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Honest Certification and the Threat of Capture

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Abstract

This paper derives conditions under which reputation enables certifiers to resist capture. These conditions alone have strong implications for the industrial organization of certification markets: 1) Honest certification requires high prices that may even exceed the static monopoly price. 2) Honest certification exhibits economies of scale and constitutes a natural monopoly. 3) Price competition tends to a monopolization. The results derive from a general principle of reputation models that favors concentration. This principle implies benefits from specialization and explains specialized certifiers as efficient market institutions that sell reputation as a service to other firms.

Keywords: certification, collusion, bribery, reputation, natural monopoly
JEL Classification No.: L15, D82, L11

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1 Introduction

Since the seminal article of Akerlof (1970) economists recognize that asymmetric information has important effects on the allocation and distribution of resources. This gives market participants incentives to undertake costly actions to signal their private information (e.g. Spence 1973), invest in reputation (e.g. Klein and Leffler 1981), or issue warranties. In addition, asymmetric information may lead to a demand for certifying intermediaries who try to reduce asymmetries by inspecting a party's private information and reveal findings publicly (e.g. Biglaiser 1993, Lizzeri 1999, Albano and Lizzeri 2001). Examples of certifiers are laboratories that test consumer products, auditors who validate the accounts of firms, ISO registrars who certify quality standards of production processes, internet search engines that rank Web sites, and schools that certify the ability of students.

Certifiers, however, may be tempted to accept bribes to certify product quality. This behavior called *capture*, enables the certifier to extract payments for favorable endorsements and may relieve him of the need to spend resources on determining product quality. This paper focuses on the role of certifiers when consumers are aware that such threats of capture exist. In particular, because consumers will learn if a certifier has been captured, the certifier faces a classic reputation dilemma in deciding whether the short term gain from capture is larger than the future profit losses from losing public trust.

Although commercial markets involving certification function relatively well, there exists evidence that problems of capture are a concern. The most prominent recent example is the Andersen-Enron accounting scandal, where Andersen, as Enron's accountant, falsely certified Enron's accounts as accurate. To name two other cases that will motivate our modelling of capture: In January 2002 the German government had to recall the meat of 26,000 cattle after it was uncovered that a certifying laboratory had performed 40,000 dodgy BSE-tests. In March 2002 Sony Pictures was fined $325,000 for certifying its own films by inventing fake reviews that it attributed to an actual newspaper.

Despite these examples, actual cases of capture are relatively rare. In general certifiers do seem to be able to resist pressures of capture. This paper investigates the role of reputation as a safeguard against capture. It thereby shows that these considerations alone have strong implications for the industrial organization of certification markets:

1. Honest certification requires high prices that may even exceed the static monopoly price.

2. Honest certification exhibits economies of scale.

3. Price competition tends to a monopolization of certification markets.

4. The threat of capture is responsible for a demand for *external* certification.

We discuss these results in turn. First, from the literature on reputation (e.g. Klein and Leffler 1981, Shapiro 1983), it is well known that reputation requires prices to exceed marginal costs. This holds for the current model in an extreme way: For low discount factors even the static monopoly price is too low to sustain a reputation for honesty. This result is new and, at first sight, counter intuitive. The monopoly price maximizes the certifier's gain from honesty and one may therefore expect that it also minimizes the overall threat of capture. Yet, since the price of certification also affects the potential gain from capture, the overall threat of capture is minimized at some higher price.[1]

To explain the other three results we start from the well–known observation that reputation models hinge on a trade–off between the short run gain from cheating and the long run gain for honesty. Hence, when the certifier expects a larger future demand, the long run gain rises and capture becomes less attractive. It follows that honesty is easier to sustain when the number of (future) certification jobs is high. This insight yields our second result that honest certification exhibits increasing returns to scale. From this reasoning it also follows that a certifier can perform honest certification at a lower

[1] The underlying mechanism leading to prices that exceed monopoly prices is therefore fundamentally different from that in models of signalling (e.g. Bagwell and Riordan 1991).

price, when he serves the entire future demand himself rather than sharing it with competitors. In a monopoly, therefore, a certifier may guarantee honest certification at a lower price than in an oligopoly. This leads to our third result that price competition tends to a monopolization of the certification market.

Effectively, honest certification is easier to sustain when certification is concentrated at one party. This general principle explains the existence of external, specialized certifiers: For low discount factors a reputation for honesty is only sustainable when there is one institution — an external certifier — who provides this reputation rather than many independent ones — the actual producers of goods. The insight constitutes our final result and solves the more fundamental, institutional question why producers demand external certification rather than build up their own reputation. Ultimately, we demonstrate gains from specialization in reputation building. This provides an economic justification for certifiers as an efficient market institution.

2 The Setup

It is instructive to start with a market setup in which in each period $\tau = 1, 2, \ldots, \infty$ a different, short–lived monopolistic producer enters with a single unit of some quality $q_\tau \in [0, 1]$. Quality is stochastic and drawn from a uniform distribution that is i.i.d. of the qualities in previous periods. The good's quality represents the reservation price of consumers. Only the producer observes the quality, i.e., the market exhibits informational asymmetries. Each producer is short–lived in that he leaves the market after offering his good in a second price auction.[2,3] Consumers observe the product's quality only after consumption. Production costs are zero. All variables other than the product quality q are observable.

Without any further economic institutions, a producer cannot persuade

[2] The second price auction results in a standard monopoly price while circumventing numerous complications associated with letting the informed party take a publicly–observed action that may be interpreted as a signal.

[3] Section 5 considers a setup in which producers are long–lived.

consumers of the quality of his good.[4] Since Akerlof (1970) it has become standard to compute the equilibrium outcome. Consumers have a belief q_τ^e about the offered quality which, in equilibrium, coincides with the actual expected quality $E\{q_\tau\}$. Hence, in the second price auction consumers bid the expected market quality $E\{q_\tau\}$ and the good is sold at a price $E\{q_\tau\}$. The argument leads to the following result.

Lemma 1 *Without certification the good is sold every period for a price* $q_\tau^e = E\{q_\tau\} = 1/2$.

Due to asymmetric information all producers are pooled and consumers are only willing to pay a uniform price reflecting the average quality in the market. The price is therefore independent of actual quality and producers with a high quality sell their goods at a relatively low, average price. These producers would gain if they could prove their quality through certification.[5]

To study the potential of certification, assume that an honest certifier offers producers the possibility to certify their quality at some price p. In particular, the certifier determines the good's quality perfectly at a personal cost $c \geq 0$ and announces it honestly. In this case, a certified good will be sold at a price reflecting its true quality. To a producer q_τ certification therefore yields the profit $\pi^c(q_\tau) \equiv q_\tau - p$.

Instead, if a producer q_τ decides to sell his good uncertified, he obtains some price q_τ^e, where q_τ^e represents the consumer's belief of the average quality of non–certified goods. Thus, a non–certified good yields a profit $\pi^n \equiv q_\tau^e$. Consequently, the producer certifies only if[6]

$$\pi^c(q_\tau) \geq \pi^n. \tag{1}$$

[4]We focus on certification as the only way to reduce informational asymmetries and abstract from all other remedies such as signalling and warranties.

[5]Hence, we focus on a distortion that is purely redistributive and not allocative. This enables us to address the positive questions of certification in a clear, tractable way. The final section discusses possible extensions that would enable a study of normative issues.

[6]We assume that an indifferent producer certifies. Due to the uniform distribution this assumption is inconsequential.

Since the difference in the producer's profit $\pi^c(q_\tau) - \pi^n$ is monotonically increasing in q_τ, the market with certification is a partition equilibrium. That is, at most one producer $\bar{q}_\tau$ is indifferent concerning certification. All producers $q_\tau > \bar{q}_\tau$ have a strict preference for certification, whereas all producers $q_\tau < \bar{q}_\tau$ do not certify.

For the indifferent producer $\bar{q}_\tau$ it holds $\pi^c(\bar{q}_\tau) = \pi^n$ and, hence, $\bar{q}_\tau(p) = q^e_\tau + p$. That is, all producers with a quality of at least $\bar{q}_\tau(p)$ certify and, given $\bar{q}_\tau(p) \in [0, 1]$, (expected) demand for certification is $1 - \bar{q}_\tau(p)$. Since exactly those producers with a quality below $\bar{q}_\tau(p)$ do not certify, the consumers' belief q^e_τ concerning the average quality of a non–certified product is, in equilibrium, $\bar{q}_\tau(p)/2$. It follows that the indifferent producer equals $\bar{q}_\tau(p) = 2p$. Demand for certification is therefore

$$D^h(p) = 1 - 2p.$$

The static monopoly price may be calculated from the certifier's profit $\Pi^h(p) = D^h(p)(p - c)$ as

$$p^m = (1 + 2c)/4 \text{ if } c \leq 1/2. \tag{2}$$

For $c > 1/2$, the certifier is unable to make a profit, as any price $p > c > 1/2$ yields no demand. Finally, the certifier obtains a maximum overall profit, if he charges p^m in every period. This yields a discounted profit of

$$\sum_{t=0}^{\infty} \delta^t D^c(p^m)(p^m - c) = \frac{(1 - 2c)^2}{8(1 - \delta)},$$

where $\delta < 1$ represents the discount factor.

3 Capture

Until now we assumed that the certifier reports his finding honestly. Yet, there exists a pressure from low quality producers to have their product certified at a higher level. Also, the certifier may simply announce some level of quality without expending resources to determine the actual quality. This section addresses these problems by introducing the possibility of capture.

To model the possibility of capture we use the framework of enforceable capture as initiated by Tirole (1986). This framework assumes that the certifier and producer can write an enforceable side-contract with transfers.[7] Consumers cannot observe these side–contracts, but are fully aware of their possibility. The framework allows us to introduce capture in a relatively straightforward way without given explicit considerations to its enforceability. Indeed, Martimort (1999) demonstrates the equivalence of a dynamic repeated framework with implicit enforceability to an enforceability approach with a linear transaction cost of side–contracting. We introduce such a transaction cost by a parameter $\lambda \leq 1$ with the interpretation that a bribe b from the producer is only worth λb to the certifier. The parameter λ offers a convenient way to parameterize the potential threat of capture. For instance, the Sony Picture case, where the producer also acted as certifier, illustrates the extreme case $\lambda = 1$.[8] In the Andersen-Enron case there were no direct monetary bribes. Instead, bribery was of a more inefficient, indirect nature so that $\lambda < 1$.[9]

The possibility of capture is introduced as follows: After a producer q_τ enters, the certifier, without observing q_τ, may make an offer (b, q^b) to the producer. The offer describes the terms at which the certifier is willing to become captured, where b represents the required financial transfer and q^b the offered level of certification. If the producer accepts, he pays the bribe b, which has a value λb to the certifier, and his product is certified at quality level q^b. If the producer rejects the offer, he may still ask for an honest certification at price p. That is, a producer may insist on honest certification simply by rejecting any capture offer (b, q^b) and, subsequently, paying the fee p. In this case, the certifier cannot manipulate the certification outcome.

[7] See also Laffont and Tirole (1991) and the survey in Tirole (1992) and Khalil and Lawarrée (1995).

[8] Hence, an explanation why Sony Pictures attributed its self–certifying efforts to an independent newspaper is that it tried to convince its consumers that λ was low. Interestingly, Sony Pictures was not fined for its self–certifying activities perse, but for its claim that this "certification" was done by an independent newspaper.

[9] Allegedly, Andersen obtained some lucrative complementary deals in exchange for its favorable certification services. A practise which the Sarbanes–Oxley Act of 2002 tries to prevent. We comment on this Act in the last section.

We motivate this assumption by following Kofman and Lawarrée (1993) and assume that the certifier is unable to forge certification without the help of the producer.

Within this framework the possibility of capture may upset honest certification for two reasons. First, producers with low qualities are willing to side–contract and capture the certifier to obtain a higher certification. Second, when captured the certifier saves the cost c. Hence, by allowing collusion before the certifier expends c and observes actual quality, we may analyze these two threats simultaneously.[10]

We investigate consumers who stop trusting a certifier once they detect a false testimony about a product's quality.[11] A certifier who anticipates this behavior may be prevented from issuing forged certification reports, because he knows that he will lose the trust and thereby the potential demand for certification in subsequent periods.

As shown in the previous section producers only certify in an honest equilibrium when their quality lies in the interval $[2p, 1]$. Hence, as soon as the certifier reports some quality outside this interval, it is evident to consumers that play diverged from the honest equilibrium. Consumers interpret such deviations as a sign that the certifier is dishonest and, subsequently, believe that the producer's quality is zero.[12]

To make the behavior of consumers more precise, let $h_\tau = (n^c_\tau, q^c_\tau, q_\tau)$ denote the certification outcome in period τ, where $n^c_\tau \in \{0,1\}$ indicates whether certification in period τ took place, q^c_τ represents the certifier's claimed quality, and q_τ the actual quality observed after consumption. If certification in period τ did not take place, it holds $n^c_\tau = 0$ and $q^c_\tau = 0$. Now

[10] The examples in the introduction show that both concerns are important. The Enron-Andersen and the Sony case illustrate situation in which the intent was a false certification. The German BSE testing scandal was mainly attributed to the laboratory's aim to cut costs even though producers were aware of the sloppy testing procedures.

[11] The demise of Anderson after the Enron scandal seems to confirm such behavior.

[12] These extreme out–of–equilibrium beliefs are not crucial. They motivate the underlying idea that a dishonest certifier receives zero profits after he has been exposed.

let $H_t = (h_1, \dots, h_{t-1})$ summarize the history of certification outcomes at the beginning of period t. Finally, let $q_t^e(q_t^c, n_t^c, H_t)$ represent the consumers' belief in period t, when the consumers are faced with a certified quality q_t^c and have observed the certification history H_t. The consumers' behavior may then be captured by the following assumption about beliefs.

Assumption 1 *For the consumers' belief* $q_t^e(q_t^c, n_t^c, H_t)$ *it holds* $q_t^e(q_t^c, 1, H_t) = q_t^c$ *whenever* $q_t^c \in [2p, 1]$ *and* $\{\tau < t | n_\tau^c = 1 \wedge q_\tau^c \neq q_\tau\} = \emptyset$*. Moreover,* $q_t^e(q_t^c, 1, H_t) = 0$ *whenever* $\{\tau < t | n_\tau^c = 1 \wedge q_\tau^c \neq q_\tau\} \neq \emptyset$ *or* $q_t^c \notin [2p, 1]$*.*

The assumption states that consumers believe the certifier if he announces a quality in the interval $[2p, 1]$ and has not cheated in previous periods. Whenever the certifier did cheat in some former period or announces some quality outside the interval, consumers do not trust the certifier's claim and believe that the quality is in fact zero. Assumption 1 therefore captures the intuitive idea that consumers trust the certifier if they have no reason to distrust him. Since in equilibrium beliefs are confirmed, this implies that such equilibria are *honest*, in the sense that capture takes place with probability zero.

In order to derive an equilibrium in which certification is honest, we proceed in two steps. First we analyze the potential threat of capture by studying the behavior of a producer when faced with a bribing offer (b, q^b). In a second step, we derive conditions under which the certifier will not make any offer (b, q^b) that is acceptable to some producer $q \in [0, 1]$. This would imply that capture occurs with probability zero so that Assumption 1 is consistent with the behavior of the certifier. Note that since the consumers trust a certification level of at most 1, a bribing offer with $q^b = 1$ poses the largest threat of capture. Hence, in the following we focus on such offers and talk of a bribing offer b rather than $(b, 1)$.

Suppose the certifier makes an offer b to some producer q_τ. If the producer accepts the offer, he receives a net profit $1 - b$. His profit from rejecting the offer depends on his quality q_τ and the price of certification p. If the producer's quality exceeds $2p$, he would, according to the previous section,

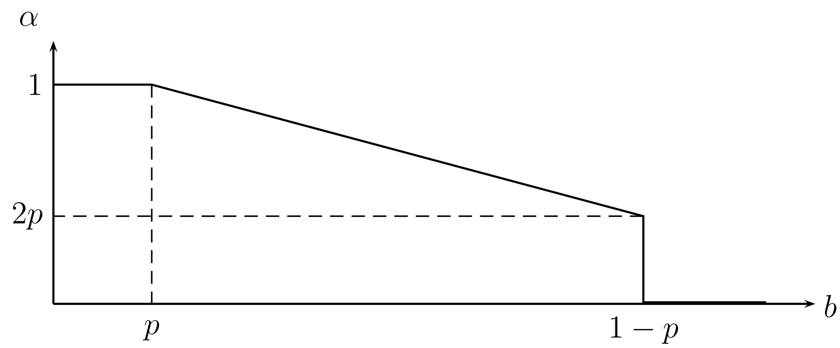

Figure 1: Acceptance probability $\alpha(b|p)$ in an honest equilibrium

certify and receive a profit $q_\tau - p$. Consequently, in an honest equilibrium a producer $q_\tau \geq 2p$ rejects the offer only if $1 - b \leq q_\tau - p$. On the other hand, a producer with quality $q_\tau < 2p$ does not certify in an honest equilibrium and receives a profit p. Hence, he rejects the offer if $1 - b \leq p$. Since a producer's quality is uniformly distributed over $[0, 1]$, it follows that, in an honest equilibrium, the expected acceptance probability of a capture offer b is

$$\alpha(b|p) = \begin{cases} 1 & \text{if } b < p \\ 1 + p - b & \text{if } b \in [p, 1-p) \\ 0 & \text{if } b \geq 1 - p. \end{cases}$$

Figure 1 illustrates the acceptance probability graphically. Using this probability one may calculate the certifier's expected payoff $V(b|p)$ from an offer b. For $b < p$ all producers accept the offer and the certifier obtains a profit $V(b|p) = \lambda b$. For $b \in [p, 1-p]$ only producers $q_\tau < 1 + p - b$ accept, while producers $q_\tau \geq 1 + p - b$ reject and apply for honest certification. Hence, the certifier's profit is $V(b|p) = (1+p-b)\lambda b + (b-p)(p-c+\delta V^h(p))$. Whenever $b \geq 1 - p$ all producers reject and the certifier obtains $V(b|p) = V^h(p) = (1-2p)(p-c)/(1-\delta)$.

The payoff $V(b|p)$ represents the certifier's expected payoff from the offer b. If it exceeds the certifier's payoff from honest certification, $V^h(p)$, the certifier is better off becoming captured with the associated probability $\alpha(b|p)$. Consequently, we may interpret $V(b|p)$ as the *threat* of the offer b to honest certification. We say that certification at a price p is *capture proof* if and only if

$$V^h(p) \geq V(b|p) \tag{3}$$

for all b. That is, Assumption 1 is consistent with equilibrium play only when Condition (3) holds. Hence, only in this case we obtain an equilibrium in which reputation prevents capture. An analysis of Condition (3) yields the following result:

Proposition 1 *An equilibrium satisfying Assumption 1 is capture proof. It exists if and only if*

$$\delta \geq \delta^c(p) \equiv \frac{\lambda(1-p)}{\lambda(1-p)+(1-2p)(p-c)}.$$

The proposition shows that the discount factor plays a crucial role for the existence of honest, i.e., capture proof, equilibria. As is well–known from the literature on repeated games, it determines the relative weights of the short run gain — the bribe b — and the long run loss of capture — relinquishing future orders for certification. Since the price of certification p determines the certifier's profit from future orders, the critical discount factor, $\delta^c(p)$, itself depends on the price p. Figure 2 plots the typical shape of the curve $\delta^c(p)$. The shaded area illustrates the combinations of (p, δ) for which capture proofness is sustainable. As formally proved in the appendix the curve $\delta^c(p)$ is convex and obtains a minimum. These properties of $\delta^c(p)$ yield the following insight.

Proposition 2 *For any discount factor $\delta \geq \delta^*$ there exists an interval of prices $[p_l(\delta), p_h(\delta)]$ which sustain truthful certification, where*

$$\delta^* \equiv \frac{\lambda}{3-2\sqrt{2-2c}-2c+\lambda}$$

and

$$p_l(\delta) \equiv \min_p\{p|\delta^c(p)=\delta\} \text{ and } p_h(\delta) \equiv \max_p\{p|\delta^c(p)=\delta\}.$$

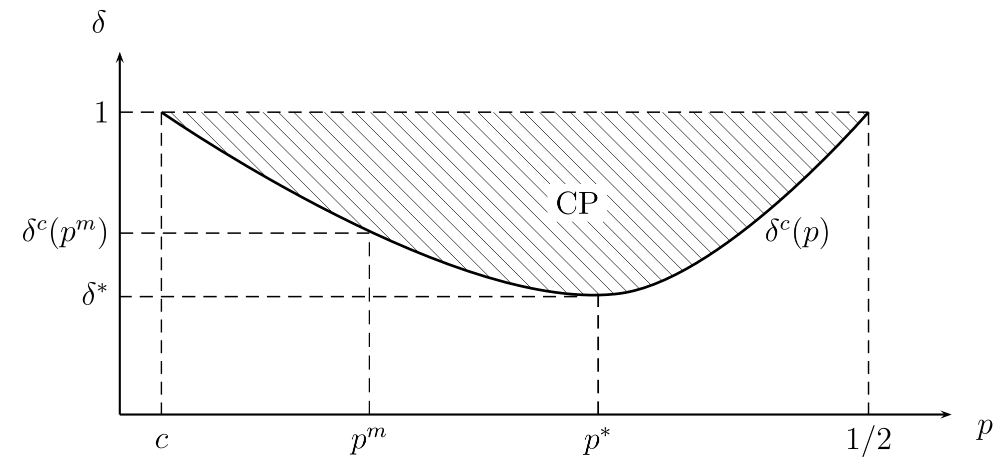

Figure 2: Capture proof (CP) combinations of (p, δ).

Hence, for a given discount factor $\delta > \delta^*$ there exist multiple prices that sustain truthful certification. The most preferable price from the perspective of the certifier is the monopoly price p^m as, under honest certification, this price yields the certifier the highest payoff. Yet, as Figure 2 indicates, at relatively low discount factors honest certification may require a price that exceeds the monopoly price p^m.

Proposition 3 *It holds $\delta^* < \delta^c(p^m)$. I.e., for all $\delta \in [\delta^*, \delta^c(p^m))$ only prices that exceed the static monopoly price p^m sustain honest certification.*

At first sight the result is counter intuitive. The static monopoly price yields the certifier the highest per period payoff and, thereby, maximizes the long run penalty from becoming captured, i.e., losing future monopoly profits. This suggests that a monopoly price minimizes the overall threat of capture. Yet, the argument neglects that also the short run gain from capture depends on the price p. Indeed, at the monopoly price p^m there is no first order effect of a price change on the certifier's profit. Hence, the question whether the critical discount factor δ^c increases or decreases at p^m depends only on the effect of a price change on the short run gain. Figure

1 reveals that a raise in p has an ambiguous effect. On the one hand, a higher p reduces the maximum bribe $b = 1-p$ that non–certifying producers are willing to pay. On the other hand, a higher p raises the minimum bribe $b = p$ at which all producers accept. The following lemma shows that the maximum threat of capture comes from an offer $b = 1-p$ so that the relevant effect is the former one.

Lemma 2 *In a capture proof equilibrium the threat of capture, $V^c(b|p)$, is maximized for $b = 1 - p$. At the monopoly price p^m the maximum threat of capture, $V^c(1 - p|p)$, is decreasing in p.*

From Lemma 2 it follows that a marginal increase from the monopoly price p^m reduces the overall threat of capture and therefore allows a reduction of the critical discount factor. Consequently, $\delta^c(p)$ is decreasing at p^m and obtains its minimum δ^* at a price that exceeds p^m. This explains that the principle underlying the result of Proposition 3 differs from that found in the literature on signalling (e.g. Bagwell and Riordan 1991), where a credible signalling of high quality may require prices exceeding the monopoly price.

Until now we investigated the existence of capture proof equilibria for some exogenously given price of certification p. In the remainder of this section we look at the optimal pricing behavior of a monopolistic certifier.[13] In this case, the price of certification becomes an explicit strategic variable and consumers may interpret it as a signal about the certifier's honesty. We must therefore extend $q^e_t(q^c_t, n^c_t, H_t)$ to include p and write $q^e_t(q^c_t, n^c_t, H_t, p)$. Since out–of–equilibrium beliefs regarding the price of certification are, in principle, arbitrary, a multiplicity of equilibria obtains. For instance, it is easy to sustain any price $\bar{p} \in [p_l(\delta), p_h(\delta)]$ as an equilibrium price by specifying that consumers interpret all other prices as set by a dishonest certifier. Such out–of–equilibrium beliefs prevent the monopolist from charging any other price than $\bar{p}$. To avoid such arbitrariness, we extend the intuitive principle underlying Assumption 1 that consumers trust a certifier if they have no compelling reason to distrust him. Effectively, consumers therefore separate

[13]Formally, we extend the game by an initial stage, where the certifiers chooses the price p. The equilibrium in Proposition 1 is then an equilibrium of the subgame given a price p.

prices in two categories; prices that can sustain honest certification and prices which cannot:

Assumption 2 *For the consumers' beliefs it holds* $q_t^e(q_t^c, 1, H_t, p) = q_t^c$ *whenever* $\delta(p) \leq \delta$, $q_t^c \in [2p, 1]$, *and* $\{\tau < t | n_\tau^c = 1 \wedge q_\tau^c \neq q_\tau\} = \emptyset$. *Moreover, for* $\delta(p) \leq \delta$ *it holds* $q_t^e(q_t^c, 1, H_t, p) = 0$ *whenever* $\{\tau < t | n_\tau^c = 1 \wedge q_\tau^c \neq q_\tau\} \neq \emptyset$ *or* $q_t^c \notin [2p, 1]$.

Beliefs that satisfy Assumption 2 imply the following equilibrium outcome:

Proposition 4 *In any equilibrium satisfying Assumption 2 certification takes place if and only if* $\delta \geq \delta^*$. *In any such equilibrium the monopolistic certifier sets* $\hat{p}^m = \max\{p^m, p_l(\delta)\}$. *Whenever* $\delta < \delta^*$ *honest certification is not sustainable and the monopolist's profit is zero.*

The proposition shows that the monopolist's pricing behavior depends on the discount factor. First, for large discount factors the static monopoly price is able to sustain honest certification and, since this price gives the highest per period payoff, the monopolist has no incentive to deviate from it. In this case, the certifier charges higher prices than needed to sustain honest certification. Second, when the discount factor is small, consumers anticipate that even high prices of certification cannot prevent the certifier from becoming captured. Consequently, they will not trust the certifier and the monopolist is unable to derive a profit from certification. Third, for intermediate values of the discount factor, the static monopoly price is unable to sustain honest certification. As consumers recognize this, the monopolist is forced to charge a price that exceeds the static monopoly price.

4 Price Competition

The previous section showed that for relatively high discount rates, a monopolistic certifier charges prices that are higher than the minimum price at which honest certification is sustainable. This raises the question whether price competition from competing certifiers may lead to lower prices. Moreover, the sustainability of honest certification depends crucially on the possibility of maintaining prices that exceed costs. Since price competition tends to lower prices, it may undermine the viability of certification markets.

To address these questions we first extend the monopolistic model to allow for price competition. Suppose there exist $N > 1$ certifiers who each, at the beginning of the game, commit to a price of certification p_j.[14] All certifiers face the same discount factor δ. They are equally efficient, i.e., may all certify a product at costs c. After setting prices producers enter and exit sequentially. We assume that the producer's choice whether and where to certify is observable by consumers and subsequent producers. We assume further that each producer uses at most one certifier.

Consequently, let $n^c_\tau \in \{0, \ldots, N\}$ in the consumers' information set H_t denote the certifier who performed the certification in period τ. Whenever certification did not take place, it holds $n^c_\tau = 0$ and $q^c_\tau = 0$. The consumers' beliefs in period t may be written as $q^e(q^c_t, n^c_t, H_t, p)$, where $p = (p_1, \ldots, p_N)$ is the vector of prices set by the certifiers.

Before analyzing the market game with price competition between certifiers, we first establish a preliminary result concerning the relation between market structure and the price of certification p.

Lemma 3 *Suppose $\delta \geq \delta^*$. At a price $p_l(\delta)$ honest certification is sustainable only if the entire demand for certification is satisfied by a unique certifier.*

Effectively, the proposition shows that the lowest price at which honest certification is sustainable is only attainable in a monopoly. The reason for this is straightforward. Honest certification depends on the threat that a certifier loses enough future payoffs. Yet, if multiple certifiers are active, the expected number of future certification jobs for a single certifier is smaller, as total demand is shared with others. In order to compensate for the reduced number of jobs the benefits of a single job, i.e., its price, must be larger to prevent capture.

This intuition indicates that, even though certification itself is a technology with constant returns to scale, *honest* certification exhibits increasing

[14] As we will discuss in Section 6 commitment is not a crucial assumption.

returns to scale. If future demand for certification is higher, then honest certification can be achieved at lower prices, i.e., from the perspective of producers, at lower costs. Note that we obtained this feature endogenously, implying that the increasing return to scale has an economic rather than a technological origin. As the remainder of this section verifies, this reasoning also suggests that certification markets display characteristics of a natural monopoly and possess a tendency towards monopolization.

Since consumers now observe multiple prices, we have to extend our assumption on out–of–equilibrium beliefs. Continuing the idea that consumers trust certifiers if they have no reason to distrust them, we adapt Assumption 2 as follows:

Assumption 3 *If* $p_k \in \min\{p_j|\delta(p_j) < \delta\}$, $q_t^c \in [2p_k, 1]$ *and* $\{\tau < t|n_\tau^c = k \wedge q_\tau^c \neq q_\tau\} = \emptyset$, *then* $q_t^e(q_t^c, k, H_t, p) = q_t^c$. *Moreover, if* $n_t^c > 0$ *then* $q_t^e(q_t^c, n_t^c, H_t, p) = 0$ *whenever* $\{\tau < t|n_\tau^c = n_t^c \wedge q_\tau^c \neq q_\tau\} \neq \emptyset$ *or* $q_t^c \notin [2p_{n_t^c}, 1]$.

The assumption states that consumers trust certifiers who charge the lowest price such that $\delta(p_j) < \delta$. It is therefore weaker than a straightforward extension of Assumption 2 to all certifiers. The following proposition shows that the assumption implies the following equilibrium outcome.

Proposition 5 *An equilibrium in which Assumption 3 is satisfied exists. In any such equilibrium certification is performed honestly by a unique certifier at price* $p_l(\delta)$.

The proposition shows that price competition leads to a monopolization of the market. The driving mechanism leading to the result is Lemma 3. Assumption 3 thereby only ensures that price competition "works" in that it drives down prices. As in a classic Bertrand competition model, certifiers have an incentive to undercut any price $p > p_l(\delta)$. Yet, a certifier cannot effectively undercut the price $p_l(\delta)$, because consumers anticipate that at such prices, the certifier will not stay honest. Hence, the only remaining candidate is the price $p_l(\delta)$, but according to Lemma 3 honest certification at this price is only sustainable if a unique certifier performs all certification. Consequently, effective price competition yields a monopolization of certification markets. Interestingly, this result is consistent with the empirical observation that certification markets tend to be highly concentrated.

5 Long Lived Producers

Until now we assumed that the certifiers are long–lived, whereas producers were short–lived. Producers therefore could not build a reputation themselves and this asymmetry created a demand for external certification. The results in the previous sections, however, indicate that a demand for external certification may exist even when producers are long–lived. Indeed, this section confirms the idea that by accumulating the certification jobs of different producers it is easier for an external certifier to maintain a credible reputation for honesty than for each producer individually.

Let there be m long–lived producers. Producers produce sequentially, in that a producer $a \in \{1, \ldots, m\}$ produces a single good in periods $a, m + a, 2m + a, \ldots$.[15] The quality of a producer differs over the periods and is drawn i.i.d. from the uniform distribution over $[0, 1]$.[16] As before, the producer observes the quality directly, whereas consumers only observe it after consumption. The good is sold in a second price auction and the discount factor is δ.

Playing a repeated game himself, a producer may try to build his own reputation by announcing his current quality before selling it to the market. In line with our previous belief restrictions, let consumers believe the producer's announcement if they have no reason to mistrust him. That is, they believe the producer if he has not cheated in previous periods. Otherwise, they believe that the quality is zero. These beliefs are only confirmed in

[15] The sequential structure is not crucial, but allows us to apply our previous results directly to this extension.

[16] Clearly, if the quality of a producer is drawn only once and remains fixed over the periods, reputation is not sustainable in equilibrium. A producer with a quality close to zero always has an incentive to mimic higher ones.

equilibrium if the producer's announcement is indeed truthful. Hence, a necessary condition for the existence of such an equilibrium is that no producer has an incentive to cheat and claim a false quality. Clearly, a producer with a current quality of zero has the strongest incentive to cheat and announce a quality of 1 in order to receive a current profit of 1. Instead, when the producer remains honest, he receives an expected payoff of

$$0 + \sum_{t=1}^{\infty} (\delta^m)^t \, 1/2 = \frac{\delta^m}{2 - 2\delta^m},$$

as his expected quality in each future period is 1/2. Hence, producers are able to build up their own reputation only if

$$\delta \geq \delta^e \equiv \left(\frac{2}{3}\right)^{1/m}.$$

Now consider that as an alternative to building his own reputation a producer may turn to an external certifier. Clearly, whenever $\delta \geq \delta^e$, it will not be profitable to do so, because external certification requires an additional cost p without providing an additional service. However, an external certifier, who accumulates the certification jobs from multiple producers, may sustain honest certification at lower discount factors than a single producer. This insight yields the following result:

Proposition 6 *There exists a demand for external certification for discount factors $\delta \in [\delta^*, \delta^e]$, whenever*

$$\frac{\lambda}{3 - 2\sqrt{2 - 2c} - 2c + \lambda} < \left(\frac{2}{3}\right)^{1/m}. \tag{4}$$

The proposition shows that there is a potential demand for external certification if the number of producers, m, is large and the parameters λ and c are small enough. It is instructive to discuss the role of these parameters in turn.

First, a demand for external certification obtains when m is large. This observation demonstrates the accumulation effect of external certification. If an individual producer tries to build up his own reputation, he has to ensure that his long run gain from staying honest outweighs the short run gain from cheating. Even though the external certifier is in a similar position, his ability to accumulate certification jobs implies that the certifier's long run gain from honesty is higher than that of an individual producer. The more producers, the larger this difference. In contrast, the short run gain from cheating is independent of the number of producers. This is because a certifier may collect at most the short run gain of an individual producer rather than all producers together. Hence, the crucial observation is that an external certifier accumulates only the long run gains from staying honest, but not the short run ones from cheating. Hence, Proposition 6 identifies endogenous benefits from specialization. It is easier for a single institution — the external certifier — to provide a reputation than for many individual ones — the producers.

Second, a demand for certification is established for λ small enough. This emphasizes a second beneficial effect from external certification. Since λ represent a direct, inverted cost of capture, a lower λ makes it more costly for a producer to capture the certifier. Consequently, a smaller λ makes honest certification easier to achieve. In contrast, cheating on one's own reputation does not involve a cost and hence a potential for external supervision exists if λ is low.

Finally, inequality (4) requires that the certifier's identification costs c are small. Indeed, when c rises, the certifier's long run gain from staying honest decreases. Since a producer observes his quality without incurring any costs, it is intuitive that a demand for external certification exists only if c is small enough.

6 Conclusion and Discussion

This paper derives conditions under which reputation is an effective mechanism for external certifiers to resist capture and to maintain their honesty. The need for reputation induces a demand for external certification, because a credible reputation is easier to establish when it is concentrated. In addition, for low discount rates honest certification requires high prices that exceed the static monopoly price. It moreover exhibits features of a natural monopoly and represents a technology with increasing returns to scale.

The introduction motivates the study of capture with actual cases where capture did occur. In contrast, in the equilibria of the current paper such events only occur out–of–equilibrium. This raises the question whether the paper's framework may also explain capture as an equilibrium event. Following the logic of the folk theorem, this is clearly the case. For instance, one may construct equilibria in which the certifier colludes every second period. However, since these equilibria presume that consumers rationally anticipate capture, they do not provide a convincing explanation for cases such as the Enron–Anderson scandal, where there was a large public outcry. On the contrary, public behavior was much more in accordance with the paper's trigger strategies that described the consumer's extreme behavior off–the–equilibrium–path; after Anderson was exposed, it lost all public credibility and the firm went bankrupt. In fact, despite its obvious threat to certification, the number of documented cases of capture are relatively small in practise. More often there are only *indications* of capture. Following Rotemberg and Saloner (1986) indications of capture rather than actual capture may be generated as an equilibrium phenomenon in the current framework. In particular, when the detection technology of the consumers is imperfect, one may generate indications of capture and subsequent punishments as an equilibrium outcome similar to the equilibrium price wars in Rotemberg and Saloner (1986).

In order to analyze the problem we made a set of simplifying assumptions. First, we assumed a perfect detection technology of the certifier and also the consumer. This allows a straightforward application of the standard theory of repeated games. If either the certifier's or the consumers' detection mechanism is imperfect, consumers cannot determine the certifier's honesty with certainty. In this case one has to resort to the more complicated theory of repeated games with imperfect public information (e.g. Fudenberg, Levine and Maskin 1994). Second, we assumed that at the beginning of the game certifiers commit for once and for all to a price of certification p. This assumption is not crucial; one may also assume that prices are chosen each period. For the monopoly case one may even dispense with the assumption that consumers observe prices. In the setting with competition, the observability of the price p is important. However, the assumption that consumers observe all other variables such as the discount rate or the certifier's cost is not crucial. Indeed, qualitative results remain unchanged, as long as there exists a range of prices $[p_l, p_h]$ for which honest certification is sustainable *for any* realization of these variables. In this case, consumers can, without knowing the exact realization, be sure that a price $p \in [p_l, p_h]$ induces a certifier to stay honest. Again, the lowest price p_l will only be sustainable in monopoly. Third, because this paper focuses on the problem of capture rather than one–sided opportunistic behavior, we did not allow the certifier to forge a certification outcome by himself even though he may save the cost c this way. For $\lambda = 1$ this possibility does not affect the outcome, because taking the payment p and certifying at some false quality q yields the certifier less than a bribing offer $(p, 1)$. Finally, the paper uses a specific extensive form to model capture. Other, more sophisticated extensive forms may be studied. For instance, instead of asking a uniform bribe b, the certifier may elicit the producer's private information through a general mechanism. Also, producers may be given the possibility to signal their private information, or given a second chance of bribing after the certifier learns the true quality. Although the exact extensive form may affect parts of the analysis, the main findings of an advantage of concentration and the need for super monopoly pricing are due to general principles which do not depend on the specific extensive form.

In our setup certification addresses distributive distortions rather than allocative ones. Hence, certification has no positive effect on social welfare and the framework cannot be used to study normative questions. The advantage of this setup is that it illustrates the main issues in a transparent way. The intuition behind our results is nevertheless general and robust if we extend the framework to address allocative distortions. A straightforward extension is to introduce moral hazard on part of the producers and assume that producers actively choose their quality level. This extension would give certification a welfare enhancing effect, because it induces producers to choose higher, more socially efficient qualities.

Finally, we want to close this paper with a remark concerning the Sarbanes–Oxley Act of 2002 which demands a separation of accounting and consulting services in the US. The Act was introduced after the Enron–Andersen scandal and the separation is meant to reduce the threat of capture in accounting. However, if honest certification is based on the reputation arguments of this paper, the separation may actually exacerbate the threat of capture. The Act reduces the amount of future rents to honest certification and, hence, it pays the certifier less to remain honest. In popular debate this effect of the Act does not seem to have been recognized.

Appendix

Proof of Proposition 1: In any equilibrium in which Assumption 1 holds capture may not take place, since otherwise the beliefs of consumers are not consistent with the behavior of the certifier. Hence, condition (3) must be satisfied for all b. This is the case if and only if for all $b \in [p, 1-p]$ it holds

$$(1+p-b)\lambda b + (b-p)(p-c+\delta V^h(p)) \leq V^h(p), \tag{5}$$

where $V^h(p) = (1-2p)(p-c)/(1-\delta)$. Solving (5) with respect to δ yields

$$\delta \geq \tilde{\delta}(b) \equiv \frac{b\lambda(1-b+p) - (1-b-p)(p-c)}{2p(p-c)(b-p) + b\lambda((1-p)-b+2p)}.$$

Consequently, capture does not take place if and only if $\delta \geq \delta(b)$ for all $b \in [p, 1-p]$, i.e. if $\delta \geq \max_{b \in [p,1-p]} \delta(b)$. It holds

$$\delta'(b) = \frac{(p-c)(1-2p)((1-b+p)^2\lambda + 2p(p-c))}{[b\lambda(1+p-b) + 2(b-p)(p-c)p]^2} > 0.$$

Hence, $\delta(b)$ is increasing in b and obtains its maximum

$$\tilde{\delta}(1-p) \equiv \frac{\lambda(1-p)}{\lambda(1-p) + (1-2p)(p-c)}$$

at the corner solution $b = 1-p$. It follows that if an equilibrium exists which satisfies Assumption 1, it must hold

$$\delta > \delta^c(p) \equiv \tilde{\delta}(1-p).$$

Q.E.D.

Proof of Proposition 2: We first demonstrate convexity of $\delta^c(p)$. The second derivative of $\delta^c(p)$ computes as

$$\frac{\partial^2 \delta(p)}{\partial p^2} = \frac{2\lambda(1 + 2c^2 - 6p + 12p^2 - 4p^3 + c(1-6p) + \lambda(1-c))}{[(p-c)(1-2p) + \lambda(1-p)]^3} \tag{6}$$

The denominator is positive, hence the sign of (6) depends on the numerator. Since $\lambda \geq 0$ and $c < 1$, the numerator is positive if $1 + 2c^2 - 6p + 12p^2 - 4p^3 + c(1-6p)$ is positive. The expression is quadratic in c and obtains a minimum at $c = (6p-1)/4$ of $(1-2p)^2(7-8p)/8$ which is positive for $p \leq 1/2$. Consequently, also the numerator in (6) is positive and the second derivative of $\delta^c(p)$ is positive, which implies convexity.

From the convexity of $\delta^c(p)$ it follows that first order conditions are sufficient for a minimum. Taking first order conditions yields

$$\delta^* \equiv \frac{\lambda}{3 - 2\sqrt{2-2c} - 2c + \lambda}$$

and obtains for $p^* = 1 - \sqrt{(1-c)/2}$. Due to $c \leq 1/2$, it follows that $p^* \in (p^m, 1)$. From the continuity of $\delta^c(p)$, $\delta^c(c) = \delta^c(1/2) = 1$ and the existence of a minimum δ^* on $[0,1]$ it follows that for any $\delta \in (\delta^*, 1]$ that there exist a price such that $\delta^c(p) = \delta$. Due to the convexity of $\delta^c(p)$ it holds for any price $p \in [p_l(\delta), p_h(\delta)$ that $\delta > \delta(p)$. From Proposition 1 it follows then that truthful certification for price p is sustainable. Q.E.D.

Proof of Proposition 3: The proof of Proposition 2 shows $\delta^c(p)$ obtains a minimum at $p^* = 1 - \sqrt{(1-c)/2}$. Due to $c \leq 1/2$, it holds $p^* > p^m$. Q.E.D.

Proof of Lemma 2: For $b \in [p, 1-p]$ a bribe is accepted with positive probability and yields the principal $V^c(b|p) = (1-b+p)b\lambda + (p-b)(p-c)(1-2\delta p)/(1-\delta)$. The derivative w.r.t. b is

$$(1 + p - 2b)\lambda - (p-c)(1-2\delta p)/(1-\delta) \tag{7}$$

which is linearly decreasing in b and therefore greater than

$$(1+p-2(1-p))\lambda-(p-c)(1-2\delta p)/(1-\delta). \tag{8}$$

The derivative of (8) w.r.t. δ is $(p-c)(1-2p)/(1-\delta)^2>0$ and, therefore, (8) is increasing in δ. Since capture proofness implies that $\delta>\delta^c(p)$ it implies that (8) is greater than $(p-c)(1-2p)/(1-\delta)^2$, which is greater than zero. It follows that the derivative $V^c(b|p)$ w.r.t. b itself is larger than zero and attains its maximum at $b=1-p$. That is,

$$V^{max}(p)\equiv V^c(1-p|p)=\frac{(p-c)(1-2p)(1-2\delta p)+(2(1-p)p\lambda)(1-\delta)}{1-\delta}.$$

It holds

$$\frac{\partial V^{max}}{\partial p}\,|_{p=p^m}=\frac{(1-2c)(4\lambda(1-\delta)-\delta(1-2c)}{4(1-\delta)}. \tag{9}$$

Expression (9) is decreasing in δ, because the derivative of (9) with respect to δ is $-(1-2c)^2/(4(1-\delta)^2)<0$. Since it holds $\delta\geq\delta^c(p^m)$ it follows that (9) is less than $-(1+2c)\lambda/2$ and therefore negative. Q.E.D.

Proof of Proposition 4: In any equilibrium that satisfies Assumption 2 capture occurs with zero probability, since otherwise any belief that satisfies Assumption 2 is not consistent with the behavior of the certifier. Hence, if certification is to take place, Proposition 1 implies that for any equilibrium price $\hat{p}^m$ it holds that $\delta\geq\delta^c(\hat{p}^m)$. As $\delta^c(\hat{p}^m)\geq\delta^*$ it follows $\delta\geq\delta^*$. Moreover, for $\hat{p}^m$ to be an equilibrium price, it must be optimal for the certifier. Consequently, Assumption 2 is consistent only with an equilibrium price that solves

$$\max_{\{p|\delta(p)\leq\delta\}} V^h(p)$$

which implies $\hat{p}^m=\max\{p^m,p_l(\delta)\}$. To show existence of such an equilibrium take the out–of–equilibrium beliefs $q_t^e(q_t^c,n_t^c,H_t,p)=0$ for $\delta(p)>\delta$ and $n_t^c>0$ and $q_t^e(q_t^c,0,H_t,p)=\hat{p}^m$. These beliefs ensure that any price p' with $\delta(p')>\delta$ yields the certifier zero profit, such that $\hat{p}^m$ is indeed optimal. Q.E.D.

Proof of Lemma 3: For a price $p_l(\delta)$ it holds per definition that $V^h(p_l(\delta))=\max_b V(b|p_l(\delta))$, where $V^h(p_l(\delta))=\sum_{t=1}\delta^t D^h(p_l(\delta))(p_l(\delta)-c)$. Hence, $V^h(p_l(\delta))$

is the payoff of a certifier who sets the price $p_l(\delta)$ and receives the demand from any producer $q \geq 2p_l(\delta)$ If some of this demand is served by some other certifier, the payoff from honest certification is strictly less than $V^h(p_l(\delta))$ such that condition (3) is violated. Q.E.D.

Proof of Proposition 5: Let $(p_1^*, \ldots, p_N^*)$ represent a vector of equilibrium prices. Define $\bar{p} = \min\{p_i^* | \delta(p_i^*) \leq \delta\}$. In any equilibrium $\bar{p}$ exists, because otherwise all certifiers make zero profit and any certifier is better off setting a price $p_l(\delta) + \varepsilon$ which yields a strictly positive profit. Suppose $\bar{p} > p_l(\delta)$, then there exists at least one certifier who does not receive the entire demand for certification. This certifier is better off when he undercuts the price $\bar{p}$ by some $\varepsilon > 0$. In this case, he is the certifier that offers the lowest price greater than δ such that assumption 3 implies that consumers will trust him. Hence, all producers have a strict incentive to perform their certification at this certifier rather than a different one. Consequently, whenever $\bar{p} > p_l(\delta)$, there exists a certifier who has an incentive to deviate. Thus, in any equilibrium that satisfies Assumption 3 it must hold $\bar{p} = p_l(\delta)$.

To show existence, define the following beliefs $q_t^e(q_t^c, 0, H_t, p) = p_l(\delta)$ and $q_t^e(q_t^c, 1, H_t, p) = q_t^c$ whenever $q_t^c \in [2p_i, 1]$, $\{\tau < t | n_\tau^c = i \wedge q_\tau^c \neq q_\tau\} = \emptyset$ and $p_i > p_l(\delta)$. Moreover, $q_t^e(q_t^c, 1, H_t, p) = q_t^c$ whenever $q_t^c \in [2p_1, 1]$, $\{\tau < t | n_\tau^c = 1 \wedge q_\tau^c \neq q_\tau\} = \emptyset$ and $p_1 = p_l(\delta)$. Otherwise, $q_t^e(q_t^c, i, H_t, p) = 0$. These beliefs satisfy Assumption 3. Let $p_1 = \ldots = p_N = p_l(\delta)$ and let a producer $q_\tau \in [2p_l(\delta), 1]$ certify at certifier 1 and let all producers $q_\tau \in [0, 2p_l(\delta))$ offer their goods uncertified. It is straightforward to show that these beliefs and strategies constitute an equilibrium with the outcome that all producers with $q \in [2p_1, 1]$ certify at certifier 1, who certifies honestly at a price $p_l(\delta)$. Q.E.D.

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