Imprecise information disclosure and truthful certification

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Abstract

This paper studies the interaction of information disclosure and reputational concerns in certification markets. We argue that by revealing information less precisely, a certifier reduces the threat of capture because this constrains feasible bribes. As a result, only imprecise disclosure rules are implementable for intermediate discount factors. Our results therefore suggest that contrary to the common view, imprecise disclosure may be socially desirable. Regulatory intervention may provoke market failure especially in industries where certifier reputational rents are low.

Keywords: Certification; Information Disclosure; Bribery

JEL Classification Numbers: L15; D82; L14; L11

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1 Introduction

Informational asymmetries in markets give rise to the emergence of certification intermediaries. By inspecting products and revealing quality information to the public, certifiers contribute an important share to prevent breakdowns of trade. Yet, albeit at hand, information is typically not fully revealed. For instance, certifiers of organic food dispose of precise information concerning animal housing and breeding. However, certification is mostly based on a Pass/Fail decision. Similarly, restaurant raters, eco-labels, rating agencies, wine certifiers or technical inspectors do not reveal all information at hand. Why?

A rich literature starting with Lizzeri (1999) identifies profit concerns as the motive for adopting such imprecise information disclosure.1 We call attention to a different explanation. We show that imprecise disclosure rules can serve as a safeguard against fraud: certifiers may be tempted to accept bribes for releasing favorable certificates. Such behavior, called capture, enables the certifier to extract payments other than the certification fee. If consumers are aware of this threat of capture, the certifier must find ways to credibly commit to reveal her information truthfully, that is, according to some previously announced disclosure rule. One way to do so is to employ an imprecise disclosure rule. Stated differently, a certifier adopts an imprecise disclosure rule not to increase her profits, but to generate positive profits at all. In contrast to earlier findings, imprecise disclosure may thus be socially desirable – regulatory intervention that enforces a more transparent disclosure may provoke market failure.

To get an intuition for this result, consider the following infinitely repeated certification game: in each period, short-lived producers first have to make an investment choice, which in turn determines the probability distribution of their products’ qualities. Contingent on the quality outcome, producers decide whether or not to apply for certification, which is costly. Products are then inspected and certificates are awarded according to some preset disclosure rule. In the absence of a threat of capture – the certifier commits

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1Roughly speaking, disclosing information less precisely is an optimal strategy for a profit maximizing certifier because this induces more sellers to pay for certification. See also the related literature section.
to disclose according to the announced disclosure rule and does not face any reputational concerns – full disclosure maximizes certifier profits.\(^2\)

If the certifier is threatened by capture, she may offer producers, against the payment of a bribe, to release favorable certificates. When the true quality experienced after consumption does not match the awarded certificate, capture is detected and punished in future periods. This makes the certifier face a classical reputation dilemma: she trades off short-run gains from capture against future profits. With information being fully disclosed, the short-run gains from capture are large because low quality producers are willing to pay high bribes in order to be awarded the most valuable certificate.

By contrast, imprecision reduces this willingness to pay. When different qualities are pooled into the same certificate, a good carrying this certificate is worth less on the market than a good which is unambiguously identified as the highest quality good. Also, imprecision increases demand for certification services. If the certifier, when being captured, forgoes regular fee payments, short-run gains from capture are further reduced. We show that these two levers can be used without affecting certifier profits. As a result, the threat of capture is reduced as compared to full disclosure.

Our results provide important insights into the role of certifiers as providers of transparency in markets with imperfect information. The literature has so far emphasized that certifier profit concerns are usually in conflict with a social desire for transparency. This calls for regulatory intervention.\(^3\) However, transparency enforcement may evoke adverse effects, namely if it confines market functionality. This is an implication of our

\(^{2}\)In fact, the setting is chosen such that full disclosure maximizes certifier profits. As mentioned earlier, previous studies have demonstrated how coarseness can result in higher certifier profits. A setting in which full disclosure is optimal helps us to differentiate the reputational effect which arises due to the threat of capture. The basic insights however apply to much more general settings.

\(^{3}\)For instance the Dodd-Frank Wall Street Reform and Consumer Protection Act finds that credit rating agencies are “matters of national public interest” (SEC. 931 (1)). SEC 931 (5) directly addresses inaccuracy of ratings: “In the recent financial crisis, the ratings on structured financial products have proven to be inaccurate. This inaccuracy contributed significantly to the mismanagement of risks by financial institutions and investors, which in turn adversely impacted the health of the economy in the United States and around the world. Such inaccuracy necessitates increased accountability on the part of credit rating agencies.” SEC. 932 directly addresses transparency of ratings: “The rules of the Commission under this subsection shall require, at a minimum, disclosures that […] (B) are clear and informative for investors having a wide range of sophistication who use or might use credit ratings; (C) include performance information over a range of years and for a variety of types of credit ratings, including for credit ratings withdrawn by the nationally recognized statistical rating organization […]”
The remainder of the paper is organized as follows. The following section reviews the related literature. Section 3 presents the model. Section 4 provides the relevant benchmark cases, such as the outcome under complete information and with a certifier who cannot engage in capture. The capture problem is analyzed in section 5, where we present our main results. Section 6 reviews the model with multiple quality specifications. A discussion of our modeling assumptions is provided in section 7. Section 8 concludes. All proofs are presented in the appendix.

2 Related literature

A stream of literature identifies profit concerns as the cause for imprecise information revelation in private certification markets (Lizzeri, 1999; Albano and Lizzeri, 2001; Rayo and Segal, 2010; Kartasheva and Yilmaz, 2013; Farhi et al., 2013; Faure-Grimaud et al., 2009; Pagano and Volpin, 2012). Here, the certifier is committed to reveal information according to her disclosure policy, the possibility of capture is ruled out by assumption. As opposed to the present study, these works suggest that market regulation which seeks to reduce asymmetries of information improves welfare.

Lizzeri (1999) finds that it is optimal for a monopolistic certifier in a static adverse selection environment to reveal almost no information. Albano and Lizzeri (2001) study optimal disclosure rules in a static model where quality is endogenous. Some information disclosure is required to create incentives for quality provision. Optimal disclosure is noisy, when only flat certification fees are feasible. In a very general setting, Rayo and Segal (2010) show that when products are exogenously characterized by its value to the certifier and the consumer, disclosure is typically coarse: products with different characteristics are pooled into the same certificate. Kartasheva and Yilmaz (2013) demonstrate how imprecision improves certifier profits when some buyers are informed and sellers have heterogeneous reservation prices. In Kartasheva and Yilmaz (2013), as in the present paper, the quality space is finite discrete and imprecision refers to a noisy disclosure of
information.

In Farhi et al. (2013) and Faure-Grimaud et al. (2009), information disclosure is referred to as the potential concealment of certificates or certification procedures while the disclosure rule – as it is defined in the present paper – is exogenously given.

In Pagano and Volpin (2012), it is the seller who decides to release imprecise information. In their model of rating asset-backed securities, rating agencies serve to confirm the information the issuer wishes to reveal and therefore act non-strategically. The term imprecision here means that the systematic risk exposure of an asset-backed security is not revealed at all.

Some works find that imprecise disclosure rules may enhance welfare in certification markets where the certifier is a governmental organization that seeks to maximize overall welfare. In Buehler and Schuett (2014), a social planner sets a Pass/Fail standard, thereby shaping competing firms’ incentives to invest in quality. The Pass/Fail threshold induces effort levels above those employed if consumers perfectly observe quality. This effect would be thwarted by the use of a full disclosure rule.

Reputational concerns in certification markets have been analyzed by Strausz (2005), Mathis et al. (2009) and Bolton et al. (2012). The disclosure rule is exogenously given in these studies. We add to this stream by directly analyzing how reputation and information disclosure interact.

3 The setup

We consider a dynamic framework in discrete time, where time is indexed by $t$.

3.1 The basic setup

Producers. In each period $t$, a single short-lived producer is born. He produces one indivisible unit of a good whose quality $q_t$ can be either high ($q_t = q^h$), or low ($q_t = q^l$). The producer privately learns the good’s quality immediately after production. In the following, we refer to a high type as a producer with high quality $q^h$ and to a low type as
a producer with low quality $q^l$. Prior to production, a producer chooses an investment level $e_t \in [0, 1]$. Quality is stochastic and the probability that the good is of high quality is given by $e_t$. Investment costs are given by the strictly increasing and strictly convex function $k(\cdot)$, which additionally features a non-negative third derivative. A producer’s valuation for the good is zero and thus independent of the actual quality.

**Consumers.** In each period, (at least) two consumers bid for the good in a second price auction. A consumer’s reservation price for a good of high quality is $v > 0$, whereas it is zero for a good of low quality. To guarantee interior solutions for producer investment, we assume $k'(1) > v$ and $k'(0) = 0$. The quality of the good is unobservable to consumers and is learned only after consumption.

**Certification.** A long-lived monopolistic certifier offers to publicly disclose information on the good’s quality in each period before it is sold. The certifier charges a certification fee $f$ and discloses information according to some disclosure rule $D = (C, \alpha^l, \alpha^h)$. Disclosure rule and fee are referred to as the certifier’s terms, which we assume are given at the outset. The fee has to be paid by any producer who wishes to have his good tested. A flat fee implies that first, the fee cannot be made contingent on the outcome of the certification process, and second, it cannot be used to elicit the producer’s private information.

The disclosure rule specifies how information is revealed. It consists of a (finite) set of certificates $C = \{C^1, \ldots, C^n\}$ and probability vectors $\alpha^l$ and $\alpha^h$. The $k$-th entry of vector $\alpha^i$ reflects the probability that a good of quality $q^i$ is awarded certificate $C^k$. These

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4Note that this probability function is independent of $t$. Hence, quality levels are independent across time periods.

5The assumption on the third derivative is purely technical. It guarantees existence of a disclosure rule that maximizes certifier profits.

6Consumers may be short- or long-lived. The second price auction results in a standard monopoly price. With this simple selling procedure we circumvent numerous complications. Otherwise, the informed party’s publicly observable actions may be interpreted as a quality signal.

7Explicitly modeling the certifier’s choice of a fee and a disclosure rule creates no difficulties, but comes at the cost of heavier notation. We would have to introduce off-path belief for unexpected choices of the disclosure rule. Setting these to the ‘worst’ beliefs we introduce later on re-establishes the equilibria we obtain.

8This assumption is briefly discussed in section 7.

9An alternative interpretation of the disclosure rule is that the test is executed by a computer or a statistical (i.e. potentially imperfect) procedure. It is therefore not necessary that the certifier learns the true quality of a good when certifying it.
probabilities do not necessarily add up to one, i.e. $\sum_k \alpha_k i_k < 1$ is allowed for. Hence, a good may remain uncertified and will be sold as such. Consumers cannot observe whether a good was tested unless it is offered with a certificate, and an uncertified good is referred to as $\emptyset$. Possible disclosure rules encompass for example full disclosure, where $\mathcal{C} = \{C^1, C^2\}$ and $\alpha^h = (0, 1)$ as well as $\alpha^l = (1, 0)$, or no disclosure, where $\mathcal{C} = \{C\}$ and $\alpha^l = (1)$.

3.2 Capture

The literature on certification typically assumes that quality is revealed truthfully, that is, according to the previously announced disclosure rule. Yet, there exists pressure from producers to bypass customary certification in order to obtain better certificates. To address this issue we introduce the possibility of capture.

The way we model capture is based on the framework of enforceable capture as initiated by Tirole (1986) and used by Strausz (2005). Specifically, capture is modeled as follows: after a producer has learned his quality $q_t$ – but before applying for certification – he is offered an enforceable side-contract $(C, b)$ by the certifier. We impose that the certifier is bound to make a capture offer. Yet, by making an offer which is considered unacceptable by all producer types, she can always prevent capture from occurring. The capture offer consists of a certificate $C \in \mathcal{C}$, issued in case of acceptance, and a financial transfer $b$ to be paid by the producer. The certifier thus offers to ‘sell’ certificate $C$ at price $b$. In case of acceptance, the customary certification procedure is bypassed. Hence, $(C, b)$ are the terms on which the certifier is willing to become captured. A producer can reject this offer and apply for regular certification by paying the fee $f$.

All players – producers, consumers and the certifier – are assumed to be risk neutral. The rate at which the certifier discounts the future is $\delta \in (0, 1)$.

\footnote{Note that certificates do not carry an intrinsic value. In the case of full disclosure, $\alpha^h = (1, 0)$ and $\alpha^l = (0, 1)$ describe an equivalent disclosure rule.}

\footnote{This last assumption is motivated following Kofman and Lawarrée (1993). It implies that the certifier cannot forge certification without the help of the producer. Thus, the certifier cannot blackmail the producer, for instance because the producer is able to resort to legal measures. The assumption of enforceable side-contracts is briefly discussed in section 8.}
Timing. Given certifier terms \((D, f)\) induce an infinitely repeated game under the threat of capture. The timing in the stage game is as follows. First, the producer chooses investment level \(e\), produces the good and privately observes its quality. Second, the certifier makes a capture offer \((C, b)\) to the producer, which is either accepted or rejected. In case of acceptance, the producer pays the bribe \(b\) and his good is awarded certificate \(C\) in return. When rejecting the capture offer, the producer decides whether to apply for regular certification. If he decides to do so, he pays the fee \(f\) and the good is awarded certificate \(C^i\) according to the disclosure rule. Otherwise no further information is revealed. At the end of the period the good is sold in a second price auction. The timing is illustrated in Figure 1.

Histories, Strategies and Equilibrium Concept. Let \(\Gamma^{f,D}\) denote the infinitely repeated certification game induced by certification fee \(f\) and disclosure rule \(D\). The present paper characterizes equilibria for given terms. Let \(h_t = (C_1, q_1, \ldots, C_{t-1}, q_{t-1})\) denote the public history at time \(t\). A history in \(t\) comprises both the awarded certificate and the true quality in each preceding period. If a good remained uncertified in period \(\tau\), then \(C_\tau = \emptyset\). We employ the usual convention \(h_1 := ()\) for the empty history in the initial period. Further, denote by \(H_t\) the set of all (public) histories \(h_t\). One way to think of the history being public is that consumers report their consumption experience either by
These public histories enable consumers to detect whether the certifier deviated from the disclosure rule in the past.

In a given period \( t \), a producer first chooses an investment, second, decides whether to accept the capture offer, and, in case of rejection, decides whether to apply for customary certification. A behavioral strategy for a producer in period \( t \) is a triple \((\sigma^e_t, \sigma^b_t, \sigma^c_t)\), where \( \sigma^e_t : H_t \rightarrow [0, 1] \) maps the current history into an investment level. \( \sigma^b_t : H_t \times \{q^l, q^h\} \times C \times \mathbb{R}_+ \rightarrow \{a, r\} \) describes the producer’s acceptance decision – \( a \) stands for acceptance and \( r \) for rejection – for a capture offer \((C, b)\) which also depends on the history and the product quality. Finally, \( \sigma^c_t : H_t \times \{q^l, q^h\} \rightarrow \{y, n\} \) maps history and quality into a decision for or against application, where \( y \) stands for a positive decision.

In each period, the certifier holds a belief \( \mu_t \) about whether the good’s quality is high, where \( \mu_t : H_t \rightarrow [0, 1] \). Based on the history, the certifier chooses to make a capture offer \((C, b)(h_t)\). Thus, the certifier’s behavioral strategy is a collection of functions \( \tau_t : H_t \rightarrow C \times \mathbb{R}_+ \).

Consumers bid in the second-price auction after observing the certificate (resp., that there is no certificate) in the respective period. Their strategy is therefore a mapping \( \kappa : H_t \times C \cup \{\emptyset\} \rightarrow \mathbb{R}_+ \), which maps history \( h_t \) and certificate \( C_t \) into a bid \( \kappa(h_t, C_t) \). Furthermore, consumers hold a belief \( \nu_t(h_t, C_t) \in [0, 1] \), which is the probability that a good awarded certificate \( C_t \) in period \( t \) after history \( h_t \) is of high quality.

The solution concept we use is the perfect Bayesian equilibrium. We check for the existence of perfect Bayesian equilibria in which capture does not occur, i.e. where on the equilibrium path the certifier never makes a capture offer that is accepted. Also, this study focusses on a special class of disclosure rules which we call partial disclosure rules and which will be defined further below. Clearly, this considerably restricts the set of

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\[^{12}\text{For our results it suffices that future generations are aware of past mismatches between the true and the certified quality. Such ‘scandals’ are typically spread through the media. A recent example is the case of the German automotive club (ADAC), which deliberately mis-communicated consumer evaluation results. Similarly the Volkswagen-scanal was widely discussed throughout the media.}

\[^{13}\text{We focus on pure strategies here. Because } k \text{ is strictly convex, it is without loss of generality to assume that } \sigma^b_t \text{ is a pure strategy. Given our focus on capture proof equilibria (see further below), also } \sigma^c_t \text{ is a pure strategy which is also without loss of generality. Random certification decisions are not excluded per se. With full disclosure the stage game has a unique perfect Bayesian equilibrium, as shown in Lemma B.1. For partial disclosure, it is not necessary to consider mixed strategies in order to demonstrate our main result.}

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possible equilibria. However, it is not the aim of this paper to characterize the full set of equilibria, but instead to demonstrate how the threat of capture can force a certifier to employ disclosure rules which are not fully revealing.

4 Preliminary analysis

Before analyzing the game with capture, we briefly review four cases which will serve as benchmarks. In the first case, quality is observable by all players which makes a certifier redundant. This complete information setting allows us to identify first best investment levels which in turn help to evaluate the social implications of coarse disclosure. Second, the case of asymmetric information in the absence of any certification intermediary yields a standard market failure result. Third, in the absence of a threat of capture, that is, when the certifier is bound to certify truthfully, a full disclosure rule yields maximal certifier profits. Thus, profit concerns should not be the reason to resort to imprecise disclosure. Not that the setting is chosen such that full disclosure is optimal. This allows us to clearly work out the reputational effect and separate it from any profit concerns.

Finally, certification does not take place in the stage game with capture. This provides the rationale for repeating the game, where reputation creates a counterbalance to the certifier’s incentives to engage in capture.

Because the only long-lived player, the certifier, has no action choice in the first three settings, we confine the analysis to a single stage and consequently drop all time indices. The same is done in the final setting which takes into consideration the stage game only.

4.1 Complete information

Complete information implies that consumers observe the good’s quality. Certification is therefore redundant. High quality goods sell at price \( v \) and low quality sells at price \( 0 \). The producer chooses the investment level \( e \) to maximize expected profits, which are
\( e \cdot v - k(e) \). The first best investment level \( e^* \) is thus given by\(^{14}\)

\[
k'(e^*) = v. \tag{4.1}
\]

### 4.2 Asymmetric information without certification

Under asymmetric information and in the absence of any further economic institution, a producer cannot persuade consumers to offer a high quality good. Thus, the market price cannot be made contingent on a good’s quality. It is standard to show that the Perfect Bayesian market outcome involves a market failure.

**Lemma 1.** Without certification, producers choose \( e = 0 \). In equilibrium, quality is low and the good sells at price \( p = 0 \).

Consumers form a belief about the offered quality. Let \( \nu \) denote the expected value, based on consumer beliefs. The good sells at price \( p = \nu \) in the second price auction. Consequently, the producer chooses his investment in order to maximize \( \nu - k(e) \), which yields \( e = 0 \) irrespective of consumer beliefs. In equilibrium, consumers correctly anticipate a producer’s investment choice, and thus anticipate that the good is of the low quality. The result is a market failure: high quality is never offered in equilibrium.

### 4.3 Absence of a threat of capture

In the absence of a threat of capture - that is, when the certifier truthfully discloses information according to the disclosure policy - our model is equivalent to a special case of Albano and Lizzeri (2001).\(^{15}\) The disclosure policy that maximizes certifier profits is derived from their Propositions 3 and 4.

**Lemma 2.** A disclosure policy that maximizes certifier profits is given by a full disclosure

\(^{14}\)Our assumptions on the cost function \( k \) imply that \( 0 < e^* < 1 \).

\(^{15}\)Strictly speaking the models are not equivalent, because ours is a one of moral hazard and adverse selection, while Albano and Lizzeri have a double adverse selection problem. But from the certifier’s perspective, both are equivalent when considering the following special case. Let \( t \sim U[0,1] \) and \( \Theta = \{0, v\} \). With the cost function \( c(0, t) \equiv 0 \), as well as \( c(v, t) = k'(t) \), equivalence prevails.
rule, that implements $e^{FD}$ with the fee $f^{FD} = v - k'(e^{FD})$, where

$$v - k'(e^{FD}) = e^{FD}k''(e^{FD}).$$

(4.2)

In equilibrium, only high quality products are certified.

By Lemma 2, certifier profits are maximized under a full disclosure rule. Under a full disclosure rule, products awarded certificate $C^2$ are sold at price $v$ whereas the certificate $C^1$ is worth nothing. Clearly, whenever the fee is strictly positive, only high types apply for certification.

Expressing certifier profits in terms of a producer’s investment allows us to directly compare different disclosure rules. Under a full disclosure rule and some fee, the producer’s investment choice is determined by the first-order condition $f = v - k'(e)$. Substituting this into the certifier’s expected profit yields

$$\pi^{FD}(e) = e \cdot (v - k'(e)).$$

(4.3)

Condition (4.2) in Lemma 2 states the maximizer of this expression.

A certain class of disclosure rules will play a crucial role in the remainder of this paper. We call them partial disclosure rules: let there be two certificates, $C^1$ and $C^2$, with $\alpha^h = (1 - \alpha, \alpha)$ and $\alpha^l = (1, 0)$. Thus, low quality products are eligible for certificate $C^1$ only, whereas high quality products are awarded the high value certificate $C^2$ with probability $\alpha \in (0, 1)$ and the low value certificate otherwise. Since this value is then strictly positive, also lower types are willing to pay positive fees.

Note that partial disclosure rules can be implemented as Pass/Fail schemes, namely if the requirements for passing a test a subject to randomness. A good which is eligible for passing a test may then nevertheless fail it with probability $1 - \alpha$. This probability can be controlled by certifier, either by using imperfect testing technologies or by setting standards which are subject to measurement errors. For instance, if an eco-label requires the use of pesticides to not exceed 5%, controls are necessarily imprecise.

**Lemma 3.** For any $\alpha \in (0, 1)$ there exists a unique $f(\alpha) > 0$ such that
\[(1) \text{for any } f \leq f(\alpha) \text{ there exists a unique equilibrium where all producer types certify,}
\]
\[(2) \text{in any of the above equilibria producer investment is } e(\alpha) \in (0, e^*).\]

Conversely, for any \( e \in (0, e^*) \) there exists an \( \alpha(e) \in (0, 1) \) such that the certifier’s equilibrium profit (in the equilibrium described above) is \( \pi^{PD}(e) = e(v - k'(e)) \) when the fee is \( f(\alpha) \).

Lemma 3 establishes a remarkable parallel between full and partial disclosure. For a given producer investment level \( e \), both rules yield identical certifier profits in the stage game, namely \( \pi(e) = e(v - k'(e)) \). The rules differ with respect to the party that bears the risk. Under a full disclosure rule the certifier’s profit is risky – it is either \( f \) or zero. Partial disclosure transfers this risk to the high type producer whose payoff is either zero or \( v - f \). This seemingly innocuous difference will play a crucial role in our subsequent analysis.

4.4 Capture in the stage game

Under a threat of capture, the stage equilibrium outcome of the previous section cannot be sustained.

**Lemma 4.** Fix a certifier policy \( D = (C, f) \). In any perfect Bayesian equilibrium of the stage game the producer does not invest and certifier profits are zero.

To ensure strictly positive investment, there must be at least one certificate that ensures a strictly positive sales price. The certificate with the highest value can be part of a capture offer that is always profitable to the certifier.

5 The capture problem

Reputational concerns may help to deter the certifier from being captured, and thus to restore the outcome without capture. When the discount factor is large future expected profits outweigh the short-run gain from becoming captured. In this section, we seek
to give an answer to the following question: how does the set of discount factors which allow for equilibria in which capture does not occur differ under different disclosure rules? Stated differently: may for intermediate discount factors partial disclosure facilitate the implementation of truthful certification, when full disclosure – which by Lemma 2 maximizes certifier profits – fails to do so?

In order to give an answer to this question, we start by investigating the game with capture when information is fully disclosed. In a second step, partial disclosure rules are analyzed. Comparing both cases yields our main result, namely that partial disclosure enlarges the set of discount factors which allow for equilibria in which capture does not occur. We also derive welfare implications of the threat of capture which, in view of the restricted setting, do not serve as a general result.

Our focus lies on equilibria in which capture does not occur, which we refer to as capture proof equilibria. Because consumers and producers are short-lived, the equilibrium outcome in a given period on the equilibrium path corresponds to the equilibrium outcome of the stage game without capture, analyzed in section 4.3.

We impose the following with respect to punishments after capture was detected: consumers trust certificates as long as they have not detected a deviation. However, they lose trust once and for all if a false testimony about a good’s quality is detected. A certifier who anticipates this behavior may be prevented from succumbing to the temptation of becoming captured by the fact that losing credibility will leave her without demand, hence without profits, in future periods.

Formally, under both full and partial disclosure – where certificate $C^2$ is awarded exclusively to high quality goods – consumer beliefs satisfy

\( (i) \quad \nu_t(h_t, C_t) = \nu(C_t), \text{ if } \# \tau < t \text{ such that } C_\tau = C^2 \text{ and } q_\tau = q^l, \)

\( (ii) \quad \nu_t(h_t, C_t) = 0 \text{ otherwise,} \)

where $\nu(C_t)$ corresponds to consumer beliefs in the respective static equilibrium (see section 4).

For full disclosure, consumers expect to consume a high quality good when purchasing a good which is certified as such. If the quality turns out to be low, consumers attribute
this to the fact that the certifier was captured and, hence, lose trust in the certifier’s credibility once and for all.

Similarly, for partial disclosure, consumers expect to consume a high quality good when purchasing a \( C^2 \)-certified good. Also here, if the good’s quality turns out to be low, consumers attribute this to the fact that the certifier was captured and punish accordingly.

In our setting the one-shot deviation principle applies. An equilibrium is capture proof if and only if there exists no capture offer which yields the certifier higher expected profits than truthful certification. More precisely, fix a disclosure rule \( D \) and a certification fee \( f \). Denote by \( \Pi^D_f(h_t) \) the certifier’s expected discounted profit on the equilibrium path starting in period \( t \) at history \( h_t \). Further, let \( \hat{\Pi}^D_f((C,b)|h_t) \) denote her expected discounted profit from making a one-shot capture offer \((C,b)\) in the current period \( t \). An equilibrium is capture proof if and only if

\[
\Pi^D_f(h_t) \geq \hat{\Pi}^D_f((C,b)|h_t) \quad \forall (C,b).
\] (5.1)
in every period \( t \) and after every history \( h_t \) on the equilibrium path.

### 5.1 Capture under full disclosure

The outcome of the stage game without capture is uniquely given under a full disclosure rule.\(^{16}\) Hence, play along the equilibrium path is identical in each period. Consequently, we drop time index and history in condition (5.1). Also, making an acceptable offer \((C^1,b)\) is not a relevant deviation. Therefore, we can restrict our attention to offers \((C^2,b)\) – or simply \( b \).\(^{17}\)

Capture offers that are accepted by high type producers are also accepted by low type producers. Offers which are designed to be accepted only by low producer types are accepted with some probability from the certifier’s point of view. This probability is determined by the certifier’s belief about the producer type, and hence given by \( 1 - \mu \).

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\(^{16}\)This claim is formally proven in Lemma B.1 in appendix B.

\(^{17}\)Recall that \( C^2 \) certifies high quality only, while \( C^1 \) certifies low quality. I.e. we have \( \alpha^l = (1,0) \) and \( \alpha^h = (0,1) \).
High producer types accept a bribe if it does not exceed the regular fee. Low quality producers accept any bribe which does not exceed a consumer’s willingness to pay for a high quality good, \(v\). Note that detection and hence punishment occurs only when the quality was indeed low, independent of whether also high producer types accepted the bribing offer. If no producer type considers the offer acceptable, the certifier’s profit corresponds to her profit when information is truthfully revealed. The certifier’s expected profit from offering bribe \(b\) is then given by

\[
\Pi_{FD}(b|f) = \begin{cases} 
  b + \mu \delta \Pi_{FD}(f), & \text{if } b < f, \\
  (1 - \mu) b + \mu (f + \delta \Pi_{FD}(f)), & \text{if } f \leq b < v, \\
  \Pi_{FD}(f), & \text{if } b \geq v.
\end{cases}
\]  

(5.2)

The following proposition identifies the range of discount factors for which a capture proof equilibrium exists.

**Proposition 1.** Under full disclosure with certification fee \(f\), a capture proof equilibrium exists if and only if

\[
\delta \geq \delta_{FD}(f) \equiv \frac{v}{v + \pi_{FD}(f)}.
\]

(5.3)

The critical discount factor mirrors the classical trade-off between short-run gains – the bribe – and long-run losses – foregone future profits. Short-run gains are largest when the bribe approaches \(v\), which is a low type producer’s maximum willingness to pay for the high-value certificate.

From Proposition 1, the certification fee impacts the critical discount factor only through the per-period profit which is a concave function hereof. As a result, the critical discount factor minimizes where per-period profits maximize, that is, for \(f = f_{FD}\). The next corollary follows immediately.

**Corollary 1.** For any discount factor \(\delta \geq \delta_{FD}\) there exists an interval of fees \([f_l(\delta), f_h(\delta)]\), which sustains capture proof certification under full disclosure, where

\[
\delta_{FD} \equiv \frac{v}{v + \pi_{FB}}.
\]

(5.4)
Figure 2: Capture proof combinations of \((e, \delta)\) resp. \((f, \delta)\) under full disclosure.

Alternatively, the critical discount factor can be expressed as a function of producer investment. The analysis is analogue to the one above except that certifier profits are expressed in terms of producer investment \(e\).

**Proposition 2.** For any discount factor \(\delta \geq \delta^{FD}\) there exists an interval of investment levels \([e^{FD}_l(\delta), e^{FD}_h(\delta)]\) that can be implemented in a capture proof equilibrium. A particular investment level \(e \in [0, e^*]\) can be implemented in a capture proof equilibrium with full disclosure if and only if

\[
\delta \geq \delta^{FD}(e) \equiv \frac{v}{v + e \cdot (v - k'(e))}.
\]  

(5.5)

Figure 2 illustrates the findings of Propositions 1 and 2. The solid curve represents the critical discount factor as a function of the investment level (left panel), respectively the certification fee (right panel). For a given level of investment, resp. certification fee, a capture proof equilibrium exists for all discount factors above the curve. Notice further that the curve has a unique minimum at \(e = e^{FD}\), resp. \(f = f^{FD}\), which illustrates Corollary 1.

### 5.2 Capture under partial disclosure

In contrast to the full disclosure case, the stage game without capture has multiple equilibria under a partial disclosure rule.\(^{18}\) For our purposes it suffices to restrict attention

\(^{18}\)Recall that partial disclosure rules can be implemented by using imperfect testing technologies.
to the unique pure strategy equilibrium identified in Lemma 3. Consequently, we again drop time index and history.

Awarding the low value certificate $C^1$ to high quality products is not punished under a partial disclosure rule. Low type producers accept a capture offer $(C^1, b)$ only when the bribe is smaller than the regular fee. Such an offer is certainly unprofitable for the certifier because all producers are willing to pay the regular fee in order to be certified. As before, we can therefore restrict our attention to offers $(C^2, b)$ – or simply $b$.

A $C^2$-certified good sells at price $v$, while a $C^1$-certified good sells at price $v^1$. Here $v^1$ denotes the expected quality for equilibrium consumer beliefs. The expected certifier profits for a given bribing offer are then given by

$$
\Pi^{PD}(b|\alpha, f) = \begin{cases} 
  b + \mu \delta^{PD}(\alpha, f), & \text{if } b < f + (1 - \alpha)(v - v^1), \\
  (1 - \mu) b + \mu \left( f + \delta^{PD}(\alpha, f) \right), & \text{if } f + (1 - \alpha)(v - v^1) \\
  \Pi^{PD}(\alpha, f), & \text{if } b \geq f + (v - v^1).
\end{cases}
$$

This profit is obtained in analogy to the case with full disclosure. The only difference lies in the cut-offs for the producer’s acceptance decision. High types are now willing to accept bribes which exceed the regular fee in order to avoid the lottery associated with customary certification. On the other hand, a low type producer values the high certificate less because the low certificate has already a strictly positive value.

The following proposition characterizes capture proof equilibria under partial disclosure.

**Proposition 3.** Under a partial disclosure rule with parameter $\alpha \in (0, 1)$ and certification fee $f$ a capture proof equilibrium exists, if and only if

$$
\delta \geq \delta^{PD}(\alpha, f) \equiv \max \left\{ \delta^{PD}(\alpha, f), \bar{\delta}^{PD}(\alpha, f) \right\},
$$

where $\delta^{PD}(\alpha, f) = \frac{v - v^1}{v - v^1 + f}$ and $\bar{\delta}^{PD}(\alpha, f) = \frac{(1 - \alpha)(v - v^1)}{(1 - \alpha)(v - v^1) + (1 - e(\alpha))f}$. 

18
In analogy to Proposition 1, the critical discount factor trades off short-run gains against long-run losses from capture. Unlike in the case with full disclosure, the largest threat of capture may stem from bribes that are accepted by both producer types. High quality producers are willing to pay bribes that exceed the certification fee in order to avoid the risk associated with customary certification. The term $\delta_{PD}(\alpha, f)$ refers to this case, whereas the term $\delta^{PD}(\alpha, f)$ refers to the case where the largest threat stems from bribes accepted only by low type producers.

Clearly, $\delta^{PD}(\alpha, f)$ is decreasing in the certification fee, which implies that for any partial disclosure rule (i.e. any $\alpha$) the threat of capture decreases in the regular fee. To ensure participation of all producers, the fee should not exceed a consumer’s willingness to pay for a good which is awarded the lower valued certificate $C^1$. Consequently, $f = v^1$ not only maximizes static certifier profits but also minimizes the threat of capture for any given partial disclosure rule. The following corollary takes this into account.

**Corollary 2.** With partial disclosure a capture proof equilibrium exists if and only if

$$\delta \geq \delta^{PD}(\alpha) \equiv \max \left\{ \delta^{PD}(\alpha), \delta^{PD}(\alpha) \right\},$$

(5.7)

where $\delta^{PD}(\alpha) = \frac{v - e(\alpha)(v - k'(\alpha)))}{v}$ and $\delta^{PD}(\alpha) = \frac{1}{1 + e(\alpha)}$.

Define $\delta^{PD} := \min_{\alpha} \delta^{PD}(\alpha)$. This allows us to formulate the analogue of Proposition 2 for partial disclosure rules.

**Proposition 4.** For any discount factor $\delta \geq \delta^{PD}$ there exists an interval of investment levels $[e_{PD}(\delta), e_{PD}(\delta)]$ that can be implemented in a capture proof equilibrium. The investment level $e \in [0, e^*]$ can be implemented in a capture proof equilibrium with partial disclosure if and only if

$$\delta \geq \delta^{PD}(e) = \max \left\{ \delta^{PD}(e), \delta^{PD}(e) \right\}$$

(5.8)

where $\delta^{PD}(e) = \frac{v - e(v - k'(e))}{v}$ and $\delta^{PD}(e) = \frac{1}{1 + e}$.

Figure 3 illustrates the finding in Proposition 4. The parabola displays the curve
5.3 Partial disclosure reduces the threat of capture

In the previous sections we have identified conditions under which capture proof equilibria exist for full and partial disclosure rules. These conditions are expressed in terms of the critical discount factors $\delta^{FD}(e)$ and $\delta^{PD}(e)$. Comparing these functions is short hand for comparing the entire sets of $(e, \delta)$-combinations for which capture proof equilibria exist.

Proposition 5 states our main result.

**Proposition 5.** It holds that $\delta^{PD}(e) < \delta^{FD}(e)$ for all $e \in (0, e^*)$.

Implementing a given investment level results in the same maximal profit, both under a full and a partial disclosure rule. Hence, long-run losses from becoming captured are the same under both rules. The difference in susceptibility against collusion is, thus, solely explained by differences in short-run gains. To see why the short-run gain is always lower under a partial disclosure rule, consider capture offers that are accepted by high type producers. Their (expected) profit from certification is the same under both rules, and so is the maximal bribe they are willing to pay.\textsuperscript{19} As a result, short-run gains from capture are also identical under both rules. This is not the case for capture offers that are accepted

\textsuperscript{19}Under a partial disclosure rule the fee is lower but producers face the risk of being awarded the low-valued certificate. Because certifier profits are identical under both rules, and low type producers as well as consumers always earn zero, it must hold that high type producers have the same expected payoff.
by low type producers only. Although the willingness to pay for the best certificate is again the same under both rules, short-run gains from capture are not. Under a partial disclosure rule, the certifier forgoes the regular certification fee in case his capture offer is accepted. Also, the most profitable bribe always targets only low type producers under a full disclosure rule. Consequently, short-run gains from capture are lower under a partial disclosure rule. This makes capture less likely.

Figure 4 illustrates our main result. The dark-gray area contains all combinations of a discount factor and an investment level for which a capture proof equilibrium exists. In the dark-gray area both full and partial disclosure allow for the implementation of capture proof equilibria. In the light-gray area, capture proof equilibria can be implemented under a partial, but not under a full disclosure rule.

As mentioned above, implementing $e^{FD}$ maximizes the certifier’s period-profits. Under a full disclosure rule, this is possible for all $\delta \geq \delta^{FD}$. Remarkably, under partial disclosure, $e^{FD}$ can be implemented even for lower discount factors.

5.4 The threat of capture improves welfare

Whenever feasible, the certifier considers it optimal to implement the profit maximizing investment level, $e^{FD}$. For sufficiently small discount factors, this may not be possible. Static certifier profits may decrease if a capture proof equilibrium cannot be sustained under a full disclosure rule. The following proposition is concerned with the welfare effects
Proposition 6. Suppose \( e^{FD} v > (1 + e^{FD}) k'(e^{FD}) \). There exists some \( \hat{\delta} \in (\delta^{PD}, \delta^{FD}) \) such that for any \( \delta \in [\delta^{PD}, \hat{\delta}) \) the producer investment satisfies \( e > e^{FD} \) in any capture proof equilibrium with partial disclosure.

Whenever the condition in Proposition 6 is met\(^{20}\), the largest threat of capture stems, at the profit maximizing investment level, from a bribe that is accepted by all producer types. By Proposition 6, these bribes become less attractive as investment levels increase. It is for this reason that a larger investment level reduces the threat of capture. For intermediate discount factors, any disclosure rule which implements profit maximizing investment levels is not capture proof – be it full or partial. Some other partial disclosure rule, which however yields reduced per-period profits, still allows for a capture proof equilibrium. Because welfare increases as investment levels increase, welfare is improved as compared to the profit maximizing investment level.

6 Multiple quality levels

Albeit partial disclosure rules may well be understood as Pass/Fail schemes with an imperfect testing technology, the term ‘imprecision’ refers to ‘noisy’ rather than ‘coarse’ disclosure rules in the sense of quality partitioning. With many quality specifications, disclosure rules can be defined that are in line with the traditional understanding of the term ‘coarseness’. Our main insight carries over: Under a threat of capture, the certifier benefits from coarsening the partition.

Let quality \( q \) be drawn from the interval \([0, 1]\). For the first part of the analysis focus on a given distribution function \( G \) with continuous density \( g \). It is best to think of this distribution as the equilibrium distribution given a producer’s equilibrium investment. At the end of this section, endogenized investment choices will be considered. This section restricts attention to monotone partitioning rules, which are defined as follows.

\(^{20}\)As an example, let \( k(e) = re^r \). Then \( k'(e) = e^{r-1} \) and \( k''(e) = (r-1)e^{r-2} \). We assume \( v \leq 1 \) to ensure \( k'(1) \geq v \). With this cost function we have \( k'(e^{FD}) = v/r \), and the condition in Proposition 6 can be stated as \( 1 < (r-1)^r \sqrt{v/r} \). For large enough values of \( r \), this condition is clearly satisfied.
Let \( 0 < \kappa^0 < \kappa^1 < \ldots < \kappa^n = 1 \) be a partition of the interval \([0,1]\). Further, let 
\[ C = \{C^1, \ldots, C^n\} \]
with \( \alpha_i(q) = 1 \) if and only if \( q \in (\kappa^{i-1}, \kappa^i] \). In words, a good is
deterministically awarded certificate \( C^i \) if the good’s quality lies in the respective interval.
Goods whose quality falls short of \( \kappa^0 \) remain uncertified.

We restrict attention to stage-game equilibria in which a producer applies for cer-
tification if and only if \( q > \kappa^0 \).\(^{21}\) For \( i \in \{1, \ldots, n\} \), the expected value of a good
carrying certificate \( C^i \) is 
\[ v^i = \int_{\kappa^{i-1}}^{\kappa^i} qg(q) \, dq. \]
Similarly, the value of an uncertified good is 
\[ v^0 = \int_0^{\kappa^0} qg(q) \, dq. \]
For a given partitioning rule, the certifier’s expected profits are 
\[ \pi = (1 - G(\kappa^0)) \cdot f \]
in each period.

Because the disclosure rule is deterministic, consumers can perfectly assess inconsis-
tencies. Detected deviations are again punished by distrusting the certifier in the future.

The following lemma characterizes capture proof equilibria for partitioning rules.

**Lemma 5.** Under a partitioning rule and certification fee \( f \), there exists a capture proof
equilibrium if and only if
\[ \delta \geq \delta(\kappa^0, \ldots, \kappa^n, f) := \frac{v^n - v^0}{v^n - v^0 + \pi}. \]  
\[ (6.1) \]

The proof shows that the largest threat of capture stems from producers whose goods
should remain uncertified given the partitioning rule. Their willingness to pay for the
best certificate is given by the difference in consumer valuations for the best certificate
and an uncertified good, \( v^n - v^0 \). The certifier trades off this maximal short-run gain
against future losses. This determines the critical discount factor.

Inspection of (6.1) reveals the following insight: capture proof equilibria are easier to
sustain for higher per-period profits, or lower differences in the valuations for the best
and worst certificates. When quality is exogenous it is therefore not surprising that a
no-disclosure policy, as discussed in Lizzeri (1999), is desirable. It yields maximal certifier
profits and is robust against collusion. In equilibrium, all goods are certified and obtain
the – unique – highest valued certificate.

\(^{21}\)This is without loss of generality. Suppose only goods with \( q > \kappa^k \) were certified in equilibrium.
Then relabeling \( \kappa^k = \kappa^0 \) and so on yields a monotone partitioning rule.
By contrast, when quality is endogenous, this holds no longer true. Nevertheless, to resist capture, the certifier benefits from disclosing only restricted information. To see this, consider binary investment choices. As in our baseline model, the producer chooses \( e \in \{0, 1\} \) prior to production. When \( e = 0 \), the quality of the good is zero with certainty. When \( e = 1 \), quality is distributed according to \( G(q) \) as defined above. The investment cost is zero for \( e = 0 \) and \( c > 0 \) for \( e = 1 \). The certifier cannot employ a no-disclosure policy, because this yields zero profits in equilibrium.

**Proposition 7.** Suppose the partitioning rule \( \{\kappa_0^0, \ldots, \kappa^n\} \) at fee \( f \) induces \( e = 1 \). Then the partitioning rule \( \{\kappa_0^0, \kappa^n\} \) at fee \( f \) induces \( e = 1 \), yields the same per-period profits and capture proof equilibria exist for a strictly larger set of discount factors.

The proof shows that the expected payoff from certifying does not depend on the partition, but on the cut-off \( \kappa_0^0 \). This is an artefact of the restriction to two investment levels. The coarser partition yields the same profits, because the same mass of producers applies for certification. The value of the best certificate decreases because the goods of all producers who demand certification are pooled into a single certificate. Hence, the maximal bribe decreases and capture proof equilibria can be sustained for smaller discount factors.

Proposition 7 demonstrates that coarse disclosure rules allow for capture proof equilibria where full disclosure does not. The many quality specification reveals a second channel: coarsening reduces the maximal bribe a producer is willing to pay. This effect was also present in our main analysis, but did not play a crucial role. In the general specification with both multiple levels of quality and multiple levels of investment, both effects play a role. The analytical challenge stems from the fact that coarsening the partition inevitably affects a producer’s investment incentives. Despite the same cut-off level for certification, the coarser rule thus yields a different value of uncertified goods, which precludes a direct comparison of the resulting critical discount factors as used in the proof of Proposition 7.
Discussion and generalizations

Beliefs. In our analysis we use specific off-path beliefs. These beliefs translate the idea of grim trigger to our setting. For a given – full or partial – disclosure rule, consumers perfectly detect deviations. A deviation immediately triggers a punishment which lasts forever. With the beliefs, the punishment will indeed be carried out. Because consumers beliefs are zero the producer will not invest and because the producer does not invest the consumers’ beliefs are correct. In the equilibria we consider consumer punishment results in the continuation equilibrium which is worst from the certifier’s perspective. Hence, no other punishment belief structure induces a larger set of capture proof equilibria for the respective given disclosure rule.

Furthermore, less severe punishment belief structures – such as punishing only \( N < \infty \) periods – do not invert the ranking of critical discount factors. This follows from the fact that only long-run losses from capture are affected by the punishment structure. The disclosure rule by contrast impacts only short-run gains.

Quality-contingent fees. The model assumes a flat certification fee. One might instead allow for quality contingent fees. Such an extension does not change the basic properties of the result in our setting with only two qualities. Lemma 2 is based upon results by Albano and Lizzeri (2001), who allow for quality contingent fees, and thus full disclosure maximizes certifier profits also when allowing for more flexible fee structures. Effectively, the full disclosure rule has quality contingent fees, but the fee for low quality is zero (and cannot be raised because the value of the respective certificate is also zero). The analysis of capture under a full disclosure rule is hence unaffected. Also, the partial disclosure rules we investigate yield the same profit as full disclosure. When introducing capture, it is unlikely that contingent fees improve upon the partial rules we investigate, but for our main result this of no additional value.

Discriminatory bribes. It was imposed that capture offers are non-discriminatory. A capture offer cannot condition on the producer’s true type, because his type is private information to the producer. Instead, the certifier might want to screen producers and
offer them menus of capture offers. However, screening is impossible: any capture offer yields the same expected value to the producer – irrespective of his type. The certifier can make capture offers that are accepted by both producer types, or offers that are accepted only by low producer types – because of their lower outside option. But there are no capture offers that are accepted by high producer types only, because a low type would find such an offer acceptable as well.

Stated differently, bribes may be discriminatory only if the certifier can commit to test the product even if capture occurred. This can be ruled out by assuming a high fixed cost for setting up a test in the first place. For a one-shot capture offer, where a different testing procedure is needed than for regular certification, it does not pay off for the certifier to construct a new test that is required for implementing capture.

**Enforceability of side-contracts.** Our analysis assumes enforceability of side-contracts. The problem however is that after having received the bribery payment, the certifier has no incentive to honor her part of the agreement. The literature offers at least two ways out: the certifier might be able to build a reputation for honoring side-contracts, or to make use of trustworthy third parties. A certifier may have a reputation for adhering to her obligations among producers. This is possible if she operates in various other segments. An example for a third party that facilitates enforcement is a trust account, where the producer pays the bribe on the account and the certifier gets it only after honoring her part of the agreement. PayPal’s buyer and seller protection have a similar effect.

**Possible equilibria with capture.** In the equilibria studied in this paper, capture is an off-equilibrium event, which complicates an empirical assessment of our results. Following the logic of the folk theorem, there exists a plethora of equilibria for sufficiently large discount factors among which we find equilibria in which capture occurs also on the equilibrium path. For example, consider the disclosure rule with \( \mathcal{C} = \{C^1, C^2\} \) and \( \alpha^h = (1 - \alpha, \alpha) \), as well as \( \alpha^l = (0, 0) \) – low quality goods always remain uncertified. For a given low certification fee \( f \), there exists an equilibrium with capture on the equilibrium path. In such an equilibrium the certifier offers certificate \( C^1 \) along with a bribe \( f \) and only low quality producers accept this offer. The outcome is equivalent to the partial
disclosure rules we study in the main part of the paper. For sufficiently large discount factors such an equilibrium indeed exists.

In the equilibria with capture, consumers rationally anticipate capture. Typically however, the vast majority of people is taken by surprise by incidents of fraud, for instance during the financial crisis of the years 2007 and 2008. Although there is hardly any evidence that capture occurred prior to the crisis, indicators of deliberate overrating can be found. Just recently, Standard and Poor’s entered into a $1.5 billion settlement to fully resolve accusations that the firm knowingly issued faulty ratings.\footnote{The penalty exceeds S&P’s annual profit. See also \url{http://www.bloomberg.com/news/articles/2015-02-03/s-p-ends-legal-woes-with-1-5-billion-penalty-with-u-s-states}.} Following Rotemberg and Saloner (1986), indications of capture rather than actual capture can be generated as an equilibrium phenomenon in our framework. This requires that consumers imperfectly detect deviations, which generates indications of capture and subsequent punishments as an equilibrium outcome, similar to the price wars studied in Rotemberg and Saloner (1986).

**Timing of Capture.** In our model, capture offers are made by the certifier after the producer has invested in quality and has observed its realization, but before he applies for regular certification. Alternative timing structures are conceivable. Capture offers may be made after the parties learn the certification outcome. In this case, any producer whose good is not awarded the best certificate would be willing to pay for bribery. Because the certifier does not expect any further payments in that period, short-run gains increase and capture becomes more likely. Noisy rules become particularly vulnerable. The reason is that in our main setting, capture does not need to always be detected if bribes are accepted by all producer types. This case would not be applicable under the altered timing structure.

Besides, anticipating profitable capture offers in the future undermines the certifier’s incentives to run the test according to the rules – she can always claim the good failed the test. Hence, any producer who, according to the disclosure rule, has a positive chance of not obtaining the best certificate will indeed not get it. Later on he is then willing to accept a bribe for getting the best certificate. In the case of only two quality levels
the alternative timing reverts our results and full disclosure is least susceptible against collusion. With many quality specifications our main insight carries over – the threat of capture is lowest for some Pass/Fail scheme.

8 Conclusion

We have analyzed the effects of reputational concerns on optimal disclosure rules from the point of view of a monopolistic certifier. Our main finding is that if capture is an issue, a certifier benefits from resorting to imprecise certification, which reduces the threat of capture. This identifies an new motive imprecise certification. In contrast to earlier work imprecision is not directly related to profit concerns. By contrast, our analysis highlights the value of imprecise disclosure for the functionality of certification markets.

An important implication of our analysis concerns the regulation of certifiers. As stressed in the literature, certifier profit concerns often result in imprecise information revelation. Yet, in many markets, transparency is desirable from a welfare perspective, and this gives rise to a call for regulatory intervention. Our results suggest that regulation is subject to a feasibility constraint. Enforcing transparency may otherwise possibly prevent a certification market from functioning.

An empirical implication is that for low discount factors we expect disclosure to be more imprecise. One might interpret the discount factor as the arrival rate of sellers. The empirical implication is then consistent with the casual observation that certification in markets with low volume, such as wine, technical inspections or eco-labels often involves only a few different certificates. On the other hand, the high volume rating market exhibits a rather wide variety of different but still imprecise certificates per rating agency.

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A Proofs

Proof of Lemma 1. Follows immediately from the arguments given in the text. □

Proof of Lemma 2. Follows directly from Propositions 3 and 4 in Albano and Lizzeri (2001). □

Proof of Lemma 3. Fix $\alpha > 0$ and denote by $p^i$ the price at which a $C^i$-certified product sells. A producer’s investment therefore solves

$$\max_{\tilde{e}} \bar{e}(\alpha p^2 + (1 - \alpha)p^1) + (1 - \bar{e})p^1 - f - k(e). \quad (A.1)$$

This yields $k'(e) = \alpha(p^2 - p^1)$. In equilibrium, $p^2 = v$, and $p^1 = v \cdot ((1 - \alpha)e)/(1 - \alpha e)$. Hence the first-order condition becomes

$$k'(e) = \frac{\alpha(1 - e)}{1 - \alpha e}. \quad (A.2)$$

Lemma B.2 in the supplementary material proofs the existence of a unique solution $e(\alpha) \in (0, e^*)$ to (A.2). Because $e(\alpha) > 0$, we have $p^1 > 0$ and any $f \leq f(\alpha) := p^1$ guarantees participation by both producer types.

Next, recall that in equilibrium $p^2 = v$ and $p^1 = v(1 - \alpha)e/(1 - \alpha e)$. Therefore, $e\nu = \alpha e\nu + (1 - \alpha)e\nu = \alpha ep^2 + (1 - \alpha)e^p1 = e\alpha(p^2 - p^1) + p^1$. Consequently, $p^1 = e\nu - e\alpha(p^2 - p^1)$, which allows to approximate the certifier’s profit as follows

$$\pi^{FD}(\alpha, f) = f \leq p^1 = e\nu - e\alpha(p^2 - p^1) = e\nu - ek'(e), \quad (A.3)$$

where we make use of the producer’s first-order condition $k'(e) = \alpha(p^2 - p^1)$. Setting $f = p^1$ yields equality throughout. Finally, notice that the mapping $\alpha \rightarrow e(\alpha)$ is continuous, strictly increasing and we have $e(0) = 0$, as well as $e(1) = e^*$ (see Lemma B.2 below). Hence it is invertible, which proves the converse result. □

Proof of Lemma 4. Follows from the arguments given in the main text. □

Proof of Proposition 1. As outlined in the text, the condition for capture proofness is

$$\Pi^{FD}(f) \geq \hat{\Pi}^{FD}(b|f) = \begin{cases} b + \mu \delta \Pi^{FD}(f), & b < f; \\ (1 - \mu)b + \mu (f + \delta \Pi^{FD}(f)), & f \leq b < v; \\ \Pi^{FD}(f), & b \geq v. \end{cases} \quad (A.4)$$

$\hat{\Pi}^{FD}$ strictly increases in $b$ for $b \in (0, f)$ and $b \in (f, v)$. Furthermore, $\lim_{b \to f} \hat{\Pi}^{FD}(b|f) = f + \mu \delta \Pi^{FD}(f) = (1 - \mu)b + \mu f + \mu \delta \Pi^{FD}(f) = \hat{\Pi}^{FD}(f|f)$. Hence, $\hat{\Pi}^{FD}$ increases on the whole range $[0, v)$, and the largest threat of capture stems from bribes $b \to v$. 

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By using $\pi^{FD}(f) = \mu f$ and $\Pi^{FD}(f) = \sum_t \delta^t \pi^{FD}(f) = \frac{\pi^{FD}(f)}{1 - \delta}$ we get

$$
\lim_{\hat{b} > b} \Pi^{FD}(b|f) = (1 - \mu)v + \mu \cdot (f + \delta \Pi^{FD}(f))
\quad = (1 - \mu)\left(v - \frac{\delta}{1 - \delta} \pi^{FD}(f)\right) + \Pi^{FD}(f).
$$

Condition (A.4) is thus equivalent to

$$
v - \frac{\delta}{1 - \delta} \pi^{FD}(f) \leq 0 \iff \delta \geq \frac{v}{v + \pi^{FD}(f)}.
$$

**Proof of Corollary 1.** Follows from Lemma 2 and the arguments given in the text. Strict concavity of $\pi^{FD}(f)$ in $f$ yields the interval $[f_l(\delta), f_h(\delta)]$. □

**Proof of Proposition 2.** Replacing $f$ by $v - k'(e)$, as discussed in section 4.3, yields (5.5). All other statements are straightforward reformulations of Proposition 1 and Corollary 1. □

**Proof of Proposition 3.** Let $\bar{b} = f + (1 - \alpha)v(1 - \nu^1)$ and $\bar{f} = f + v(1 - \nu^1)$. As outlined in the text, the condition for capture proofness is $\Pi^{FD}(f, \alpha) \geq \Pi^{FD}(b|f, \alpha)$ for all $b$, where

$$
\Pi^{FD}(f, \alpha) \geq \tilde{\Pi}^{FD}(b|f, \alpha) = \begin{cases} 
\Pi^{FD}(f, \alpha), & b < \bar{b}; \\
(1 - \mu)b + \mu(f + \delta \Pi^{FD}(f, \alpha)), & \bar{b} \leq b < \bar{f}; \\
(1 - \mu)f, & b \geq \bar{f}.
\end{cases}
$$

(A.5)

Again, $\tilde{\Pi}^{FD}(b|f, \alpha)$ increases in $b$ on $[0, \bar{b}]$ and $[\bar{b}, \bar{f}]$. Hence, condition (A.5) is satisfied, whenever $\lim_{b \nearrow \bar{b}} \Pi^{FD}(b|f, \alpha) \leq \Pi^{FD}(f, \alpha)$ and $\lim_{b \nearrow \bar{f}} \Pi^{FD}(b|f, \alpha) \leq \Pi^{FD}(f, \alpha)$.

Using $\Pi^{FD}(f, \alpha) = \sum_t \delta^t \pi^{FD}(\alpha, f)$ and $\pi^{FD}(\alpha, f) = f$ yields

$$
\lim_{b \nearrow \bar{b}} \tilde{\Pi}^{FD}(b|f, \alpha) = f + (1 - \alpha)v(1 - \nu^1) + \mu \delta \Pi^{FD}(f, \alpha)
\quad = (1 - \alpha)v(1 - \nu^1) - \frac{\delta}{1 - \delta} (1 - \mu)\pi^{FD}(\alpha, f) + \Pi^{FD}(f, \alpha).
$$

Consequently, $\tilde{\Pi}^{FD}(b|f, \alpha) \leq \Pi^{FD}(f, \alpha)$ for all $b < \bar{b}$ if and only if

$$
\delta \geq \delta^{PD}(\alpha, f) := \frac{(1 - \alpha)v(1 - \nu^1)}{(1 - \alpha)v(1 - \nu^1) + (1 - \mu)\pi^{FD}(\alpha, f)}.
$$

(A.6)

Similarly,

$$
\lim_{\hat{b} \nearrow \bar{b}} \tilde{\Pi}^{FD}(b|f, \alpha) = (1 - \mu) \cdot (f + v(1 - \nu^1)) + \mu(f + \delta \Pi^{FD}(f, \alpha))
\quad = (1 - \mu)\left(v(1 - \nu^1) - \frac{\delta}{1 - \delta} \pi^{PD}(\alpha, f)\right) + \Pi^{PD}(f, \alpha).
$$
Therefore, \( \widehat{\Pi}^{PD}(b|f, \alpha) \leq \Pi^{PD}(f, \alpha) \) for all \( b \in [\underline{b}, \bar{b}] \) if and only if

\[
\delta \geq \delta^{PD}(\alpha, f) := \frac{v(1 - \nu)}{v(1 - \nu) + \pi^{PD}(\alpha, f)}. \tag{A.7}
\]

Combining (A.6) and (A.7) completes the proof.

**Proof of Corollary 2.** Both \( \tilde{\delta}^{PD}(\alpha, f) \) and \( \pi^{PD}(\alpha, f) \) are decreasing in \( f \), because \( \pi^{PD}(\alpha, f) = f \). Because \( f \leq \nu \nu^{1} \), they are minimal for \( f = \nu \nu^{1} \). Consequently, the critical discount factors simplify to

\[
\tilde{\delta}^{PD}(\alpha) = \tilde{\delta}^{PD}(\alpha, \nu \nu^{1}) = \frac{(1 - \alpha)(1 - \nu)}{1 - \alpha + (\alpha - \mu)\nu^{1}}, \quad \pi^{PD}(\alpha) = \pi^{PD}(\alpha, \nu \nu^{1}) = \frac{v(1 - \nu)}{v}. \]

From the proof of Lemma 3 (in particular (A.3)) we have \( \nu \nu^{1} = e(\alpha)(v - k'(e(\alpha))) \). Hence,

\[
\pi^{PD}(\alpha) = \frac{v - e(\alpha)(v - k'(e(\alpha)))}{v}.
\]

From Bayes’ rule, we have \( \nu^{1} = ((1 - \alpha)e(\alpha))/(1 - \alpha e(\alpha)) \), which further implies \( 1 - \nu^{1} = (1 - e(\alpha))/(1 - \alpha e(\alpha)) \). Replacing \( \nu^{1} \) and \( 1 - \nu^{1} \) in \( \tilde{\delta}^{PD}(\alpha) \) yields \( \tilde{\delta}^{PD}(\alpha) = 1/(1 + e(\alpha)) \).

**Proof of Proposition 4.** Because the expressions in Corollary 2 only depend on \( e(\alpha) \) the proof is straightforward.

**Proof of Proposition 5.** Let \( e \in (0, e^{*}) \). First notice that

\[
\delta^{FD}(e) = \frac{v}{v + e(v - k'(e))} = \frac{1}{1 + e - \frac{ek'(e)}{v}} > \frac{1}{1 + e} = \delta^{PD}(e),
\]

where the strict inequality uses \( k'(e) > 0 \) for \( e > 0 \). Next, notice that \( \delta^{FD}(e) = a/(a + b) \) and \( \delta^{FD}(e) = (a - b)/a \), where \( a = v \) and \( b = e(v - k'(e)) > 0 \) for all \( e \in (0, e^{*}) \). Trivially, \( a/(a + b) > (a - b)/a \) if and only if \( b^{2} > 0 \), hence \( \delta^{FD}(e) > \tilde{\delta}^{FD}(e) \) for all \( e \in (0, e^{*}) \).

We thus have shown that \( \delta^{FD}(e) > \tilde{\delta}^{FD}(e) = \max\{\delta^{FD}(e), \tilde{\delta}^{FD}(e)\} \) for all \( e \in (0, e^{*}) \).

**Proof of Proposition 6.** Define \( \tilde{\delta} := \delta^{PD}(e^{FD}) \). If \( \tilde{\delta}^{PD}(e^{FD}) \geq \tilde{\delta}^{PD}(e^{FD}) \) then \( \delta^{PD} = \delta^{PD}(e^{FD}) \) and by Proposition 4 for any \( \delta \geq \delta^{PD} \) the investment level \( e^{FD} \) can be implemented. The reverse condition \( \tilde{\delta}^{PD}(e^{FD}) < \tilde{\delta}^{PD}(e^{FD}) \) is equivalent to \( k'(e^{FD}) < e^{FD}(v - k'(e^{FD})) \). Because \( \delta^{PD}(e) \) decreases with \( e \) we then must have \( \arg\min_{e} \delta^{PD}(e) > e^{FD} \), which completes the proof.

**Proof of Lemma 5.** As in the main part of the paper, we can restrict attention to capture offers that entail the best certificate \( C^{\alpha} \) and, hence, talk simply of a bribe \( b \). The certifier’s profit from offering bribe \( b \) is

\[
\Pi(b|f) = \begin{cases} 
\frac{b + (1 - G(\kappa^{n - 1}))\delta_{\Pi}}{v}?, & \text{if } b < f, \\
\frac{bG(\kappa^{j}) + (1 - G(\kappa^{j}))\left[f + \delta \Pi\right]}{v}, & \text{if } f + v^{n} - v^{j+1} \leq b < f + v^{n} - v^{i}, \\
\frac{bG(\kappa^{0}) + (1 - G(\kappa^{0}))\left[f + \delta \Pi\right]}{v}, & \text{if } f + v^{n} - v^{1} \leq b < v^{n} - v^{0}, \\
\Pi, & \text{if } b \geq v^{n} - v^{0}.
\end{cases}
\]
Hence, \( \delta \) which is certainly true, because we have

\[
\frac{\Pi - v^n}{\Pi - v^0} \leq \Pi
\]

We have that \( \Pi(\delta) \leq \Pi \) if and only if

\[
d \geq \delta^i = \frac{(f + v^n - v^i)G(\kappa^i) - (G(\kappa^i) - G(\kappa))f}{(f + v^n - v^i)G(\kappa^i) - (G(\kappa^i) - G(\kappa))f + G(\kappa^i)\pi}.
\]

Similarly, \( \Pi(\delta) \leq \Pi \) if and only if

\[
d \geq \delta^0 = \frac{v^n - v^0}{v^n - v^0 + \pi}.
\]

Also, \( \Pi(\delta) \leq \Pi \) if and only if

\[
d \geq \delta^n = \frac{f - \pi}{f - \pi + G(\kappa^n)\pi}.
\]

Hence \( \delta^0 > \delta^i \) if and only if

\[
(v^n - v^0)G(\kappa^i)\pi > \left\{ (f + v^n - v^i)G(\kappa^i) - (G(\kappa^i) - G(\kappa))f \right\} \pi \\
\iff (v^n - v^0 - f)G(\kappa^i) > -(G(\kappa^i) - G(\kappa))f
\]

which is certainly true, because we have \( v^i - f \geq v^0 \), since any \( q \in [k^{i-1}, k^i] \) certifies. Also \( \delta^0 > \delta^n \) because

\[
\delta^0 > \delta^n \iff (v^n - v^0 - f)G(\kappa^n) > -(G(\kappa^n) - G(\kappa))f.
\]

Hence, \( \delta^0 > \max\{\delta^1, \ldots, \delta^n\} \) and a capture proof equilibrium exists if and only if \( \delta \geq \delta^0 \).

**Proof of Proposition 7.** If fee \( f \) induces \( e = 1 \) under the partitioning rule \( \{k^0, k^1, \ldots, k^n\} \), we have

\[
\sum_{i=1}^{n} (G(\kappa^i) - G(\kappa^{i-1}))(v^i - f) + G(\kappa^0)v^0 - c \geq 0. \tag{A.8}
\]

Using \( v^i = \int_{k^{i-1}}^{k^i} qg(q) \, dq / (G(\kappa^i) - G(\kappa^{i-1})) \) allows us to rewrite (A.8) as follows

\[
\sum_{i=1}^{n} (G(\kappa^i) - G(\kappa^{i-1}))(v^i - f) + G(\kappa^0)v^0 - c = \\
\sum_{i=1}^{n} \int_{k^{i-1}}^{k^i} qg(q) \, dq - (1 - G(\kappa^0))f + G(\kappa^0)v^0 - c = \\
(1 - G(\kappa^0)) \left[ \int_{k^0}^{k^1} qg(q) \, dq \frac{1}{1 - G(\kappa^0)} \right] + G(\kappa^0)v^0 - c.
\]

A partitioning rule \( \{k^0, 1\} \) offers only a single certificate which is awarded to any good whose quality exceeds \( k^0 \). The expected value of a certified product is \( v^C = \int_{k^0}^{1} qg(q) \, dq / (1 - G(\kappa^0)) \). Thus, under such a rule the producer also invests. The critical discount factor
for this rule is strictly lower, because the maximal bribe is now \( v^C - v^0 < v^n - v^0 \).

The certifier’s profit is left unchanged, because the same producer types certify. To see this, notice that we have \( v^1 - f \geq v^0 \) for the original partitioning rule, which implies \( v^C - f \geq v^0 \).

\[ \text{B Additional Proofs} \]

**Lemma B.1.** Let \( D \) be full disclosure. For any \( f \in (0, v) \) there exists a unique PBE of the stage game without capture that features strictly positive certifier profits.

**Proof.** Any PBE entails \( \nu(C^1) = 0 \), as well as \( \nu(C^2) = 1 \). Let \( v^\emptyset \) denote the price at which uncertified products sell in equilibrium. Clearly, low type producers do not certify, because \( 0 - f < v^\emptyset \). Let \( \gamma \in [0, 1] \) denote the probability that a high type producer certifies in equilibrium. We cannot have \( \gamma = 0 \), because then the producer chooses \( e = 0 \) and we must have \( v^\emptyset = 0 \). But \( \gamma = 0 \) also requires that \( 0 < v - f \leq v^\emptyset - a \) contradiction. If \( \gamma > 0 \), the producer maximizes

\[
e \cdot (\gamma(v - f) + (1 - \gamma)v^\emptyset) + (1 - e) \cdot v^\emptyset - k(e),
\]

at the investment stage. The first-order condition is \( k'(e) = \gamma(v - f - v^\emptyset) \). Because \( \gamma < 1 \) requires \( v - f = v^\emptyset \) the optimal investment is \( e = 0 \) – again a contradiction. Hence, we have \( \gamma = 1 \), and the optimal investment is uniquely determined by \( k'(e) = v - f \).

**Lemma B.2.** For any \( \alpha \in (0, 1) \) the equation

\[ k'(e) = v \frac{\alpha(1 - e)}{1 - \alpha e} \] (B.1)

has a unique solution \( e(\alpha) \in (0, 1) \) which strictly increases with \( \alpha \). Furthermore, \( e(0) = 0 \) and \( e(1) = e^* \), and the mapping is invertible.

**Proof.** Because \( k'(0) = 0 < \alpha v \) and \( k'(1) \geq v > 0 \) there exists a solution of (B.1) that satisfies \( 0 < e < 1 \). Furthermore, the derivative of the left-hand side is \( k''(e) > 0 \) by assumption. Taking the derivative of the right-hand side yields

\[
v \alpha \frac{-1 - \alpha + \alpha(1 - e)}{(1 - \alpha e)^2} = -v \frac{\alpha(1 - \alpha)}{(1 - \alpha e)^2} < 0.
\]

Hence, there exists a unique \( e(\alpha) \in (0, 1) \) that satisfies (B.1). Applying the implicit function theorem yields

\[
\frac{\partial e}{\partial \alpha} \cdot \left( k''(e) + v \frac{\alpha(1 - \alpha)}{(1 - \alpha e)^2} \right) = v \frac{1 - e}{(1 - \alpha e)^2}
\]

Because \( \alpha, e \in (0, 1) \) and \( k'' > 0 \), this yields \( \partial e/\partial \alpha > 0 \). We can extend the mapping \( \alpha \mapsto e(\alpha) \) by setting \( e(0) = 0 \), as well as \( e(1) = e^* \). The mapping \( \alpha \mapsto e(\alpha) \) thus maps \([0, 1]\) into \([0, e^*]\). Because it is smooth and strictly increasing, it is also invertible.
References


