

Credit Rating and Competition

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Abstract

In principle, credit rating agencies are supposed to be impartial observers that bridge the gap between private information of issuers and the information available to the wider pool of investors. However, since the 1970s, rating agencies have relied on an issuer-pay model, creating a conflict of interest - the largest source of income for the rating agencies are the fees paid by the issuers the rating agencies are supposed to impartially rate. In this paper, we explore the trade-off between reputation and fees and find that relative to monopoly, rating agencies are more prone to inflate ratings under competition, resulting in lower expected welfare. Our results suggest that more competition by itself is undesirable under the current issuer-pay model and will do little to resolve the conflict of interest problem.

Keywords: Rating Agency, conflicts of interest, competition, reputation, repeated games, financial regulation

JEL Classifications: C73, D43, D82, D83, G24

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1 Introduction

The credit rating industry aims to offer investors valuable information about issuers in need of financing. Due to the asymmetric information between the issuers and the investors, credit ratings often have pivotal impacts on the issuers' financing outcomes. Before the 1970s, the rating agencies relied on an investor-pay model wherein investors subscribed to ratings released by the agencies and these subscription revenues were the main source of income for the rating agencies. However owing to the 'public good' nature of ratings¹ and the increase in free riding, rating agencies switched to the current issuer-pay model and started charging issuers for ratings. As things stand today, the largest source of income for the rating agencies² are the fees paid by the issuers the rating agencies are supposed to impartially rate.³ This tempts rating agencies to rate better than what fundamentals suggest, as many have pointed out during the recent sub-prime crisis.

It is often suggested that introducing more competition between rating agencies would alleviate the conflicts of interest. We develop an infinite horizon model where rating agencies compete for market share and face a trade-off between reputation and current fees. Competition in our model has two effects - the disciplining effect and the market-sharing effect. Competition decreases ratings inflation through the disciplining effect as rating agencies have incentives to maintain or gain the market leader position. On the other hand, the reward from maintaining reputation is lower because competition implies that the market is shared between a larger number of rating agencies, which we

¹This was officially recognised by the Securities and Exchange Commission (SEC) in the 1970s when the big three rating agencies – Standard & Poor's, Moody's and Fitch were designated self-regulatory entities. See Lowenstein (2008).

²It is also interesting to note that rating agencies are some of the most profitable businesses. Moody's has been the third most-profitable company in the S&P 500-stock index from 2002 to 2007, based on pretax margins (ahead of both Microsoft and Google).

³Summary Report of Issues Identified in the Commission Staffs Examinations of Select Credit Rating Agencies by the Staff of the Securities and Exchange Commission, 2008, p.9.

call the market-sharing effect. Our results suggest that in general the market-sharing effect will dominate and competition will aggravate ratings inflation and reduce expected welfare.

Given the structure of the market - with Standard & Poor's and Moody's having 80% of market share,⁴ we model competition amongst the rating agencies in a duopolistic setting. In our model, issuers need a good rating to finance their projects. Rating agencies, which can be of two types - *honest* or *strategic*, perfectly observe the quality of the project and can either give the issuer a good rating or refuse rating. An honest rating agency always gives good ratings to good projects and no rating to bad projects while a strategic rating agency acts to maximise its expected profits. Neither investors nor issuers know for sure if a rating agency is honest and they Bayesian update on the reputation of the rating agencies (*i.e.* the probability that a rating agency is honest). The market share of the rating agency is modelled such that rating agencies with higher reputation will attract more projects. Hence the rating agencies face a trade-off between current income and reputation which determines their future market share and income.

We compare the behaviour of rating agencies between the duopolistic case and the monopolistic case⁵ and find that on average rating agencies inflate ratings more under duopoly. Intuitively, given that the total market size is fixed, more competition will result in smaller market share and expected revenue for each rating agency, resulting in more ratings inflation, due to the market-sharing effect. When one rating agency is dominant and its competitor has a very low reputation, the rating agencies' market share is relatively inelastic to small changes in their reputation. Thus the disciplining effect of competition is relatively weaker and the rating agency behaves more laxly. On the other hand, if the reputation of the two rating agencies are close to each other,

⁴The figure stands at 95% if we include the third major player, Fitch.

⁵Although we only focus on competition in a duopolistic setting, our results intuitively extend to situations with higher degrees of competition.

the rating agencies' market share is more sensitive to changes in reputation and ratings inflation is relatively smaller. On balance, our results show that the market share effect dominates the disciplining effect of competition and increasing competition results in more ratings inflation.

Mathis, McAndrews, and Rochet (2009) demonstrate that reputational concerns are not enough to solve the conflict of interest problem. In equilibrium, rating agencies are likely to behave laxly, *i.e.* rate bad projects as good and are prone to reputation cycles. Our model innovates by introducing competition through an endogenous market share function and studying how competition affects the behaviour of rating agencies.

Becker and Milbourn (2008) lends support to our results by providing an empirical test of the impact of competition on rating agencies. They measure competition using the growth of Fitch's market share and find three pieces of evidence. First, the overall standards of ratings issued by S&P and Moody's increased (closer to the top AAA rating) with competition, so that ratings are more 'friendly'. Second, the correlation between bond yields and ratings fell as competition increased, implying that ratings became less informative. Third, equity prices react more negatively to rating downgrades, suggesting a lower bar for rating categories. Their findings are consistent with our results that competition will tend to lower the quality of ratings in the market.

The adverse effects of competition on the building and maintenance of reputation has been studied by Klein and Leffler (1981). They argue that when faced with a choice between supplying high quality products or low quality ones, firms would be induced to supply high quality products when the expected value of future income given a high reputation outweighs the short-run gain of cheating. However, competition would undermine this mechanism since the expected future income would fall as competition intensifies, and hence the firm would have less incentives to maintain reputation. This is similar to our intuition that rating agencies tend to behave more laxly as competition

increases. However, competition in our model also has a disciplining effect and we explore the overall impact of competition on rating agencies' behaviour.

Bolton, Freixas, and Shapiro (2009) also analyse the behaviour of strategic rating agencies in monopolistic and duopolistic settings. They look at ratings-shopping of issuers in the presence of naïve investors. They find that ratings are inflated when there are more naïve investors, and that monopoly is superior in terms of total *ex-ante* investor welfare. In addition, Skreta and Veldkamp (2008) do not consider the strategic behaviour of rating agencies but explore the interaction between ratings-shopping, complexity of the security (project) and competition. They show that the intensity for ratings-shopping increases with the complexity of the security and that competition between rating agencies makes the problem even more acute.

Damiano, Hao, and Suen (2008) study how the rating scheme may affect the strategic behaviour of rating agencies. They compare rate inflation among centralised (all firms are rated together) and decentralised (firms are rated separately) rating schemes. When the quality of projects is weakly correlated, centralised rating dominates because decentralised rating leads to lower ratings inflation. The reverse holds when the correlation is strong.

The rest of the paper is organised as follows. In Section 2 we outline the basic features of our model. Section 3 describes the equilibrium in our model. In Section 4 we solve the model numerically in an infinite horizon. We go on to compare the behaviour of rating agencies under monopoly and duopoly in Section 4.3 and discuss the expected welfare consequences of enhanced competition. Section 5 concludes. The proofs are presented in the Appendix.

2 Model Setup

We consider a discrete time setting with 3 types of agents – the issuers, the rating agencies (RA) and the investors. Each period, we have a *new issuer*⁶ with a project that requires financing. We assume that issuers do not have funds of their own and need to obtain outside financing. The investors have funds and are willing to invest in the project provided they are convinced that it is profitable to do so. The role of the RA in this setting is to issue ratings that convince investors to provide financing.

More formally, each period we have one issuer that has a project which lasts for one period. The project has a pay-off Φ if successful and 0 otherwise and requires an investment of X , with X uniformly distributed⁷ over (a,b) . The project is *good* with probability λ and *bad* with probability $1 - \lambda$. λ is independent of X . Good projects succeed with probability p_G and fail with $1 - p_G$. Bad projects always fail.

We assume that *a-priori* projects are not worth financing without rating, *i.e.* $\lambda p_G \Phi \leq X$. Further, the RAs can perfectly observe the type of project at no cost. After observing the type, the RA can either issue a good rating (GR) or no rating (NR). Note that we do not distinguish between bad rating and NR and abstract away from a ratings scale. In our setup, a good rating is one that allows the issuer to borrow from investors. It does not matter if this rating is AAA or A or BBB or even C. As long as the rating allows the firm to get financing, we consider it to be a GR. A bad rating in this setting will be a rating which does not enable a project to get financing. This is the same outcome as a NR and thus, a bad rating and NR are equivalent in our model.

⁶*New Issuer* implies that it is a one shot game for the issuer and we rule out the possibility that issuers try to maximise profits over multiple periods. This assumption also ensures that issuers have the same belief as the investors about the reputation of the RAs. If we allow the same issuers to approach the rating agencies in subsequent periods, then issuers will have more information than investors.

⁷This assumption ensures that we have a range of projects with different returns. Projects that require low investment have high return and vice versa. We can get similar results if we assume fixed investment with uncertain pay-off.

The rating agency receives income I if it issues GR, and 0 otherwise.⁸ This assumption arises from the conflict of interest in the rating agency industry. Given the *non-transparent* nature of the market and the widespread use of *negotiated ratings*, issuers and RAs routinely have negotiations and consultations before an official rating is issued. RAs, as part of their day-to-day operations, give their clients ‘creative suggestions’ on how to repackage their portfolios/projects in order to get better ratings. To quote former chief of Moody’s, Tom McGuire⁹

“The banks pay only if [the rating agency] delivers the desired rating... If Moody’s and a client bank don’t see eye-to-eye, the bank can either tweak the numbers or try its luck with a competitor...”

We assume that there are two types of RAs - *honest* and *strategic*. An honest RA always issues a GR to a good project and NR to a bad project while a strategic RA behaves strategically to maximise its expected future profits. The strategic RA faces the following trade-off :

1. (**Truthful**) It can either be truthful and maintain its reputation, thus ensuring profits in the future
2. (**Lie**) It can inflate ratings (rate a bad project good) and get fees now, at the cost of future profits

We consider a duopolistic setting with 2 rating agencies.¹⁰ The type of the RA is chosen *ex ante* by nature and is known only to the rating agency itself. The *reputation* of the rating agency is defined as the probability that it is honest, denoted by $q_i, i \in \{1, 2\}$.

⁸This is a standard simplifying assumption in the literature. See Mathis, McAndrews, and Rochet (2009) and Skreta and Veldkamp (2008).

⁹New York Times Magazine, Triple-A-Failure, April 27, 2008.

¹⁰Given the structure of the market, with Moody’s and S&P controlling nearly 80% of the market, we believe that this is a reasonable approximation of reality.

The reputation evolves over time depending on the ratings and outcome of the projects. The *strategic* variable for the RA is x_i , the probability the RA issues a GR to a bad project.¹¹

The investors (and issuers) have some priors about the types of the RAs and they Bayesian update on their beliefs. Firstly, investors and issuers take into account the rating and update the reputation of the RA, before observing the outcome of the project. Given prior reputation q_t ,

$$\text{If RA issues GR, } q_t^{GR} = \frac{\lambda q_t}{\lambda + (1 - q_t)(1 - \lambda)x} < q_t \quad (1)$$

$$\text{If not rated, } q_{t+1}^N = \frac{q_t}{1 - x(1 - q_t)} > q_t \quad (2)$$

If the project is issued a good rating by the RA, the investors update their beliefs after observing the outcome of the project.

$$\text{If the project succeeds, } q_{t+1}^S = \frac{\lambda p_G q_t}{\lambda p_G q_t + \lambda p_G (1 - q_t)} = q_t \quad (3)$$

$$\text{If the project fails, } q_{t+1}^F = \frac{\lambda(1 - p_G)q_t}{\lambda(1 - p_G)q_t + [\lambda(1 - p_G) + (1 - \lambda)x](1 - q_t)} < q_t \quad (4)$$

We make the simplifying assumption that each issuer can only approach one RA for rating. Thus we abstract away from *multiple ratings*, *herd behaviour* by RAs and *ratings-shopping* by the issuers. While these are important issues that merit attention, they are not the focus of this paper. Here we look at the competition for market share among rating agencies and show that ratings inflation increases with competition.

Investors observe the rating decision and decide whether to invest. If they observe a GR from a RA with reputation q , their subjective belief that the project will succeed

¹¹Note that the strategic RA will always issue GR to a good project (see section 3).

(using equation (1)) is given by

$$\begin{aligned}
s(q, x) &= q^{GR}p_G + (1 - q^{GR})\frac{\lambda p_G}{\lambda + (1 - \lambda)x} \\
&= \frac{\lambda q}{\lambda + (1 - q)(1 - \lambda)x}p_G + \left(1 - \frac{\lambda q}{\lambda + (1 - q)(1 - \lambda)x}\right)\frac{\lambda p_G}{\lambda + (1 - \lambda)x} \\
&= \frac{\lambda p_G}{\lambda + (1 - q)(1 - \lambda)x}
\end{aligned} \tag{5}$$

Given the required investment level X , investors are willing to finance the project *if and only if* $X \leq s(q, x)\Phi$, *i.e.* if the initial investment required for the project is no greater than its expected pay-off. Without loss of generality, assume $s(q_1, x_1) > s(q_2, x_2)$. We have 3 cases:

1. If X is such that a good rating from either RA is enough, *i.e.* $X \leq s(q, x)\Phi$ for both q_1 and q_2 , the firm can approach either RA.¹² We assume that in this case the firm will randomly choose one of the RAs, *i.e.* the project goes to both RAs with equal probability.¹³
2. If $s(q_2, x_2)\Phi < X < s(q_1, x_1)\Phi$, *i.e.* only the high reputation RA can issue ratings that can convince the investors to provide financing, hence the firm will go to RA1 and not RA2.
3. If $X > s(q_1, x_1)\Phi$, the project does not get financed.

¹²We assume that the issuers are only paid when projects succeed. This implies that the issuers will be indifferent between RAs (with different reputation) given that both can guarantee financing.

¹³Note that this is one of infinite many possible equilibria. Since the issuers are indifferent, we have an equilibrium for all probabilities ($\alpha \in (0, 1)$) of approaching a specific RA. We focus on the case where $\alpha = \frac{1}{2}$. Our qualitative results do not depend on the choice of α .

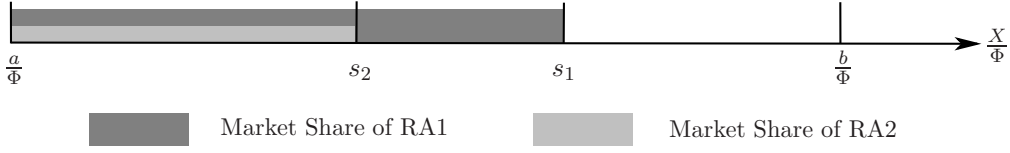


Figure 1: The Market for Ratings

Thus we get the following result as illustrated in Figure 1 -

$$\text{Probability that a project comes to RA1} = \frac{(s_1 - s_2) + \frac{1}{2}(s_2 - \frac{a}{\Phi})}{\frac{b}{\Phi} - \frac{a}{\Phi}}$$

$$\text{Probability that a project comes to RA2} = \frac{\frac{1}{2}(s_2 - \frac{a}{\Phi})}{\frac{b}{\Phi} - \frac{a}{\Phi}}$$

We set $(a, b) = (\lambda p_G \Phi, p_G \Phi)$, because any project with $X < \lambda p_G \Phi$ does not need a rating to be financed, and any project with $X > p_G \Phi$ is never worth financing *ex-ante*. Substituting, we get

$$\text{The probability that a project comes to RA1} = \frac{s_1 - \frac{1}{2}(s_2 + \frac{a}{\Phi})}{p_G(1 - \lambda)} \quad (6)$$

$$\text{The probability that a project comes to RA2} = \frac{\frac{1}{2}(s_2 - \frac{a}{\Phi})}{p_G(1 - \lambda)} \quad (7)$$

Reputation plays a critical role in our model. The market share of the RAs depends on s , and thus on reputation q . Since the income from giving a GR is constant (denoted by I), the future profits of the RA will solely depend on its market share. Moreover, the RA with a higher reputation enjoys additional benefits of being the market leader, because it owns entirely the proportion of the market that cannot be possibly rated by its competitor but can be rated by itself, whereas its competitor can only share its market with the leader. This creates incentives for RAs to maintain or gain the market leader position and hence disciplines the RAs through competition.

We can now see that competition (modelled through market share) has two effects

on lax behaviour: the market-sharing effect and the disciplining effect. The market-sharing effect refers to the fact that the RA finds lying and receiving income today more attractive as its expected future income is shared with another RA, and the disciplining effect refers to the fact that the RA finds lying less attractive in order to maintain/gain the advantages of being a market leader. We will show later that the market-sharing effect tends to dominate the disciplining effect and hence competition aggravates the lax behaviour of RAs in general.

3 Equilibrium Definition

Definition 1. *The equilibrium in our model is a set of strategies such that: At each period t , the strategic RA always*

- (i) *Gives a good rating to a good project.*
- (ii) *Gives a good rating to a bad project with probability x_t , where $0 \leq x_t \leq 1$.*

The strategic RA does not have any incentives to deviate from the above strategy.

Let RA1 be a strategic RA and let $V_t(q_1, q_2)$ denote its discounted future profits, given its reputation q_1 and its competitor's reputation q_2 , and let δ be the discount rate. The RA's new reputation after it gives NR and the failure of a project following a GR are denoted by q_1^N and q_1^F respectively.¹⁴ Note that q_1^F and q_1^N are functions of the strategy of the RA and its current reputation level. For notational simplicity, we suppress the time subscript of these reputation-updating functions.

Figure 2 shows the decision tree of RA1. Suppose it is approached for rating. If the project is good, RA1 gives it a GR and gets income I .¹⁵ On the other hand, if the project is bad, RA1 strategically decides whether to give a GR and get fees I or refuse

¹⁴A successful project with a GR leaves the RA's reputation unchanged.

¹⁵see Proposition 2

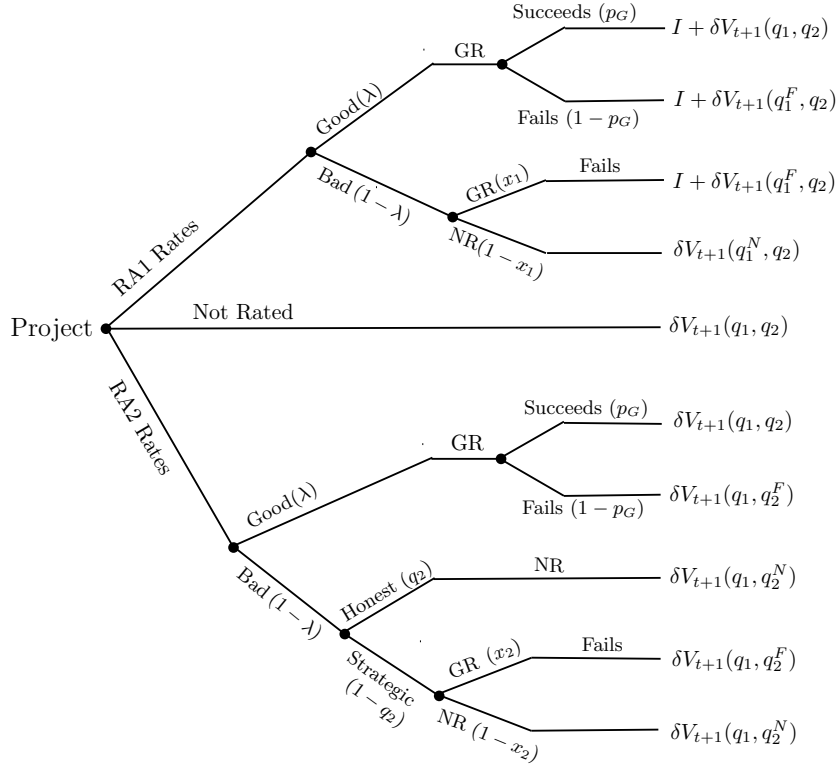


Figure 2: Decision Tree for strategic RA1

rating. In case of NR, RA1's reputation rises as it gets a larger market share in the future. In case of a GR, RA1's reputation falls if the project fails and remains the same if it succeeds. This in turn determines the RA1's expected future income. A similar analysis applies if RA2 is approached for rating. In this case the fees go to RA2 and RA1 is only indirectly affected through a change in RA2's reputation. Note that since RA1 does not know the type of RA2, it has to take into account the possibility that RA2 is either honest or strategic.

$$\begin{aligned}
V_t(q_1, q_2) = & P(RA1rates) \left\{ P(Good) [I + p_G \delta V_{t+1}(q_1, q_2) + (1 - p_G) \delta V_{t+1}(q_1^F, q_2)] \right. \\
& \left. + P(Bad) [x_1(q_1, q_2) (I + \delta V_{t+1}(q_1^F, q_2)) + (1 - x_1(q_1, q_2)) \delta V_{t+1}(q_1^N, q_2)] \right\} \\
& + P(RA2rates) \left\{ P(Good) [p_G \delta V_{t+1}(q_1, q_2) + (1 - p_G) \delta V_{t+1}(q_1, q_2^F)] \right. \\
& \left. + P(Bad) [(1 - q_2) x_2(q_1, q_2) \delta V(q_1, q_2^F) + [q_2 + (1 - q_2)(1 - x_2(q_1, q_2))] \delta V(q_1, q_2^N)] \right\} \\
& + P(NotRated) \delta V_{t+1}(q_1, q_2) \quad (8)
\end{aligned}$$

The objective function of RA1 is to maximise $V_t(q_1, q_2)$, the choice variable being x_1 . Note that RA1's choice variable is only effectual when it rates a bad project. In all other cases, RA1's strategy is inconsequential.

Proposition 1. *There exists a unique x_1 , where $0 \leq x_1 \leq 1$, given that $V_t(q_1, q_2)$ is an increasing function in q_1 .*

Proof. See Appendix A.1 □

Intuitively, it is easy to see from equation (8) that $V_t(q_1, q_2)$ is linear in x_1 . This ensures that RA1's maximisation problem has a unique solution.

Proposition 2. *A strategic RA does not have incentives to give NR to a good project.*

Proof. See Appendix A.2 □

Proposition 2 implies that a strategic RA always gives GR to a good project. This is because it gets a lower pay-off if it deviates from this strategy and gives a NR to a good project. The proposition follows directly from the pay-off structure of the RAs and the beliefs.

Proposition 3. *There exists a unique equilibrium as described in Definition 1.*

Proof. Follows from propositions 1 and 2. □

Corollary 1. *Assume $p_G < 1$. Then the equilibrium strategy of the strategic RA is always positive.*

Proof. See Appendix A.3 □

Corollary 2. *Suppose the model ends in period T . Then the equilibrium strategy of the strategic RA is $x = 1$ at $t = T - 1, T$.*

Proof. See Appendix A.4 □

We now solve the model numerically in infinite horizon. We present an analytical solution in a finite period setting in Appendix A.5.

4 Model Solution

We now present the numerical solution of the model in infinite horizon. The numerical solution is computed using backward induction, *i.e.* we first solve the model in the finite period case, and then increase the number of periods so that the equilibrium strategy converges to the infinite horizon solution.

In an infinite period setting, V_t by itself is independent of t . Hence we suppress the time subscript for notational simplicity. However, the reputations evolve over time as investors (and issuers) update their beliefs. Let RA1 be the rating agency that behaves

strategically. Then, RA1's value function takes the following form:

$$\begin{aligned}
V(q_1, q_2) = & \frac{\frac{1}{2}(s_1 - \frac{a}{\Phi})}{(1-\lambda)p_G} \left\{ \lambda \left[I + p_G \delta V(q_1, q_2) + (1-p_G) \delta V(q_1^F, q_2) \right] + \right. \\
& (1-\lambda) \left[x_1(q_1, q_2) (I + \delta V(q_1^F, q_2)) + (1-x_1(q_1, q_2)) \delta V(q_1^N, q_2) \right] \left. \right\} \\
& + \frac{s_2 - \frac{1}{2}(s_1 + \frac{a}{\Phi})}{(1-\lambda)p_G} \left\{ \lambda \left[p_G \delta V(q_1, q_2) + (1-p_G) \delta V(q_1, q_2^F) \right] + \right. \\
(1-\lambda) \left[& (1-q_2) x_2(q_1, q_2) \delta V(q_1, q_2^F) + [q_2 + (1-q_2)(1-x_2(q_1, q_2))] \delta V(q_1, q_2^N) \right] \left. \right\} \\
& + \frac{p_G - s_2}{(1-\lambda)p_G} \delta V(q_1, q_2) \quad (9)
\end{aligned}$$

where $\frac{\frac{1}{2}(s_1 - \frac{a}{\Phi})}{(1-\lambda)p_G}$ is the probability that the issuer approaches RA1 for rating, $\frac{s_2 - \frac{1}{2}(s_1 + \frac{a}{\Phi})}{(1-\lambda)p_G}$ is the probability that the issuer approaches RA2 and $\frac{p_G - s_2}{(1-\lambda)p_G}$ is the probability that the project is not rated by either RA.

We assume that the model ends at period T and solve the model backwards. We know that the strategic RA will always lie at period T and $T-1$ according to Corollary 2. For all $t < T-1$, the strategy of the RA depends on its own and its competitors' reputation. We solve for the Nash equilibrium strategy of the RA described in Section 3. We look at the pay-offs from lying and being honest and determine the strategy. As long as $I + V_t(q_1^F, q_2) > V_t(q_1^N, q_2)$ for $x_t = 1$, RA1 will always choose to lie. Conversely, if $I + V_t(q_1^F, q_2) < V_t(q_1^N, q_2)$ for $x_t = 0$, RA1 will always tell the truth. In all other intermediate cases, there exists a unique x_t s.t. $I + V_t(q_1^F, q_2) = V_t(q_1^N, q_2)$ at which RA1 is indifferent between lying or not. Hence we deduce inductively the equilibrium strategies of RA1. As T goes to infinity, we approach the infinite horizon solution.¹⁶

Using this procedure, we solve the model for various parameter values. At the first

¹⁶Since $\delta < 1$, the Blackwell conditions are satisfied.

instance, we solve the model for a monopolistic RA. Next, we introduce competition in the form of RA2 and show that the additional competitive element is not sufficient to discipline the RAs. Furthermore, our results show that competition will in fact increase ratings inflation.

4.1 Monopolistic RA

First we consider the case where there is only one RA in the market. In order to make RA1 a monopolist, we set the reputation of RA2 to 0.

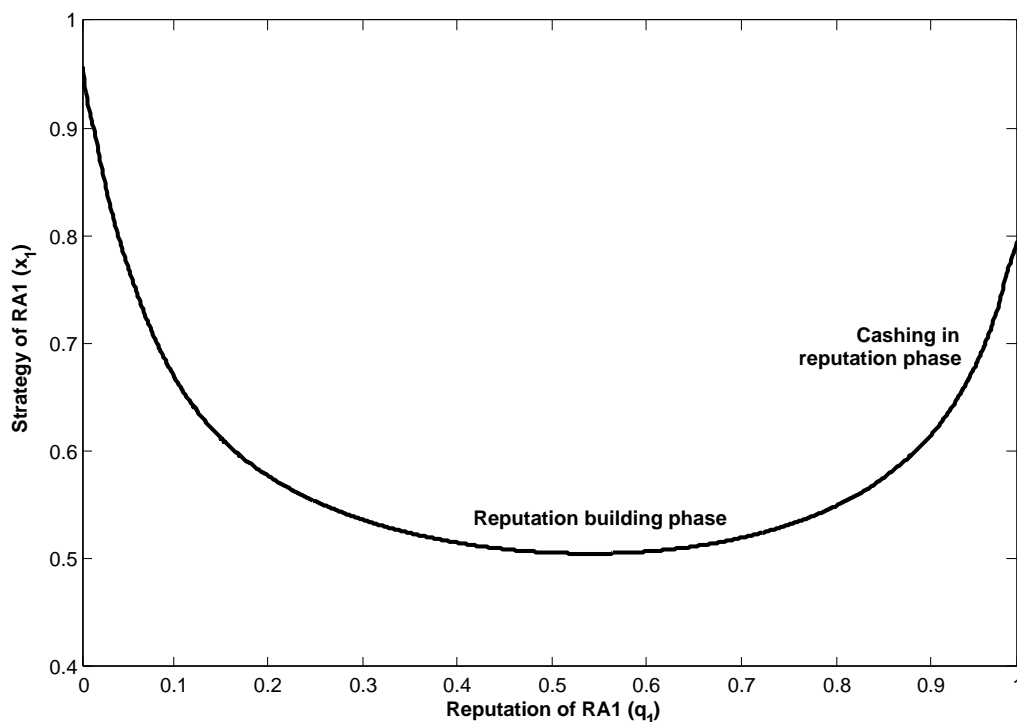


Figure 3: Strategy vs Reputation, Monopolistic RA $(\lambda, p_G, \delta, q_2) = (0.5, 0.7, 0.9, 0)$

Figure 3 plots the strategy of the monopolistic RA for parameters $(\lambda, p_G, \delta) = (0.5, 0.7, 0.9)$.¹⁷ We can clearly see the strategy of RA1 is ‘u-shaped’ in its reputation and it tends to lie more when its reputation is very high or very low. Intuitively, the

¹⁷Note that our qualitative results are robust to parameter specification.

RA's strategy is determined by the trade-off between current fees and expected future income. When its reputation is very low, the RA's expected future income is very small compared to current fees, hence it has little incentive to behave honestly. When its reputation increases, the RA's future income becomes larger while current fees stay the same, the RA tends to lie less. However, when the RA's reputation becomes very high, the penalty for lying decreases, therefore the RA starts to lie more. The reason that the penalty for lying decreases with reputation is that investors attribute project failures to bad luck rather than lax behaviour when they believe that the RA is very likely to be of the honest type.

4.2 Competitive RA

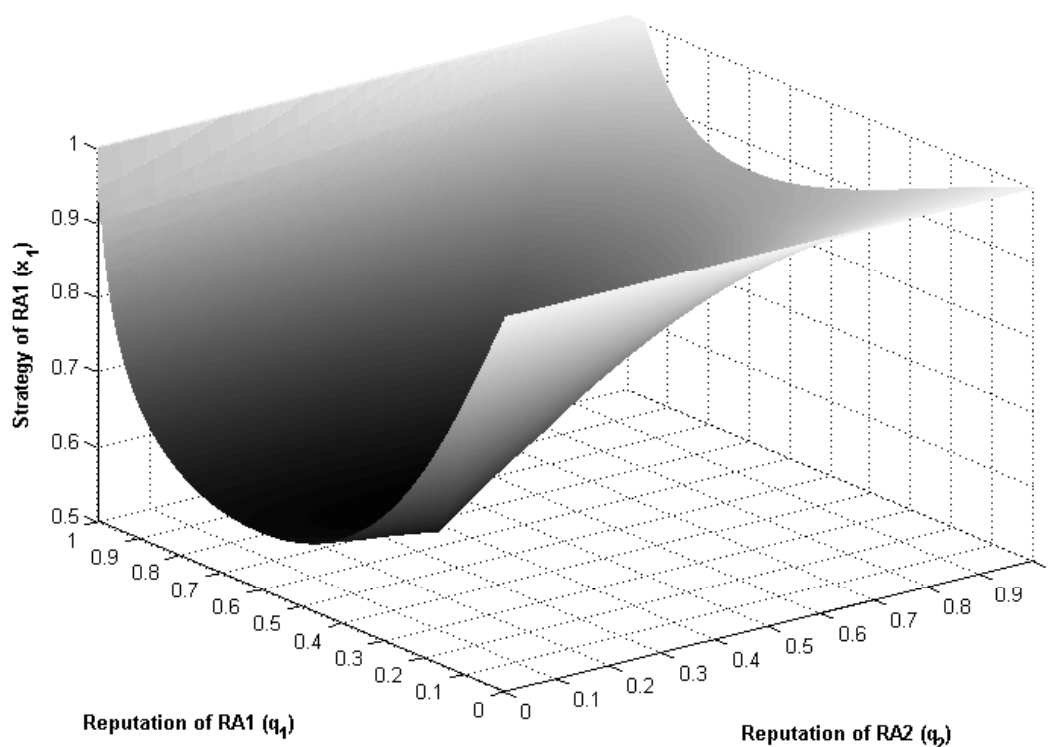


Figure 4: Strategy vs Reputation, $(\lambda, p_G, \delta) = (0.5, 0.7, 0.9)$

We now look at the impact of competition on the behaviour of rating agencies by

introducing a second RA (RA2). Figure 4 plots the strategy of RA1 for parameter values $(\lambda, p_G, \delta) = (0.5, 0.7, 0.9)$. Figures 5 and 6 show cross-sections of this figure, for different values of q_2 and q_1 respectively.

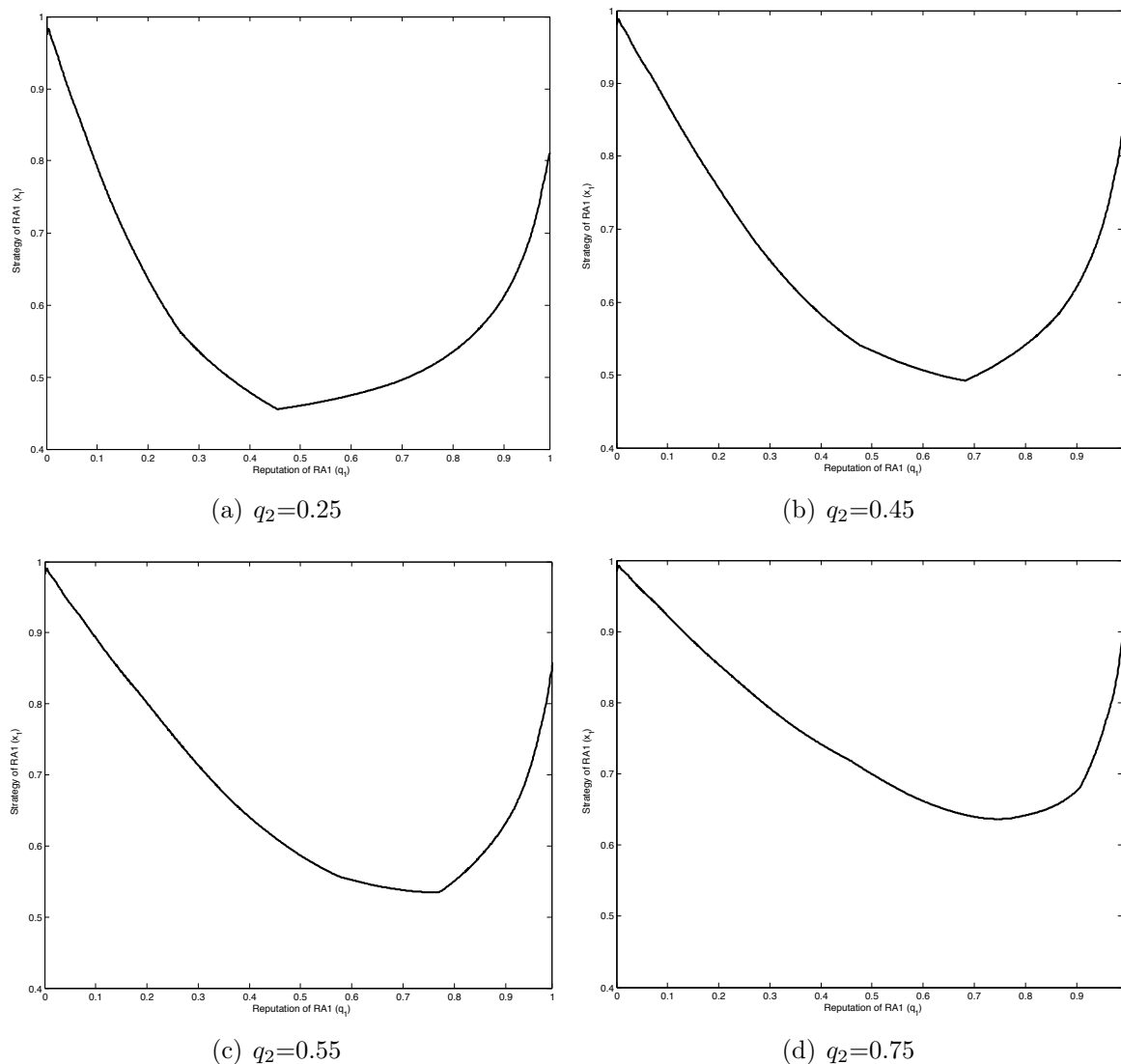


Figure 5: Strategy vs Reputation, $(\lambda, p_G, \delta) = (0.5, 0.7, 0.9)$, different values of q_2

Figure 5 shows the relationship between the reputation and strategy of RA1 for different values of the competing RA2's reputation. As we can see, the relationship between the reputation and strategy of RA1 remains 'u-shaped' as in the monopolistic case. Moreover, as the reputation of RA2 increases, the reputation at which RA1 has

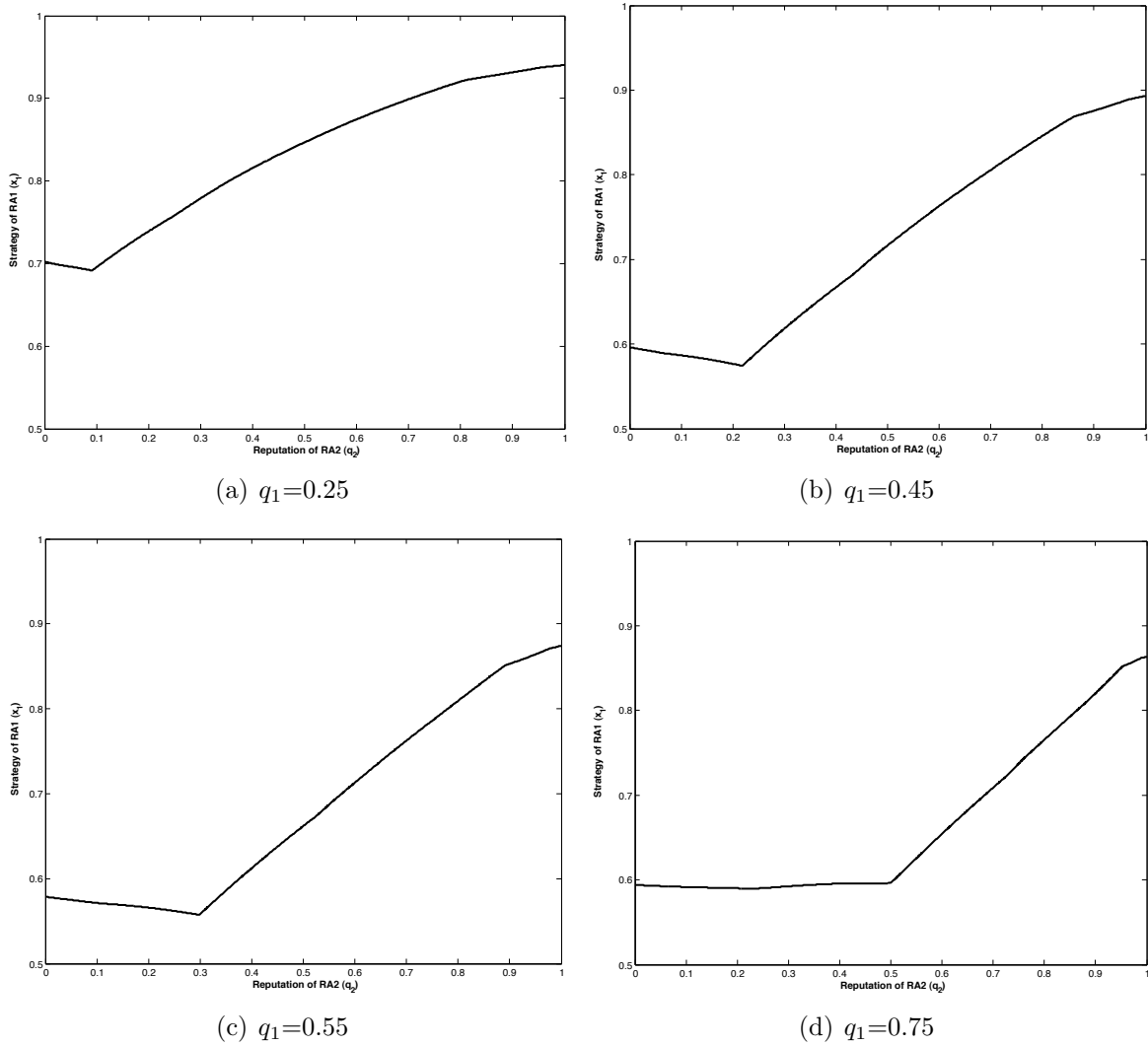


Figure 6: Strategy vs Reputation, $(\lambda, p_G, \delta) = (0.5, 0.7, 0.9)$, different values of q_1

minimum x_1 , *i.e.* is least likely to lie, also increases. This is not surprising as the disciplining effect is greatest when the reputation of the competing RA (RA2) is close to the reputation of RA1. This is because when the RAs' reputations are close, it is more likely that the market leadership will change, resulting in more disciplined behaviour. Conversely, if the two RAs have very different reputations, the disciplining effect is relatively weaker.

Moreover, as Figure 6 shows, the strategy of RA1 is initially decreasing with or flat

in RA2's reputation, and then increasing. This effect of competition is a combination of the disciplining effect and the market-sharing effect. The disciplining effect is strongest when the two RA's reputations are close, and weakest when the two RA's reputations are far apart, which implies that the probability of a change of market leader is very small. On the other hand, the market-sharing effect is always increasing in the competing RA's reputation. When the reputation of RA2 is low, the market-sharing effect is very small as RA2 can only take away a tiny fraction of market share. As RA2's reputation starts to increase, RA1 tends to lie less as the disciplining effect dominates the market-sharing effect. However, when RA2's reputation goes beyond a certain level, the market-sharing effect dominates as RA2's reputation becomes much higher than RA1's. Hence RA1 will lie more for high values of RA2's reputation, due to the dominance of the market-sharing effect.

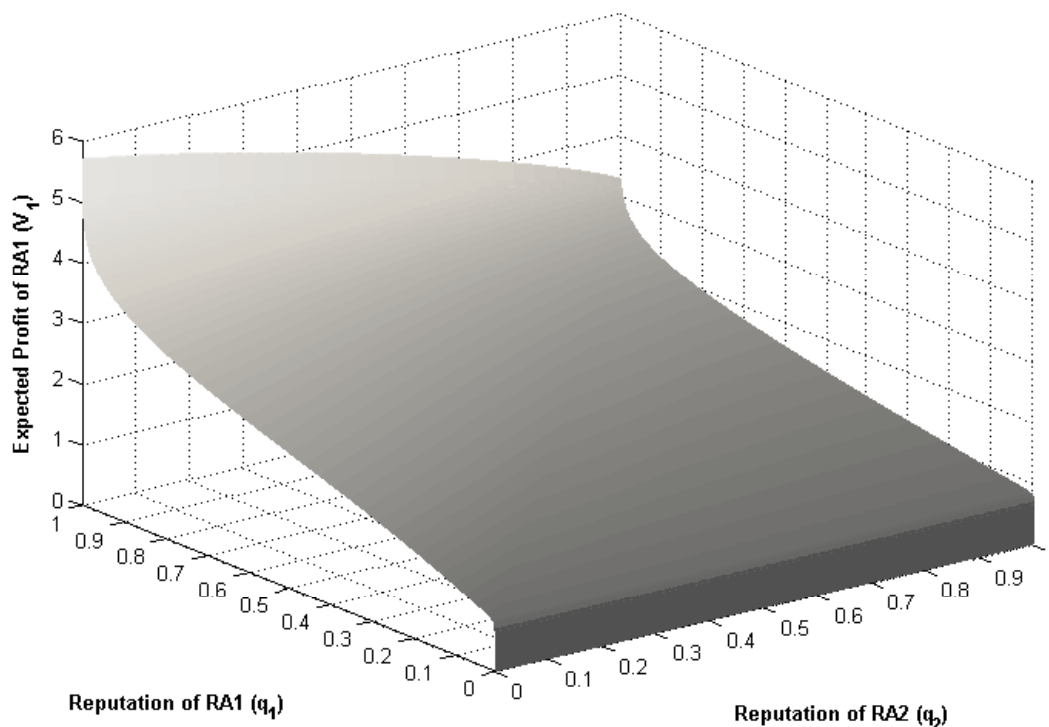


Figure 7: Expected Profits vs Reputation, $(\lambda, p_G, \delta) = (0.5, 0.7, 0.9)$

Figures 7 and 8 show the expected profits of RA1 as a function of RA1 and RA2's

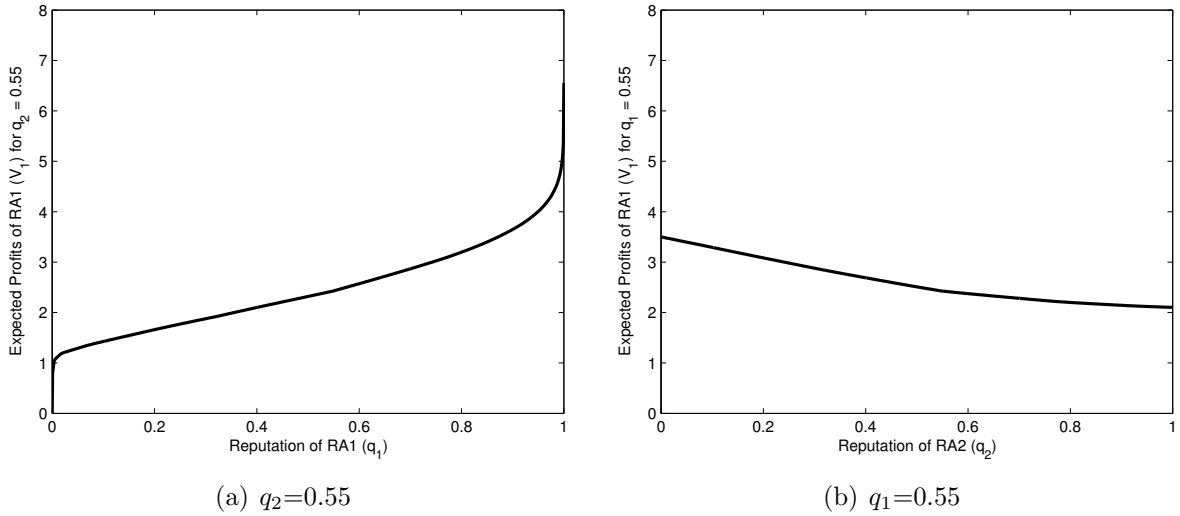


Figure 8: Expected Profits vs q_1 and q_2 , $(\lambda, p_G, \delta) = (0.5, 0.7, 0.9)$

reputation. We can clearly see that the expected profits of RA1 is increasing in its own reputation, and decreasing in its competitor's reputation, illustrating the market-sharing effect.

Finally, Figure 9 shows the convergence dynamics. It plots the change in RA1's strategy as the number of periods remaining increases. Reputation becomes less and less important as the number of periods remaining declines since there are fewer periods to reap the benefits of higher reputation. Thus ratings inflation increases. Note that as the number of periods remaining increases, the strategy converges, implying that we approach a long (infinite) horizon equilibrium.

In summary, our results show that introducing competition in the form of a second RA is not sufficient to discipline the RAs which always lie with positive probability in equilibrium. We now show that competition will actually increase the lax behaviour of RAs and reduce expected welfare.

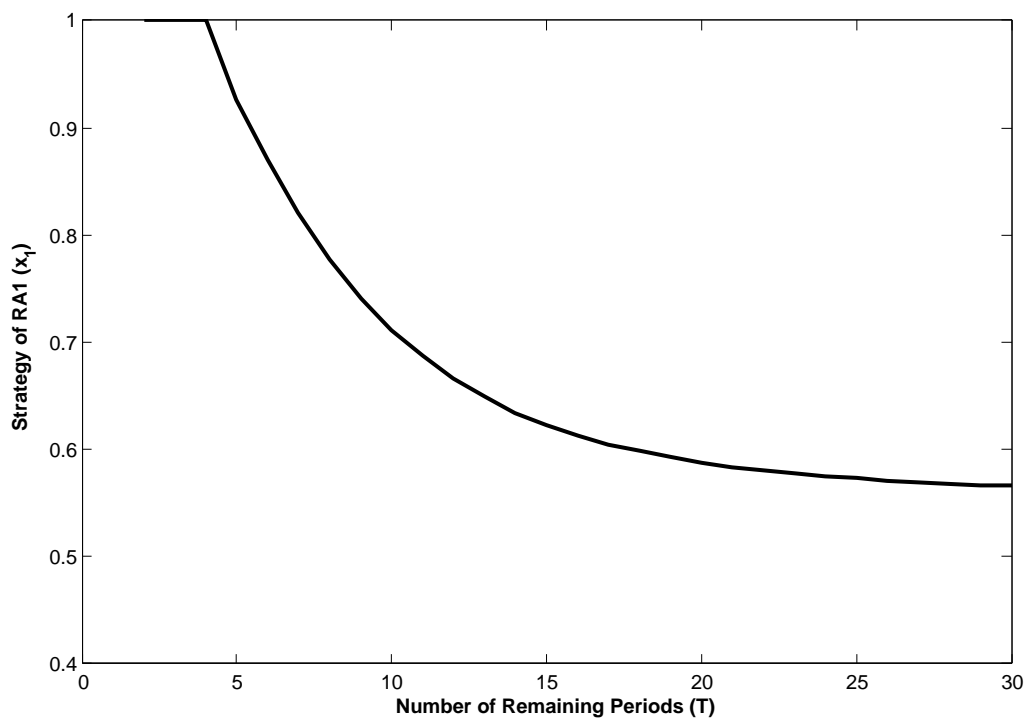
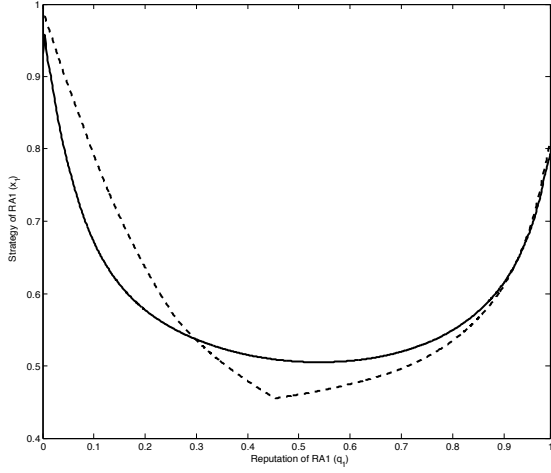


Figure 9: Convergence Dynamics of RA1

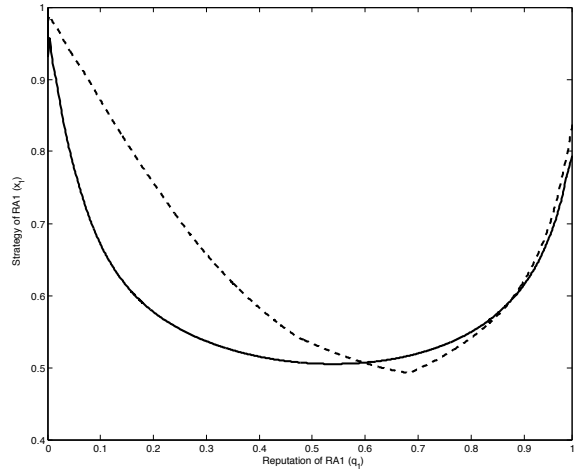
4.3 Comparing Monopolistic and Competitive RA

It is often suggested that introducing more competition in the ratings industry can alleviate the problem of improper incentives and ratings inflation. However, our results show that competition is likely to worsen this situation and lead to more ratings inflation.

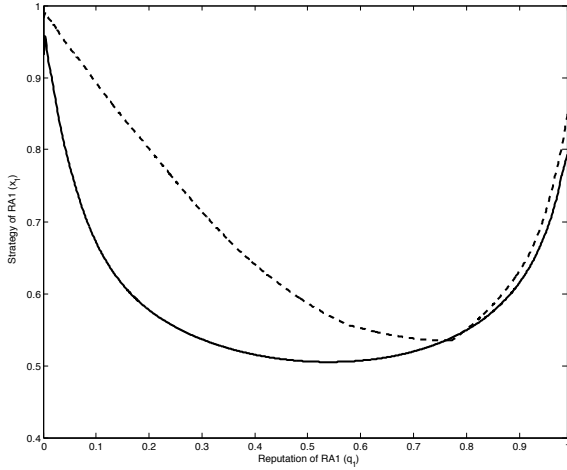
Figure 10 compares the strategic behaviour of RA1 under no competition, *i.e.* monopolistic RA ($q_2 = 0$), and under a competitive setting with different values of q_2 . We observe that in most cases, RA1 is prone to greater ratings inflation relative to the monopolistic RA.



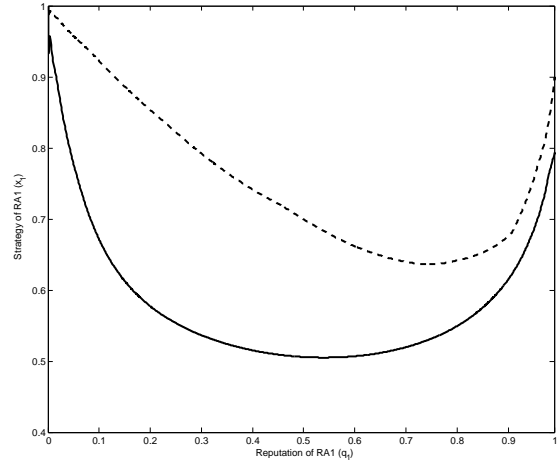
(a) $q_2=0.25$



(b) $q_2=0.45$



(c) $q_2=0.55$



(d) $q_2=0.75$

Figure 10: Comparing Monopolistic and Competitive RA, $(\lambda, p_G, \delta) = (0.5, 0.7, 0.9)$

Solid line represents monopolistic RA while dashed line represents competitive RA with different values of q_2

As described before, the implication of competition can be divided into the market-sharing effect and the disciplining effect. We can see that the market-sharing effect dominates the disciplining effect (*i.e.* competition aggravates lax behaviour) in most cases. The only case where competition may actually alleviate the lax behaviour of RA1 is when q_2 is very low (as shown in Figure 10(a)). This is because the market-sharing

effect is weakest relative to the disciplining effect for low values of q_2 . Intuitively, the disciplining effect only depends on the difference between q_1 and q_2 , whereas the market-sharing effect increases with the absolute level of q_2 . Hence the market-sharing effect tends to dominate the disciplining effect except for low values of q_2 .

In order to assess the overall impact of competition, we compute the expected increase in lax behaviour of RA1 given its own reputation, assuming that the reputation of RA2 is uniformly distributed on $[0, 1]$. A positive value of this measure means the overall effect of enhanced competition on RA1 is to lie more (*i.e* inflate ratings more).

$$\text{Excess Lax Behaviour of RA1} = \int_{q_2 \in [0,1]} x_1(q_1, q_2) dq_2 - x_1(q_1, 0) \quad (10)$$

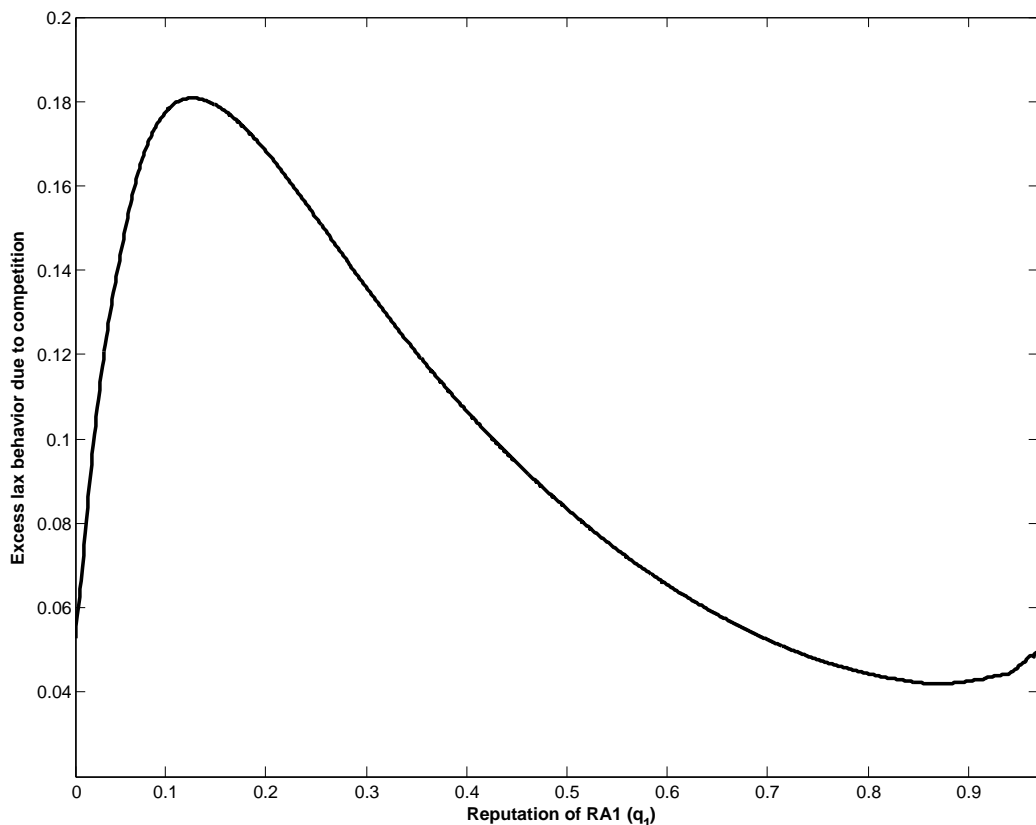


Figure 11: Excess Lax Behaviour of RA1 Due to Competition

As shown in Figure 11, the expected increase in lax behaviour of RA1 is always

positive, indicating that competition will, in general, aggravate ratings inflation. This is because a smaller market share will tend to reduce the reputational concerns of the RAs, and this market-sharing effect outweighs the disciplining effect brought by competition. Moreover, we can see that the expected increase in lax behaviour is increasing for low values of RA1's own reputation and decreasing for high values of RA1's reputation. The intuition is that, when the reputation of RA1 is low, the market share of RA1 is going to shrink significantly after introducing RA2 and the market-sharing effect of competition is strongest. However, when the reputation of RA1 is high, the impact of introducing RA2 on RA1's market share is small, hence the market-sharing effect becomes weaker and RA1 will lie relatively less.

In addition, we measure the expected total welfare in the monopolistic and duopolistic settings as defined below.

$$\begin{aligned}
\text{Expected Total Welfare} &= E(\text{Project Payoff}) - E(\text{Financing Cost}) \\
&= P(\text{RA1 rates}) \left(P(\text{Good})\Phi - E(X)(P(\text{Good}) + P(\text{Bad})(1 - q_1)x_1) \right) \\
&\quad + P(\text{RA2 rates}) \left(P(\text{Good})\Phi - E(X)(P(\text{Good}) + P(\text{Bad})(1 - q_2)x_2) \right)
\end{aligned}$$

Figure 12 compares the total welfare¹⁸ between the monopolistic case and the duopolistic case where both RAs have the same reputation. We can see that if a new RA is introduced with the same reputation as the incumbent RA, then the total welfare will always decrease, due to the fact that both RAs are more likely to inflate ratings.

¹⁸We are computing the welfare in one period only because it does not depend on time.

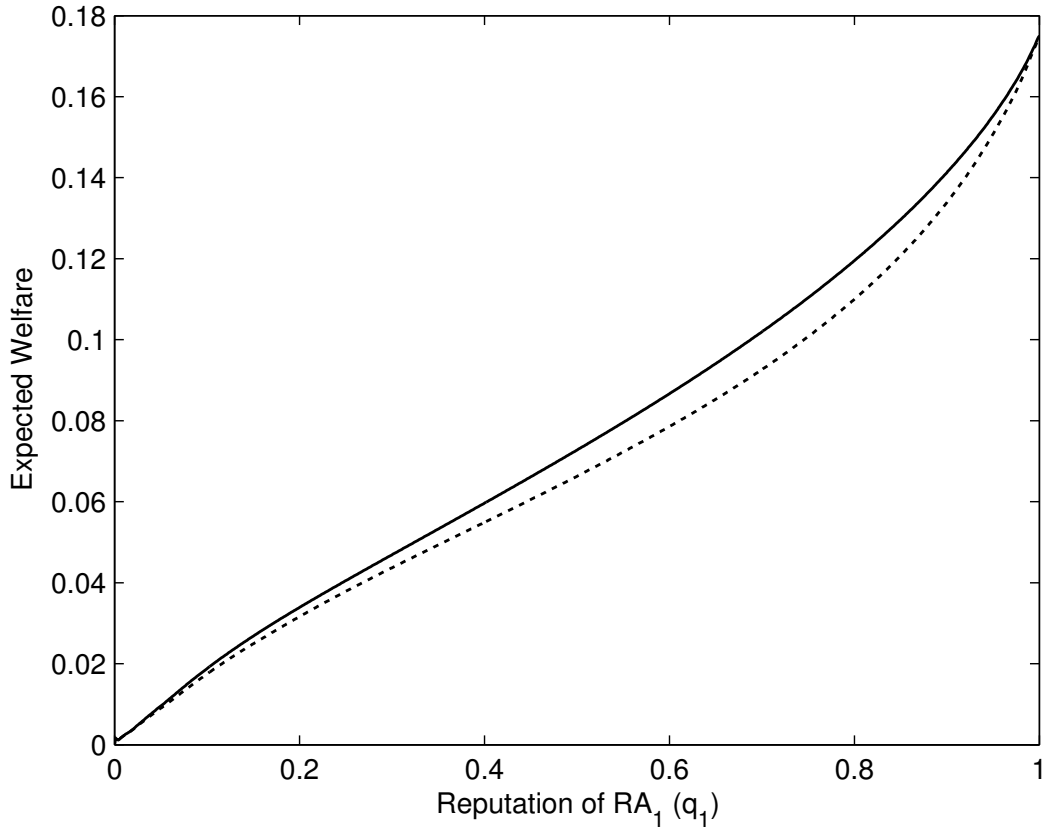


Figure 12: Expected Welfare - Competitor has same Reputation
 Solid line represents monopoly while dashed line represents duopoly with $q_1 = q_2$

Moreover, we compare in Figure 13 the expected total welfare between the monopolistic case and the duopolistic case with fixed values of reputations of RA2. We can see that introducing competition will always lead to lower total welfare as long as the reputation of RA2 is lower than the reputation of RA1.¹⁹ More importantly, even when RA2 has a higher reputation than RA1, the total welfare may still decrease in some cases. This implies that competition may adversely impact total welfare even when we introduce a new RA with higher reputation.

¹⁹The reason that total welfare may increase for very low values of q_1 is that we are introducing a new RA that is much more likely to be honest.

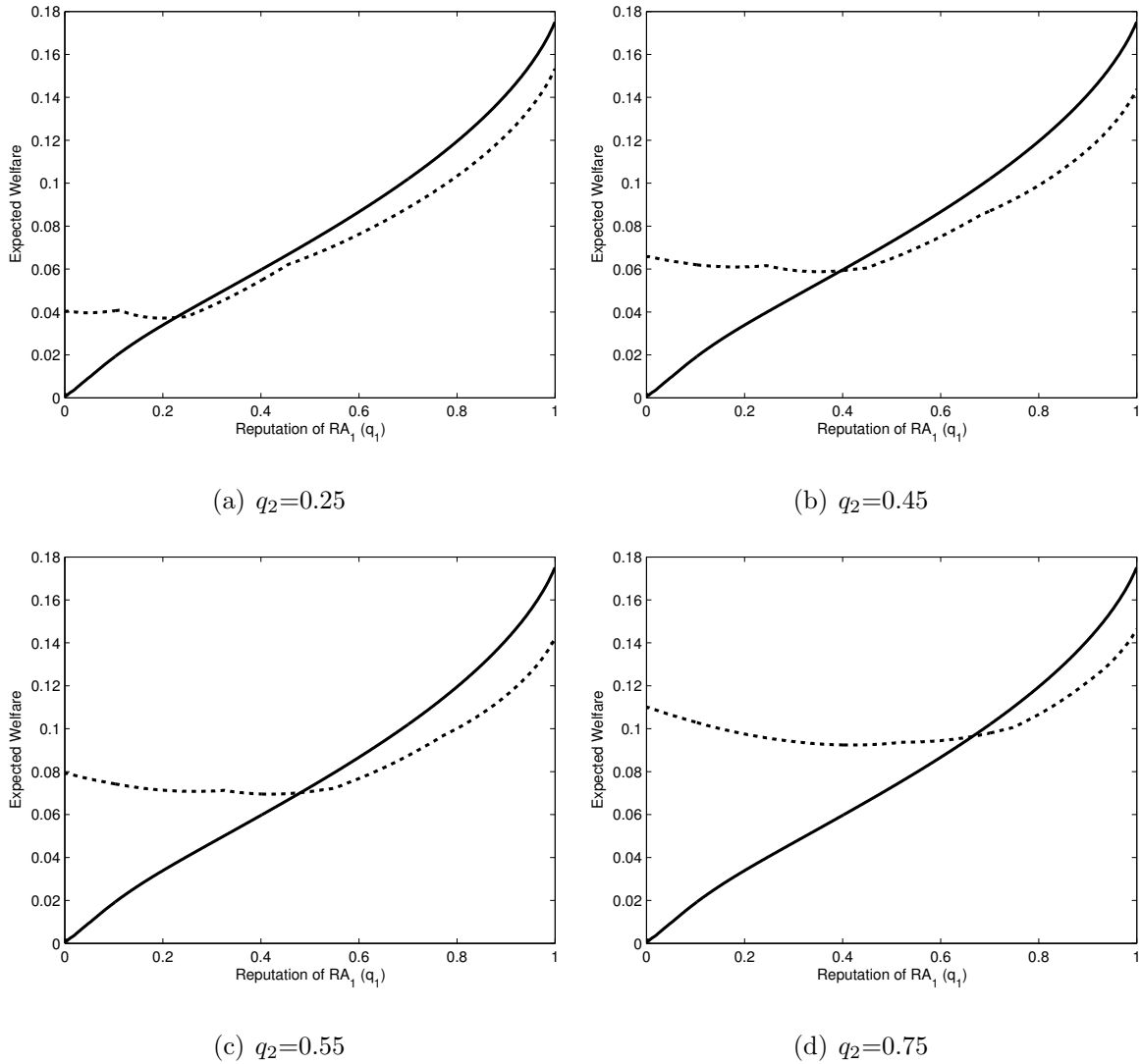


Figure 13: Expected Welfare - Competitor has Different Reputation

Solid line represents monopoly while dashed line represents duopoly for different values of q_2

5 Conclusion

In this paper we show that competition tends to amplify the lax behaviour of rating agencies and reduce total welfare. This result has important policy implications since it suggests that the most often cited solution to ratings inflation - enhanced competition in the ratings industry - is likely to render the situation worse.

While we acknowledge that in order to focus on the implications of competition in the rating agency industry, we have abstracted from other important issues such as herd behaviour, ratings-shopping and the quality of the models used by rating agencies, we hope that our results can serve as a baseline for evaluating the reform proposals currently being discussed. In conjunction with related work on rating shopping and herd behaviour in the rating industry, our results suggest that a fundamental reorganisation of the ratings industry may be required to align the incentives. The conflict of interest highlighted in our paper is fundamental to the issuer-pay model and any meaningful attempt to resolve the conflict would require a fundamental shift in the way rating agencies are compensated.²⁰

²⁰See Deb and Murphy (2009) for a detailed study of the policy implications of our results and a proposal to reorganise the ratings industry.

A Appendix

A.1 Proof of Proposition 1

There exists a unique x_1 , where $0 \leq x_1 \leq 1$, given that $V_t(q_1, q_2)$ is an increasing function in q_1 .

Proof. When the strategic RA (RA1) gets a bad project, it will get pay-off $\Psi(\textit{lie}) = I + \delta V_t(q_1^F, q_2)$ if it gives the project a GR, and $\Psi(\textit{honest}) = \delta V_t(q_1^N, q_2)$ if it refuses rating. Note that $q_1^F = \frac{\lambda(1-p_G)q_t}{\lambda(1-p_G)+(1-\lambda)(1-q_1)x_1}$ and $q_1^N = \frac{q_t}{1-x_1(1-q_t)}$, *i.e.* q_1^F is decreasing in x_1 and q_1^N is increasing in x_1 . Given that $V_t(q_1, q_2)$ is increasing in q_1 , it is easy to see that $\Psi(\textit{lie})$ is decreasing in x_1 and that $\Psi(\textit{honest})$ is increasing in x_1 . Thus if we define x_1 such that

- $x_1 = 1$ if $\Psi(\textit{lie}) \geq \Psi(\textit{honest})$
- $x_1 = 0$ if $\Psi(\textit{lie}) \leq \Psi(\textit{honest})$ for
- $x_1 = x_1^*$ such that $0 < x_1^* < 1$ if $\Psi(\textit{lie}) = \Psi(\textit{honest})$

it follows that x_1 is well-defined and unique. □

A.2 Proof of Proposition 2

The strategic RA does not have incentives to give NR to a good project.

Proof. Suppose that the strategic RA (RA1) gets a good project and that its strategy is x_1 . Let's examine whether RA1 wants to deviate:

- if $x_1 = 1$, we have $\Psi(\text{lie}) \geq \Psi(\text{honest})$, or $I + \delta V_t(q_1^F, q_2) \geq \delta V_t(q_1^N, q_2)$. If the RA1 gives NR to the good project, it will get $\delta V_t(q_1^N, q_2)$, and $I + p_G \delta V_t(q_1, q_2) + (1 - p_G) \delta V_t(q_1^F, q_2)$ otherwise. Since $I + p_G \delta V_t(q_1, q_2) + (1 - p_G) \delta V_t(q_1^F, q_2) \geq I + \delta V_t(q_1^F, q_2) \geq \delta V_t(q_1^N, q_2)$, RA1 does not want to deviate.
- if $x_1 = 0$, $q_1^N = q_1^F = q_1$, hence reputation becomes irrelevant and the RA does not have an incentive to give NR to the good project.
- if $0 < x_1 < 1$, we have $\Psi(\text{lie}) = \Psi(\text{honest})$, so $I + p_G \delta V_t(q_1, q_2) + (1 - p_G) \delta V_t(q_1^F, q_2) \geq I + \delta V_t(q_1^F, q_2) = \delta V_t(q_1^N, q_2)$, and hence RA1 does not want to deviate.

Therefore RA1 does not have incentives to give NR to a good project. □

A.3 Proof of Corollary 1

Assume $p_G < 1$. Then the equilibrium strategy of the strategic RA is always positive.

Proof. Suppose that the equilibrium strategy is $x_1 = 0$. Then $q_1^N = q_1^F = q_1$ and we must have $I + \delta V_t(q_1, q_2) \leq \delta V_t(q_1, q_2)$. This is impossible as long as $I > 0$. Hence $x_1 = 0$ cannot be an equilibrium strategy. □

A.4 Proof of Corollary 2

Suppose the model ends in period T . Then the equilibrium strategy of the strategic RA is $x_t = 1$ at $t = T - 1, T$.

Proof. At $t = T$, the strategic RA does not have any reputational concerns. This implies that the strategy of strategic RA will be to always give GR if the project is bad, *i.e.* $x_T = 1$.

Similarly, at $t = T - 1$ the strategic RA will always lie. Suppose that a bad project comes to strategic RA, say RA1. The expected pay-off of RA1 is

$$I + \delta V_{T-1}(q_1^F, q_2) = I + f(q_1^F, 1, q_2, 1)\delta I \quad (11)$$

if it lies, *i.e.* gives a good rating, and

$$\delta V_{T-1}(q_1^N, q_2) = f(q_1^N, 1, q_2, 1)\delta I \quad (12)$$

if it does not lie, *i.e.* gives no rating, where $f(q_1, x_1, q_2, x_2)$ is the probability that the project comes to RA1 in the next period. Using equations (5), (6) and (7) we have

- $f(q_1, x_1, q_2, x_2) = \frac{\frac{1}{2}\left(s(q_1, x_1) - \frac{a}{\Phi}\right)}{p_G(1-\lambda)}$ if $s(q_1, x_1) \leq s(q_2, x_2)$
- $f(q_1, x_1, q_2, x_2) = \frac{s(q_1, x_1) - \frac{1}{2}\left(s(q_2, x_2) + \frac{a}{\Phi}\right)}{p_G(1-\lambda)}$ otherwise

where $s(q, x) = \frac{\lambda p_G}{\lambda + (1-q)(1-\lambda)x}$.

Although in this case RA1 does have reputational concerns, these are not sufficient to prevent RA1 from being lax and not giving GR to bad projects. Since by being honest RA1 is giving up I today, in exchange for having a higher chance of getting I in the next period, it is not optimal for RA1 to be honest, given that RA1 is impatient (*i.e.* $\delta < 1$). Hence the optimal strategy of RA1 is to always lie, *i.e.* $x_{T-1} = 1$.

□

A.5 Finite Horizon Solution

We assume the model only lasts for three periods, $t = 1, 2, 3$, and the RAs maximise their expected total income over the three periods. We compute the equilibrium strategy of the RAs using backward induction. We already know that the strategic RA will always lie in the last two periods, as shown in Corollary 2.

We solve for the equilibrium strategy at $t = 1$. Again, let's look at the decision of RA1. Since RA1 will always lie at $t = 2, 3$, the expected pay-off of RA1 at $t = 1$ is

$$\begin{aligned} \Psi(\text{lie}) &= I + \delta V_2(q_1^F, q_2) = I + \delta f(q_1^F, 1, q_2, 1)I + \delta^2 \left(f(q_1^F, 1, q_2, 1) [\lambda p_G f(q_1^F, 1, q_2, 1) \right. \\ &\quad \left. + ((1 - p_G)\lambda + (1 - \lambda)) f(q_1^{FF}, 1, q_2, 1)] + f(q_2, 1, q_1^F, 1) [\lambda p_G f(q_1^F, 1, q_2, 1) \right. \\ &\quad \left. + (\lambda(1 - p_G) + (1 - \lambda)(1 - q_2)) f(q_1^F, 1, q_2^F, 1) + (1 - \lambda) q_2 f(q_1^F, 1, q_2^N, 1)] \right) I \quad (13) \end{aligned}$$

if it lies, and

$$\begin{aligned}
\Psi(\text{honest}) &= \delta V_2(q_1^N, q_2) = \delta f(q_1^N, 1, q_2, 1)I + \delta^2 \left(f(q_1^N, 1, q_2, 1)[\lambda p_G f(q_1^N, 1, q_2, 1) \right. \\
&\quad \left. + ((1 - p_G)\lambda + (1 - \lambda))f(q_1^{NF}, 1, q_2, 1)] + f(q_2, 1, q_1^N, 1)[\lambda p_G f(q_1^N, 1, q_2, 1) \right. \\
&\quad \left. + (\lambda(1 - p_G) + (1 - \lambda)(1 - q_2))f(q_1^N, 1, q_2^F, 1) + (1 - \lambda)q_2 f(q_1^N, 1, q_2^N, 1)] \right) I \quad (14)
\end{aligned}$$

if it is honest.

As described in Section 3, we look for a Nash equilibrium of the game by examining the trade-off facing RA1, *i.e.* the difference between expressions (13) and (14). If the pay-off from lying is greater then $x_1 = 1$ and we have a pure-strategy equilibrium in which RA1 always lies; if the pay-off from not lying is greater then $x_1 = 0$ and we have a pure-strategy equilibrium in which RA1 never lies; otherwise we have a mixed-strategy equilibrium in which RA1 is indifferent between lying and not lying, given some prior beliefs about its strategy, *i.e.* $0 < x_1 < 1$.

To derive an analytical solution to this game, we make a simplifying assumption that $p_G = 1$. This assumption implies that the reputation of the strategic RA goes to zero if it gives a GR to a bad project since now every good project succeeds and every bad project fails. This simplifies expressions (13) and (14) and allows us to derive the equilibrium strategy of RA1.

The expression of market share of RA1 depends on whether RA1 has a higher probability of success than its competitor. Given that the strategy of the strategic RA in

the last two periods is to always lie, the RA with a higher reputation will have a higher market share in any single period. Hence we compute the strategy of RA1 in different ranges of the reputation of RA2.

Proposition 4. *The equilibrium strategy at $t = 1$ assuming $p_G = 1$ is*

$$x_1 = \begin{cases} 0 & \text{if } A \leq \frac{\lambda q_1}{2(\lambda q_1 + (1 - q_1))} \\ 1 - \frac{(1 - 2A)\lambda q_1}{2A(1 - q_1)} & \text{if } \frac{\lambda q_1}{2(\lambda q_1 + (1 - q_1))} < A < \frac{1}{2} \\ 1 & \text{if } A \geq \frac{1}{2} \end{cases}$$

where A is the solution to the equation

$$\Psi(\text{lie}) - \Psi(\text{honest}) = I - \delta(2A - \min\{A, B\})I - \delta^2 \left(\lambda(2A - \min\{A, B\})^2 + (2B - \min\{A, B\})[\lambda(2A - \min\{A, B\}) + 2(1 - \lambda)(1 - q_2)A + (1 - \lambda)q_2A] \right) I = 0$$

$$\text{and } B = \frac{\frac{1}{2}(s(q_2, 1) - \frac{a}{\Phi})}{p_G(1 - \lambda)}.$$

Proof. Since $p_G = 1$, the reputation of RA1 (*i.e.* the strategic RA) will go to zero if it gives a GR to a bad project since now every good project succeeds and every bad project fails. So the expected pay-off from giving a GR to a bad project is I . This simplifies expressions (13) and (14) and allows us to derive RA1's equilibrium strategy.

The expected pay-off from being honest is

$$\begin{aligned} \Psi(\text{honest}) = & \delta f(q_1^N, 1, q_2, 1)I + \delta^2 \left(f(q_1^N, 1, q_2, 1)\lambda f(q_1^N, 1, q_2, 1) \right. \\ & \left. + f(q_2, 1, q_1^N, 1)[\lambda f(q_1^N, 1, q_2, 1) + (1-\lambda)(1-q_2)f(q_1^N, 1, q_2^F, 1) + (1-\lambda)q_2 f(q_1^N, 1, q_2^N, 1)] \right) I \end{aligned}$$

Using equations (6) and (7) and noting that RA1 will always lie in periods $t = 2, 3$, this can be rewritten as

$$\begin{aligned} \Psi(\text{honest}) = & \delta(2A - \min\{A, B\})I + \delta^2 \left(\lambda(2A - \min\{A, B\})^2 \right. \\ & \left. + (2B - \min\{A, B\})[\lambda(2A - \min\{A, B\}) + 2(1-\lambda)(1-q_2)A + (1-\lambda)q_2A] \right) I \end{aligned}$$

where $A = \frac{\frac{1}{2}(s(q_1^N, 1) - \frac{a}{\Phi})}{p_G(1-\lambda)}$ and $B = \frac{\frac{1}{2}(s(q_2, 1) - \frac{a}{\Phi})}{p_G(1-\lambda)}$

The expected pay-off from lying is I , since the RA's reputation goes to zero

$$\Psi(\text{lie}) = I$$

We look for a Nash equilibrium of the game by examining RA1's trade-off between lying and not lying. If the pay-off from lying is greater when $x_1 = 1$, we have a pure-strategy equilibrium in which RA1 always lies; if the pay-off from not lying is greater when $x_1 = 0$, we have a pure-strategy equilibrium in which RA1 never lies; otherwise we have a mixed-strategy equilibrium in which RA1 is indifferent between lying or not given some prior beliefs about its strategy, *i.e.* $0 < x_1 < 1$.

We now solve the equation $\Psi(lie) - \Psi(honest) = 0$. We do this in 2 stages. In the first stage, we solve the equation in terms of A and then using the expression for A , we solve for the equilibrium value of x_1 .

For $A < B$ we have

$$\Psi(lie) - \Psi(honest) = \delta^2(1 - \lambda)(2 - q_2)A^2 - (\delta + 2B\delta^2\lambda + 2B\delta^2(1 - \lambda)(2 - q_2))A + 1$$

The solution is

$$A = B + \frac{\delta + 2B\delta^2\lambda - \sqrt{(\delta + 2B\delta^2\lambda)^2 + \varrho}}{2\delta^2(1 - \lambda)(2 - q_2)}$$

which is valid²¹ as long as $\varrho = B^2\delta^2(2 - (1 - \lambda)q_2) + \delta B - 1 > 0$.

Now for $A \geq B$ we have

$$\Psi(lie) - \Psi(honest) = -4\delta^2\lambda A^2 - (2\delta - 2B\delta^2\lambda + B\delta^2(1 - \lambda)(2 - q_2))A - \delta B - 1$$

The solution is

$$A = \frac{\sqrt{(B + (2\delta + B\delta^2(1 - \lambda)(2 - q_2)))^2 - \varrho} - (2\delta + B\delta^2(1 - \lambda)(2 - q_2))}{8\delta^2\lambda}$$

which is valid²² given $\varrho = B^2\delta^2(2 - (1 - \lambda)q_2) + \delta B - 1 \leq 0$.

Hence we show that there always exists a solution which depends on the parameter

²¹*i.e.* consistent with our assumption that $A < B$.

²²*i.e.* $A \geq 0$.

ϱ . Since A always has a solution, we can use it to find the equilibrium strategy x_1 in terms of A , *i.e.* we will look for the value of x_1 such that $\frac{\frac{1}{2}(s(q_1^N, 1) - \frac{a}{\Phi})}{p_G(1-\lambda)} = A$.

Note that assuming $p_G = 1$ implies $\frac{a}{\Phi} = \lambda$. Using this and equation (5), the above expression can be rewritten as $\frac{\lambda q_1^N}{\lambda q_1^N + 1 - q_1^N} = 2A$, where $q_1^N = \frac{q_1}{1 - (1 - q_1)x_1}$.

Solving, we obtain

$$x_1 = 1 - \frac{(1 - 2A)\lambda q_1}{2A(1 - q_1)}$$

for $0 < x_1 < 1$. This holds when $\frac{\lambda q_1}{2(\lambda q_1 + (1 - q_1))} < A < \frac{1}{2}$.

□

Proposition 4 implies that the strategy of RA1 depends on its own and its competitor's reputation. When A is large, RA1 always gives a GR to a bad project. Conversely, when A is small RA1 behaves honestly and gives NR to bad projects. In the intermediate range, RA1 has a mixed strategy, with $0 < x_1 < 1$. Note that the lower threshold for A is increasing with RA1's reputation.

Figure 14 plots RA1's strategy against the reputation of RA1 and RA2. We can see that RA1 tends to lie less as its reputation increases, and it tends to lie more as the reputation of RA2 increases.

The intuition behind this result is straightforward. Since we assumed $p_G = 1$, the reputation of RA1 goes to zero immediately after a project fails. This means that the cost of lying increases with RA1's reputation while the benefit of lying stays constant. Hence it is not surprising that RA1 prefers to lie less as its reputation increases. On the

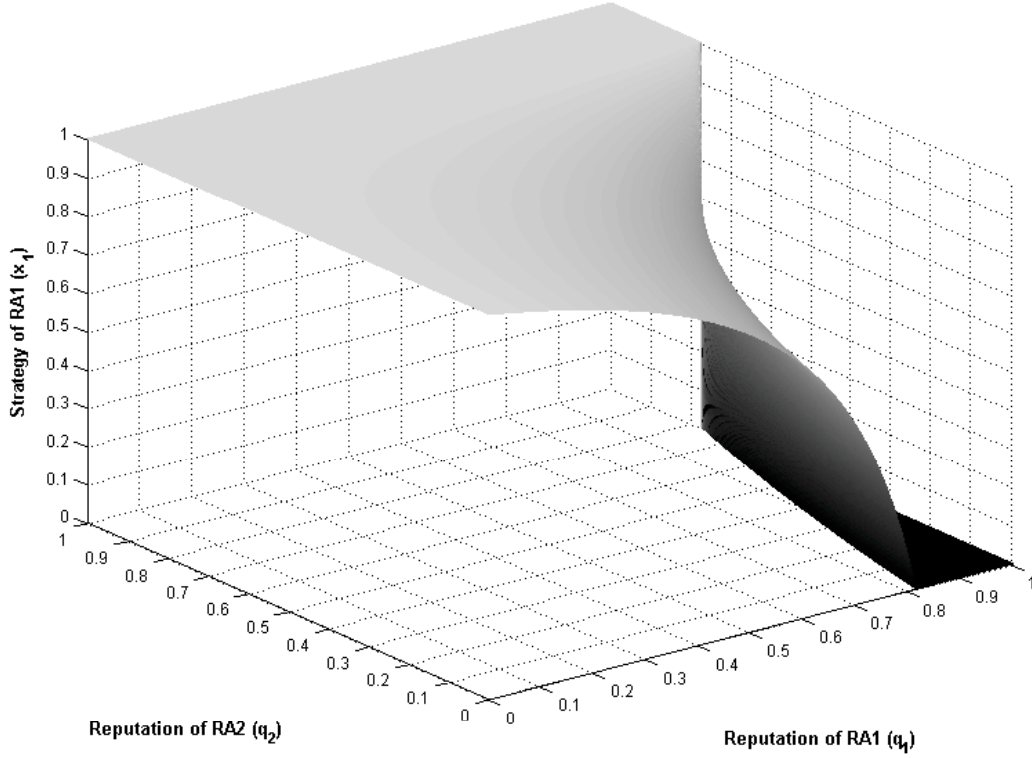


Figure 14: Strategy against reputation ($\lambda = 0.7$, $\delta = 0.9$)

other hand, the higher the reputation of RA2, the less expected future income RA1 has, and the market-sharing effect becomes stronger and dominates the disciplining effect. Therefore RA1 would like to inflate ratings when RA2 has a higher reputation.

Note that in this special case (when $p_G = 1$), the RA's strategy is concave in reputation. This stems from the fact that with $p_G = 1$, the strategic RA is caught immediately after the project fails and thus the cost of ratings inflation increases with reputation. However, our results in section 4 clearly show that this is no longer true if $p_G < 1$. The penalty on reputation will be smaller as the reputation of RA increases, *i.e.* the cost of ratings inflation can decrease with reputation, resulting in a 'u-shaped' relationship between strategy and reputation.

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