(\frac{\lambda_{I,t}+1}{4}\widehat{V}(\lambda_{I,t}^{+}) + \frac{1}{2}\widehat{V}(\lambda_{I,t})\right)$$

whose solution is given in the Lemma 3(ii).

3.2.3 Phase with the original incumbent

This situation occurs at $t=1$ and continues as long as the original incumbent manages to stay in the market. Define $\lambda_I^{**}(\lambda_E)(> \lambda_E)$ as the λ_I solving the following equation

$$(1-\delta)(\lambda_I - \lambda_E)\frac{X}{4} = \delta\frac{\lambda_E+1}{4}\widehat{V}(\lambda_E^{+}).$$

We have the following proposition.

Proposition 2 *If CRAs' signals are publicly observable, then*

(i) If $\lambda_I \geq \lambda_I^{**}(\lambda_E)$, no experimentation of any entrant is possible: the competition will lead the original incumbent to rate all projects and its equilibrium payoff is

$$V_I = (1-\delta)(\lambda_I - \lambda_E)\frac{X}{4} - \delta\frac{\lambda_E+1}{4}\widehat{V}(\lambda_E^{+})$$

whereas the equilibrium payoff of period t entrant is equal to 0.

(ii) If $\lambda_I < \lambda_I^{**}(\lambda_E)$, then the experimentation of the entrant occurs during the first period: the first entrant is hired and the original incumbent exits the market at the end of period 1*. The entrant's expected payoff is*

$$V_E = -(1-\delta)(\lambda_I - \lambda_E)\frac{X}{4} + \delta\frac{\lambda_E + 1}{4}\widehat{V}(\lambda_E^+).$$

The game eventually reaches a steady state where the incumbent has the accurate type.

The proposition says that there is a cut-off level of reputation $\lambda_I^{**}(\lambda_E)(> \lambda_E)$ such that if the original incumbent's reputation is higher than this threshold, it always wins the competition and hence rates all the projects; otherwise, the entrant wins the competition in period one, which induces the exit of the original incumbent at the end of period one. Since one realization of the event S^G is enough to allow an entrant to kick off the original incumbent, the entrant pledges the future profit it can realize from increasing its reputation, which the original incumbent should match in order to win the competition. It is interesting to note that an entrant makes a different offer to an issuer depending on whether it faces as competitor the original incumbent or an incumbent with varying reputation: the entrant pledges its future profit when it faces the original incumbent while it does not when it faces an incumbent with varying reputation. In other words, an entrant is more aggressive with respect to the original incumbent than with respect to an incumbent with varying reputation.

3.3 Comparison: social optimum vs. market outcome

We now compare the social optimum and the market outcome in order to see whether the market leads to too much or too little experimentation. For this purpose, we compare $\lambda_I^*(\lambda_E)$ with $\lambda_I^{**}(\lambda_E)$ and find:

$$\lambda_I^{**}(\lambda_E) > \lambda_I^*(\lambda_E) \text{ for } \delta > 0.$$

Proposition 3 *If CRA's signals are publicly observable, then the market leads to either a socially optimal experimentation of entrants or a socially excessive experimentation.*

In other words, if it is socially optimal to experiment with entrants, the market outcome always leads to the experimentation. However, the market may lead to the experimentation even when this is not socially desirable. This socially excessive experimentation results from the fact that an identical entrant is more aggressive with respect to the original incumbent than with respect to an incumbent with varying reputation. This fact implies that the competition from a sequence of identical entrants reduces more the continuation payoff of the original incumbent than that of a varying reputation incumbent. This creates a bias against the original incumbent.

4 Private Information

In this section, we consider the case in which the signal that a CRA receives is its private information. This creates an incentive problem on the part of an entrant CRA: in order to maximize the chances of increasing its reputation an entrant CRA may have an incentive to give a rating different from its private signal. This incentive problem affects the competition between the original incumbent and an entrant.

Formally, consider competition between the original incumbent and an entrant CRA i in period t. Suppose that the entrant wins the competition to rate issuer t. Note that this implies that the entrant did not realize a positive profit in period t since if it charges a fee superior or equal to c, the original incumbent can win the competition. Therefore, the entrant does not generate any profit in period t regardless of whether it wins or not the competition. If in addition, the entrant expects that it cannot realize a positive profit in period $t+1$, then he exits the market at the end of period t, from A3(ii). We first study the subgame that starts after the entrant wins the competition in which the entrant has to decide how to rate the issuer. And then, we study the competition.

4.1 Entrant's rating policy

Consider the subgame that starts after the period t entrant wins the competition against the original incumbent, and receives a private signal s_t. The purpose here is to study the rating policy that the entrant uses to rate issuer t. This subgame is a game of incomplete information where $s_t \in \{G, B\}$ can be considered the entrant's type. Let $D : \{G, B\} \to [0, 1]$ be the entrant's disclosure policy at period t: The function D maps the entrant's signal s_t into the probability of giving a good rating:

$$D(s) = \Pr(r = G|\, s_t = s)$$

For example, when the entrant truthfully reports its signal $D(G) = 1 = 1 - D(B)$, whereas $D(G) = D(B)$ indicates that the entrant's rating is babbling and not correlated with its signal.

For a given rating $r \in \{G, B\}$ assigned by the entrant using the disclosure policy D, let

$$\mu_r^D := \Pr\left(\widetilde{X}_t = X \middle| r\right).$$

For example when the entrant truthfully reports its signal $\mu_G^D = \mu_G(\lambda_E)$ and $\mu_B^D = \mu_B(\lambda_E)$ hold, whereas in the babbling disclosure policy, $\mu_G^D = \mu_B^D = \mu$ holds. Without loss of generality, we shall focus on disclosure policies satisfying $D(G) \geq D(B)$, that implies that a bad rating is no better news than a good rating. Formally,

$$\mu_B(\lambda_E) \leq \mu_B^D \leq \mu \leq \mu_G^D \leq \mu_G(\lambda_E).$$

Note that in the absence of rating, we have either $X\mu < 1$ or $X\mu \geq 1$. Then, we can have $X\mu_G^D \geq X\mu_B^D \geq 1$, $X\mu_G^D \geq 1 > X\mu_B^D$ or $1 > X\mu_G^D \geq X\mu_B^D$. If $X\mu < 1$, only the second and the third can arise whereas if $X\mu \geq 1$, only the first and the third can happen. In the first case, all ratings of the entrant will induce project implementation. In the second case, only a good rating from the entrant induces project implementation. In the last case no rating from the entrant can induce the financing of the project. Hence five events are relevant:

- $\omega_t = \widehat{S}^G$ meaning that the project was financed with a CRA i good rating and it succeeded;
- $\omega_t = \widehat{F}^G$ meaning that the project was financed with a CRA i good rating and it failed,
- $\omega_t = \widehat{S}^B$ meaning that the project was financed with a CRA i bad rating and it succeeded;
- $\omega_t = \widehat{F}^B$ meaning that the project was financed with a CAR i bad rating and it failed;
- $\omega_t = N$ meaning that the project was not financed.

Since CRAs' signals are private, the market updates its belief about the entrant's accuracy by comparing the outcome of the project with the rating given by the entrant. For a given event ω_t and a disclosure policy D, we shall denote

$$\lambda_{\omega_t}^D : \Pr\left(\text{Entrant is accurate} | \, \omega_t\right)$$

Note that $D(G) \geq D(B)$ implies that

$$\begin{aligned} \lambda_{\widehat{F}^G}^D &\leq \lambda_E \leq \lambda_{\widehat{S}^G}^D \\ \lambda_{\widehat{S}^B}^D &\leq \lambda_E \leq \lambda_{\widehat{F}^B}^D \end{aligned}$$

In other words, the entrant reputation cannot suffer (gain) from issuing a rating that is confirmed (contradicted) by the actual quality of the project.

Let $V^D(\lambda, s)$ denote its continuation payoff from having a reputation of λ at the beginning of period $t+1$ when it received signal $s \in \{G, B\}$ in period t. The probability λ represents the market's belief about its accuracy while s is the entrant's private information. We can decompose $V^D(\lambda, s)$ into two parts

$$V^D(\lambda, s) = (1-\delta)\pi^D_{t+1}(\lambda, s) + \delta V_2^D(\lambda, s),$$

where $\pi^D_{t+1}(\lambda, s)$ is the entrant's expected profit in $t+1$ given $(\lambda_{t+1}, s_t) = (\lambda, s)$ and $V_2^D(\lambda, s)$ is the expected continuation payoff starting from $t+2$ given $(\lambda_{t+1}, s_t) = (\lambda, s)$. Note that the functions $V^D(\lambda, s)$, $\pi^D_{t+1}(\lambda, s)$ and $V_2^D(\lambda, s)$ must satisfy the following properties:

i) $V^D(\lambda, s) \geq 0$ and $V_2^D(\lambda, s) \geq 0$
ii) $\pi^D_{t+1}(\lambda, s) = V_2^D(\lambda, s) = 0$ for $\lambda \leq \lambda_I$.
iii) $V^D(\lambda, s)$ is a non-decreasing function of λ.
iv) $V^D(\lambda^D_{\widehat{S}^G}, G) \geq V^D(\lambda^D_{\widehat{S}^G}, B)$ and $V^D(\lambda^D_{\widehat{F}^B}, B) \geq V^D(\lambda^D_{\widehat{F}^B}, G)$.

Property i) holds because the entrant can always exit the market at no cost. Property ii) holds because in period $t+1$ if the entrant with $\lambda_{t+1} \leq \lambda_I$ charges a fee $f_E > c$, the original incumbent can defeat it by charging a fee $f_I = f_E + (\lambda_I - \lambda_{t+1})\frac{X}{4}$ and in this case, from A3(ii), the entrant must exit the market by the end of $t+1$. Property iii) holds because a high reputation CRA can always reduce the informativeness of its rating to mimic the behavior of a low reputation CRA. To interpret Property iv), let $\lambda^D_{\omega_t}$ be the entrant public reputation after the event ω_t has been observed. Note that entrant belief of being accurate after observing an outcome of the project that confirms (contradicts) its signal is higher (lower) than $\lambda^D_{\omega_t}$. Property iv) holds because keeping fixed its public reputation, the entrant who expected its accuracy is high can always reduce the informativeness of its rating to mimic the behavior of an entrant who think its accuracy low. These four properties imply that, after winning the competition with the original incumbent to rate issuer t, the period t entrant's equilibrium continuation payoff is zero. Formally,

Lemma 4 *Consider the subgame that starts after the period t entrant wins the competition to rate issuer t and receives a private signal s_t. In all equilibria, it results $\pi^D_{t+1}(\lambda^D_\omega, s_t) = 0$ (equivalently, $V^D(\lambda^D_\omega, s_t) = 0$) for all $s_t \in \{G, B\}$ and all $\omega \in \left\{\widehat{S}^G, \widehat{F}^G, \widehat{S}^B, \widehat{F}^B, N\right\}$ occurring with positive probability.*

The lemma shows that an entrant CRA faces a fundamental conflict between informative rating and reputational concern. After period t entrant rated a project, if its reputation does not increase, then the CRA has to exit the business at the end of period t. Hence the CRA has an incentive to issue the rating that maximizes its expected reputation conditional on its private signals, and for this it needs the project to be implemented, which is incompatible with truthful rating. More generally, the CRA will never issue a rating preventing the implementation of the project if it can issue another rating that induces investors to finance the project. This is because in the absence of the project implementation, the CRA's reputation does not change, while if a project is implemented with a good rating there is some positive probability that the project is successful even if the CRA's signal is bad. As a consequence, in equilibrium, an entrant's rating cannot affect the investors' decision to finance or not the project. If the project is never implemented, the CRA will never improve its reputation. If the project is always implemented, then disclosure strategy must be such that the negative information contained in a bad rating is not strong enough to deter investment in the project. This is equivalent to saying that some times a bad rating is also given when the CRA's signal is good. This is possible only if the CRA is indifferent between giving a good or a bad rating upon receiving a good signal. Such disclosure policy also implies that different ratings have different information content and, in expectation, will affect differently the expected gain in reputation and hence the CRA's continuation payoff. However, such difference in continuation payoff is incompatible with the indifference in rating.

4.2 Competition between the original incumbent and an entrant

We now study the competition between the original incumbent and an entrant in period t. From Lemma 4, it follows that period t entrant facing the original incumbent cannot pledge future profits to attract period-t issuer hence in period t the maximum fee it can charge is c and hence the original incumbent will always be hired by the issuer. Therefore, we have:

Proposition 4 *Under assumption A1, A2, A3(i)-(iii), when the signal is private information and the entrants charge fixed fees there is never experimentation of any entrant and the original incumbent dominates the market forever.*

Surprisingly, even an entrant with the initial reputation λ_E equal to λ_I cannot win the competition against the original incumbent. On the one hand, the entrant has no profit to pledge (from Lemma 4). On the other hand, it cannot commit to truthful reporting of the signal: a truthful reporting of the signal implies that it can improve its reputation to λ_E^+

and obtain a continuation payoff of $\widehat{V}(\lambda_E^+) > 0$,[7] which contradicts Lemma 4.

5 Complete Contracts

Suppose that the signal is private information but each CRA can use complete contracts, i.e. rating fees can be contingent on the rating note: one for good rating (f_G), another for bad rating (f_B). We show that in this case, any CRA can commit to the truthful reporting of its signal and furthermore it is profitable to do so. Suppose the period t entrant proposes an incentive compatible fee scheme inducing truthful report of its signal. Then, if period-t issuer chooses the entrant, given the credibility of the entrant rating, the project will be financed only if it has a good rating. Moreover, if the outcome of the project is $\widetilde{X}_t = X$ then the entrant reputation jumps to $\lambda_E^+ > \lambda_I$ and the original incumbent will have to exit the market.[8] In the next section we study what will be the entrant equilibrium payoff after becoming the incumbent by forcing the original incumbent out of business.

5.1 Post reputation-building game

In this subsection we show that even if the signal is private information and the rating fees are flat, in the phase with a varying reputation incumbent, the incumbent always has an incentive to truthfully reveal its signal if its reputation is $\lambda_{I,t} \geq \lambda_E^+$. From Lemma 3, in this phase, if an incumbent with reputation $\lambda_{I,t}$ keeps truth-telling, its continuation payoff is given by $\widehat{V}(\lambda_{I,t})$. Remember that when we computed the above value, we assumed that any new entrant makes the competitive offer of $f_E = c$ and its signal becomes public information if it is chosen to rate the entrant. When the signal is private information and the incumbent's reputation is equal to or larger than λ_E^+, an entrant has no chance to replace the incumbent by building its reputation: an $\widehat{S}^G$ event allows him to have at best λ_E^+ and then the tie is broken in favor of the incumbent. Therefore the entrant cares only about today's payoff (i.e. has no reputational concern) and for this reason has an incentive to truthfully report the signal. Therefore, any new entrant makes the competitive offer of $f_E = c$ and truthfully reports its signal if chosen to rate the project.

We now show that any incumbent with $\lambda_{I,t} \geq \lambda_E^+$ has an incentive to truthfully report its signal. First, regardless of the signal, in the truth-telling equilibrium, a bad rating makes the project not financed and then its reputation remains unchanged and hence its

[7] See Lemma 5 for the analysis of why it obtains $\widehat{V}(\lambda_E^+) > 0$.

[8] This is because the original incumbent generated no revenue in t and it cannot generate any positive profit in $t+1$ by competing with a CRA that has a stronger reputation.

continuation payoff is $\widehat{V}(\lambda_{I,t})$. Suppose that he received a good signal and truthfully reports it. Then, its continuation payoff is $\frac{1+\lambda_{I,t}}{2}\widehat{V}(\lambda_{I,t}^{+})$. Suppose that he received a bad signal but reports a good rating. Then, its continuation payoff is $\frac{1-\lambda_{I,t}}{2}\widehat{V}(\lambda_{I,t}^{+})$. Finally, the condition for a truth-telling equilibrium is

$$\frac{1+\lambda_{I,t}}{2}\widehat{V}(\lambda_{I,t}^{+}) \geq \widehat{V}(\lambda_{I,t}) \geq \frac{1-\lambda_{I,t}}{2}\widehat{V}(\lambda_{I,t}^{+})$$

These inequalities are satisfied for any $\delta \in [0,1]$ and for any $\lambda_{I,t} \geq \lambda_E^{+}$.

Summarizing, we have:

Lemma 5 *Consider competition between an entrant in period t and a varying reputation incumbent with reputation $\lambda_{I,t} \geq \lambda_E^{+}$.*

(i) Even in the presence of fixed fees both the incumbent and the entrant have an incentive to truthfully reveal their private signal.

(ii) The issuer selects the incumbent whose continuation payoff as function of its reputation $\lambda_{I,t}$ is

$$\widehat{V}(\lambda_{I,t}) = \frac{X}{4-3\delta}\left(\frac{4-3\delta-\delta\lambda_E}{4}\lambda_{I,t} - (1-\delta)\lambda_E\right) > 0$$

for $\lambda_{I,t} \geq \lambda_E$

5.2 Incentive compatible contracts

Consider now the competition between period t entrant and the original incumbent. If investors believe the entrant uses a truthful disclosure strategy, then they will (not) finance projects that received a good (bad) rating. Thus in case the entrant issues a bad rating, its reputation will not change and it will exit the market at the end of period t. If it issues a good rating and the project is successful, then the entrant's reputation jumps to λ_E^{+} and its continuation payoff will be $\widehat{V}(\lambda_E^{+})$ from Lemma 5. Hence in order to commit to a truthful reporting the entrant fee scheme must satisfy the following incentive compatibility constraints.

$$f_G + \frac{\delta}{1-\delta}\mu_B(\lambda_E)\widehat{V}(\lambda_E^{+}) \leq f_B \leq f_G + \frac{\delta}{(1-\delta)}\mu_G(\lambda_E)\widehat{V}(\lambda_E^{+})$$

The first (second) inequality guarantees that the entrant prefer to give a bad (good) rating after receiving a bad (good) signal. Moreover f_G and f_B must be such that the entrant's ex-ante payoff is not negative:

$$(1-\delta)\left(\frac{1}{2}(f_G+f_B) - c\right) + \delta\frac{1}{2}\mu_G(\lambda_E)\widehat{V}(\lambda_E^{+}) \geq 0$$

Proposition 5 *Under assumption A1, A2, A3(i)-(iii), when the signal is private information and CRAs can condition their fees to the rating,*

(i) If $\lambda_I \geq \lambda_I^{**}(\lambda_E)$, no experimentation of any entrant is possible: the competition will lead the original incumbent to rate all projects and its equilibrium payoff is V_I whereas the equilibrium payoff of period t entrant is equal to 0.

(ii) If $\lambda_I < \lambda_I^{**}(\lambda_E)$, then the experimentation of the entrant occurs during the first period: the first entrant is hired and the original incumbent exits the market at the end of period 1. The entrant's expected payoff is V_E. The period 1 entrant fees are such that $f_G < f_B$. The game eventually reaches a steady state where the incumbent has the accurate type.

It is interesting to note that in order to allow some endogenous experimentation with entrant CRAs, rating fees should not be fixed as suggested in the Cuomo plan. On the other hand the current practice of charging higher fees when the rating is positive is opposite to what could open the CRAs market to the competition of entrants. Only by charging fees that are higher for bad rating compared to the fee charged for good rating, the entrant can credibly commit to disclose its private signal and build the reputation necessary to enter the business. Note also that an entrant CRA might have to pay the issuers.

6 Policy implications

In our model, we already considered the Cuomo plan (i.e. the fees do not depend on ratings) and assumed away rating shopping (a rating becomes always public). This is normally the solution to resolve the conflict of interest that CRAs face (Bolton et al. (2009) and Mathis et al. (2009)). This also solves rating inflation generated by asset complexity and rating shopping (Skreta and Veldkamp, (2009)). Therefore, it is surprising that even if we consider a scenario minimizing conflict of interests in the credit rating industries, we find that there is a natural barrier to entry such that can leave a rather inaccurate incumbent in a monopolistic position without being worried about the entry of potentially more competent entrants.

Quite to the opposite of the Cuomo plan, the remedy that can open the credit rating market to competition consists in giving more freedom to entrant CRAs as to the way they determine their rating fees. First, an entrant CRA must be allowed to charge negative fees. In fact, in the presence of a known reputation incumbent, an entrant CRA with lower reputation can attract an issuer only by compensating it for the weaker signal that the entrant's rating gives to investors. To compensate issuer entrant's fees might be negative until it manages to build a reputation that is stronger than the one of its competitors. Allowing negative non-contnigent fees however is not sufficient to open the market when the entrant signal is private information. In fact, when rating fees are non-contingent on the note, the entrant faces a conflict of interest due to the fact that it cannot build up reputation when a project is not implemented. In to truthfully deliver its signal, when the signal is negative, the entrant CRA should be compensated for the cost due to the fact that it cannot build reputation when the project is not implemented. Hence the entrant rating fees should be allowed to be larger when it provides a bad rating compared to the entrant's fee for a good rating. This is the exact opposite practice of the current market. Nevertheless, Propositions 3 and 5 suggest that allowing complete pricing freedom to entrant CRAs does not necessarily lead to the social optimum as in some situations an entrant CRA could undermine the original incumbent even when the entrant ex-ante reputation is too small to justify experimentation from a social welfare perspective. The remedy can be obtained by imposing a lower bound to the entrant average fee.

Proposition 6 *Under assumption A1, A2, A3(i)-(iii), when the signal is private information and CRAs can condition their fees to the rating, socially optimal experimentation is attained by the market if entrants expected fees are not allowed to below the following lower bound:*

$$\frac{1}{2}(f_G + f_B) \geq (\lambda_E - \lambda_I^*(\lambda_E))\,\frac{X}{4} + c < 0 \tag{2}$$

Furthermore, previous studies (Bolton et al. (2009), Mathis et al. (2009), Skreta and Veldkamp, (2009)) find that changing from the issuer-pays pricing to the investor-pays pricing can solve both the conflict of interest and the rating inflation although the investor-pays pricing can create its own problem of free-riding among investors. On the contrary, in our model, the switch to the investor-pays pricing does not remove the natural barrier to entry since an entrant CRA still suffers from the reputational conflict of interest: as long as we assume Bertrand competition between CRAs, the proof of Lemma 4 applies to the investor-pays pricing and hence Proposition 4 applies as well.

The policy remedy we find is contingent fees such that an entrant CRA can receive a higher fee when giving a bad rating than when giving a good rating. Of course, this creates a strong incentive for rating shopping and obviously rating shopping must be prohibited for the contingent fees to work.

Remedies	Bolton-Freixas-Shapiro (2009) Mathis-McAndrews-Rochet (2009) Skreta-Veldkamp (2009)	Our paper
Cuomo plans and no rating shopping	Can solve conflict of interest and remove rating inflation	Cannot remove barrier to entry
Investor-Pays pricing	Can solve conflict of interest and remove rating inflation	Cannot remove barrier to entry

7 Multiple Issuers

Let consdier now the case where there are two issuers per period. In case a CRA with variable reputation λ rates both issuers in one period if the entrant signals are observable then there are nine possible observable outcomes. The following table provides the probability of each of these events as welle as the CRA following the observation of each event:

ω	$S^G S^G$	NS^G	$S^G N$	NN	NF^G	$F^G N$	$S^G F^G$	$F^G S^G$	$F^G F^G$
$\Pr(\omega)$	$\frac{1+3\lambda}{16}$	$\frac{1+\lambda}{8}$	$\frac{1+\lambda}{8}$	$\frac{1}{4}$	$\frac{1-\lambda}{8}$	$\frac{1-\lambda}{8}$	$\frac{1-\lambda}{16}$	$\frac{1-\lambda}{16}$	$\frac{1-\lambda}{16}$
$\Pr(acc.\vert\,\omega)$	λ^{++}	λ^{+}	λ^{+}	λ	0	0	0	0	0

where $\lambda^{++} := \frac{4\lambda}{1+3\lambda} > \lambda^{+} := \frac{2\lambda}{1+\lambda}$.

7.1 Social welfare

The social welfare from having the original incumbent both issuers in every period is

$$W_{2I} = \left(\frac{1+\lambda_I}{2}X - 1\right)$$

When CRAs signal are observable the optimal way of experimenting with an enrant is to keep hiring the same entrant for both issuers untill one project who received a good rating fails. In this instance a new entrant shall be hired. This leads to the following functional equation

$$W_{2E}(\lambda) = (1-\delta)\left(\tfrac{1+\lambda}{2}X - 1\right) + \delta\left(\tfrac{1+3\lambda}{16}W_{2E}(\lambda^{++}) + \tfrac{1+\lambda}{4}W_{2E}(\lambda^{+}) + \tfrac{1}{4}W_{2E}(\lambda) + \tfrac{7(1-\lambda)}{16}W_{2E}(\lambda_E)\right)$$

whose solution is

$$W_{2E}(\lambda) = \left(\frac{8(1-\delta)(1+\lambda) + 7\delta\lambda_E}{16(1-\delta) + 7\delta\lambda_E}X - 1\right).$$

It is optimal to experiment with the entrant when $W_{2E}(\lambda_E) > W_{2I}$, that is to say when

$$\lambda_I < \lambda_E + \frac{7\delta\lambda_E(1+\lambda_E)}{16(1-\delta) + 7\delta\lambda_E} := \lambda^*_{2I}(\lambda_E) > \lambda^*_I(\lambda_E)$$

The last inequality implies that when there are two issuers per period experimenting with the entrant is socially optimal more often.

7.2 Competition

Similarly to the case whith one issuer per period, in case of competition there are three possible regimes. The phase with no incumbent where two entrants compete and realize zero profit, the phase witha varying reputation incumbent, and the phase with the original incumbent.

In the phase with the varying reputation incumbent, the i,cumbent reputation, $\lambda_{I,t}$, is at least λ_E^+ hence entrants cannot threaten the incumbent dominant position until an event F^G is observed on one of the projects. Hence the functional equation providing the entant equilibrium payoff in this phase is

$$\widehat{V}_2(\lambda_{I,t}) = (1-\delta)\left(\lambda_{I,t}-\lambda_E\right)\frac{X}{2} + \delta\left(\frac{1+3\lambda_{I,t}}{16}\widehat{V}(\lambda_{I,t}^{++})\frac{1+\lambda_{I,t}}{4}\widehat{V}(\lambda_{I,t}^{+}) + \frac{1}{4}\widehat{V}(\lambda_{I,t})\right)$$

whose solution is

$$\widehat{V}_2(\lambda_{I,t}) = \frac{X}{32-18\delta}\left((16-9\delta-7\delta\lambda_E)\lambda_{I,t} - 16(1-\delta)\lambda_E\right).$$

We can now study the competition between the original incumbent and the entrant. Note that now CRAs can decide to compete on the two issuers, on one issuer only or to share the market rating one issuer each. However, if for simplicity we assume that CRA cannot differentiate their fees for the two issuers, then there are only two possible outcomes: both issuers hires either the entrant or the incumbent.

If the entrant rates the two issuers (one issuer) and either event S^GS^G, NS^G or S^GN realizes (resp. S^G relizes), then its reputation becomes greater than the one of the original iincumbent that will have to exit the marketleading to the phase with varying reputation incumbent. Otherwise it is the entrant who exits the market after one period. The value to the entrant from rating one issuer is $-c(1-\delta)+\delta\frac{1+\lambda_E}{4}\widehat{V}_2(\lambda_E^+)$. The value to the entrant from rating two issuers is $-2c(1-\delta)+\delta\left(\frac{1+3\lambda E}{16}\widehat{V}_2(\lambda_E^{++})+\frac{1+\lambda_E}{4}\widehat{V}_2(\lambda_E^+)\right)$. The entrant payoff is zero if it rates no issuer. [9] Thus the maximum amount the entrant is willing to pay per

[9] Hence the maximum that the entrant is willing to pay to rate the one issuer is issuers is

$$b_{2E}(1) := -c + \frac{\delta}{1-\delta}\left(\frac{1+\lambda_E}{4}\widehat{V}_2(\lambda_E^+)\right)$$

while for the second issuer he is willing to pay at most

$$b_{2E}(2) := -c + \frac{\delta}{1-\delta}\left(\frac{1+3\lambda E}{16}\widehat{V}_2(\lambda_E^{++})\right) < b_{2E}(1)$$

issuer is

$$\widehat{b}_{2E} = \frac{\delta}{2(1-\delta)}\left(\frac{1+3\lambda E}{16}\widehat{V}_2(\lambda_E^{++}) + \frac{1+\lambda_E}{4}\widehat{V}_2(\lambda_E^{+})\right) - c$$

Let $\overline{V}_{2I}$ denote the original incumbent's continuation pyoff when it is not replaced in the next period. The value to the incumbent in case the entrant rates the two issuers is $\delta\left(1-\frac{1+3\lambda_E}{16}-\frac{1+\lambda_E}{4}\right)\overline{V}_{2I}$; the value to the incumbent of rating only one issuer is $-c(1-\delta)+\delta\left(1-\frac{1+\lambda_E}{4}\right)\overline{V}_{2I}$ while the value to the incumbent of rating two isseur is $-2c(1-\delta)+\delta\overline{V}_{2I}$.[10] Thus the maximum amount the invumbent is willing to pay per issuer is

$$\widehat{b}_{2I} = \frac{\delta}{2(1-\delta)}\left(\frac{1+3\lambda E}{16} + \frac{1+\lambda_E}{4}\right)\overline{V}_{2I} - c$$

Hence, the competition is won by the incumbent if

$$\frac{\delta}{2(1-\delta)}\left(\frac{1+3\lambda E}{16} + \frac{1+\lambda_E}{4}\right)\overline{V}_{2I} + \lambda_I\frac{X}{4} \geq \frac{\delta}{2(1-\delta)}\left(\frac{1+3\lambda E}{16}\widehat{V}_2(\lambda_E^{++}) + \frac{1+\lambda_E}{4}\widehat{V}_2(\lambda_E^{+})\right) + \lambda_E\frac{X}{4}$$

This inequality is satisfied for all non negative $\overline{V}_{2I}$ as long as λ_I is not smaller than $\lambda_{2I}^{**}(\lambda_E)$ taht is defined as the λ solving the following equation

$$(1-\delta)(\lambda-\lambda_E)\frac{X}{2} = \delta\left(\frac{1+3\lambda E}{16}\widehat{V}_2(\lambda_E^{++}) + \frac{1+\lambda_E}{4}\widehat{V}_2(\lambda_E^{+})\right).$$

Thus for $\lambda_I \geq \lambda_{2I}^{**}(\lambda_E)$ the entrant wins the auction with both issuers and bids

$$\frac{\delta}{2(1-\delta)}\left(\frac{1+3\lambda E}{16}\widehat{V}_2(\lambda_E^{++}) + \frac{1+\lambda_E}{4}\widehat{V}_2(\lambda_E^{+})\right) - (\lambda_I-\lambda_E)\frac{X}{4} - c$$

to each issuer realizing an equilibrium payoff of

$$V_{2I} = (1-\delta)(\lambda_I-\lambda_E)\frac{X}{2} - \delta\left(\frac{1+3\lambda E}{16}\widehat{V}_2(\lambda_E^{++}) + \frac{1+\lambda_E}{4}\widehat{V}_2(\lambda_E^{+})\right) = \left(\frac{(\lambda_I-\lambda_E)}{4} - \frac{7(4-\delta)(1-\lambda_E)\lambda_E}{8(16-9\delta)}\right)X$$

[10] Thus the maximum that the original incumbent is willing pay to attract one issuers is

$$b_{2I}(1) := -c + \frac{\delta}{1-\delta}\left(\frac{1+3\lambda_E}{16}\right)\overline{V}_{2I}$$

the extra amount he is willing to pay to attract the second issuer is

$$b_{2I}(2) := -c + \frac{\delta}{1-\delta}\left(\frac{1+\lambda_E}{4}\right)\overline{V}_{2I} > b_{2I}(1)$$

Note that if $\lambda_I \leq \lambda_{2I}^{**}(\lambda_E)$ then the incumbent cannot realize a positive profit and hence $V_{2I} = 0$. In this case it is the incumbent who rates both issuer in the first period and pays $(\lambda_I - \lambda_E) \frac{X}{4} - c$ to each issuer cannot be positive. This leads to an rquilibrium payoff of

$$V_{2E} = -(1-\delta)(\lambda_I - \lambda_E)\frac{X}{4} + \delta\frac{7(4-\delta)(1-\lambda_E)\lambda_E}{8(16-9\delta)}$$

8 Conclusion

We present an infinite horizon model that studies entry and firm selection in the credit rating business. Our purpose is to explain why this sector experiences such a high level of concentration enjoying relatively high returns but provides a service of questionable quality. We presented a model where a relatively inaccurate original incumbent CRA competes with a sequence of entrants that are potentially more effective in assessing risk, but have not yet demonstrated their accuracy. We show that when entrants can commit to truthfully disclose their private information, an entrant CRA wins competition over the original incumbent more often than what would be socially optimal. On the contrary, when entrants cannot commit to truthful disclosure, for example because rating fees cannot be contingent on the rating, then reputation concerns make it impossible for an entrant CRA to access the business. As a result a relatively inaccurate CRA can maintain a monopolistic position even when facing entry from potentially more competent CRAs.

We claim that the interdiction of contingent rating fees included in the Cuomo plan has the effect of preventing successful entry of new CRAs, which reinforces the position of the original incumbent CRA. Allowing contingent fees can facilitate entry in the credit rating business but the relation between the level of fees and the sign of rating should be opposite to the current practice; entrant CRAs should be allowed to charge higher fees for a bad rating than for a good rating. This policy lead to social optimum when the expected entrant's accuracy is close enough to, or not much smaller than, the original incumbent actual accuracy. For intermediate values of the entrant expected accuracy, contingent fees can lead to over experimentation of entrant CRAs. Still we believe that this policy remains optimal for a forward looking government as the region where contingent fees lead to excessive entry shrinks as the discount factor increases.

Some recent papers have offered explanations of the CRAs' failures. These models generate inflated ratings due to CRAs' tendency to be too lax and/or to issuers' predilection for publishing only good ratings. In our model, even though CRAs can manipulate their ratings, in equilibrium an incumbent CRA truthfully reports its signal. Hence our explanation of recent rating inflation relates to the possibility that inaccurate CRAs dominate the market. In fact, an inaccurate CRA can make two types of errors: give a good rating to a bad security or a bad rating to a good security. However since only good rating securities tend to be issued, the error we should observe in data are of the first type, resulting in an observation of rating inflation.

9 Appendix

Proof of Lemma 2

Let λ_i, λ_j, with $\lambda_i \leq \lambda_j$be period t reputation of the two competing agencies at period t. If CRA i wants to generate a positive profit, then it cannot bid more than $-c$. However, CRA j can easily win period t competition by bidding $-c-(\mu_G(\lambda_j)-\mu_G(\lambda_i))\frac{X}{2}$, realizing a positive profit.

Proof of Lemma 3

(i) The entrant's initial reputation is $\lambda_E(<\lambda_E^+ \leq \lambda_{I,t})$, and at the end of period t it can be at most $\lambda_E^+ \leq \lambda_{I,t}$. If the entrant does not rate the issuer t, it make zero profit at t and expects zero profit in $t+1$ (because of Lemma 2) and hence exits the market at the end of t because of Assumption A3(ii). Hence the entrant's overall payoff is zero. If in period t the entrant rates the issuer t it must realize a negative profit in t (because of Lemma 2). Since in period $t+1$ its reputation is at most λ_E^+, Bertrand competition with the incumbent implies that the entrant cannot make any positive profit in $t+1$ and hence exits the market at the end of t according to A3(ii).

(ii) From the proof of (i), we know that as long as the incumbent stays in the market, every period each new entrant charges a fee of c and hence the incumbent can gain period t issuer by charging a fee of $c+\frac{1}{2}(\mu_G(\lambda_{I,t})-\mu_G(\lambda_E))X$ realizing a profit of $(\lambda_{I,t}-\lambda_E)X/4$. its reputation will move to $\lambda_{I,t}^+$ $\lambda_{I,t}$ and 0 in event S^G, N and F^G respectively. Considering that the ex ante probability of these events are $\Pr(S^G)=\frac{\lambda_{I,t}+1}{4}$, $\Pr(N)=1/2$ and $\Pr(F^G)=\frac{1-\lambda_{I,t}}{4}$, the incumbent equilibrium payoff $\widehat{V}(\lambda_{I,t})$ must satisfy the following functional equation

$$\widehat{V}(\lambda_{I,t})=(1-\delta)(\lambda_{I,t}-\lambda_E)\frac{X}{4}+\delta\left[\frac{\lambda_{I,t}+1}{4}\widehat{V}(\lambda_{I,t}^+)+\frac{1}{2}\widehat{V}(\lambda_{I,t})\right]$$

whose solution is given in the lemma.

(iii) Suppose now the incumbent rates the period t issuer. If an event F^G occurs, then the reputation of the incumbent drops to 0 and he exits the market. In this case the entrant realizes zero profit at t and he expects to face in $t+1$ and new entrant with the same reputation, hence he expects zero profit at $t+1$. As a consequence he will exit at the end of t.

Proof of Proposition 2

Consider the competition between the original incumbent and the entrant in period one. If the entrant rates period one project and realizes an S^G event, its reputation becomes $\lambda_E^+ > \lambda_I$ and then either the entrant will also rate period 2 issuer if the original incumbent remains in the market or the original incumbent will rate period 2 issuer but will realize negative profit to compensate the issuer for its lower reputation. This together with A3(ii) implies that the original incumbent exits the market and then from period 2 the phase with a varying reputation incumbent starts with the incumbent's expected continuation payoff equal to $\widehat{V}(\lambda_E^+)$. If the entrant does not rate period one project, the entrant will exit the market at the end of period one with zero profit from A3(ii). Thus the maximum that the entrant is willing to pay to have the opportunity to rate period one project is

$$b_E = -c + \frac{\delta}{1-\delta}\frac{\lambda_E+1}{4}\widehat{V}(\lambda_E^+).$$

Let $\overline{V}_I$ denote the original incumbent's continuation payoff in period 2 when it is not replaced. The value to the incumbent of rating period one project is $-c(1-\delta)+\delta\overline{V}_I$ while the value to the incumbent of letting the entrant rate period one project is $\delta(1-\frac{\lambda_E+1}{4})\overline{V}_I$ where the original incumbent is assumed to remain period two incumbent whenever the entrant does not manage to increase its reputation.[11] Thus, the maximum that the original incumbent is willing to pay to have the opportunity to rate period one project is

$$b_I = -c + \frac{\delta}{1-\delta}\frac{\lambda_E+1}{4}\overline{V}_I.$$

Therefore, the competition to rate period one project will be won by the incumbent whenever

$$\frac{\delta}{1-\delta}\frac{\lambda_E+1}{4}\overline{V}_I + \lambda_I\frac{X}{4} - c \geq \frac{\delta}{1-\delta}\frac{\lambda_E+1}{4}\widehat{V}(\lambda_E^+) + \lambda_E\frac{X}{4} - c.$$

that is satisfied for $\lambda_I \geq \lambda_I^{**}(\lambda_E)$ and all non-negative $\overline{V}_I$. In this instance the incumbent can win the competition with the entrant by offering the issuer a bid of $\frac{\delta}{1-\delta}\frac{\lambda_E+1}{4}\widehat{V}(\lambda_E^+) - (\lambda_I-\lambda_E)\frac{X}{4} - c$. Since the same situation occurs in every period, it must be that $\overline{V}_I = V_I$. Note that if $\lambda_I < \lambda_I^{**}(\lambda_E)$ and nevertheless the original incumbent rates projects all the

[11] This assumption is correct whenever $\overline{V}_I > 0$ and is innocuous if $\overline{V}_I = 0$.

time, its stage payoff will be $(\lambda_I - \lambda_E)\frac{X}{4} - \frac{\delta}{1-\delta}\frac{\lambda_E+1}{4}\widehat{V}(\lambda_E^+)$ leading to a negative profit to the incumbent. Hence when $\lambda_I < \lambda_I^{**}(\lambda_E)$, we have $\overline{V}_I = 0$ and it will be period 1 entrant who rates the period one project. To win the competition, the entrant pays $(\lambda_I - \lambda_E)\frac{X}{4} - c$ to the issuer and realizes an overall expected payoff of V_E. Once the entrant replaces the original incumbent, the phase with a varying reputation incumbent starts and eventually this leads to the selection of an accurate CRA.

Proof of Lemma 4

We begin by a lemma regarding the possible values of π_{t+1}^D.

Lemma 6 *Under A3(ii),*

(i) If $\pi_{t+1}^D(\lambda, s) = 0$, then the period t entrant with the private signal s exits the market at the end of t and $V_2^D(\lambda, s) = 0$.

(ii) It is impossible to have "$\pi_{t+1}^D(\lambda, G) > 0$ and $\pi_{t+1}^D(\lambda, B) = 0$" or "$\pi_{t+1}^D(\lambda, G) = 0$ and $\pi_{t+1}^D(\lambda, B) > 0$".

Proof: (i) The proof is a straightforward consequence of A3(ii).

(ii) Consider for instance $\pi_{t+1}^D(\lambda, G) > 0$ and $\pi_{t+1}^D(\lambda, B) = 0$. Let $f(> c)$ be the fee that the entrant with $s = G$ charges in period $t+1$. Then, the entrant with $s = B$ can charge the same fee and realize $\pi_{t+1}^D(\lambda, B) > 0$, which is a contradiction. The same logic applies to the case of $\pi_{t+1}^D(\lambda, G) = 0$ and $\pi_{t+1}^D(\lambda, B) > 0$.□

Lemma 6 implies that we can have either "$\pi_{t+1}^D(\lambda, G) > 0$ and $\pi_{t+1}^D(\lambda, B) > 0$" or "$\pi_{t+1}^D(\lambda, G) = 0$ and $\pi_{t+1}^D(\lambda, B) = 0$", which is equivalent to saying that we can have either "$V^D(\lambda, G) > 0$ and $V^D(\lambda, B) > 0$" or "$V^D(\lambda, G) = 0$ and $V^D(\lambda, B) = 0$". Lemma **4** states that only "$V^D(\lambda, G) = 0$ and $V^D(\lambda, B) = 0$" is possible.

First, consider the case where the equilibrium disclosing strategy D satisfies $1 \geq X\mu_G^D > X\mu_B^D$ then the project is never implemented, $\omega = N$ and in period $t+1$ entrant reputation is $\lambda_{E,t+1} = \lambda_E < \lambda_I$. Thus $\pi_{t+1}^D(\lambda_\omega^D, s) = 0$ for $s \in \{G, B\}$ because of property ii).

Second, consider the case $X\mu_G^D > 1 > X\mu_B^D$. Whenever the entrant reports a bad rating $\omega = N$ and thus the possible rating performances are $\{\widehat{S}^G, \widehat{F}^G, N\}$. Note that $\lambda_N^D = \lambda_E < \lambda_I$. Hence, after giving a bad rating, $\pi_{t+1}^D(\lambda_N^D, s) = 0$ for $s \in \{G, B\}$ because of property ii). Moreover $\lambda_{\widehat{F}G}^D \leq \lambda_E < \lambda_I$ implies $\pi_{t+1}^D(\lambda_{\widehat{F}G}^D, s) = 0$ for $s \in \{G, B\}$. Suppose now that $\lambda_{\widehat{S}G}^D > \lambda_I$ and $\pi_{t+1}^D(\lambda_{\widehat{S}G}^D, s) > 0$ for some $s \in \{G, B\}$, then Lemma implies 6 implies that for the other realization of the signal $s' \neq s$, we have $\pi_{t+1}^D(\lambda_{\widehat{S}G}^D, s') > 0$. Then the entrant's expected period $t+1$ profit by giving a good rating is

$$\Pr\left(\widehat{S}^G \middle| s\right)\pi_{t+1}^D(\lambda_{\widehat{S}G}^D, s) + \Pr\left(\widehat{F}^G \middle| s\right)\pi_{t+1}^D(\lambda_{\widehat{F}G}^D, s) > 0,$$

for all $s \in \{G, B\}$. Therefore, the continuation payoff conditional on giving a good rating is strictly positive and hence strictly larger than the continuation payoff of giving a bad rating regardless of whether the entrant receives a good signal or a bad signal. Hence in equilibrium it must be $D(G) = D(B) = 1$ implying $\mu_G^D = \mu_B^D = \mu$. Hence contradicting $X\mu_G^D > 1 > X\mu_B^D$.

Third, consider the case $X\mu_G^D \geq X\mu_B^D > 1$. Since $\lambda_{\omega_t}^D \leq \lambda_E < \lambda_I$ for $\omega_t \in \left\{\widehat{S}^B, \widehat{F}^G, N\right\}$, it must be $\pi_{t+1}^D(\lambda_{\omega_t}^D, s) = 0$ for $\omega_t \in \left\{\widehat{S}^B, \widehat{F}^G, N\right\}$. If $\pi_{t+1}^D(\lambda_{\widehat{S}^G}^D, s) > 0$ and $\pi_{t+1}^D(\lambda_{\widehat{F}^B}, s) \leq 0$ (respectively, $\pi_{t+1}^D(\lambda_{\widehat{S}^G}^D, s) \leq 0$ and $\pi_{t+1}^D(\lambda_{\widehat{F}^B}^D, s) > 0$) hold, then the entrant has an incentive to manipulate the signal to announce always a good rating (respectively, a bad rating). This would imply $\mu_G^D = \mu_B^D = \mu$ and hence $\lambda_{\widehat{S}^G}^D = \lambda_{\widehat{F}^B}^D = \lambda_E < \lambda_I$ contradicting $\pi_{t+1}^D(\lambda_{\widehat{S}^G}^D, s) > 0$ (respectively, $\pi_{t+1}^D(\lambda_{\widehat{F}^B}^D, s) > 0$). Therefore, we consider $\pi_{t+1}^D(\lambda_{\widehat{S}^G}^D, s) > 0$ and $\pi_{t+1}^D(\lambda_{\widehat{F}^B}, s) > 0$. Note $D(G) \geq D(B)$ requires

$$\mu_G(\lambda_E)V(\lambda_{\widehat{S}^G}^D, G) \;\geq\; (1 - \mu_G(\lambda_E))V(\lambda_{\widehat{F}^B}^D, G) \tag{3}$$

$$(1 - \mu_B(\lambda_E))V(\lambda_{\widehat{F}^B}^D, B) \;\geq\; \mu_B(\lambda_E)V(\lambda_{\widehat{S}^G}^D, B) \tag{4}$$

that are the incentive compatibility constraints guaranteeing that the entrant does not strictly prefer to report a rating opposite to its signal. If both (3) and (4) are strict, then the entrant finds it optimal to truthfully report its signal. But since $\lambda_E > \lambda_{\min}$, this would imply $X\mu_G^D > 1 > X\mu_B^D$ and leads to a contradiction. If both (3) and (4) hold with equality, then from $\mu_G(\lambda_E) = (1 - \mu_B(\lambda_E)) = (1 + \lambda_E)/2$ and $\mu_B(\lambda_E) = (1 - \mu_G(\lambda_E)) = (1 - \lambda_E)/2$, we have

$$\frac{V(\lambda_{\widehat{F}^B}^D, G)}{V(\lambda_{\widehat{S}^G}^D, G)} = \frac{V(\lambda_{\widehat{S}^G}^D, B)}{V(\lambda_{\widehat{F}^B}^D, B)} = \frac{1 + \lambda_E}{1 - \lambda_E} > 1.$$

which implies

$$V(\lambda_{\widehat{F}^B}^D, G) = \frac{1 + \lambda_E}{1 - \lambda_E}V(\lambda_{\widehat{S}^G}^D, G) \geq \frac{1 + \lambda_E}{1 - \lambda_E}V(\lambda_{\widehat{S}^G}^D, B) = \left(\frac{1 + \lambda_E}{1 - \lambda_E}\right)^2 V(\lambda_{\widehat{F}^B}^D, B),$$

where the inequality results from property iv), which gives

$$V(\lambda_{\widehat{F}^B}^D, G) \geq \left(\frac{1 + \lambda_E}{1 - \lambda_E}\right)^2 V(\lambda_{\widehat{F}^B}^D, B),$$

which contradicts property iv) whenever $\pi_{t+1}^D(\lambda_{\widehat{F}^B}, s) > 0$.

Suppose then that (3) is strict but (4) is weak. In this instance the entrant strictly prefers to truthfully report a good signal but after receiving a bad signal he is indifferent between reporting G or D. We already eliminated truthful reporting for both signals and we know that always reporting a good rating cannot change the entrant's reputation. Thus it must be

$$D(G)=1 \text{ and } 1>D(B)>0,$$

that implies $\lambda^D_{\widehat{F}^B} > \lambda^D_{\widehat{S}^G}$ because:

$$\begin{aligned}
\lambda^D_{\widehat{F}^B} &= \Pr\left(\text{Entrant is accurate}\middle|\, \widehat{F}^B\right) = \\
&= \frac{\Pr\left(\text{Entrant is accurate}\right)\Pr\left(\widehat{F}^B\middle|\text{Entrant is accurate}\right)}{\Pr\left(\widehat{F}^B\right)} = \\
&= \frac{\lambda_E(1-D(B))\frac{1}{2}}{\lambda_E(1-D(B))\frac{1}{2}+(1-\lambda_E)(1-D(B))\frac{1}{4}} = \lambda_E^+
\end{aligned}$$

and

$$\begin{aligned}
\lambda^D_{\widehat{S}^G} &= \Pr\left(\text{Entrant is accurate}\middle|\, \widehat{S}^G\right) = \\
&= \frac{\Pr\left(\text{Entrant is accurate}\right)\Pr\left(\widehat{S}^G\middle|\text{Entrant is accurate}\right)}{\Pr\left(\widehat{S}^G\right)} = \\
&= \frac{\lambda_E D(G)\frac{1}{2}}{\lambda_E D(G)\frac{1}{2}+(1-\lambda_E)\frac{1}{2}(\frac{1}{2}D(G)+\frac{1}{2}D(B))} = \\
&= \frac{\lambda_E}{\lambda_E+(1-\lambda_E)(\frac{1}{2}+\frac{1}{2}D(B))} < \frac{\lambda_E}{\lambda_E+(1-\lambda_E)\frac{1}{2}} = \lambda_E^+
\end{aligned}$$

However the fact that (4) holds with equality and $(1-\mu_B(\lambda_E)) > \mu_B(\lambda_E)$ implies $V^D(\lambda^D_{\widehat{F}^B}, B) < V^D(\lambda^D_{\widehat{S}^G}, B)$ and thus $\lambda^D_{\widehat{F}^B} \leq \lambda^D_{\widehat{S}^G}$ because of property iii), thus a contradiction. If (3) is weak but (4) is strict, the symmetric argument applies. Indeed, in this case,

$$1>D(G)>0 \text{ and } D(B)=0,$$

that implies $\lambda^D_{\widehat{F}^B} < \lambda^D_{\widehat{S}^G}$ because:

$$\begin{aligned}
\lambda^D_{\widehat{F}^B} &= \Pr\left(\text{Entrant is accurate}\middle|\, \widehat{F}^B\right) = \\
&= \frac{\Pr\left(\text{Entrant is accurate}\right)\Pr\left(\widehat{F}^B\middle|\text{Entrant is accurate}\right)}{\Pr\left(\widehat{F}^B\right)} = \\
&= \frac{\lambda_E\frac{1}{2}}{\lambda_E\frac{1}{2}+(1-\lambda_E)\frac{1}{2}(\frac{1}{2}+\frac{1}{2}(1-D(G)))} < \lambda_E^+
\end{aligned}$$

and

$$\lambda^D_{\widehat{S}^G} = \Pr\left(\text{Entrant is accurate}|\,\widehat{S}^G\right) =$$

$$= \frac{\Pr\left(\text{Entrant is accurate}\right)\Pr\left(\widehat{S}^G\middle|\,\text{Entrant is accurate}\right)}{\Pr\left(\widehat{S}^G\right)} =$$

$$= \frac{\lambda_E D(G)\frac{1}{2}}{\lambda_E D(G)\frac{1}{2} + (1-\lambda_E)\frac{1}{2}(\frac{1}{2}D(G))} = \lambda_E^+$$

However the fact that (3) holds with equality and $\mu_G(\lambda_E) > 1-\mu_G(\lambda_E)$ implies $V^D(\lambda^D_{\widehat{F}^B}, G) > V^D(\lambda^D_{\widehat{S}^G}, G)$ and thus $\lambda^D_{\widehat{F}^B} \geq \lambda^D_{\widehat{S}^G}$ because of property iii), thus a contradiction.

Proof of Proposition 5

The proof is similar to the proof of Proposition 2. The competition to rate period one project will be won by the original incumbent whenever

$$\frac{\delta}{1-\delta}\frac{\lambda_E+1}{4}\overline{V}_I + \lambda_I\frac{X}{4} - c \geq \frac{\delta}{1-\delta}\frac{\lambda_E+1}{4}\widehat{V}(\lambda_E^+) + \lambda_E\frac{X}{4} - c,$$

which is satisfied for $\lambda_I \geq \lambda_I^{**}(\lambda_E)$ and all non-negative $\overline{V}_I$. In this instance the incumbent can win the competition with the entrant by offering the issuer a bid of $\frac{\delta}{1-\delta}\frac{\lambda_E+1}{4}\widehat{V}(\lambda_E^+) - (\lambda_I - \lambda_E)\frac{X}{4} - c$. Since the same situation occurs in every period, it must be that $\overline{V}_I = V_I$. When $\lambda_I < \lambda_I^{**}(\lambda_E)$ it results $\overline{V}_I = 0$ and it will be period 1 entrant to rate the period one project. In order to win the competition, the entrant will make an expected payment to the issuer of

$$-\frac{1}{2}(f_G + f_B) = (\lambda_I - \lambda_E)\frac{X}{4} - c$$

and realize an overall expected payoff of V_E. It is straightforward to see that there are $(f_G,\ f_B)$ satisfying the previous equality as well as the entrant's incentive compatibility constraints that implies $f_G < f_B$.

Proof or Proposition 6

From Proposition 5 we know that in the absence of the constraint 2 the entrant would undermine the incumbent whenever the latter reputation is smaller than $\lambda_I^{**}(\lambda_E) > \lambda_I^*(\lambda_E)$. Hence when $\lambda_I^*(\lambda_E) < \lambda_I < \lambda_I^{**}(\lambda_E)$ the market lead to excessive experimentation and to optimal experimentation otherwise. In order to attract its first issuer the entrant has to compensate it for its lower accuracy and has to offer an expected bid

$$-\frac{1}{2}(f_G + f_B) = b_E > b_I + (\lambda_I - \lambda_E)\,\frac{X}{4}$$

where b_I is the original incumbent bid. Now equation 2 implies that $b_E \leq (\lambda_I^*(\lambda_E) - \lambda_E)\,\frac{X}{4} + c$, and hence when the constraint on the entrant's fees is binding, the incumbent can win the issuer by bidding $b_I = (\lambda_I^*(\lambda_E) - \lambda_I)\,\frac{X}{4} - c$ and realize a stage payoff of $(\lambda_I - \lambda_I^*(\lambda_E))\,\frac{X}{4}$ that is positive for $\lambda_I^*(\lambda_E) < \lambda_I$. If $\lambda_I^*(\lambda_E) > \lambda_I$, then the entrant can win the auction by bidding $b_E = (\lambda_I - \lambda_E)\,\frac{X}{4} - c$ since this bid does not hit the constraint, we are in the same situation a sin Proposition 5 and the entrant will win the auction against the incumbent.■

10 References

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