

Credit Rating Dynamics and Competition

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Abstract

I analyze credit rating agencies and competition on a market with more than two agencies. Both investors and agencies react to each other's behavior. My model predicts cyclic dynamics in the base case: not only does the presence of trusting investors facilitate ratings inflation. In turn, ratings inflation also induces investors to be less trusting. If trusting investors have a high impact on agencies' reputation, the dynamics exhibits a saddle point rather than cycles. This is one case in which regulatory support for new, honest rating agencies is only needed for a limited time, but the effect is sustainable in the long run.

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1 Introduction

How does the complex interaction between credit rating agencies (CRAs), issuers, and investors affect the quality and informativeness of credit ratings? And how can honest rating behavior be achieved?

CRAs are widely considered to have been a major factor within the development of the 2008 subprime mortgage crisis, accused of intentionally inflating ratings, i.e., giving good ratings to bad issues. Most recently, the U.S. Justice Department charged the largest CRA, Standard & Poor's (S&P), with fraud and demanded US\$5-billion in restitution in early February 2013, see Mattingly (2013). The U.S. market for credit ratings is characterized by a limited number of approved CRAs, so-called Nationally Recognized Statistical Rating Organizations (NRSRO). First there were only Moody's and S&P, and since approximately 1997, Fitch has been there as the third agency. In the meantime, seven more agencies have been approved, so there are now ten CRAs that are designated as NRSROs.¹ The three big CRAs have more than 90 percent of the market share, see Atkins (2008).

In earlier years, the NRSRO designation possibly was a barrier of entry. However, the current situation with ten NRSROs on the market and seven of them not significantly improving their market shares suggests that further analysis is needed: within a theoretical framework that allows for ten or more agencies, it remains to be answered under which conditions players with negligible market shares can improve their positions. It might be particularly interesting to determine the conditions under which a new rating agency that possibly has different ethical standards and business practices can successfully invade the market, even if it starts off with a tiny market share.

As two shortcomings of existing theoretical models, I identify that they only consider competition in duopoly and usually neglect the dynamic properties of the

¹See <http://www.sec.gov/answers/nrsro.htm>, retrieved February 2, 2012.

market. This gap that my paper aims to fill is well motivated by quoting Bolton, Freixas, and Shapiro (2012) (hereafter BFS), p.104: “It would be of interest (but beyond the scope of [their] paper) to explore these issues more systematically in a fully general dynamic game, possibly with an infinite horizon. There is currently no model of oligopolistic competition over an infinite horizon in the CRA literature; indeed, there are very few such models in the industrial organization literature for obvious reasons of tractability.” Therefore I develop a tractable framework using Evolutionary Game Theory, previously applied by Friedman (1991) to similar economic settings, to analyze the interaction of CRAs over an infinite horizon in a competitive market with an arbitrary number of agencies. I model the CRAs’ incentives to inform the investors honestly about the quality of investments, rather than to inflate ratings, as an interplay with investors’ sophistication level. These characteristics of CRAs and investors are similarly modeled in BFS and other papers. As the main innovation on the modeling side, the methodology of Evolutionary Game Theory allows for an arbitrary number of market participants, as well as the analysis whether new behavioral traits successfully enter an established market.

As an important innovation, I do not only consider changes in CRA behavior, but I also allow the behavior of the investors to react on the characteristics of the CRA market they face. On the one hand, CRAs are more likely to inflate ratings for a high share of trusting investors, as the benefits from receiving more fees outweigh the possible reputation costs if caught inflating. On the other hand, investors will in turn change their behavior when they face a CRA market with a lot of ratings inflation. As sophisticated investors usually perform better than trusting investors on such a market, the latter will either start leaving the market or learn to be more sophisticated as well. In my model, sophisticated investors have to spend costs for the monitoring of investment and ratings quality, whereas trusting investors save these costs but suffer when they happen to buy bad investments.

The results of my paper are as follows: I show that the interaction between the CRAs' and the investors' behavior can lead to different equilibria. Dependent on the parametrization, either honest or inflating CRAs dominate in the end, while the population of investors ends up being either trusting or sophisticated. If sophisticated investors have the main impact on CRAs' reputation, there can be cyclic dynamics with the distribution shares in both populations periodically increasing and decreasing over time. In contrast, if trusting investors have a higher impact on CRAs' reputation than sophisticated investors, then the dynamics can exhibit a saddle point rather than cycles. Then a small perturbation of investor/CRA types can determine whether the outcome will be a sophisticated/inflating or a trusting/honest equilibrium. Honest rating agencies can be supported by regulatory measures. There are situations in which direct support for new, honest CRAs is only needed for a limited time, but the effect is sustainable in the long run. Other measures include affecting the CRAs' fee and compensation structures, as well as a centralized monitoring of ratings quality.

The current market for credit ratings is dominated by the “issuer pays” business model.² It was switched from an earlier “investor pays” model due to information drain and difficulties in collecting sufficient fees.³ However, the “issuer pays” model has an inherent conflict of interest: It can be profitable for the CRA to inflate

²In the present paper, I consider only the case of solicited credit ratings, i.e., that the issuer pays for receiving a rating. See, e.g., Bannier, Behr, and Güttler (2010) and Fulghieri, Strobl, and Xia (2012) for a discussion of unsolicited credit ratings, i.e., those provided by CRAs without receiving compensation from the market. For the U.S. market, Gan (2004) estimates that unsolicited ratings account for 22% of all new issue ratings between 1994 and 1998.

³There are some smaller CRAs on the market that apply the “investor pays” model. One of them, namely Egan-Jones Ratings Company, is even an NRSRO. A recent investigation by the U.S. Securities and Exchange Commission (SEC) against Egan-Jones shows that the “investor pays” model is not necessarily free of conflicts of interest either, see SEC (2012). The theoretical model by Stahl and Strausz (2011) suggests that the “issuer pays” business model might be superior to the “investor pays” model. They argue in a more general context that sellers (issuers) rather than buyers (investors) of an information-sensitive good should pay for certification (ratings). While sellers want to signal quality, buyers have to inspect quality, the former being both socially more desirable and generating higher rents to the certifier (CRA).

ratings.⁴ A related problem is ratings shopping: The issuer chooses to pay the fee only to a CRA that promises to give a favorable rating, and approaches a competitor otherwise. The question whether more competition can increase ratings quality is thus related to whether it helps to prevent ratings inflation, although it can give more opportunities for ratings shopping.

Most researchers agree that ratings inflation is most severe for complex investment products as in structured finance, see e.g. Skreta and Veldkamp (2009) and BFS. On the other hand, Baghai, Servaes, and Tamayo (2013) show that CRAs have even become more conservative in assigning corporate credit ratings. In line with this, my paper should also be understood in the context of rating complex investment products rather than corporations.⁵ Mathis, McAndrews, and Rochet (2009) analyze ratings inflation for a monopolistic CRA. They derive a reputation cycle similar to the cyclic dynamics in the base case of my model, however they exclude the possibility of the CRA to recover its reputation, once it is caught lying. In general, the existing literature comes to ambiguous conclusions on the relation between competition and ratings inflation.⁶ Camanho, Deb, and Liu (2012) extend Mathis, McAndrews, and Rochet (2009) by competition effects. They find that competition results in greater ratings inflation. Similarly, Skreta and Veldkamp (2009) and BFS find that competition makes ratings shopping worse. On the contrary, Manso (2012) highlights that credit ratings can have feedback effects on the credit quality of issuers.

⁴Throughout my paper I assume that CRAs have perfect knowledge about the actual quality of investments, and the only remaining issue is whether they truthfully report information to the investors. This assumption is questionable, especially in the light of recent underperformance when rating structured products. Among others, Pagano and Volpin (2010) investigate the interplay of ratings inflation and the failure of CRAs to provide accurate ratings, and Bar-Isaac and Shapiro (2012) discuss how ratings quality is related to analyst skills. Pagano and Volpin (2012) show that issuers may prefer (and CRAs produce) coarse and uninformative ratings even in the absence of ratings inflation and ratings shopping.

⁵I thank David Lando for pointing this out.

⁶Apart from competition effects, ratings inflation is influenced by other factors. For example, Opp, Opp, and Harris (2013) explain how rating-contingent regulation can contribute to ratings inflation. Stolper (2009) suggests that the problem might be solved by a proper regulatory approval scheme for CRAs.

He finds that increased competition between rating agencies can create downward pressure on ratings and tougher rating policies. Doherty, Kartasheva, and Phillips (2012) show both theoretically and empirically that the market entry of a new CRA can improve ratings quality and precision. Their story is that the entrant CRA can attract business from good issuers that have been pooled with worse quality issuers. By using a more precise rating scale, the entrant CRA allows the good issuers to receive higher prices for the investments they sell. Becker and Milbourn (2011) take the market entry of Fitch as a natural experiment to analyze the effect of increasing competition. Overall, they show a decrease in ratings quality. Bongaerts, Cremers, and Goetzmann (2012) suggest a different role of Fitch, namely being a tiebreaker if the other two big rating agencies, S&P and Moody's, disagree whether a bond issue has investment grade or high yield status. Assuming that a Fitch rating is solicited more often if the issuer expects it to break the tie towards investment grade, this endogeneity provides an alternative to the "ratings inflation" story, explaining why the observed Fitch ratings are higher on average. Similarly, Xia (2012) provides evidence in the opposite direction of Becker and Milbourn (2011). He shows that increased competition by the entry of investor-paid Egan-Jones Rating Company led to higher ratings quality for S&P. He, Qian, and Strahan (2011) examine whether rating agencies reward large issuers of mortgage-backed securities. After controlling for deal characteristics, they can analyze a situation in which small and large issuers differ only in the amount of possible future business. They find evidence for a positive bias of CRAs towards large issuers and thus for ratings inflation. Similarly, Mählmann (2011) shows that firms with longer rating agency relationships have better credit ratings, although they do not have lower default rates. Hörner (2002) provides a general reputational theory in which competition can increase quality if the consumers' competitive choice makes loss of reputation a real threat. One of the first papers analyzing the trade-off between building up a long-term reputation and

making higher short-term profits by misbehaving is by Klein and Leffler (1981). So in principle, if more competition should be a cure of ratings inflation, it would need to affect this trade-off towards the benefit of building up a long-term reputation.

The paper is structured as follows: In Section 2, I introduce the modeling framework. Next, I present a simple two-player game between one investor and one CRA as a reference point, and derive the corresponding Nash equilibria in Section 3. On this basis, I extend the model to the evolutionary dynamics and present the corresponding results in Section 4. Then I provide empirical implications in Section 5. Section 6 concludes the paper.

2 Model

The economic setting of the model is similar to BFS, from which I also use the notation as far as possible to ensure comparability. I consider a market on which issuers provide two types of investments. First, a good investment, which is present on the market with a share $\lambda \in [0, 1]$. It yields a payoff $1 + R > 1$ upon investment of 1, i.e., a net payoff of $R > 0$. Second, a bad investment, which is present on the market with a share $(1 - \lambda)$. It yields a payoff of zero, which can be interpreted as default, upon investment of 1. Without additional information, the investment's expected NPV is

$$V_0 = \lambda R - (1 - \lambda), \quad (1)$$

which I assume to be negative, i.e.,

$$\lambda < \frac{1}{1 + R}. \quad (2)$$

This assumption ensures that investments cannot be sold to the market unless there is additional information, and thus there is a role for rating agencies.

Apart from the issuers, there are two populations that interact with each other. First, I consider the population of investors (Inv). There is a share $\alpha \in [0, 1]$ of trusting investors (T), and a share $(1 - \alpha)$ of sophisticated investors (S). Second, I consider the population of rating agencies (CRAs). There is a share $\beta \in [0, 1]$ of honest CRAs (H), and a share $(1 - \beta)$ of inflating CRAs (I). The population space thus consists of all possible states (α, β) within the square $(0,0)$, $(1,0)$, $(1,1)$, $(0,1)$.

For each interaction, a random issuer's investment is to be rated, which is good with probability λ . The corresponding issuer does not know its own type. One CRA is randomly chosen from the CRA population. If the CRA produces a rating, it is communicated to the investor population. The players cannot recognize each other's types. Depending on the players' types, they receive payoffs as derived in the following.

The CRA charges a fee $\varphi(\alpha, \beta)$ from the issuer of the investment for giving a "good" rating. The fee is based on the usefulness of the rating for the issuer. Given that $\Phi \geq 0$ is the value of a rating that makes all investors buy, the issuer is willing to pay $\varphi(\alpha, \beta)$ for a "good" rating, with

$$\frac{\varphi(\alpha, \beta)}{\Phi} = Pr(\text{buy} | \text{"G"}) = \frac{\overbrace{Pr(\text{"G"} | \text{buy})}^{=1} Pr(\text{buy})}{Pr(\text{"G"})} = \frac{\lambda + (1 - \lambda)\alpha(1 - \beta)}{\lambda + (1 - \lambda)(1 - \beta)} \in [\lambda, 1]. \quad (3)$$

This fraction represents the expected share of investors buying the product, given a "good" rating is issued. Therefore the issuers effectively become an active third population in the game and negotiate fees dependent on the expected benefits. As the issuers do not know their own types, there is the same willingness to pay for all issuers. The fee is received only for a good rating. This assumption is common in the literature and can be interpreted as a reduced-form modeling of ratings shopping, as the issuer will then move on and hope to find another agency who promises to give him the good rating. Therefore one could argue that the issuer's behavior, namely

the choice to accept and pay only for good ratings, is modeled here in a simple form. Also, my model resembles that in practice, the fee for a rating depends on the volume of the issue.⁷ Effectively, an investment without rating is equivalent to an investment rated as bad in my model. According to (2), it cannot be sold on the market.

I assume that honest CRAs have to spend some production costs or effort (call it ϵ) for rating the investment, while inflating CRAs do not. Honest CRAs can then perfectly observe whether investments are good or bad. An honest CRA truthfully reports the type of the investment. Thus, if the investment is bad, it cannot sell the rating to the issuer and does not receive a fee. An inflating CRA, in contrast, always reports “good” and receives the fee.

On the investor side, trusting investors cannot judge the investments. They buy all investments that are rated as “good”. Whenever they experience default of their investment, they impose reputation costs $\rho_T \geq 0$ on the CRA. In contrast, whenever sophisticated investors observe a “good” rating, they spend a cost $C \geq 0$ to verify the CRA’s work and evaluate the investments. If they meet an inflating CRA with a bad investment rated as good, they do not buy it, and at the same time they cause reputation costs $\rho_S \geq 0$ for the CRA. The ρ_S and ρ_T are realistically interpreted as the present values of the CRA’s foregone future profits, as a result of the respective investor clienteles losing confidence in the CRA’s judgments, and thus the CRA being approached by less issuers. Thus, I capture effects that go beyond the random pairing and the lack of individual memories.

Summarizing the payoffs for the investors, I first consider the trusting investors. If they are meeting an honest CRA, they observe a good rating for a good investment, which occurs with probability λ . In this case they invest and receive a net payoff of R . If the investment is bad, the investors are warned, as the honest CRA refuses

⁷I thank Jean-Charles Rochet for making this remark.

to give a good rating, so they do not invest and receive zero payoff. Together, the expected payoff is $V_{TH} = \lambda R$. Against an inflating CRA, they receive a net payoff of R for a good investment, which occurs with probability λ . However, if the investment is bad, which occurs with probability $(1 - \lambda)$, the CRA still gives a good rating. The trusting investors invest, and consequently receive a net payoff of (-1) . Together, their expected payoff is

$$V_{TI} = \lambda R - (1 - \lambda) = V_0 < 0, \quad (4)$$

with V_0 from (1). The resulting expected payoff for trusting investors is

$$\Pi_T^{Inv} = \beta V_{TH} + (1 - \beta)V_{TI} = \lambda R - (1 - \beta)(1 - \lambda),$$

as they meet an honest (inflating) CRA with probabilities β and $1 - \beta$, respectively. Second, consider the sophisticated investors. If they are meeting an inflating CRA, the payoff is $V_{SI} = \lambda R - C$. While the inflating CRA reports “good” investments in any circumstance, the sophisticated investors spend the cost C to judge the investments themselves. Thus, they manage to invest only in the good investments, which occur with probability λ . Meeting an honest CRA, the sophisticated investors receive the payoff $V_{SH} = \lambda(R - C)$. The rationale is that within the model, an observed bad (or missing) rating indicates an honest CRA, and therefore no monitoring costs have to be spent in that case.⁸ The resulting expected payoff for sophisticated investors is

$$\Pi_S^{Inv} = \beta V_{SH} + (1 - \beta)V_{SI} = \lambda R - C[1 - \beta(1 - \lambda)].$$

The expected payoff differential between trusting and sophisticated investors is

$$\Delta \Pi^{Inv} = \Pi_T^{Inv} - \Pi_S^{Inv} = \lambda - (1 - C)[1 - \beta(1 - \lambda)]. \quad (5)$$

⁸I thank Henri Pagès for suggesting this way of modelling.

Considering the rating agencies, I first state the payoffs for the honest CRAs. They spend the effort ϵ to perfectly evaluate the investments. As they are committed to reporting truthfully (if at all), they receive $\varphi(\alpha, \beta)$ only for rating good investments “good”. These occur with probability λ . On the other hand, they are never punished for inflating ratings. Their expected payoff is therefore

$$\Pi_H^{CRA} = \alpha X_{HT} + (1 - \alpha) X_{HS} = X_{HT} = X_{HS} = \lambda \varphi(\alpha, \beta) - \epsilon.$$

Second, consider the inflating CRAs. As they always give good ratings, they are always paid $\varphi(\alpha, \beta)$ by the issuers, regardless of the quality of the investment. However, if they inflate ratings, which occurs with probability $(1 - \lambda)$, then they suffer reputation costs both from trusting and sophisticated investors. The respective payoffs are $X_{IT} = \varphi(\alpha, \beta) - (1 - \lambda)\rho_T$ and $X_{IS} = \varphi(\alpha, \beta) - (1 - \lambda)\rho_S$. The resulting expected payoff for inflating CRAs is

$$\Pi_I^{CRA} = \alpha X_{IT} + (1 - \alpha) X_{IS} = \varphi(\alpha, \beta) - (1 - \lambda)[\alpha \rho_T + (1 - \alpha)\rho_S].$$

The expected payoff differential between honest and inflating CRAs is

$$\Delta \Pi^{CRA} = \Pi_H^{CRA} - \Pi_I^{CRA} = (1 - \lambda)[\alpha \rho_T + (1 - \alpha)\rho_S - \varphi(\alpha, \beta)] - \epsilon. \quad (6)$$

3 Nash equilibria of the two-player game

Before analyzing the evolutionary game between the two populations of investors and CRAs, I present the related two-player game between one investor and one CRA. I show the game in normal form in Table 1. As usually done in two-player game theory, the first and second entry represent the payoffs for the investor (column player) and the CRA (row player), respectively. These payoffs are derived in the

Table 1: Two-Player Game in Normal Form. For each possible investor/CRA strategy pair, the investors being either trusting or sophisticated and the CRA being either honest or inflating, the table states the payoffs for the investor and CRA, respectively, as a pair separated by commas in each cell.

Investor / CRA	honest	inflating
trusting	$\lambda R, \lambda\varphi(\alpha, \beta) - \epsilon$	$\lambda R - (1 - \lambda), \varphi(\alpha, \beta) - (1 - \lambda)\rho_T$
sophisticated	$\lambda(R - C), \lambda\varphi(\alpha, \beta) - \epsilon$	$\lambda R - C, \varphi(\alpha, \beta) - (1 - \lambda)\rho_S$

previous subsection.

Throughout the evolutionary dynamics, I will assume that for each interaction, the expected strategies of CRA and investors are given by the proportions of strategies in each population. In contrast, for the current section I assume that both the investor and the CRA each choose their optimal strategies. They can either choose a pure strategy, i.e., perform one of their two respective actions with certainty, or choose a mixed strategy, which is to randomize their actions. In the latter case, the investor chooses to be trusting with probability α , and the CRA chooses to be honest with probability β , respectively. The limit cases of choosing probabilities 0 or 1 reflect the pure strategies.

3.1 Pure strategy Nash equilibria

I check for the existence of Nash equilibria, i.e., strategies that are the best responses to each other's choices. The definitions $\Delta\Pi^{Inv}$ and $\Delta\Pi^{CRA}$ from (5) and (6) prove useful to make this analysis. Note that I calculate $\Delta\Pi^{CRA}$ using (3) to replace $\varphi(\alpha, \beta)$, given that the respective pair of pure strategies is followed. As shown in Table 2, a necessary condition for a Nash equilibrium is that the payoff differential favors the currently chosen strategy for each player. For example, in the trusting/inflating case, $\Delta\Pi^{Inv}$ becomes $C - (1 - \lambda)$. If the latter was negative, then this would indicate that an investor could be better off by becoming sophisticated,

Table 2: Pure Strategy Nash Equilibria. For each possible investor/CRA pure strategy pair, the investors being either trusting or sophisticated and the CRA being either honest or inflating, the table states the value of $\varphi(\alpha, \beta)$, given that the respective strategies are followed, as well as necessary conditions for $\Delta\Pi^{Inv}$ and $\Delta\Pi^{CRA}$ such that the respective strategy pair is a Nash equilibrium.

Investor / CRA	honest ($\beta = 1$)	inflating ($\beta = 0$)
trusting ($\alpha = 1$)	$\varphi(1, 1) = \Phi$	$\varphi(1, 0) = \Phi$
$\Delta\Pi^{Inv} =$	$\lambda C \geq 0$	$C - (1 - \lambda) \geq 0$
$\Delta\Pi^{CRA} =$	$(1 - \lambda)(\rho_T - \Phi) - \epsilon \geq 0$	$(1 - \lambda)(\rho_T - \Phi) - \epsilon \leq 0$
soph'd ($\alpha = 0$)	$\varphi(0, 1) = \Phi$	$\varphi(0, 0) = \lambda\Phi$
$\Delta\Pi^{Inv} =$	$\lambda C \leq 0$	$C - (1 - \lambda) \leq 0$
$\Delta\Pi^{CRA} =$	$(1 - \lambda)(\rho_S - \Phi) - \epsilon \geq 0$	$(1 - \lambda)(\rho_S - \lambda\Phi) - \epsilon \leq 0$

and trusting/inflating would not be a Nash equilibrium. The usage of the expected payoff differentials, rather than directly comparing the payoffs in Table 1, is needed when looking at the cases of sophisticated investors and honest vs. inflating CRAs. Here, $\varphi(\alpha, \beta)$ translates into different expressions for the two cells in the bottom line of Table 2, and thus also $\Delta\Pi^{CRA}$ is defined differently between the two cells. Effectively, I assume that $\varphi(\alpha, \beta)$ remains as in the original strategy when CRAs consider switching between being honest vs. inflating – the fee negotiations with the issuers would not be affected before the change in strategies and thus CRA population shares has materialized.

The Nash equilibrium conditions related to $\Delta\Pi^{Inv}$ and $\Delta\Pi^{CRA}$ can easily be reformulated in terms of the positive and negative contributions to the investors' and CRAs' trade-offs. Figure 1 shows how the possible equilibrium outcomes vary dependent on the monitoring costs C and ϵ borne by sophisticated investors and honest rating agencies, respectively.

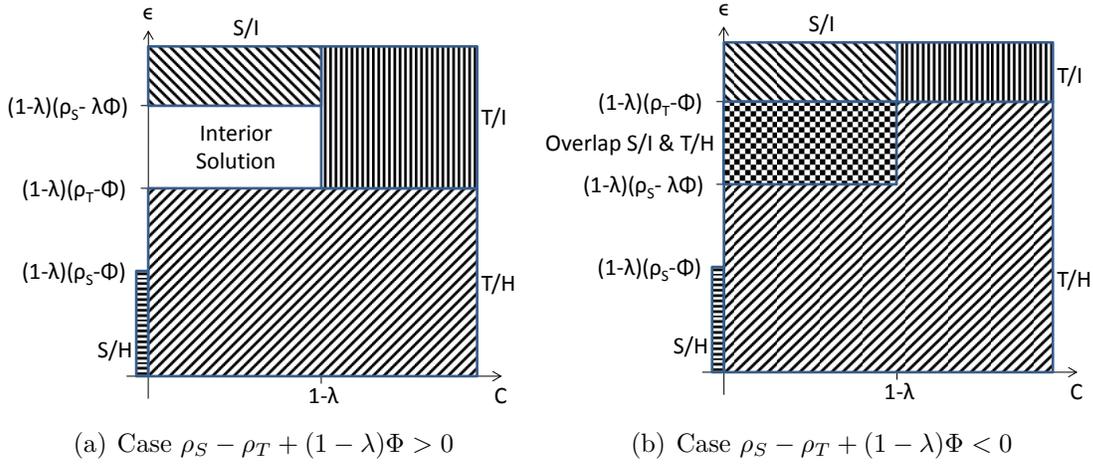


Figure 1: Illustration of equilibrium conditions.

The two figures show how the possible equilibrium outcomes vary dependent on the monitoring costs C and ϵ borne by sophisticated investors and honest rating agencies, respectively. Apart from the four Nash equilibria in pure strategies, there is an area in Panel 1(a) in which none of the pure Nash equilibrium conditions applies, as well as an area in Panel 1(b) in which the conditions for the S/I and the T/H equilibria overlap.

3.2 Discussion

For the discussion, I start with two cases in which it is not attractive for the CRAs to be honest. First, if $\epsilon + (1 - \lambda)\lambda\Phi \geq (1 - \lambda)\rho_S$ and $C \leq 1 - \lambda$, “sophisticated/inflating” is an equilibrium. For the CRA, the effort to judge the investments and the foregone fees resulting from not inflating outweigh the possible reputation costs. For the investor, monitoring pays off, as the monitoring cost is low relative to the share of bad investments and thus to the possible losses when suffering a default.

Second, if $\epsilon + (1 - \lambda)\Phi \geq (1 - \lambda)\rho_T$ and $C \geq 1 - \lambda$, “trusting/inflating” is an equilibrium. Similar to the first case, from the CRA’s perspective honesty does not pay off. However, on the investor side there is no incentive to monitor the investment quality, because there are relatively few bad investments on the market. With an inflating CRA, trusting investors make losses on average according to (4). However, sophisticated investors are relatively even worse off ($V_{SI} < V_{TI}$) due to the high monitoring costs. This is a situation similar to what BFS associate with boom

times. If there is a high ex-ante quality of investments on the market, then trusting investors perform better than sophisticated ones.

Third, if $\epsilon + (1 - \lambda)\Phi \leq (1 - \lambda)\rho_T$, “trusting/honest” is an equilibrium. Here, the effort to judge the investments and the foregone fees resulting from not inflating are low compared to the possible reputation costs. Therefore there is no incentive for the CRA to inflate ratings. The investor, on the other hand, can encounter such a CRA in trusting mood and does not have to spend costs on monitoring the investment quality.

Finally, if $\epsilon + (1 - \lambda)\Phi \leq (1 - \lambda)\rho_S$ and $C = 0$, then “sophisticated/honest” is an equilibrium. Similar to the previous case, the CRA’s trade-off favors being honest. If the investor does not have to spend monitoring costs, it is the best choice to be sophisticated and thus deter inflating CRA behavior. The lesson could be that a regulator or a central market authority, instead of individual investors, should take over the burden of monitoring the CRAs’ performance. After all, the sophisticated investors bear the cost of monitoring individually, but the trusting investors can free-ride on the benefits of these monitoring efforts.

3.3 Mixed strategy Nash equilibrium

Apart from the four possible Nash equilibria in pure strategies, there is also one Nash equilibrium in mixed strategies with the probabilities (α^*, β^*) for being a trusting investor and an honest CRA, respectively. This means that each player randomizes such that the other player is indifferent between the available strategies. More precisely, the investor chooses α such that, replacing $\varphi(\alpha, \beta)$ from (3) into (6),

$$\Delta\Pi^{CRA} = 0 \Leftrightarrow \alpha = \alpha^* = \frac{(1 - (1 - \lambda)\beta)\epsilon - (1 - \lambda)((1 - (1 - \lambda)\beta)\rho_S - \lambda\Phi)}{(1 - \lambda)((1 - \lambda)(\beta(\rho_S - \rho_T) - (1 - \beta)\Phi) - \rho_S + \rho_T)}. \quad (7)$$

Similarly, the CRA chooses β such that

$$\Delta\Pi^{Inv} = 0 \Leftrightarrow \beta = \beta^* := \frac{1 - \lambda - C}{(1 - \lambda)(1 - C)}. \quad (8)$$

4 Dynamics

As I will show in the following, the fixed points of the evolutionary dynamics correspond to the Nash equilibria of the two-player game presented in the previous section.

4.1 Evolutionary game

From now on, I assume that there are interactions between a large number of individual investors and CRAs. The population shares change over time as a result of the payoffs achieved in the interactions. There are several possible economic explanations: As a result of the realized payoffs, individuals switch their behavior towards another pure strategy, unsuccessful market participants leave the market, or new market entrants observe and imitate the most successful behavior.

For such a situation, the corresponding replicator dynamics can be derived as in Taylor and Jonker (1978) and Taylor (1979) to be⁹

$$\frac{\partial\alpha}{\partial t} = \alpha(\Pi_T^{Inv} - \bar{\Pi}^{Inv}) \quad \text{and} \quad \frac{\partial\beta}{\partial t} = \beta(\Pi_H^{CRA} - \bar{\Pi}^{CRA}). \quad (9)$$

Here, the $\bar{\Pi}^{Inv}$ and $\bar{\Pi}^{CRA}$ represent the average payoffs in the investor and CRA population, respectively. Thus, (9) means that the growth rate $\frac{\partial\alpha}{\partial t}/\alpha$ of the trusting investors' population share equals the difference between the trusting investors' current payoff and the current average payoff in the investor population. If trusting investors perform better than average, then their share is growing. Formerly

⁹See Appendix A for more details on the derivation.

sophisticated investors and new market entrants will adopt the successful behavior of being trusting. If trusting investors perform worse than average, their share is shrinking. The opposite holds for the share $(1 - \alpha)$ of sophisticated investors, respectively, and an analogous mechanism is at work in the CRA population. Note that there is some stickiness in the behavior. The intuition behind is that it takes some time for the knowledge about the success of the respective strategy to reach all the market participants. The dynamics can be transformed using (5) and (6) into

$$\frac{\partial \alpha}{\partial t} = \alpha(1 - \alpha)\Delta\Pi^{Inv} \quad \text{and} \quad \frac{\partial \beta}{\partial t} = \beta(1 - \beta)\Delta\Pi^{CRA} \quad (10)$$

The transformation allows the following interpretation: When trusting investors perform relatively better than sophisticated investors, then the trusting investors' share α in the investor population is increasing. Similarly, when honest CRAs perform relatively better than inflating CRAs, then the honest CRAs' share β in the CRA population is increasing. As there are only two strategies in each population, "better than average" is equivalent to "better than the other strategy".

My next step is to derive stationary regions. These refer to states in which there is no movement in either α or β direction, or neither. There is no movement in α direction, if $\frac{\partial \alpha}{\partial t} = 0$ in (10). This is the case if either $\alpha = 0$ or $\alpha = 1$ (on the margins of the population space), or $\Delta\Pi^{Inv} = 0 \Leftrightarrow \beta = \beta^*$ according to (8). Similarly, there is no movement in β direction, if $\frac{\partial \beta}{\partial t} = 0$ in (10). This is the case if either $\beta = 0$ or $\beta = 1$ (again, on the margins of the population space), or $\Delta\Pi^{CRA} = 0 \Leftrightarrow \alpha = \alpha^*$ according to (7). Note that the solutions for α^* and β^* are the same as those derived as probabilities for the Nash equilibrium in mixed strategies.

If there is no movement in either direction, then the corresponding state is a fixed point in the dynamics. From the condition $\frac{\partial \alpha}{\partial t} = \frac{\partial \beta}{\partial t} = 0$, I derive the corners of the population space as fixed points, as well as the interior fixed point (α^*, β^*) .

For the existence of an interior fixed point, I need $\alpha^*, \beta^* \in (0, 1)$. From (7) and (8), I find that the (α^*, β^*) lies on the margins rather than in the interior for some special values of ϵ and C , namely

$$\alpha^* = 0 \quad \text{for} \quad \epsilon = (1 - \lambda)(\rho_S - \varphi(0, \beta)) \quad \text{with} \quad \varphi(0, \beta) = \frac{\lambda\Phi}{1 - \beta(1 - \lambda)} \quad (11)$$

$$\alpha^* = 1 \quad \text{for} \quad \epsilon = (1 - \lambda)(\rho_T - \Phi) \quad (12)$$

$$\beta^* = 0 \quad \text{for} \quad C = 1 - \lambda \quad (13)$$

$$\beta^* = 1 \quad \text{for} \quad C = 0 \quad (\text{or } \lambda = 0) \quad (14)$$

Note that (11) translates to $\epsilon = (1 - \lambda)(\rho_S - \lambda\Phi)$ and $\epsilon = (1 - \lambda)(\rho_S - \Phi)$ for $\beta = 0$ and $\beta = 1$, respectively. For $\beta^* \in (0, 1)$, Conditions (13) and (14) can easily be translated into $0 < C < 1 - \lambda$. This shows again the correspondence to the Nash equilibrium conditions for the static case in Table 2 and illustrated in Figure 1. As I will illustrate in the following subsections, there are several possible outcomes resulting from the interaction of an arbitrary number of CRAs and investors, depending on the parametrization of the model. and the conditions above.

4.2 Base case: interior fixed point and cycles

As base case I define the situation with one interior fixed point at (α^*, β^*) , i.e., $\alpha^*, \beta^* \in (0, 1)$. Moreover, I consider the case

$$\rho_S - \rho_T + (1 - \lambda)\Phi > 0 \quad (15)$$

illustrated in Figure 1(a), i.e., the reputation costs imposed by sophisticated investors, corrected for the difference in fees, exceed those imposed by trusting investors. A motivation is that the sophisticated investors are the more professional ones and those who have better access to the media, so they can cause more harm

Table 3: Base Case Parameter Values. The table states the numerical values chosen for each of the parameters in the base case of the model.

share of good investments	$\lambda = 0.5$
honest CRAs' effort	$\epsilon = 0.3$
fee if all investors buy	$\Phi = 0.4$
reputation cost (S)	$\rho_S = 1.5$
reputation cost (T)	$\rho_T = 0.7$
verification cost	$C = 0.3$
net payoff upon investment	$R = 0.1$

to the CRAs. To satisfy these conditions, I choose the share of good investments as $\lambda = 0.5$, the effort that honest CRAs spend to evaluate investments as $\epsilon = 0.3$, the fee that an issuer is willing to pay to the CRA for a good rating that makes all investors buy as $\Phi = 0.4$, the CRA's reputation cost imposed by sophisticated and trusting investors if caught lying as $\rho_S = 1.5$ and $\rho_T = 0.7$, respectively, and the verification cost borne by sophisticated investors as $C = 0.3$. The net payoff upon investment is chosen as $R = 0.1$. Note that the latter affects neither the location of (α^*, β^*) nor the dynamics in (10). These are driven only by the differences in payoffs between strategies, and the investor payoffs can all be shifted by λR to eliminate R . The parameter values are summarized in Table 3.

The resulting dynamics is visualized in Figure 2. The arrows indicate the vectors $(\frac{\partial \alpha}{\partial t}, \frac{\partial \beta}{\partial t})$, i.e., the direction and speed of adjustment of the shares in each population for given current shares of trusting investors (α) and honest CRAs (β). Also shown are the fixed lines on the margins of the population space, and the two interior fixed lines. The latter separate four different regimes. Dependent on the current investor sophistication level, either the honest or inflating CRAs are more successful, which in turn again affects the investor behavior.

For example, in the upper left quadrant of the population space, e.g., at $(0.5, 0.8)$. This means that the share of trusting investors (α) is lower than on the fixed line

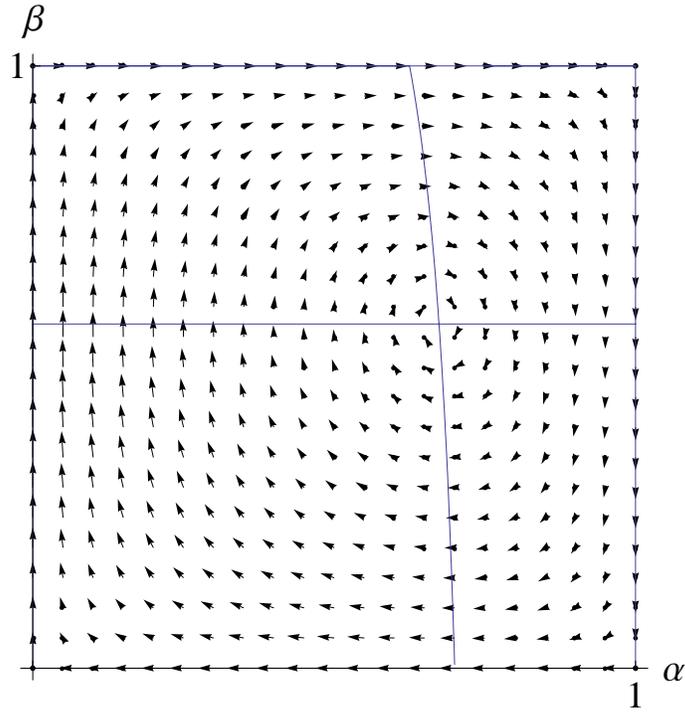


Figure 2: Base case: interior fixed point and cycles.

The figure shows the dynamic evolution of the population shares, with α representing the share of trusting (rather than sophisticated) investors and β representing the share of honest (rather than inflating) CRAs. It is displayed as a vector field for $\alpha^*, \beta^* \in (0, 1)$. The fixed lines α^* and β^* are indicated by vertical and horizontal lines, respectively. Parameter values correspond to the base case parametrization given in Table 3.

(α^*). On the other hand, the share of honest CRAs (β) is above the fixed line (β^*). Thus, β is high enough that it does not pay off for the individual investors to invest in the monitoring of the CRAs. Therefore the trusting investors perform better than the sophisticated ones and gain in market share. Still, there are enough sophisticated investors in the market to make the honest CRAs better off than the inflating ones (remember that according to (15), the reputation costs imposed by sophisticated investors are particularly important in the current case), and thus the honest CRAs' market share is growing. As the arrows indicate, the combined effect is that the market moves towards more honest (and less inflating) CRAs and more trusting (and less sophisticated) investors.

Once the dynamics crosses the fixed line at α^* , it enters the upper right quadrant of the population space. Here, the trusting investors still become more and more numerous. Due to the low share of the inflating CRAs, it is still safe to buy all investments rated as good, rather than investing in monitoring. However, the trusting investors have already become such a big group that it is beneficial for the CRAs to inflate ratings, as they can do so with little risk of being caught. Therefore the inflating CRAs gain market share on expense of the honest ones.

The next regime transition leads into the lower right quadrant of the population space, i.e., the region below the fixed line at β^* . The inflating CRAs are still the more successful ones, and their share is further growing. However, with so much rating inflation on the market, the trusting investors often happen to put their money in bad investments. The sophisticated investors are better off in such a situation and can improve their market share, which means that α is decreasing.

Once the fixed line at α^* is crossed, the lower left quadrant of the population space is entered. Now the share of trusting investors is still shrinking, because of the high market share of inflating CRAs. However, now there are enough sophisticated investors in the market to make reputation costs more important for the CRAs

than rating fees (remember that according to (15), the reputation costs imposed by sophisticated investors are particularly important in the current case). Therefore the honest CRAs make more profit again, and they consequently improve their market share. Finally, the last transition over the fixed line at β^* leads again into the upper left quadrant of the population space, where I started the investigation.

As (15) holds in the base case, the fixed point (α^*, β^*) is a center in the dynamics. This means that the clockwise cycles of movement in the population that are displayed in Figure 2 will spiral periodically around the fixed point, rather than move towards or away from it. These cycles of movement are consistent with evidence of both CRAs' and investors' behavior varying over the business cycle.¹⁰ Related are the following two theoretical predictions: Bar-Isaac and Shapiro (2012) find that ratings accuracy is counter-cyclical. BFS predict that "ratings inflation is more likely in boom times when investors have lower incentives to perform due diligence, as the ex ante quality of investments is then higher." In the language of my model, this corresponds to a higher share of inflating CRAs for a lower share of sophisticated investors in the market.

The conclusion for the base case depends on the current regime of the market. It pays off temporarily for CRAs to be honest, but only if there are enough sophisticated investors in the market, who make reputation loss a real threat. Otherwise, ratings inflation is the best strategy for the CRAs. My result for the base case is consistent with other theories, e.g., Skreta and Veldkamp (2009) and BFS, who suggest that ratings inflation is most severe for complex investment products, i.e., products exceeding the investor sophistication level, and for more trusting investors. However, in contrast to the existing theories I emphasize that even for the base case of my model, "strategic honesty" can pay off at least temporarily.

¹⁰My base case is also quite similar to an evolutionary game between buyers (honest/cheat) and sellers (inspect/don't inspect) in a more general economics context, presented by Friedman (1991).

4.3 Saddle case: interior fixed point and two basins of attraction

For this subsection, I examine an interior fixed point at (α^*, β^*) , i.e., $\alpha^*, \beta^* \in (0, 1)$ as in the base case. Differently, however, I now consider the case

$$\rho_S - \rho_T + (1 - \lambda)\Phi < 0 \tag{16}$$

illustrated in Figure 1(b), i.e., the reputation costs imposed by trusting investors, corrected for the difference in fees, exceed those imposed by sophisticated investors. A motivation is that the trusting investors are more dependent on the CRAs, as trusting investors have no other means to avoid investing in defaulting investments. When they actually experience default of investments they have believed in, they have a higher motivation to spread the news than sophisticated investors, who only had to do the monitoring work themselves. To satisfy these conditions, I choose the parameter values $\lambda = 0.5$, $\epsilon = 0.3$, $\Phi = 0.2$, $\rho_S = 0.6$, $\rho_T = 0.9$, $C = 0.3$, and $R = 0.1$.

As Figure 1(b) indicates, the interior fixed point is surrounded by a region that allows the movement towards two different Nash equilibria. Depending on the starting point, the dynamics leads either to the sophisticated/inflating or the trusting/honest equilibrium. The two sets of starting points are also called basins of attraction. Figure 3 confirms the proposed dynamics.

Remember that according to (16), the present case is characterized by particularly high reputation costs imposed by trusting investors. This explains also the outcome: For a high share of trusting investors, it becomes beneficial for the CRAs to rate honest. Similarly, starting off with a market consisting of many honest CRAs can encourage the investors to become more trusting. There is a ridge line connecting the points $(1/0)$ and $(0/1)$ and separating the two basins of attraction. Just below the line, the previously described dynamics will not hold anymore, as there

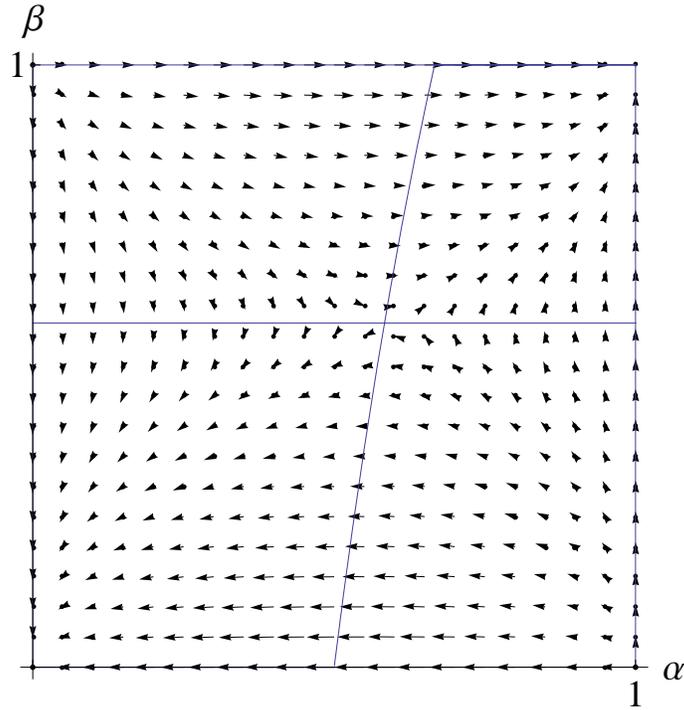


Figure 3: Saddle case: interior fixed point and two basins of attraction. The figure shows the dynamic evolution of the population shares, with α representing the share of trusting (rather than sophisticated) investors and β representing the share of honest (rather than inflating) CRAs. It is displayed as a vector field for $\alpha^*, \beta^* \in (0, 1)$. The fixed lines α^* and β^* are indicated by vertical and horizontal lines, respectively. Parameter values are $\lambda = 0.5, \epsilon = 0.3, \Phi = 0.2, \rho_S = 0.6, \rho_T = 0.9, C = 0.3, R = 0.1$.

are either not enough honest CRAs or not enough trusting investors to support the evolution towards $(1/1)$, and the market will eventually converge towards $(0/0)$.

Observing this situation leads to the following policy implication: Given that there is a sufficiently high share of trusting investors, a regulatory measure supporting only a few more honest CRAs for a limited time can change the equilibrium outcome. Once such a measure takes the market across the ridge line, the effect will be sustainable and does not require regulatory support any longer. In that sense, Roland Berger's proposal for a European rating agency supported by a foundation, see McKay (2012), could have been a sustainable approach in such a market situation.

4.4 Dynamics without interior fixed point

Now I present the dynamics without interior fixed point, which lead to the Nash equilibria in pure strategies presented in Section 3.1. The dynamics for the four possible cases are illustrated in Figure 4, whereas the respective discussion is provided in Section 3.2. I use the parametrization from the base case given in Table 3. Then I adjust one parameter at a time to match the respective Nash equilibrium conditions. Panel 4(a) shows the equilibrium with sophisticated investors and inflating CRAs, for which I apply $\epsilon = 0.65$, which yields $\alpha^* < 0$. Panel 4(b) shows the equilibrium with trusting investors and inflating CRAs. It is achieved with $\lambda = 0.71$, which yields $\beta^* < 0$. The third panel, 4(c), shows the equilibrium with trusting investors and honest CRAs. Here I choose $\epsilon = 0.1$, which yields $\alpha^* > 1$. Finally, Panel 4(d) shows the equilibrium with sophisticated investors and honest CRAs, for which I apply $C = 0$, which yields $\beta^* = 1$.

5 Empirical implications

5.1 Evolutionary dynamics

For the base case setting of Section 4.2, my model predicts cyclic dynamics of population and market shares. First, it allows the prediction made by BFS: for a high share of trusting investors, CRAs are more likely to inflate ratings. However, in BFS the share of trusting investors α is exogenously given and constant over time. In contrast, my model allows for a second effect in the opposite direction: I predict that facing a CRA market with a lot of ratings inflation, the investors will in turn change their behavior. As sophisticated investors perform better than trusting investors on such a market, the latter will either start leaving the market or learn to be more sophisticated as well. Mathis, McAndrews, and Rochet (2009) predict a

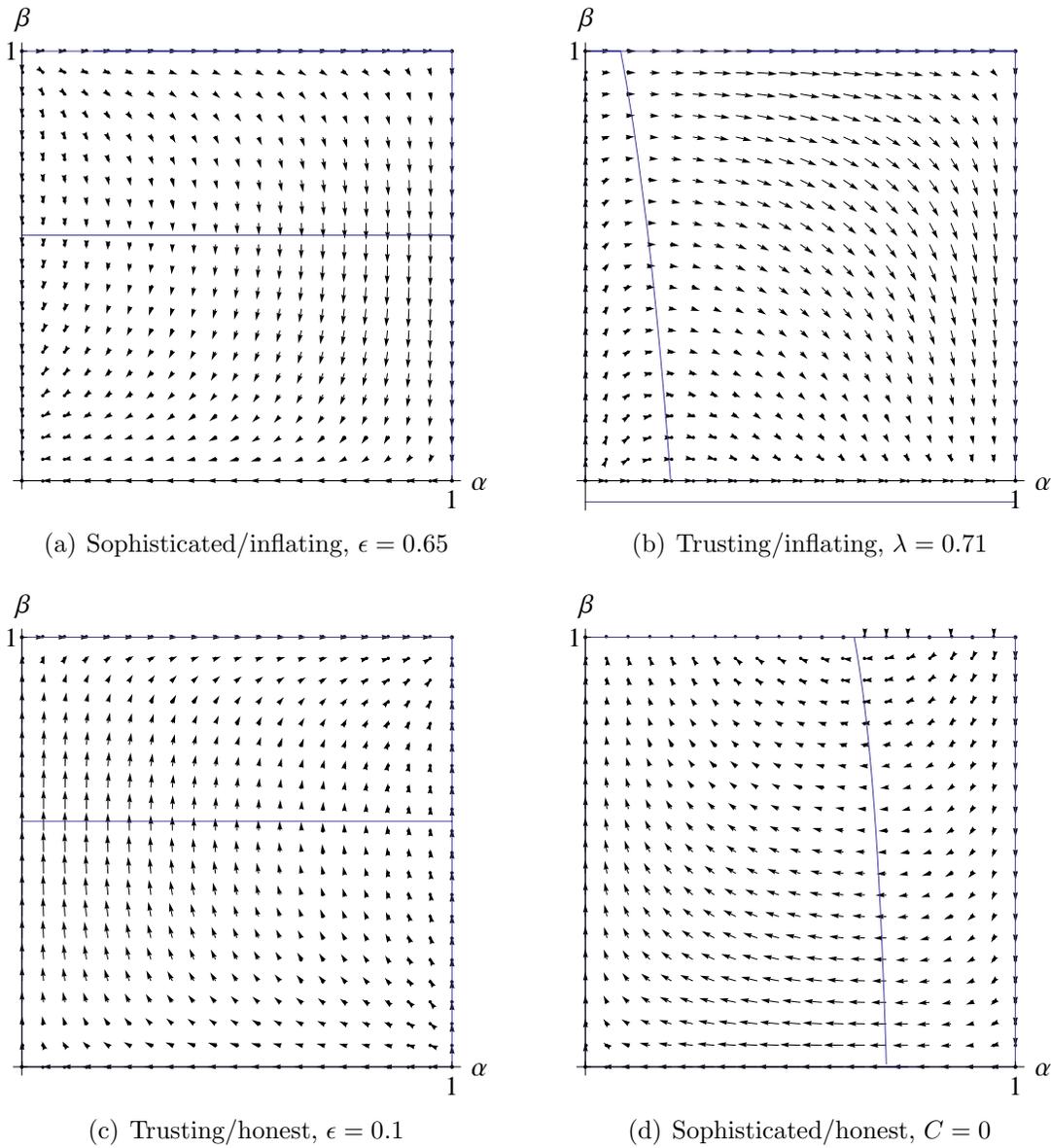


Figure 4: Equilibrium outcomes corresponding to pure Nash equilibria. The four figures show the dynamic evolution of the population shares, with α representing the share of trusting (rather than sophisticated) investors and β representing the share of honest (rather than inflating) CRAs. The fixed lines α^* and β^* are indicated by vertical and horizontal lines, respectively. Different from the base case parametrization given in Table 3, each figure shows the effect of changing one of the parameters, each leading to a different equilibrium (both as given in the captions).

similar dynamics for the CRA market, however they do not allow for a full cycle, as they exclude the possibility of the CRA to recover its reputation, once it is caught lying. My theory is also in line with the predictions by Skreta and Veldkamp (2009) and BFS that ratings inflation is most severe for complex investment products, i.e., products exceeding the investor sophistication level. To sum up, the dynamics in the base case do not only explain the CRAs' behavior as a result of the investors' sophistication level, but also the investors' behavior as a function of the CRAs' ratings quality. The result is the cyclic dynamics of the base case.

Next, I compare the base case of Section 4.2 and the saddle case of Section 4.3. This shows that it makes an important difference which investor clienteles are mostly affecting the build-up and loss of the CRAs' reputation. If one observes that sophisticated investors are the more relevant ones for the CRAs, then the base case describes best the situation. On the other hand, if CRAs are most concerned about the reactions of trusting investors, then it is best described by the saddle case. The implications are dramatically different. While there are cyclic dynamics in the base case, the model predicts for the saddle case that the market will approach one out of two possible stable equilibria, namely the sophisticated/inflating or the trusting/honest equilibrium. One possible empirical test is to check whether the market is following cycles or rather one out of the two other equilibria has been established, and whether this is in line with estimates for the model's parameters. Another possible test is to identify changes in the market environment over time, as they are described in the following, and to check whether these go along with the predicted changes in equilibrium outcomes.

5.2 Effects of competition and exogenous factors

In this section, I shed light on the effect of a change in the model's parameters, which can be caused by factors that are exogenous to the model. First, I establish that the

model's parameters in a realistic setting will also depend on the number of CRAs and the nature of competition on the market. For example, the reputation costs ρ_S and ρ_T are interpreted as the present values of the CRA's foregone future profits. As such, it makes sense to assume that a higher number of CRAs on the market will increase the investors' and issuers' number of alternative options. Therefore, the CRAs' reputation costs should be increasing in the number of CRAs.

Second, other factors that are exogenous to the model can affect the parameters. As an example, the ex ante quality of investments λ can reasonably be assumed to be changing over time. Considering different levels of λ allows the following prediction: The base case setting of Section 4.2 corresponds to a situation with rather low ex ante investment quality, in which it pays off at least temporarily to be a sophisticated investor and to spend some monitoring effort. In contrast, the trusting/inflating equilibrium corresponds to a situation with a sufficiently high ex ante investment quality, which BFS associate with boom times – then the trusting investors perform better, as the sophisticated investors' monitoring does not pay off. Similarly, Bar-Isaac and Shapiro (2012) find that CRAs work less accurate in boom times, which corresponds well with the lower risk of being caught lying that dominates the trade-off against the CRAs' effort in my model. It might be questionable whether there is indeed a higher ex ante investment quality in boom times, rather than merely more optimism into products of possibly lower quality. Still, the association of trusting investors with boom times seems universally valid, and thus also the dynamic bidirectional relation between investor and CRA types over the business cycle, as predicted by my model.

5.3 Effects of market entry and viability of new types

Whenever the conditions for pure Nash equilibria are satisfied, my model provides solutions in which the equilibrium outcomes lie in the corners of the population

space. These equilibria are stable, which means the following: assume that, without being explained by the model, one representative of a new type enters the market that otherwise consists purely of the other type. Then, such a new type is not viable: my model predicts that the new type will not be successful, but be driven out of the market. As an example, consider the equilibrium with trusting investors and inflating CRAs, if both the sophisticated investors' monitoring costs and the CRAs' cost of effort for honest ratings are high. My model predicts that if one sophisticated investor or one honest CRA enter the market, they will be driven out of the market again. However, I discuss in the following along three different examples how new behavioral types can successfully enter the market and be viable, in line with the corresponding equilibria.

First, assume that the market has reached one of the pure Nash equilibria, say it is the trusting/inflating one. Then assume that over time, there is a change in the model's parameters due to exogenous factors as explained in the previous section. Consequently, the effort ϵ for honest ratings no longer exceeds $(1 - \lambda)(\rho_T - \Phi)$. As Table 2 and Figure 1 illustrate, there is now room to switch to the trusting/honest equilibrium. How can such a switch happen? In traditional game theory, trusting/inflating is no longer a Nash equilibrium. Rational CRAs recognize immediately that it is better to be honest and switch. In evolutionary dynamics, the corners of the population space are absorbing, i.e., there is no endogenous movement away from them. Like a black swan,¹¹ the strategy of being a honest CRA has no longer been known to the market until the first of its type reappears. But once just one honest CRA enters the market, it will experience higher profits than the incumbents and thus be able to improve its market share. Eventually, the whole market will turn to the trusting/honest equilibrium.

Second, consider the situation of the base case, i.e., the market shares are varying

¹¹Credits go to the title of the book by Taleb (2010).

over time in cyclic dynamics. If in this case, the model's parameters change such that one of the pure Nash equilibrium conditions is fulfilled, then this will also be reflected in the dynamics, and the market will gradually change towards the respective corner solution in the evolutionary dynamics. Other than in the first example, here the change happens at an interior point in the population space. Therefore the evolution to the new equilibrium can happen without exogenous market entry.

Third, the saddle case is particularly suitable to discuss the possible effect of a new market entrant. Assume that the proportion of honest CRAs (β) changes due to a new CRA entering the market. As explained in Section 4.3, such a change can be critical if the market is close to the ridge between the two basins of attraction. For example, with a high share of trusting investors and the proportion of honest CRAs just below the ridge, the entry of a new CRA can lead to the dynamics eventually reaching the trusting/honest equilibrium instead of the sophisticated/inflating one.

On the empirical side, it will be interesting to examine, similar to Becker and Milbourn (2011) with the market entry of Fitch, how the market is changing by the designation of additional agencies as NRSRO. The existing evidence is mixed: Becker and Milbourn (2011) argue that increasing competition after the market entry of Fitch leads to a decrease in ratings quality. In contrast, Bongaerts, Cremers, and Goetzmann (2012) point out the role of Fitch as a tiebreaker, thus endogenously being chosen by the better issuers. Similarly, Doherty, Kartasheva, and Phillips (2012) show that the market entry of a new CRA can improve ratings quality and precision, if it helps good issuers to separate themselves from bad ones. Jeon and Lovo (2011) suggest that apart from the approval as NRSRO, natural barriers of entry can be a critical factor and prevent new CRAs from being successful against the incumbent.

5.4 Policy recommendations

As just illustrated for the saddle case, small perturbations of the market forces have the potential to facilitate a long-run sustainable change of the equilibrium outcome. This insight is good news for policy makers, and it supports approaches like Roland Berger's proposal for a European rating agency, see McKay (2012). Given the right conditions, i.e., in my case, if there is a low share of honest CRAs, but a sufficiently high share of trusting investors, and at the same time the trusting investors are able to impose serious reputation costs on CRAs, then a regulatory measure supporting only a few more honest CRAs for a limited time can change the equilibrium outcome.

Moreover, a regulator could aim to affect the trade-offs that the market participants face. An analysis of the desirable cases in Figure 1, i.e., those in which the honest CRAs survive in the long run, shows that they can be achieved in two different ways:

First, $C = 0$ is necessary to establish the sophisticated/honest equilibrium. This can be interpreted such that the monitoring of CRAs' performance and their possible punishment should rather be done (even more so) by a regulator or a central market authority, rather than individual investors. BFS suggest on the one hand the oversight of minimum analytical standards by regulators, and on the other hand the enhancement of the market's ability to punish CRAs and thus increase the reputation cost. In contrast, I predict that the investors are not likely to fulfill their part of control and punishment, as there is the incentive for trusting investors to free-ride on the efforts of sophisticated investors.¹² Therefore I suggest that regulators should take over the task of monitoring, the costs of which could be covered by fees that all market participants have to pay to the regulating authorities. As far as CRAs can be found guilty of fraud, they can also be held legally liable as in the recent attempt

¹²In practice, it is even possible that not all investors are interested in the most truthful and objective ratings. As Efung (2013) shows, regulatory bank capital requirements may lead to collusion between banks (as investors) and rating agencies.

by the U.S. Justice Department, see the first paragraph of this paper and Mattingly (2013). Instead of direct punishment, like for example the denial of approval as suggested by Stolper (2009), one could also think of the regulator “rating the raters”¹³, i.e., giving the CRAs grades based on their past performance, as a guideline for the market participants.

However, it is not surprising that investors are willing to choose the “sophisticated” strategy, if this does not occur any costs to them (as $C = 0$). Moreover, note that a second condition for the sophisticated/honest equilibrium to be established is that the effort ϵ for honest ratings does not exceed $(1 - \lambda)(\rho_S - \Phi)$, and the upper bound on ϵ for the trusting/honest equilibrium is $(1 - \lambda)(\rho_T - \Phi)$, respectively. This leads to the second way how to achieve honest rating behavior: One should focus directly on the CRAs’ trade-offs. The reputation costs imposed by investors are discussed in the previous paragraph, and I take λ as exogenous. The remaining components are the CRAs’ effort ϵ and the fee level Φ . So in general, finding appropriate means to compensate the CRAs for their efforts, as well as to avoid that favorable ratings yield higher fees, remains the key issue to achieve honest rating behavior.

¹³Credits for this formulation go to the title of Mathis, McAndrews, and Rochet (2009).

6 Conclusion

I develop a framework using Evolutionary Game Theory to analyze the interaction of credit rating agencies on a market with more than two agencies. The focus of interest is how honest rating behavior can be achieved, i.e. how it can be avoided that agencies give good ratings to bad issues. I draw the following conclusions:

First, the presence of trusting investors facilitates ratings inflation. In turn, ratings inflation also induces investors to be less trusting. The interplay of the two effects can lead to cyclic dynamics in the distribution of both CRA and investor types.

Second, if trusting investors have a high impact on CRAs' reputation, the dynamics exhibits a saddle point rather than cycles. Then a small perturbation of investor/CRA types (e.g., the market entry of a new, honest CRA) can determine whether the outcome will be a sophisticated/inflating or a trusting/honest equilibrium.

Third, off-equilibrium states can prevail in the dynamics, e.g., one with all CRAs behaving inflating. In such a situation, a new market entrant, e.g., an honest CRA, is viable and can turn the whole CRA market to an honest one.

Finally, honest rating agencies can be supported by regulatory measures. As indicated in the last two points, there are situations in which direct support for new, honest CRAs is only needed for a limited time, but the effect is sustainable in the long run. Other measures include affecting the CRAs' fee and compensation structures, as well as a centralized monitoring of ratings quality.

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A Derivation of the Replicator Dynamics

The derivation of (9) follows Taylor and Jonker (1978) for one population and Taylor (1979) for the extension to two populations. For one population, Taylor and Jonker (1978) define as n_i the number of i -strategists in the population. Let I be the number of available strategies (in my paper, $I = 2$). Then $N = \sum_{i=1}^I n_i$ is the total number of individuals. Defining furthermore $s_i = n_i/N$ as the proportion of i -strategists, the state of the population is $s = (s_1, \dots, s_I)$. With r_i being the current growth rate of n_i , it follows for the evolution that $\frac{\partial n_i}{\partial t} = r_i n_i$. Moreover, with $\bar{r} = \sum_{i=1}^I s_i r_i$ being the average growth rate, it follows that $\frac{\partial N}{\partial t} = \bar{r} N$. Differentiating $s_i = n_i/N$ leads to

$$\frac{\partial s_i}{\partial t} = s_i(r_i - \bar{r}). \quad (17)$$

Now the assumption is that the fitness of strategy i is an estimate of the growth rate r_i . In my model, the fitness of strategy i corresponds to the expected payoff of the respective strategy (e.g., Π_T^{Inv} for the expected payoff of the trusting investors), and the average growth rate corresponds to the average payoff in the population (e.g., $\bar{\Pi}^{Inv}$ for the average payoff in the investor population). Then the growth of the share of trusting investors α follows

$$\frac{\partial \alpha}{\partial t} = \alpha(\Pi_T^{Inv} - \bar{\Pi}^{Inv}), \quad (18)$$

as given in (9). As there are only two strategies for the investors, the dynamics for the share $(1 - \alpha)$ of the second strategy follow implicitly. An analogous formula is given in (9) for the CRA population. As Taylor (1979) shows, the solutions are also valid for two interacting populations. In addition, Weibull (1997) introduces background birth and death rates in the populations, and he shows that they will not affect the Taylor and Jonker (1978) dynamics.

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