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# The Optimal Regulation of Credit Rating Agencies

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## Abstract

Credit rating agencies (CRAs) very often have been criticized for announcing inaccurate credit ratings and are suspected of being exposed to conflicts of interest. Despite these objections CRAs remained largely unregulated. Based on Pagano & Immordino (2007), we study the optimal regulation of CRAs in a model where rating quality is unobservable and enforcing regulation is costly. The model shows that minimum rating standards increase the social value of credit ratings. The model also analyzes implications for regulation in the presence of conflicts of interest between the CRA and the rated clients by direct bribes and by the joint provision of rating and consulting services.

**Keywords:** credit rating agencies, regulation, conflicts of interest

**JEL Classification:** G20, G24, G28

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# 1 Introduction

Credit rating agencies (CRAs) play a very meaningful role in today's financial markets. According to Moody's (2006) - one of the largest CRAs worldwide - , the volume of rated debt issues increased globally from US\$ 3,500 billion in the year 2002 to over 8,000 billion in 2006.<sup>1</sup> In principle, credit ratings should serve as third-party opinions about the solvency of a debt instrument and should reduce the information asymmetry between an issuer of a debt instrument and the potential investors, and therefore improve efficiency and transparency in financial markets. The CRAs pronounce that their credit ratings should not be interpreted as default probabilities and that credit ratings are rather opinions about risk only. The higher is the credit rating of a debt instrument, the less likely it should be to default and the longer it should take to default. A closer look at corporate scandals and financial crisis during the last years reveals that CRAs have been involved several times and have been confronted with heavy criticism for publishing inaccurate credit ratings. Examples are the Asian crisis, where the CRAs gave Thailand an investment-grade rating until five months after the start of the crisis or the Enron case, where the CRAs gave Enron investment-grade until days before it went bankrupt. Another recent example for public discussion about the behavior of CRAs is the debacle of subprime lending in the USA with its impact on financial markets globally.<sup>2</sup> Furthermore, CRAs very often are confronted with the suspicion of being exposed to conflicts of interest as mostly the issuers of the debt instrument pay for the credit rating, which fees account for about 90 per cent of the CRAs' revenues, and as CRAs offer additional consulting services to their clients. Again, the crisis in subprime

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<sup>1</sup>A closer look at the market structure of CRAs shows that the market is dominated by three big global firms (Moody's Investors Services, Standard & Poor's and Fitch Ratings). According to published data from Moody's (see Moody's, 2006) the global industry market share of the three big agencies was estimated to be 95% in 2006. The largest CRA is Standard & Poor's with a market share of 40%, followed closely by Moody's with 39% and Fitch with 16%.

<sup>2</sup>Due to the rise in housing prices the volume of subprime loans increased rapidly. Those loans were securitized into mortgage backed securities and again these were securitized into collateralized debt obligations (CDOs). Those complex debt contracts received a very high rating from the CRAs, comparable to government bonds. In the first half of 2007 CDOs lost almost 40% of their value. In order to limit turbulences, the ECB injected around 200 billion Euro and the FED around 40 billion US Dollars emergency liquidity in August 2007.

lending can serve as an illustration of that issue. The CRAs not only issued credit ratings for structured finance instruments, but also supported investment banks in designing them (see for example Mason & Rosner, 2007).

Despite these objections, CRAs remained themselves largely unregulated, but the discussion on further regulation is active in the media as well as in institutions of financial market supervision. In 2005 the SEC (securities and exchange commission) published a report on the behavior of CRAs and issued a concept release on how the regulation of CRAs should be changed. Amongst others regulation would be needed for requirements on the qualifications of rating-analysts, the avoidance of conflicts of interest in the presence of additional services of CRAs and the current monitoring of CRAs.<sup>3</sup> In 2004 the IOSCO<sup>4</sup> published a code of conduct fundamentals for CRAs in which was proposed amongst others that the quality and integrity of the rating-procedure should be warranted and that credit ratings should be free from conflicts of interest.<sup>5</sup> In September 2006, the U.S. legislations passed the "Credit Rating Agency Reform Act 2006", with the goal to improve the quality of credit ratings "for the protection of investors and in the public interest by fostering accountability, transparency, and competition in the credit rating industry" (see CRA Reform Act, 2006). After the subprime loan crisis in 2007, the EU-commission and US politicians blamed the CRAs of being jointly responsible for the financial crisis. The EU-commission considered to react with legal regulations for the credit rating agencies and also US authorities announced to investigate the role of CRAs in the subprime loan crisis that was set off in August 2007. However, very little progress has been made in implementing those proposals in national laws and regulations.

This paper contributes to the question whether CRAs should be regulated and especially concentrates on the allegation of inaccurate credit ratings and adverse effects of conflicts of interest. The paper studies the optimal regulation of CRAs in a model where rating quality is unobservable and enforcement of regulation is costly. The applied theoretical model is based on Pagano & Immordino (2007), where

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<sup>3</sup>see Bafin (2004)

<sup>4</sup>The IOSCO (International organization of securities commissions) is a union of national institutions of financial supervision of over one hundred countries.

<sup>5</sup>see IOSCO (2004) and Bafin (2004).

the regulation of auditing firms is analyzed. The model considers a representative investment bank<sup>6</sup> that wants to invest in a risky portfolio and needs to raise debt from external investors to finance the investment. A CRA has a costly evaluation technology and issues a credit rating for the debt contract, which is made available for external investors. The credit rating is based on the risk of the underlying portfolio and a credit rating is being issued, if a CRA is assigned by the investment bank. In the setup, the external investors use the credit rating for their investment decision and the credit rating helps to allocate investment more efficiently, compared to the case without a credit rating. If rating quality is unobservable, the CRA has an incentive to lower the rating quality, because the costs can then be reduced and hence the profits increased.

The model motivates a rationale for regulation by showing that due to the unobservable rating quality the allocation of investment becomes inefficient and social welfare inefficiently low. In a next step a regulator with a costly technology may detect compliance with a minimum rating standard with a certain probability. Being benevolent, the regulator decides on the minimum rating standard and the costly detection effort employed in regulation in order to maximize social welfare. The introduction of regulation leads to the trade-off that more efficient allocation of investment leads to a rise in social welfare, but because regulation is costly, to a reduction in social welfare. The results show that the optimal rating standard is lower than the first-best rating quality. In order to give consideration to the fact that CRAs may be exposed to conflicts of interest, the model is extended in a next step by assuming that the rated issuer may bribe the CRA in exchange for a better credit rating and that CRAs do not only rate but also have the ability to offer consulting services.<sup>7</sup> It will be shown that with the joint provision of ratings and consulting services the possibility of collusion may arise, which could have negative effects on social welfare. The model shows that on the one hand the regulator could get rid

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<sup>6</sup>By using an investment bank in our model setup we give consideration to the extensive public discussion about the role of credit rating agencies in the subprime loan crisis in 2007. Our model of course can be generalized by using the term "firm" or "financial intermediary", that has a risky investment project and needs external funds to finance the project.

<sup>7</sup>Associated with the subprime loan crisis in August 2007, CRAs were under suspicion to give too favourable credit ratings for structured debt products, because CRAs did not only rate the products, but also were involved in designing products with a good credit rating.

of the collusion problem by forbidding the joint provision of ratings and consulting services, but on the other hand that this may not always be optimal from a welfare perspective. That paper contributes to the theoretical literature on CRAs by filling the gap on the optimal regulation of CRAs and by giving consideration to broadly discussed issues regarding the alleged inglorious role of CRAs in financial markets in the recent past.

The remainder of this paper is organized as follows: Section 2 presents a review of the related literature about the role of CRAs in financial markets and the regulation of CRAs. Section 3 introduces the framework of the model, motivates the rationale for regulation when rating quality is unobservable and analyzes the optimal regulation. In section 4 the model is extended by introducing conflicts of interest between the issuer of the debt instrument and the CRAs which may emerge by the joint provision of ratings and additional consulting services. Finally, section 5 concludes.

## **2 Related Literature**

Richard Cantor (2004) points to the fact that the literature on the role of CRAs has almost exclusively an empirical focus. In the small category of theoretical literature, Millon & Thakor (1984) analyze the rationale, why CRAs exist and motivate their existence with the possibility of information and risk sharing. They conclude that CRAs might not have an incentive to employ costly effort into the process of information production. However, neither conflicts of interest nor regulation of CRAs are considered. Regulation is not considered either in Kuhner (2001), who analyzes the role of CRAs in times of enhanced systemic risk, where CRAs act as frontrunners in a Bayesian herding process. Boom (2001) concentrates on the demand and the price for a rating of a monopolistic rating agencies. But again, no regulatory issues are incorporated explicitly in the model. Mostly related with our approach is the contribution of Mukhopadhyay (2004), where moral hazard aspects are considered. That paper motivates the moral hazard problem with unobservable evaluation standards,

which CRAs use in the rating process, and show, somewhat questionable from a policy perspective, that a regulator can enforce an evaluation standard with incentive payments to the rating agency. But again, this contribution neither considers conflicts of interest between the CRA and the rated firm nor welfare implications of regulation. Another interesting theoretical motivation for the role of CRAs in financial markets is Boot et al. (2006). They show that credit ratings can act as a coordination mechanism in the presence of multiple equilibria and that credit ratings then have the ability to improve financial market stability. Despite those valuable results, issues regarding possible conflicts of interest, moral hazard and regulation of CRAs are not addressed in this paper. As will be shown in section 3 in more detail, credit ratings of CRAs and auditing reports of auditing firms are products with related characteristics. Hence, the framework of analyzing the behavior and regulation of auditing firms is closely related to the analysis of CRAs. Dye (1993) analyzes the role of auditing standards and litigation against auditors. They derive auditors' responses to auditing standards and optimal liability rules. Pagano & Immordino (2007) extend the analysis of auditing firms by focusing on unobservable auditing quality, conflicts of interest and optimal regulation.

### **3 The Model**

This section introduces a framework for analyzing the regulation of credit rating agencies. The model is based on Pagano & Immordino (2007), where the optimal regulation of auditing is analyzed, and on Dye (1993), who studies the relationship between auditing standards and auditor's wealth. The rationale for regulation will be derived by the assumption that the quality of credit ratings is neither observable nor contractible. It will be shown that a minimum rating standard, set by the regulator, can improve the outcome from a welfare perspective. The regulatory issues for auditing firms in Pagano & Immordino (2007) are closely related to those of CRAs. Similar to CRAs, auditing firms serve as information providers for investors and are assigned and remunerated by the audited firm. One difference is that auditing firms provide information to shareholders, who provide equity, whereas the CRAs

provide information to investors, which provide debt finance. Another difference is that firms are legally forced very often to be audited whereas getting rated is mostly voluntary. At last, the product of auditing firms and CRAs is different from a legal perspective. As mentioned in the introduction, until today a credit rating has to be regarded as an opinion on the default probability only, whose accuracy cannot be sued by the clients of the CRA in contrast to auditing firms.<sup>8</sup>

At first we construct a benchmark model with the assumption that the rating quality is observable and contractible. After relaxing this assumption, we show in a next step that the equilibrium rating quality becomes inefficiently low. By introducing a regulator with a costly detection technology, we show that a minimum rating standard improves efficiency in the allocation of investment and that welfare will be increased. Taking into account that CRAs in the real world have often been blamed to profit from market power, we extend our analysis by distinguishing the cases of perfect competition and market power in the CRA sector.

### **3.1 Investment Bank, Investors, and the Credit Rating Agency**

We assume an environment with universal risk neutrality and a continuum of investment banks (IB). A representative IB has the possibility to invest in a risky portfolio. To finance investment of the portfolio, it has to raise debt finance  $d$  from external investors.<sup>9</sup> The goal of the representative IB is to maximize its profits from its investment possibilities. Without debt finance, we assume that the IB is not able to invest and the final profit of the IB would then be zero.

The risk of the portfolio can be characterized as follows: the final return of the portfolio may turn out to be high or low, so there are two possible states ( $s$ ) of the portfolio  $s = g$  (good) or  $s = b$  (bad). The type of the portfolio is a priori

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<sup>8</sup>In the aftermath of the Enron debacle, CRAs avoided regulatory scrutiny and litigation in contrast to auditing firms, who were convicted to pay high fines. Also the regulatory oversight of auditing firms was strengthened in contrast to CRAs (see for example Zachariahs, 2007).

<sup>9</sup>We assume that the IB has no own funds initially and therefore has to finance its operation entirely via debt. To keep the model tractable, we assume that external investors require an interest rate of zero.



unknown to the IB. If the portfolio is in the good state, its final value  $\tilde{\Psi}$  is given by a high payoff  $\Psi_g$ , and if the portfolio is in the bad state, the final value  $\tilde{\Psi}$  is given by a low payoff  $\Psi_b$ . We assume that each investment bank in the economy invests only in one portfolio in one period. Therefore, the final value of the portfolio is equal to the gross profit of the IB in one period. The portfolio will be in the good state with unconditional probability  $p$  and in the bad state with probability  $1 - p$ . Since we assume a continuum of IBs, the unconditional probability  $p$  is also the fraction of IBs in the economy, which has the possibility to invest in a good portfolio.<sup>10</sup> We assume that  $p$  is exogenous and a priori known by the IBs and the external investors and that neither IBs nor investors have further private information about the quality of the portfolio. If the portfolio is in the good state, the payoff is assumed to be higher than the required debt repayment to the investors  $d$ , but if the project turns out to be in the bad state, the payoff is assumed to be lower than  $d$ :  $\Psi_g > d > \Psi_b$ . Given that the fraction of good IBs  $p$  is publicly known, the expected unconditional gross profit of the representative IB is given by  $\bar{\Psi} = p\Psi_g + (1 - p)\Psi_b$ . We assume that the expected gross profit of the IB exceeds the required debt repayment ( $\bar{\Psi} > d$ ). Therefore, risk neutral investors are willing to provide debt finance, given the information about  $p$ . Obviously, all IBs that seek debt finance, will be served irrespective if their portfolio is actually good or bad.

The representative credit rating agency (CRA) has a costly technology that enables the CRA to distinguish, whether an IB has the possibility to invest in a good or a bad portfolio. A single CRA is assumed to rate only one portfolio per period. The CRA is able to detect a signal about the state of the IB's portfolio and accordingly issues a credit rating  $r$  that reflects whether the bank's portfolio is good or bad. If the CRA comes to the conclusion that the portfolio is good, it issues a good credit rating  $r = g$  and reversely a bad credit rating  $r = b$ .<sup>11</sup> Since the rating technology is costly, the CRA charges a rating fee  $\theta$  from the rated investment bank. The issued credit rating, which is made available to external investors, influences the

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<sup>10</sup>In the paper we will analogously use the terms "good" IB and "bad" IB.

<sup>11</sup>A good credit rating  $r=g$  can be regarded as reflecting an "investment grade" credit rating and a bad credit rating  $r=b$  as a "speculative grade" credit rating.

expected profits of the IB and the decision of the investors to provide debt finance.<sup>12</sup> According to Dye (1993)<sup>13</sup> we assume that the CRA can choose the precision of the signal about the state of the rated portfolio. We interpret the precision of the CRA as the quality of a credit rating  $q$ . The quality of a credit rating can be interpreted as the qualification of the staff, the information technology or the internal organization of the CRA. The CRA can choose the quality of the credit rating  $q \in [0; 1]$ . The rating technology is assumed to be perfectly accurate, if the CRA observes a good signal, but that it may be inaccurate after observing a bad signal. The conditional probabilities that the issued credit ratings after observing a good and a bad signal are correct are given by:

$$\begin{aligned}\Pr(r = g \mid s = g, q) &= 1 \\ \Pr(r = b \mid s = b, q) &= q\end{aligned}\tag{1}$$

It is obvious that the credit rating is always accurate in the case of a good signal. In the case of a bad signal, the accuracy of the credit rating increases with the quality that is employed in the rating process. The technology of the CRA can be described in such a way that credit ratings are biased upwards, meaning that after observing a good signal, the credit rating is perfectly accurate, but after observing a bad signal only with a certain probability. In the case of a bad signal, the CRA will issue an inaccurately good credit rating with a probability  $(1 - q)$ , while the probability of issuing a bad credit rating after observing a good signal is zero.<sup>14</sup>

Given the technology of the CRA, the conditional probability of a rated portfolio being in a bad state after getting a bad credit rating can be calculated using Bayes' rule:

$$\Pr(s = b \mid r = b) = \frac{\Pr(s = b \cap r = b)}{\Pr(r = b)} = 1,$$

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<sup>12</sup>Since we assume that an IB invests in only one portfolio for which it seeks external finance, the rating of the portfolio is identical to a rating of the IB itself. Unlike in reality, the model does not discriminate between issuer and issue credit ratings.

<sup>13</sup>The assumptions on the rating technology of the CRA are based on Dye (1993), who analyzes the relationship between auditing standards, auditor's wealth and litigation.

<sup>14</sup>With that assumption about the technology of CRA we take into account the real world criticism that CRA may issue too favourable ratings and that ratings may be inaccurately adjusted in the case of a deterioration of an instrument's or a firm's conditions.

while the conditional probability of a portfolio with a bad credit rating, being in a good state is given by:

$$\Pr(s = g \mid r = b) = 0.$$

The probability that the rated IB is in a good state, conditional on a good credit rating, is given by the following expression:

$$\Pr(s = g \mid r = g) = \frac{\Pr(s = g \cap r = g)}{\Pr(r = g)} = \frac{p}{p + (1 - p)(1 - q)},$$

while the probability that the rated IB is in a bad state, conditional on a good credit rating, is given by:

$$\Pr(s = b \mid r = g) = \frac{(1 - p)(1 - q)}{p + (1 - p)(1 - q)}.$$

Using the conditional probabilities above, the expected final profit of the rated IB after deduction of the debt repayment to external investors  $d$ , conditional on a good credit rating, can be formulated as:

$$\begin{aligned} E(r = g) &= \Pr(s = g \mid r = g)\Psi_g + \Pr(s = b \mid r = g)\Psi_b - d \\ \iff E(r = g) &= \frac{p\Psi_g + (1 - p)(1 - q)\Psi_b}{p + (1 - p)(1 - q)} - d \geq \bar{\Psi} - d. \end{aligned} \quad (2)$$

and the expected final profit of the rated IB, conditional on a bad credit rating can be written as:

$$\begin{aligned} E(r = b) &= \Pr(s = g \mid r = b)\Psi_g + \Pr(s = b \mid r = b)\Psi_b - d \\ \iff E(r = b) &= \Psi_b - d < 0. \end{aligned}$$

Given the technology of the CRA, the expected profit of the rated IB in the case of a good credit rating is larger than the expected profit without a credit rating (see equation (2)). Conversely, the expected value of the IB with a bad credit rating is smaller compared with the case without a credit rating ( $\Psi_b < \bar{\Psi}$ ). Since  $\Psi_b < d$ , it

is rational for the external investors not to provide  $d$  and the final expected profit in the case of a bad rating is zero ( $E(r = b) = 0$ ). It is obvious that investment will only take place in the cases of a good credit rating or without a credit rating, since the expected profit of the IB is positive in these two cases, meaning that the investors get back their funds. In the case of a bad credit rating investors are not willing to provide debt finance.<sup>15</sup>

The question on hand is: when is the IB willing to obtain a credit rating from a CRA? The IB can only observe the unconditional probability  $p$  and is only willing to pay a rating fee  $\theta$  for a credit rating, if the expected profit with a credit rating is larger than the expected profit without a credit rating. The expected profit with credit rating net of the rating fee is given by:

$$\Phi^R = \Pr(r = g) E(r = g) + \Pr(r = b)E(r = b) - \theta.$$

If no credit rating is assigned, the expected profit is given by:  $\Phi^n = \bar{\Psi} - d$ . The expected profit of a credit rating for the IB ( $\Pi^{IB}$ ) that can be interpreted as the "informative value" is therefore given by:

$$\Pi^{IB} = \Phi^R - \Phi^n \tag{3}$$

$$\iff \Pi^{IB} = q(1 - p)(d - \Psi_b) - \theta \tag{3'}$$

If equation (3) is larger or equal zero ( $\Pi^{IB} \geq 0$ ), a credit rating has informative value and it is then optimal for the IB to obtain a credit rating.<sup>16</sup> If instead equation (3) would be negative ( $\Pi^{IB} < 0$ ), the credit rating has no informative value and henceforth the IB would decide not to assign a credit rating. In that case, credit ratings do not play a useful role. From equation (3) can be derived that the value added of a credit rating is increasing in the quality of the credit rating  $q$ , decreasing in

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<sup>15</sup>The pivotal criterion for external investors is the expected profit of the IB. The group of external investors is assumed to be homogenous and they are not restricted by regulation to invest only in products with a certain credit rating.

<sup>16</sup>We assume that credit ratings are not mandatory. If equation (3) is zero, the IB is indifferent between getting a rating or not. In case of indifference we assume that the IB chooses to obtain a credit rating.

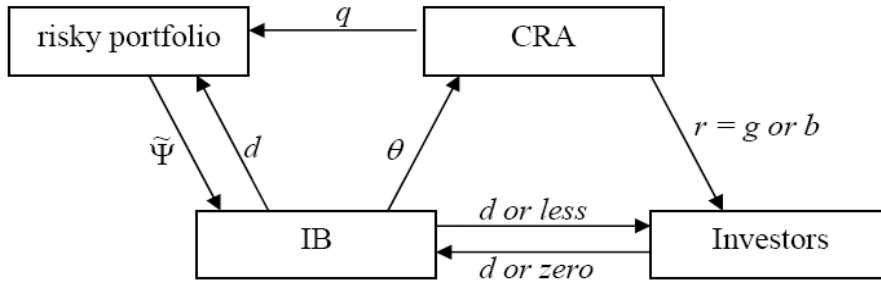


Figure 1: Interactions between CRA, IB, and investors.

the unconditional probability  $p$  and the rating fee  $\theta$ . If the fraction of good portfolios becomes larger, the informative value of a credit rating decreases. Furthermore, equation (3) is increasing in the term  $(d - \Psi_b)$ , which can be interpreted as a measure of potential misallocated investment that can be prevented by a credit rating of a CRA about the IB's portfolio. The larger the possible misallocation, the higher is the value of the credit rating. To simplify notation in the following, we define  $m \equiv d - \Psi_b$ . We assume that the parameters  $p$ ,  $\theta$ ,  $\Psi_b$  and  $d$  are public observable and given exogenous. Hence, the value of equation (3) depends on the rating quality, which is set by the CRA. Obviously, if the rating quality would be observable for the IB, the IB would be able to observe the exact value of the credit rating via equation (3), while it is not the case if rating quality would be unobservable. We take a closer look at that issue in part 3.2. Figure 1 summarizes the interactions between the three agents - IB, CRA and external investors - in the framework of the model.

### 3.2 Demand and Supply of Observable and Unobservable Rating Quality

We assume that the CRA produces only one credit rating per period and that it faces costs per rating  $c(q)$ , which are increasing and convex in the rating quality  $q$ .<sup>17</sup> Revenues are created by charging a rating fee  $\theta$  from the rated IB. Regarding the setting of the rating fee we distinguish the case of perfect competition and market power in the sector of CRAs.

**i. More CRAs than clients:** If there are more CRAs than clients in the economy, the situation can be regarded as perfect competition among CRAs. In that scenario, the CRA would set the rating fee equal to the costs per rating:  $\theta(q) = c(q)$  and therefore make zero profits. If the quality of the credit rating is observable and contractible, the IB would demand a rating quality that maximizes the additional profit of getting rated in equation (3) that includes the rating fee  $\theta(q)$ . We have assumed above that the costs per rating are increasing and convex in  $q$ . Since the rating fee  $\theta$  has to cover the costs per rating, the rating fee is increasing and convex in  $q$ , too. Due to the convexity of  $c$ , the IB's profit from getting rated ( $\Pi^{IB}$ ), expressed in equation (4), is concave and maximization with respect to the rating quality leads to an internal maximum:

$$\max_q \Pi^{IB}(q) = q(1-p)m - c(q) \quad (4)$$

The first order condition is given by:

$$(1-p)m = c'(q) \quad (5)$$

If the rating quality would be observable and contractible, the IB would require a quality, where the marginal cost of increasing the rating quality equals the marginal revenue of a higher rating quality. Solving the first order condition for  $q$  leads to

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<sup>17</sup>The cost function has the following properties:  $c'(q) > 0$ ,  $c''(q) > 0$  with  $\lim_{q \rightarrow 0} c'(q) = 0$  and  $\lim_{q \rightarrow 1} c'(q) = \infty$ , and  $c(0) = 0$ .

the first-best rating quality  $q^* \in [0, 1]$ . The characteristics of the first-best rating quality are summarized in proposition 1.<sup>18</sup>

**Proposition 1** *If rating quality is observable and contractible, the first-best rating quality  $q^*$  becomes smaller, if the unconditional probability of the IB's portfolio being in a good state  $p$  increases and becomes larger, if the size of the potential misallocation of investment  $m$  without a rating increases. The first-best rating quality becomes larger, if the marginal costs per rating  $c'(q)$  become smaller.*

**Proof.** See appendix A.1. ■

The value of getting a credit rating becomes larger, if the fraction of good portfolios in the economy decreases. Therefore it is optimal for the IB to demand a higher rating quality and to pay a higher fee for the CRA's rating service. From the optimality condition (5) it is obvious that a credit rating becomes more valuable, the higher is the potential loss  $m$ , if the IB's portfolio turns out to be in a bad state, expressed in a higher amount of debt relative to the portfolio's payoff in the bad state. Therefore, a higher rating quality will be demanded by the investment bank. The last point of Proposition 1 refers to the cost efficiency of CRAs. If the cost efficiency of CRAs increases - meaning lower marginal costs per rating for a given quality - IBs would demand a higher rating quality. From a welfare perspective, the IB's individual gains from getting a credit rating can be interpreted as the "social value" of a credit rating, where the first-best rating quality  $q^*$  maximizes the social value of a credit rating.

**ii. More clients than CRAs:** If in the economy are more IBs than CRAs there is market power on the side of CRAs. In that case, the rating fee, required by the CRA, increases as follows. In order to maximize its profits from "producing" a credit rating, the CRA will set the rating fee to the highest possible level. It optimally sets the rating fee such that it is equal to the informative value of a credit

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<sup>18</sup>All proofs are located in the appendix.

rating for the rated investment bank in equation (3):

$$\theta(q) = q(1-p)m$$

Since we assume that credit ratings are not mandatory, the IB is willing to obtain a credit rating, if the informative value of the rating minus the rating fee is larger or equal zero. In case ii. the expected additional profit for the IB of getting rated will be zero. If the IB would set a higher rating fee, the IB would not be willing to obtain a credit rating. The decision problem of the CRA is now to choose a rating quality that maximizes its profit - the difference between the fee per rating and the costs per rating:  $\Pi^{CRA}(q) = q(1-p)m - c(q)$ . Given the fee setting behavior above, the maximization problem is exactly the same as in case i. (see equation (4)) and therefore the supplied first-best rating quality that maximizes the profits of the CRA is the same ( $q = q^*$ ). The only thing that differs, is the distribution of the profits originating from the credit rating. In case i., only the IB profits from getting rated, while in case ii., the value of the credit rating is taken entirely by the CRA. The overall social surplus of a credit rating is the same in both cases. Therefore, the characteristics of the first-best rating quality in equilibrium, as described in proposition 1, applies for the case of market power of CRAs, too. It has often been a point of criticism in the real world that CRAs have market power and that the quality of credit ratings would be higher if there were more competition in the rating sector. As was shown above, the model concludes that market power in itself is no reason for regulatory intervention if rating quality is observable and contractible, since the optimal rating quality is the same in the monopoly and the perfect competition case.

However, the equilibrium rating quality would change, if the rating quality becomes unobservable and not contractible. In that case the CRA has an incentive to lower rating quality after it was assigned to issue a credit rating, because this would reduce the rating costs and increase the profits. The model does not consider a repeated game or a reputation mechanism, instead the model concentrates on possibilities of regulation in a one period game. Therefore, it is even optimal for the



CRA to set the rating quality equal zero after it was hired for a rating service by the IB, because this would maximize the profit per credit rating. According to the rating technology, the CRA would in the case of a rating quality of zero issue inaccurate good credit ratings and the social value of credit ratings would vanish. The misallocation of funds therefore increases in the case of unobservable rating quality and a rationale for regulation emerges in order to preserve the potential social value of credit ratings. Real world experience - as presented by anecdotal evidence in the introduction - has shown that the threat of losing reputation alone obviously is not enough to discipline the CRAs. Partnoy (1999) argues that CRAs "have not maintained good reputations, based on the informational content of their credit ratings. Instead, credit rating agencies have thrived, profited, and become exceedingly powerful because they have begun selling regulatory licenses, i.e. the right to be in compliance with regulation." The next section analyzes the optimal regulation by a regulator, which sets a minimum rating standard and the implications for social welfare.

### 3.3 The Optimal Rating Standard

If rating quality is neither observable nor contractible, the CRA has an incentive to lower the rating quality. This would decrease the costs per credit rating and increase the CRA's profits, which again decreases the social value of a credit rating. In order to preserve the potential social value added of a credit rating, a regulator can set a minimum rating standard.<sup>19</sup> In contrast to auditing firms, CRAs so far cannot be made liable for consequences of inaccurate credit ratings. This is because credit ratings are regarded as an opinion, comparable to a report in a newspaper. The only way to regulate CRAs would be, as in the model on hand, to supervise the surrounding conditions of the rating process.<sup>20</sup> We assume that a regulator has a costly technology, which may detect whether a CRA incorporates a rating

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<sup>19</sup>The content of minimum rating standards could for example be oversight of CRA's staff, transparency of the rating process or parts of the IOSCO code of conduct fundamentals which can be summarized in three categories: 1. Quality and integrity of the rating process, 2. CRA independence and 3. CRA responsibilities to the investing public and issuers. (see IOSCO, 2004)

<sup>20</sup>Minimum quality standards would be for example prerequisites regarding the staff, the IT systems or the organizational structure of CRAs.

quality below a certain minimum rating standard, which is set by the regulator. The detection technology is designed in such a way that the regulator can detect compliance with a rating standard with a certain probability  $h \in [0, 1]$ , which is an increasing and concave function of the employed costly effort  $e$ :  $h'(e) > 0$ ,  $h''(e) < 0$  and  $h(0) = 0$ ,  $\lim_{e \rightarrow \infty} h(e) \leq 1$ ,  $\lim_{e \rightarrow \infty} h'(e) = 0$ ,  $\lim_{e \rightarrow 0} h'(e) = \infty$ . If the regulator detects that the rating quality of a CRA is below the rating standard, the CRA has to pay a penalty  $\eta$ . Since a deviating CRA will not be detected with certainty, it faces an expected penalty  $P$ . The profit of the CRA is now given by the fee per rating minus the costs per rating minus the expected penalty:

$$\Pi^{CRA}(q) = \theta(q) - c(q) - P$$

Lemma 1 describes the expected penalty in case of deviation and compliance with the rating standard.

**Lemma 1** *If the regulator sets a rating standard  $\hat{q}$ , and if deviation from the standard is detected with probability  $h(e)$ , the CRA faces an expected penalty  $P$  with*

$$P = \begin{cases} h(e) \eta, & \text{if } q < \hat{q} \\ 0, & \text{if } q \geq \hat{q} \end{cases}.$$

Since we assume limited liability of the CRA, the penalty  $\eta$  in case of deviation from the rating standard and detection by the regulator has an upper limit. This upper limit can be characterized by the total wealth  $W$  of the CRA, accumulated from past activities plus the rating profits in the actual period in the case of deviation from the rating standard (i.e.  $c(q) = 0$ ):  $\eta \leq W + \theta$ .

The sequence of events in the model is summarized in figure 2. At first, nature determines, whether the portfolio of the IB is good or bad. In the next step, the regulator has to decide on the rating standard  $\hat{q}$ , the penalty for the CRA in case of deviation from the standard  $\eta$ , and the effort employed in the detection technology  $e$ . Taking the parameters, chosen by the regulator, as given, the IB decides to buy a credit rating at quality  $\hat{q}$ , if the informational value of the credit rating is larger or equal zero and pays the rating fee  $\theta$ . Then the CRA decides on the rating quality  $q$  and issues a credit rating ( $r = b$  or  $r = g$ ). After the credit rating is published, the

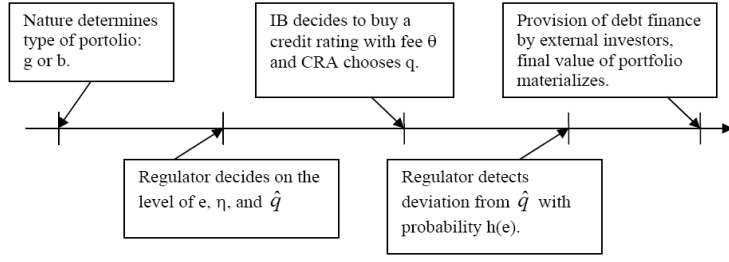


Figure 2: Sequence of events.

regulator detects deviation from the rating standard with probability  $h(e)$  and the CRA has to pay the penalty  $\eta$  in case of deviation from the standard. Debt finance  $d$  is being provided, conditional on the issued credit rating, and finally, the value of the portfolio ( $\Psi_g$  or  $\Psi_b$ ) materializes.

We assume that the objective of the regulator is to maximize the social value ( $V$ ) of the credit rating. If we take into account that regulation needs costly effort  $e$ , the decision problem of the regulator is to maximize the social value of the credit rating, given by equation (4), minus the effort costs of regulation  $e$ , by deciding on the rating standard  $q$ , the detection effort  $e$  and the penalty  $\eta$ :

$$\max_{\hat{q}, e, \eta} V(\hat{q}) = q(1-p)m - c(q) - e \quad (6)$$

The incentive compatibility constraint that induces the CRA to comply with the rating standard is given by:

$$\theta(\hat{q}) - c(\hat{q}) - P(q \geq \hat{q}) \geq \theta(\hat{q}) - c(q) - P(q < \hat{q}) \quad (7)$$

The incentive compatibility constraint states that the expected profit of the CRA in case of compliance with the rating standard net of rating costs and expected penalty must be larger or equal the expected profit in case of deviation from the standard net of the expected penalty. Since in the case of deviation the CRA chooses the lowest rating quality  $q = 0$  in order to minimize costs ( $c(0) = 0$ ), and since the optimal policy of the regulator requires the incentive compatibility constraint to be

binding, equation (7) can be rewritten, using lemma 1, as:

$$c(\hat{q}) = h(e)\eta \quad (8)$$

The rating costs  $c$  are increasing and convex in  $q \in [0; 1]$  and the probability that regulation will detect deviation from the rating standard  $h(e)$ , which could be considered as the efficiency of regulation, is monotonous increasing and concave in the employed effort  $e$  as we have defined above. Therefore, the function  $h(e)$  can be inverted and equation (8) be solved for the optimal regulatory effort, depending on the quality standard  $\hat{q}$ , and be rewritten as:

$$e(\hat{q}) = h^{-1}\left(\frac{c(\hat{q})}{\eta}\right) \quad (9)$$

This function reveals the optimal regulation effort for a given quality standard, such that the quality standard is implementable, meaning that the incentive compatibility constraint is binding. For a given penalty and due to the assumed characteristics of the cost function  $c(q)$ , the optimal effort, which is employed in regulation, is increasing and convex in the rating standard  $\hat{q}$ . The intuition of this equation is straightforward. If the rating standard increases, the costs of rating increase, too. Therefore, the incentive for a CRA to deviate from the standard (i.e. setting the rating quality equal zero) increases. In order to make the higher standard incentive compatible, the expected penalty must increase. For a given penalty  $\eta$ , the regulator has to increase effort  $e$  to implement the more demanding rating standard  $\hat{q}$ . We have mentioned above that due to limited liability, the penalty, the CRA has to pay in case of deviation from the standard is limited by the wealth, accumulated in the past plus the profits of rating in the actual period. Furthermore, equation (6) shows that effort, employed in regulation, reduces social welfare. In order to set the expected penalty such that the incentive compatibility constraint is binding, it is optimal from a welfare perspective, to set the penalty in case of deviation to its highest possible level:  $\hat{\eta} = W + \theta$ . A lower penalty would require the regulator to employ more effort to keep  $h(e)\eta$  constant, which would reduce social value.

The maximization problem of the regulator in equation (6) can now be reduced to the optimal choice of the rating standard. The optimal penalty is given by  $\hat{\eta}$  and the optimal effort  $e$  is the optimal response to  $q$  according to equation (9). Inserting equation (9) in equation (6) leads to:

$$\max_{\hat{q}} \hat{V}(\hat{q}) = \hat{q}(1-p)m - c(\hat{q}) - e(\hat{q})$$

Because rating costs and effort costs are convex in the rating quality, the objective function leads to an interior solution. The first-order condition is given by:

$$(1-p)m = c'(\hat{q}) + e'(\hat{q}),$$

which leads to the optimal rating standard that maximizes social welfare, under the assumption that rating quality is unobservable. In part 3.2 we have shown that the first-best rating quality in the case of observable and contractible rating quality was given by  $(1-p)m = c'(q^*)$ . A comparison with the optimal rating standard under regulation shows that  $\hat{q} < q^*$ . The intuition is straightforward. Monitoring of a certain rating standard is costly, which reduces social welfare. Therefore a lower rating standard compared to the first-best will be implemented by the regulator. The influence of the exogenous parameters is analog to proposition 1 and are summarized in proposition 2 point (i) to (iii). Additionally, the optimal rating standard is increasing in the efficiency of regulation (i.e. the optimal rating standard is higher, if the marginal effort costs of increasing the standard are lower).

**Proposition 2** *A regulator, who maximizes social welfare, chooses a rating standard  $\hat{q}$  which is lower than the first-best rating standard  $q^*$ . The optimal rating standard  $\hat{q}$  becomes*

*(i) smaller, if the unconditional probability of the IB's portfolio being in a good state  $p$  increases.*

*(ii) larger, if the size of the potential misallocation of investment  $m$  without increases.*

(iii) larger, if the cost efficiency of the CRA and the regulator increases.

(iv) The optimal rating standard  $\hat{q}$  is higher, if the wealth of the CRA increases.

**Proof.** See appendix A.2. ■

Part (iv) of proposition 2 implicitly points to the difference in the optimal rating standard in the case, where CRAs make zero profits, i.e. "perfect competition" on the CRA market, and the case, where CRAs takes the informational value of rating, i.e. the "market power case" (see for these two cases part 3.2). In the market power case (m), the wealth of the CRA that can be penalized by the regulator may be assumed to be larger than the wealth in the perfect competition case (c). Therefore, the optimal penalty, which is set by the regulator, would have the following property:  $\hat{\eta}_m > \hat{\eta}_c$ . The modified incentive compatibility constraint (9) shows that the optimal regulatory effort for a given rating standard is decreasing as the optimal penalty increases. Therefore, enforcement of regulation becomes more efficient, if the CRA has "more to lose", since less costly effort has to be employed to enforce a given rating standard. From this follows that costly regulatory effort has a less negative impact on social welfare. The optimal rating standard increases, if the representative CRA has more to lose, i.e. if the CRA has a higher "charter value". The model shows again that from this perspective, market power of some few CRAs is not in itself a rationale for regulatory intervention. In the first-best case, where rating quality is assumed to be observable and contractible, the optimal rating quality and social value of ratings is independent of the structure of the CRA market. In the case of unobservable rating quality, the model shows that a higher charter value of CRAs moves the optimal rating standard and social value of credit ratings closer to the first-best result.<sup>21</sup>

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<sup>21</sup>However, even if this is true in the framework used here, this finding should be read with caution with regards to generalization. The only consequence of market power in the model is that the surplus of credit ratings is reallocated from the IB to the CRA, the overall surplus remains unchanged. The model does not take into account potential adverse effects of CRA market power with consequences on the level of the rating fee and the overall social value of credit ratings. Inefficient high rating fees might for example induce the debt issuer to engage in riskier portfolios, which may decrease financial market stability.

## 4 Conflicts of Interest and Optimal Regulation

So far, the unobservability of rating qualities was considered as the only rationale for the regulation of CRAs. What has not yet been included in the model are potential adverse effects of conflicts of interest between the CRA and the rated firm (in our framework the rated IB). One potential source of conflicts of interest is the fact that credit ratings usually are paid by the issuer of a debt instrument and not by the investors. Facing the fact that since the early 1970<sup>22</sup> CRAs mainly are paid by their clients<sup>23</sup>, the client could in principle directly bribe the CRA in exchange for a better credit rating. Another potential conflict of interest emerged in the special role of CRAs in the rise of structured finance products during the last years. While interaction between the issuer of a traditional debt security and the CRA was rather limited, the case is different in the rating of structured finance transactions. In the rating process of those structured finance products, CRAs are involved in an iterative process with the issuer. The structuring process of these products includes implicit structuring advice by the CRAs, meaning that the CRA indicates what needs to be done to receive the desired credit rating.<sup>24</sup> Broadly speaking, CRAs not only offer the service of the pure rating, but also offer additional consulting services. This deeper involvement of CRAs has been heavily criticized in the public, especially in association with the crisis in the subprime loan market. This problematic is also captured to some degree in the U.S. "Credit Rating Agency Reform Act 2006", which among others "directs the SEC to issue final rules to prohibit unfair, coercive, or abusive acts or practices by NRSROs<sup>25</sup> [...] such as conditioning or threatening

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<sup>22</sup>For an overview on the history of credit rating agencies see for example Hill (2004) or Cantor & Packer (1995).

<sup>23</sup>An argument for this payment scheme is the emergence of information technology during the last 30 years, which gave information, once it is originated a public good character (a single investor would only be willing to pay for a rating if it is not made public). Another argument is that it is more efficient to let the issuer pay instead of each single investor of a large and dispersed investor community, that uses the credit rating for its investment decision. (see White, 2001)

<sup>24</sup>For a summary of the role of CRAs in structured finance products see Mason & Rosner (2007) and BIS (2005). According to BIS (2005) "[...] it has become common for rating agencies to offer special services relating to firms' bond ratings [...] that could impact rating levels. These services may be separately rewarded and may thus exacerbate any potential conflicts of interest arising from 'issuer fees'."

<sup>25</sup>NRSRO = nationally recognized statistical rating organization; a CRA has to be recognized by the SEC (securities and exchange commission), in order to be used for regulatory purposes. The

to condition an issuer's credit rating on the purchase of other services or products" (see CRA Reform Act, 2006). Based on Pagano & Immordino (2007) for the case of auditing firms, we extend in the following section the model by allowing the CRA to offer additionally consulting services to the rated investment bank (IB). We assume that the portfolio, for which the IB seeks debt finance from external investors, is managed by a portfolio-manager, who's salary partly consists of a payment which is proportionally to the volume of managed portfolios. Hence, the manager has an interest that the IB receives financing by external investors with certainty, since this would increase his salary. As we have shown above, external investors only finance a portfolio, if it receives a good credit rating ( $r = g$ ), therefore the portfolio-manager has an incentive to engage in activities to ensure a high credit rating for the portfolio.<sup>26</sup> One possibility to achieve that goal would be a direct bribe to the CRA in exchange for a higher credit rating. Another way of modelling conflicts of interest in our model arises from the joint provision of credit ratings and consulting services by a single CRA, from which emerges a more sophisticated possibility of collusion between the CRA and the rated IB as follows. Since the CRA is very well informed about its client in the course of the rating process, we assume that the CRA has the expertise to offer consulting services to the IB at lower costs compared with competitors due to economies of scope. The possibility of collusion now arises, if the IB is only willing to pay for an additional consulting contract, if in exchange the CRA issues a good credit rating. Since we assume that the CRA can provide such services at lower costs, the received market fee for the consulting service can be regarded as a rent for the CRA. The conflict of interest is clear: the consulting fee acts as a bribe, and the CRA only gets the fee in exchange for a good credit rating. Section 4.1 extends the model and analyzes consequences for the optimal rating standard which is set by the regulator. In section 4.2, we analyze, if forbidding the joint provision of rating and consulting services is optimal from a welfare perspective.

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"Credit Rating Agency Reform Act 2006" includes the simplification of the recognition process.

<sup>26</sup>Note, that we assume that the IB decides to get rated only, if the informational value of a credit rating is larger or equal zero (see section 3.1).



## 4.1 Optimal Rating Standard in the Presence of Conflicts of Interest

The analysis is now extended by assuming that the IB employs a portfolio-manager, whose salary consists of a proportion  $\alpha \in [0, 1]$  of the portfolio value. After deducting the rating fee and repayment of debt to external investors, the net profit of the IB after the true value of the portfolio materialized with consideration of the management compensation, is given by:  $\tilde{\Psi} - \theta - d - \alpha\tilde{\Psi}$ . According to the compensation scheme, the manager has an interest that investment takes place with certainty, which is the case without a credit rating and with a "good" credit rating  $r = g$ . Therefore, the manager - if he is opportunistic - has an incentive to induce the CRA to issue a good credit rating. The manager - who requires the CRA to issue a good credit rating in exchange - may either bribe the CRA directly by offering a bribe  $\beta > 0$  or indirectly by engaging the CRA for rating and additional consulting services. In the following it will be shown that both forms of corruption have similar implications regarding the optimal rating standard. The CRA is assumed to be able to offer consulting services additionally to the rating service. Due to economies of scope, the CRA is assumed to offer the same consulting service as an external competitor (*Comp.*) at lower costs  $\rho$ :  $\rho_{CRA} < \rho_{Comp.}$ <sup>27</sup> Under the assumption of perfect competition in the consulting sector, the market consulting fee  $\varphi$  is equal to the consulting costs:  $\varphi = \rho_{Comp.}$ . If the CRA, instead of an external firm, gets employed for performing the consulting service, the CRA receives the market consulting fee  $\varphi$  and therefore earns a rent  $\Delta\rho \equiv \varphi - \rho_{CRA} > 0$ . At the same time, making use of the CRA's economies of scope, the rent  $\Delta\rho$  increases social welfare, due to efficiency gains.

Given those assumptions, the portfolio-manager has an incentive to offer a consulting contract, contingent on a good credit rating. If the CRA accepts this offer, the profits of the CRA from rating and consulting are given as follows:

$$\Pi^{CRA}(q) = \theta(q) - c(q) + \varphi - \rho_{CRA} - P \quad (10)$$

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<sup>27</sup>From performing the rating procedure, we assume that the CRA has gained expertise to offer additional consulting at lower costs, compared to a third competitor.

The requirement for getting offered the contract for the joint provision of credit rating and consulting is that the CRA issues a good credit rating. Therefore, it is optimal for the CRA to set  $q = 0$ , since that minimizes the costs (i.e.  $c(0) = 0$ ). Using  $\Delta\rho \equiv \varphi - \rho_{CRA} > 0$  and considering the expected penalty in the case of deviation from the rating standard  $h(e)\hat{\eta}$ , equation (10) can be rewritten as:

$$\Pi^{CRA}(q) = \theta(q) + \Delta\rho - h(e)\hat{\eta} \quad (10')$$

Now it is obvious that the additional rent for the consulting service acts as a bribe. The bribe makes sure that the IB receives a good credit rating and that financing by external investors happens for sure. Therefore, the portfolio-manager gets the partial salary  $\alpha\tilde{\Psi}$  with certainty. In the case of a direct bribe  $\beta$ , the profit equation can be formulated analogously by replacing  $\Delta\rho$  with  $\beta$ . While the consequences of corruption regarding the social value are clear in the case of the direct bribe, they are twofold in the case of joint provision of services. In both cases the IB receives a good credit rating and the IB's portfolio receives even then financing, if the portfolio would have received a bad credit rating without the bribe. Henceforth, the misallocation of funds increases, which reduces the social value of a credit rating. An additional positive impact on the social value occurs with the joint provision of services, because the CRA is assumed to offer consulting services more efficiently in terms of costs compared to a third party. Therefore, the social value increases by  $\Delta\rho$  in that case. We assume that the possibility of collusion cannot be prevented by the external investors, since the large investors community is assumed to have a collective action problem.<sup>28</sup> Taking into account the opposed effects of the joint provision of services by a single CRA and the possibility of collusion, the decision problem of the regulator, who maximizes the social value of rating, is given by<sup>29</sup>:

$$\max_{\tilde{q}, e} \tilde{V}(\tilde{q}) = \tilde{q}(1-p)m + \Delta\rho - c(\tilde{q}) - e \quad (11)$$

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<sup>28</sup>If any collective action restrictions would be absent, investors could make the debt financing dependent on the requirement, that consulting and rating by the same firm is impossible.

<sup>29</sup>The efficiency gain is integrated into the social value function in the most easiest way by simply adding  $\Delta\rho$ . In the case of a direct bribe  $\beta$  the positive effect on social welfare would be absent and the objective function of the regulator is the same as equation (5) in section 3.3.

The rating standard in the presence of possible collusion is denoted by  $\tilde{q}$ . The new incentive compatibility constraint requires the CRAs profit from rating and compliance with the rating standard, set by the regulator, to be larger or equal the CRAs profit in the case of joint provision of services and acceptance of the bribe, given by equation (10’):

$$\theta(\tilde{q}) - c(\tilde{q}) \geq \theta(\tilde{q}) + \Delta\rho - h(e)\hat{\eta}$$

In the case of a direct bribe,  $\Delta\rho$  in the incentive compatibility constraint has to be replaced by  $\beta$ . The optimal rating standard has to be chosen such that it is implementable by the CRA and collusion does not happen. According to section 3.3, the incentive compatibility constraint can be reformulated as the optimal effort, employed in regulation, as a function of the optimal rating standard, which assures the constraint being binding:

$$e(\tilde{q}) = h^{-1}\left(\frac{c(\tilde{q}) + \Delta\rho}{\hat{\eta}}\right) \quad (12)$$

As equation (9) in section 3.3.3, the optimal effort is increasing and convex in the rating standard. But in contrast to equation (9), the optimal effort, given a certain rating standard is now higher, since the numerator increases by  $\Delta\rho$  in equation (12).<sup>30</sup> In that case, more costly effort has to be employed by the regulator to make a given rating standard incentive compatible. Using equation (12) in equation (11), maximizing with respect to  $\tilde{q}$  leads to the following first order condition:

$$(1 - p)m = c'(\tilde{q}) + e'(\tilde{q})$$

Proposition 3 describes the properties of the new optimal rating standard:

**Proposition 3** *If the rent from the joint provision of services is  $\Delta\rho > 0$  or if there is the possibility of a direct bribe  $\beta > 0$ , the optimal rating standard in the presence of potential collusion between CRA and IB is lower than the optimal rating*

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<sup>30</sup>Analogously, in the case of a direct bribe the optimal effort, which assures the incentive compatibility constraint being binding, can be rewritten as:  $e(\tilde{q}) = h^{-1}\left(\frac{c(\tilde{q}) + \beta}{\hat{\eta}}\right)$ .

*standard without the possibility of collusion:  $\tilde{q} < \hat{q}$ . The optimal rating standard is decreasing, if the rent of the joint provision of services  $\Delta\rho$  or the direct bribe  $\beta$  increase.*

**Proof.** See appendix A.3. ■

If there were no efficiency gains from the joint provision of services, the bribe would be zero:  $\Delta\rho = 0$ . In that case the optimal rating standard is the same as in section 3.3., where rating service only is considered:  $\tilde{q} = \hat{q}$ . Accordingly, the optimal rating standard is the same ( $\tilde{q} = \hat{q}$ ), if the regulator would forbid the joint provision of services by the CRA or the possibility of a direct bribe, since the possibility of collusion would then be eliminated. The intuition of why  $\tilde{q} < \hat{q}$  is straightforward, if  $\Delta\rho > 0$  or  $\beta > 0$ . The corresponding effort that has to be employed by the regulator for a given rating standard is now higher as shown in equation (12). Since an increase of costly regulatory effort decreases the social value, the regulator chooses a lower rating standard. If the rent  $\Delta\rho$  or the direct bribe  $\beta$  increase, also the incentive for the CRA to accept the bribe and collude with the IB increases. Therefore it is optimal for the regulator to set a lower rating standard, since that would reduce the CRA's cost in the case of compliance with the standard. In principle, one of the two sources of potential collusion can be prevented by the regulator by simply forbidding the joint provision of rating and consulting services. That issue has also been discussed by the SEC and the European Commission in reaction to the inglorious role of CRAs in the subprime loan crisis in 2007 and been addressed in the "Credit Rating Agency Reform Act 2006" in the US. While collusion through the joint provision of services cannot be presumed ex ante by the regulator, the intention for corruption is obvious for the case of a direct bribe. For the remainder of the paper is assumed that direct bribes, for example in the form of extra payments or rating fees above the market level, would easily be detectable by the regulator and the analysis concentrates on the more sophisticated form of collusion - namely conflicts of interest via the joint provision of services. Whether the joint provision of services should be prohibited by regulation from a welfare perspective, will be analyzed in the next section.

## 4.2 Regulatory Intervention and Social Value

The model showed that the consulting fee can be used by the client to bribe the CRA to issue an inaccurate higher credit rating, if a CRA offers both ratings and consulting services. As already mentioned above, the role of CRAs in the past years changed from a passive to a more active part particularly in the rating process of structured debt products, such as collateralized debt obligations. In an iterative process, CRAs are involved in advising their clients in designing products that receive the desired high credit rating to be attractive for the investors community. CRAs have been heavily criticized for this behavior in the recent past, as they were under suspicion of being exposed to conflicts of interest, therefore being jointly responsible for the financial market crisis in 2007 by issuing inaccurate credit ratings. The model's answer to a situation with existing conflicts of interest is that the regulator should either simply choose a lower rating standard or forbid the joint provision of services and eliminate the potential conflict of interest at its root. In the latter case the regulator chooses optimally a higher rating standard, as shown in the previous section. But what has not been analyzed so far, is the question, whether the regulator should allow or forbid the joint provision of services, if the decision criterion is the social value.<sup>31</sup> The objective function of the regulator in the presence of conflicts of interest was given by:

$$\max_{\tilde{q}} \tilde{V}(\tilde{q}) = \tilde{q}(1-p)m + \Delta\rho - c(\tilde{q}) - h^{-1} \left( \frac{c(\tilde{q}) + \Delta\rho}{\hat{\eta}} \right) \quad (13)$$

As we have shown above, the CRA - if it is hired for creating a credit rating - can provide consulting services more efficiently in comparison to external competitors by being able to provide the same service at lower costs. This efficiency gain  $\Delta\rho$ , that can be used by the rated IB to bribe the CRA, on the one hand increases the social value. This positive effect would be lost, if the regulator would forbid the joint provision of services. On the other hand, the joint provision of services makes

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<sup>31</sup>In the case of a direct bribe ( $\beta$ ) without joint provision of services, the implication for regulation is very easy: "forbidding" to accept the direct bribe increases the social value of rating, because there is no potential efficiency gain and no trade-off from allowing the possibility of collusion in that case.

collusion possible and the financing of bad portfolios more likely, which decreases the social value. As the efficiency gain has one negative and one positive effect on the social value, the answer is now, under which circumstances the regulator optimally should allow or forbid the joint provision of activities. If the regulator forbids the bundling of services, the social welfare of the credit rating is  $\hat{V}(\hat{q})$ , as defined in section 3.3. In the following, we compare the social value in the case of joint provision of services (case 1:  $\tilde{V}(\tilde{q})$ ), with the social value, if CRAs are allowed to offer ratings only (case 2:  $\hat{V}(\hat{q})$ )<sup>32</sup>. The partial effect of an increase of  $\Delta\rho$  on the social value in case 2 is zero ( $\partial\hat{V}/\partial\Delta\rho = 0$ ), while in case 1 is given by

$$\frac{\partial\tilde{V}}{\partial\Delta\rho} = 1 - h^{-1\nu}(\dots) \frac{1}{\hat{\eta}} \quad (14)$$

Depending on the size of equation (14), i.e. whether  $1 \geq h^{-1\nu}(\dots) \frac{1}{\hat{\eta}}$ , the social value can either increase or decrease as  $\Delta\rho$  increases. Therefore, obviously one criterion for the regulator's decision is the size of  $\Delta\rho$ , as the effect on the social value could be positive or negative for differing values. The previous section has shown that the necessary effort for a given rating quality increases as  $\Delta\rho$  becomes larger. From this follows that  $h^{-1\nu}(\dots)$  in equation (14) is a positive and increasing function of  $\Delta\rho$ . If equation (14) is negative at  $\Delta\rho = 0$ , it remains negative for any  $\Delta\rho > 0$ . In that case, despite of the efficiency gain, it is optimal for the regulator to prohibit the joint provision of services, because  $\tilde{V} < \hat{V}$  for all  $\Delta\rho > 0$ . If equation (14) is positive at  $\Delta\rho = 0$ , it becomes negative, if  $\Delta\rho$  becomes sufficiently large. In that case, there exists a threshold value for the size of  $\Delta\rho = \Delta\rho^*$ , below which it is optimal for the regulator to allow the joint provision of services (case 1), since the positive effects on the social value overweigh ( $\tilde{V} \geq \hat{V}$  for  $0 \leq \Delta\rho \leq \Delta\rho^*$ ). On the other side for  $\Delta\rho > \Delta\rho^*$  it is optimal to forbid the joint provision of ratings and consulting services, since the adverse effects of conflicts of interest dominate ( $\tilde{V} < \hat{V}$  for  $\Delta\rho > \Delta\rho^*$ ). To analyze the determinants for the decision of the regulator, besides the size of the efficiency gain (which works in our model as a bribe) further, equation

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<sup>32</sup>The objective function if the CRA offers the service of rating only was given by  $\hat{V}(\hat{q}) = \hat{q}(1-p)m - c(\hat{q}) - h^{-1}\left(\frac{c(\hat{q})}{\hat{\eta}}\right)$  (see section 3.3).

(14) can be rewritten as follows<sup>33</sup>:

$$\frac{\partial \tilde{V}}{\partial \Delta \rho} = \frac{1}{c'(\tilde{q})} (c'(\tilde{q}) - e'(\tilde{q})) \quad (15)$$

Equation (15) is negative for any positive value of  $\Delta \rho$ , if  $c'(\tilde{q}) < e'(\tilde{q})$  at  $\Delta \rho = 0$ . While  $c'(\tilde{q})$  can be interpreted as the marginal costs of rating, and therefore as the cost efficiency of CRAs,  $e'(\tilde{q})$  can be interpreted as the efficiency of the regulation technology. Above, the regulation technology was characterized by the probability to detect deviation from a certain rating standard by employing costly effort  $e$ . A more efficient regulation technology would require less effort to enforce a given rating standard and henceforth a lower increase of effort if the rating standard increases ( $e'_{high}(\tilde{q}) < e'_{low}(\tilde{q})$ ). If the efficiency of the rating technology is sufficiently low, such that  $c'(\tilde{q}) < e'(\tilde{q})$  at  $\Delta \rho = 0$ , it is optimal for the regulator to forbid the joint provision of services for any positive value of  $\Delta \rho$ , since the social value in case of the joint provision of services is always smaller, compared to case 2 ( $\tilde{V}(\tilde{q}) < \hat{V}(\hat{q})$ ). Proposition 4 describes the optimal decision of the regulator, if the regulation technology is too inefficient.

**Proposition 4** *If the regulation technology is sufficiently inefficient, such that  $c'(\tilde{q}) < e'(\tilde{q})$  at  $\Delta \rho = 0$ , the optimal strategy for the regulator is to forbid the joint provision of services and to set the optimal rating standard  $q = \hat{q}$ . Otherwise the social value of rating would be inefficiently low for any  $\Delta \rho > 0$ :  $\tilde{V}(\tilde{q}) < \hat{V}(\hat{q})$ .*

**Proof.** See appendix A.4. ■

While the decision between case 1 and case 2 is clear and independent of the size of  $\Delta \rho$ , if  $c'(\tilde{q}) < e'(\tilde{q})$  at  $\Delta \rho = 0$ , the decision problem looks different, if the efficiency of the regulation technology is sufficiently high. If the regulation technology is such that  $c'(\tilde{q}) > e'(\tilde{q})$  at  $\Delta \rho = 0$ , equation (15) is positive as  $\Delta \rho$  increases and becomes negative, if  $\Delta \rho$  becomes sufficiently large. This is true, because  $c'(\tilde{q})$

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<sup>33</sup>The derivation of equation (15) is located in appendix B.

becomes smaller and  $e'(\tilde{q})$  becomes larger as  $\Delta\rho$  increases.<sup>34</sup> From this follows that for  $c'(\tilde{q}) > e'(\tilde{q})$  at  $\Delta\rho = 0$  the optimal decision of the regulator for one of the two alternatives depends on the size of the efficiency gain  $\Delta\rho$ . Proposition 5 describes the optimal decision of the regulator.

**Proposition 5** *If the regulation technology is sufficiently efficient such that  $c'(\hat{q}) > e'(\hat{q})$  at  $\Delta\rho = 0$ , and the size of the efficiency gain is below its critical value,  $\Delta\rho < \Delta\rho^*$ , the optimal strategy for the regulator is to allow the joint provision of services and to set the optimal rating standard  $\tilde{q} < \hat{q}$ , since  $\tilde{V}(\tilde{q}) > \hat{V}(\hat{q})$  for  $\Delta\rho < \Delta\rho^*$ . If the efficiency gain is larger than its critical value,  $\Delta\rho > \Delta\rho^*$ , the optimal strategy is to forbid the joint provision of services and to set the optimal rating standard  $\hat{q}$ , since  $\tilde{V}(\tilde{q}) < \hat{V}(\hat{q})$  for  $\Delta\rho > \Delta\rho^*$ .*

**Proof.** See appendix A.5. ■

The model shows that the joint provision of services - for example expressed by the deep involvement of CRAs in the rating process of structured finance products, such as collateralized debt obligations - is not necessarily a root of inefficiency for which regulatory intervention could be justified. If the criterion for the regulator is social welfare, the decision of the regulator on the optimal rating standard and possible restrictions of activities depends on the surrounding conditions. If the potential bribe is large enough, it is optimal to restrict the activities of CRAs, as the negative effects of collusion dominate.<sup>35</sup> But it could be optimal to allow the joint provision of services, if the bribe is low enough, since the positive effects of the efficiency gain dominate in that case. Additionally, the model shows that the basic requirement for the strategy of allowing the joint provision of services lies in

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<sup>34</sup>Proposition 3 in the previous section has shown that  $\frac{\partial \tilde{q}}{\partial \Delta\rho} < 0$ . Because of the convexity of  $c(\cdot)$  follows that  $\frac{\partial c'(\cdot)}{\partial \Delta\rho} < 0$ . For the derivation of  $\frac{\partial e'(\cdot)}{\partial \Delta\rho}$ , see the proof of proposition 4 in the appendix.

<sup>35</sup>One implication of the model is to forbid the joint provision of services if consulting services could be provided very efficiently (i.e. if  $\Delta\rho > \Delta\rho^*$ ). The argument is that in those cases the incentive of the CRA to collude with the IB is so high such that the social value of ratings becomes inefficiently low. A possibility to get rid of the collusion problem and to profit from the welfare increasing efficient provision of consulting services would be for the CRA to create firewalls and for the regulator to check their effectiveness. The integration of this aspect in the model is one possible extension for future research.



the hand of the regulator, meaning that the efficiency of the regulation technology has to be sufficiently high.

## 5 Conclusion

The discussion on the role and power of CRAs in financial markets is an ongoing debate among academics, practitioners, and institutions of financial supervision.<sup>36</sup> Many times, CRAs were suspected for having issued inaccurate credit ratings or having updated already issued credit ratings too late. Furthermore, CRAs were suspected to be exposed to various conflicts of interest. Jochen Sanio, the chairman of the German federal financial supervision authority (Bafin), once blamed CRAs to be the "largest uncontrolled power in the global financial system".<sup>37</sup> On the role of CRAs in the subprime loan crisis, Keneth Rogoff presumed that "[...] rating agencies cooperated too closely with the banks and received a much too high payment for their ratings." and "I could imagine that Moody's will become the Arthur Andersen of this decade"(see Zeit, 2007).

The applied model, which is based on Pagano & Immordino (2007), has shown that intransparency of how credit ratings are generated by CRAs, could be a rationale for regulation. Without regulation, the quality of the credit ratings would be inefficiently low and misallocation of investment inefficiently high. Minimum rating standards, which can be enforced by costly regulation, would increase the social value of credit ratings in the applied model. The adverse effects of conflicts of interest were analyzed in the model, too. By the joint provision of credit ratings and consulting services, we have shown that on the one hand there is the threat of collusion, which may lead to inaccurate credit ratings, but on the other hand that potential efficiency gains are present, too. In the presented theory, the potential conflict of interest can be prevented by simply constraining the activities of CRAs. It has also been discussed that this regulatory intervention may or may not be optimal

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<sup>36</sup>See for example IOSCO (2004, 2007) and CRA Reform Act (2006).

<sup>37</sup>Own translation from German to English. This quote is from a public hearing of the financial committee of the German Bundestag at June 4th 2003.

from a welfare perspective.

The results of that paper on the one hand gives a contribution to the theoretical academic literature on CRAs, by modelling the optimal regulation of CRAs in the presence of unobservable rating quality and conflicts of interest. On the other hand, the analysis, presented in this paper, also contributes to the discussion about the possibility and necessity to regulate activities of CRAs that is consistently present among institutions of financial market regulation as well as observers and practitioners of financial markets, especially in the aftermath of the subprime loan crisis in 2007. A frequent argument against regulation of CRAs in the past was that CRAs have a strong incentive to issue accurate credit ratings, because otherwise they would lose their reputation, which is regarded to be the most important asset of CRAs.<sup>38</sup> Therefore it was argued that self-regulation among CRAs works well and no further regulation would be necessary.

However, a necessary requirement for self-regulation is competition and the possibility of market entry for competitors. Due to the market power of some few CRAs and the heavy criticism, CRAs were confronted with in the past, it is disputable whether the threat of losing reputation is enough to prevent CRAs from issuing inaccurate credit ratings and colluding with debt issuers. Regarding this limited competition, Partnoy (1999) argues that markets may become inattentive as to the CRAs' reputation as soon as some few CRAs have received recognition status by the regulator. As soon as self-regulation of CRAs fails, the results of our paper provide insights for the optimal regulation of CRAs.

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<sup>38</sup>see for example Schwarcz (2001).

# Appendix

## A Proofs of Propositions

### A.1 Proof of proposition 1.

The optimal rating quality  $q^* \in [0, 1]$  is derived by the first order condition:

$$(1 - p) m = c'(q^*) \tag{A1.}$$

Effect of  $p$ : As  $p$  increases, the left hand side of A1. becomes smaller. To keep equality, the right hand side has to become smaller, too. Due to the characteristics of the cost function  $c(\cdot)$ , the optimal rating quality  $q^*$  has to decrease.

Effect of  $m$ :  $m$  increases, if  $d$  increases and/or  $\Psi_b$  decreases. The left hand side increases, therefore the optimal rating quality  $q^*$  has to increase, too.

Effect of  $c'(q^*)$ : A more efficient rating technology is expressed with lower costs for a given rating standard. If rating quality increases, the rise of costs is lower for a more efficient technology:  $c'_{high}(\bar{q}) < c'_{low}(\bar{q})$ . The marginal rating costs for a given rating quality is lower, if cost efficiency becomes higher. The value of left hand side is exogenous and constant. If cost efficiency increases  $q^*$ , the rating standard has to rise in order to keep the right hand side constant. ■

### A.2 Proof of proposition 2.

The optimal rating standard if rating quality  $\hat{q}$  is unobservable and with costly regulation is derived by the first order condition:

$$(1 - p) m = c'(\hat{q}) + e'(\hat{q}) \tag{A2.}$$

As the left hand side of (A2.) is the same as the left hand side of (A1.), we have:

$$c'(q^*) = c'(\hat{q}) + e'(\hat{q}) \quad (\text{A.2}')$$

Since  $c(\cdot)$  and  $e(\cdot)$  are increasing and convex in  $q$ , therefore  $q^*$  has to be larger than  $\hat{q}$ :  $q^* > \hat{q}$ .

For the proof of parts (i) to (iii) of proposition 2 see the proof of proposition 1. Part (iv) claims that the optimal rating standard is higher, if optimal penalty  $\hat{\eta}$  increases. An example for a rise in  $\hat{\eta}$  is an increase in the profits per rating due to market power in the CRA sector. The necessary effort that has to be employed in order to enforce a given rating standard, is given by:

$$e(\hat{q}) = h^{-1} \left( \frac{c(\hat{q})}{\hat{\eta}} \right) \quad (\text{A3.})$$

If  $\hat{\eta}$  increases, the optimal effort corresponding to a given rating standard decreases. From this follows that the marginal effort  $e'(\cdot)$  decreases either. The right hand side therefore becomes smaller for a given rating standard. Due to the characteristics of the functions  $c(\cdot)$  and  $e(\cdot)$ , the optimal rating standard  $\hat{q}$  must increase to ensure equality of equation (A.3).■

### A.3 Proof of proposition 3.

Why the optimal rating standard in the presence of joint provision of services ( $\tilde{q}$ ) and analogously in the case of a direct bribe, is lower than the optimal rating standard in 3.3 ( $\hat{q}$ ), can be shown as follows: The first-order condition of the regulator's decision problem is given by

$$(1 - p)m = c'(\tilde{q}) + e'(\tilde{q}) \quad (\text{A.4})$$

The left hand side of A4. the same as in equation A.2, therefore it must be true that:

$$c'(\hat{q}) + e'(\hat{q}) = c'(\tilde{q}) + e'(\tilde{q}) \quad (\text{A.4}')$$

Since the effects are analog for the direct ( $\beta$ ) and the indirect bribe ( $\Delta\rho$ ), the proof is presented for  $\Delta\rho > 0$  only. Taking into account the potential bribe  $\Delta\rho$ , the necessary effort to enforce a given rating standard  $\bar{q}$  is larger in the case of joint provision of services:

$$e(\bar{q}) = h^{-1} \left( \frac{c(\bar{q})}{\hat{\eta}} \right) < e(\bar{q}) = h^{-1} \left( \frac{c(\bar{q}) + \Delta\rho}{\hat{\eta}} \right)$$

The marginal effort with bribe is therefore larger than the marginal effort without bribe for a given rating quality. Therefore the optimal rating standard has to be lower in the case of joint provision of services, to ensure equality of equation (A.4'), given the characteristics of  $c(\cdot)$  and  $e(\cdot)$ :  $\tilde{q} < \hat{q}$ .

That the optimal rating standard is decreasing as the rent of the joint provision of services increases can be shown by total differentiating equation (A.4) and using  $e'(\tilde{q}) = h'^{-1} \left( \frac{c(\tilde{q}) + \Delta\rho}{\hat{\eta}} \right) \frac{c'(\tilde{q})}{\hat{\eta}}$ :

$$\begin{aligned} \underbrace{d(1-p)m}_{=0} &= c''(\tilde{q}) d\tilde{q} + e''(\tilde{q}) d\tilde{q} + h''^{-1} \left( \frac{c(\tilde{q}) + \Delta\rho}{\hat{\eta}} \right) \frac{c'(\tilde{q})}{\hat{\eta}^2} d\Delta\rho \\ &\longrightarrow \frac{d\tilde{q}}{d\Delta\rho} = - \frac{h''^{-1} \left( \frac{c(\tilde{q}) + \Delta\rho}{\hat{\eta}} \right) \frac{c'(\tilde{q})}{\hat{\eta}^2}}{c''(\tilde{q}) + e''(\tilde{q})} < 0 \end{aligned} \quad (\text{A.5})$$

Equation is smaller than zero, because of the convexity of  $e(\cdot)$ ,  $c(\cdot)$ , and  $h^{-1}(\cdot)$ . ■

#### A.4 Proof of proposition 4.

The social value with joint provision of services is given by  $\tilde{V}$ , whereas the social value with rating only is given by  $\hat{V}$ . If  $\Delta\rho = 0$ , then  $\tilde{V} = \hat{V}$ . Equation (A.5) showed that  $\frac{d\tilde{q}}{d\Delta\rho} < 0$ . Therefore, given the characteristics of  $c(\cdot)$ , it must be true that  $\frac{\partial c'(\tilde{q})}{\partial \Delta\rho} < 0$ . Above, we have shown that  $e'(\tilde{q}) = h'^{-1} \left( \frac{c(\tilde{q}) + \Delta\rho}{\hat{\eta}} \right) \frac{c'(\tilde{q})}{\hat{\eta}}$ . Differentiating with respect to  $\Delta\rho$  yields  $\frac{\partial e'(\tilde{q})}{\partial \Delta\rho} = h''^{-1} \left( \frac{c(\tilde{q}) + \Delta\rho}{\hat{\eta}} \right) \frac{c'(\tilde{q})}{\hat{\eta}^2} > 0$ . The partial derivative of the social value  $\tilde{V}$  and  $\hat{V}$  with respect to  $\Delta\rho$  is given by:  $\frac{\partial \tilde{V}}{\partial \Delta\rho} = \frac{1}{c'(\tilde{q})} (c'(\tilde{q}) - e'(\tilde{q}))$  and  $\frac{\partial \hat{V}}{\partial \Delta\rho} = 0$ . As  $\Delta\rho$  increases, the difference  $(c'(\tilde{q}) - e'(\tilde{q}))$  decreases, since  $c'$  decreases and  $e'$  increases. If  $\frac{\partial \tilde{V}}{\partial \Delta\rho} < 0$  at  $\Delta\rho = 0$ , which is the case if  $c'(\tilde{q}) < e'(\tilde{q})$ ,

the social value  $\tilde{V}$  decreases further as  $\Delta\rho$  increases. Therefore, it is optimal to prevent the joint provision of services for any  $\Delta\rho > 0$ , since  $\tilde{V} < \hat{V}$ . ■

### A.5 Proof of proposition 5.

If  $\frac{\partial\tilde{V}}{\partial\Delta\rho} > 0$  at  $\Delta\rho = 0$ , then we must have  $c'(\tilde{q}) > e'(\tilde{q})$ . From this follows that  $\tilde{V}$  increases, if  $\Delta\rho$  becomes larger, as long as  $\Delta\rho$  is relatively small. Given the characteristics of  $\frac{\partial c'(\tilde{q})}{\partial\Delta\rho}$  and  $\frac{\partial e'(\tilde{q})}{\partial\Delta\rho}$ ,  $\tilde{V}$  decreases, for relatively large values of  $\Delta\rho$ . Therefore, at some critical level  $\Delta\rho = \Delta\rho^*$ , we have  $\tilde{V} = \hat{V}$ . For values  $\Delta\rho < \Delta\rho^*$ , we have  $\tilde{V} > \hat{V}$ , and therefore allowing the joint provision of services is optimal. For values  $\Delta\rho > \pi\Delta\rho^*$ , we have  $\tilde{V} < \hat{V}$ , and therefore forbidding the joint provision of services is optimal. ■

## B Derivation of Equation (15)

The necessary regulation effort for a given rating standard is given by:  $e(\tilde{q}) = h^{-1}\left(\frac{c(\tilde{q})+\Delta\rho}{\hat{\eta}}\right)$ . Differentiating with respect to  $\tilde{q}$  leads to  $e'(\tilde{q}) = h'^{-1}\left(\frac{c(\tilde{q})+\Delta\rho}{\hat{\eta}}\right)\frac{c'(\tilde{q})}{\hat{\eta}}$  and after rearranging:

$$\frac{e'(\tilde{q})}{c'(\tilde{q})} = h'^{-1}\left(\frac{c(\tilde{q})+\Delta\rho}{\hat{\eta}}\right)\frac{1}{\hat{\eta}} \quad (\text{A.6})$$

Inserting equation (A.6) into equation (14):  $\frac{\partial\tilde{V}}{\partial\Delta\rho} = 1 - h'^{-1}\left(\frac{c(\tilde{q})+\Delta\rho}{\hat{\eta}}\right)\frac{1}{\hat{\eta}}$  leads to equation (15):

$$\frac{\partial\tilde{V}}{\partial\Delta\rho} = 1 - \frac{e'(\tilde{q})}{c'(\tilde{q})} \longleftrightarrow \frac{\partial\tilde{V}}{\partial\Delta\rho} = \frac{1}{c'(\tilde{q})} (c'(\tilde{q}) - e'(\tilde{q}))$$

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