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Imperfect competition in certi…cation markets

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August 1999

Abstract

This paper o¤ers a theoretical analysis of imperfect competition in certi…cation markets. Firms that intend to engage in a regulated activity must produce third-party certi…cation of compliance with prescribed regulations and standards. The certi…cation service is provided by independent certi…ers competing à la Cournot. We show that the interaction between certi…ers and …rms results in a market equilibrium that can be illuminated by the techniques of standard oligopoly theory. When certi…ers' liability is not too low, the certi…cation fee is determined by the degree of concentration of the certi…cation market. Due to the peculiarity of this market, a lower concentration is not always socially desirable.

Keywords: Certi…cation, compliance auditing, third-party enforcement.

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y I am grateful to Fabrizio Zecchin for precious insights on the European certi…cation system, and seminar participants in Bologna for helpful comments. Aura and Leonardo provided enduring support.

1 Introduction

Increasingly, independent bodies are engaged to certify …rms' compliance with existing laws, regulations or production standards. Certi…cation intermediaries are found in a great variety of areas, ranging from security markets, where underwriters and auditors play a crucial role, to quality and safety assessment, where accredited bodies guarantee the conformity of products, production units and laboratories to speci…ed standards.

This paper provides a theoretical analysis of the market for certi…cation services with imperfect competition à la Cournot. We assume that certi…ers sell their services to 'judgement proof' …rms that intend to start a particular activity (enter a regulated market) and that need to produce evidence of compliance with standards. As …rms are reluctant to invest the resources needed to meet the standard, certi…ers serve as 'gatekeepers of the market,' with the task of challenging, detecting and stopping the non-compliant.

In the model, certi…ers are called upon to perform a test of conformity with given standards, loosely denoted as 'compliance with the relevant rules'. The actual nature of the standard is extraneous: we simply assume that one exists and that reduces the negative externalities produced by operating …rms (this will allow us to conduct normative analysis).[1] Services of this sort are normally provided by auditors and CPAs with respect to compliance with speci…c laws and regulations ('compliance and attestation audits')[2] and by accredited certi…cation bodies with respect to safety and health standards ('conformity assessment').[3] Compliance certi…cation by a third

[1] Quality and safety standards applying to the most variegated industries are regularly produced by public and private agencies alike. Among the best known are those produced by the International Organization for Standardization (ISO standards) and the CEN-CENELEC-ETSI triad, a set of European bodies endorsed by the European Commission (EN standards).

[2] Compliance and attestation audits are wider in scope that …nancial audits, as they can result in any sort of engagement in which the auditor is asked to provide an assertion "capable of evaluation against reasonable criteria" and "capable of reasonably consistent estimation or measurement using such criteria" (AT 3, US Auditing Standards Board).

[3] Accreditation usually results from the recognition by o¢cial committees like the American National Standards Institute and the Registrar Accreditation Board (in the US), and the European Organization for Testing and Certi…cation.

party is required, for example, from recipients of major federal …nancial assistance in the US (Single Audit Act and Circular A-128), and certi…cation of conformity (to EN standards) of products and manufacturers is mandatory in many industries and procurement settings in Europe. Registration in the European Eco-Management and Audit Scheme (EMAS) requires the 'validation' of the …rm's own environmental statement by an accredited independent veri…er. Third party veri…cation is also required from …rms claiming compliance with environmental standard ISO 14001.

We assume that certi…ers are pro…t-maximizing agents that compete in the market for certi…cation services. An important postulate is that certi…ers' e¤ort is not observable to third parties. This poses a problem of moral hazard, as certi…ers will exert e¤ort only insofar as they risk liability for erroneous certi…cation.

The main result of this paper is the demonstration that the interaction between certi…ers and …rms generates a market equilibrium that can be approached with the techniques of ordinary oligopoly theory. That is, competing certi…ers face a 'demand curve' for certi…cation services that is independent of each certi…er's level of e¤ort. The equilibrium certi…cation fee will thus be determined by the total certi…cation capacity arising from conventional quantity competition, while the fraction of non-compliant …rms among those demanding a certi…cate will be proportional to certi…ers' liability.

The involvement of private actors in the enforcement of regulatory standards raises such important issues as the optimal level of gatekeepers' liability and the need for regulation of the certi…cation market. As noted, we address these issues under the assumption that gatekeepers' function is to prevent …rms from producing a negative externality (social harm). We show that the greatest possible liability is likely to be socially desirable, whereas market regulation turns out to be very problematic. In fact, despite the formal analogy with conventional markets, the market for certi…cation services has signi…cant peculiarities. The most important is that the expected amount of social harm produced by non-compliant …rms depends on the equilibrium price in the certi…cation market. It turns out that an increase in competition or the imposition of a price cap may not be socially desirable.

So far, very little theoretical research has been devoted to certi…cation intermediaries. Kraakman (1986) gives an interesting description of the possible role of third parties in the enforcement of rules and regulations and derives a useful distinction between 'gatekeeping' and 'whistle blowing.' The former enforcement strategy requires private parties to prevent misconduct by withholding their cooperation from wrongdoers; the latter requires them to report information of wrongdoing to enforcement agencies or potential victims.

Choi (1996) provides a full-‡edged if informal analysis of the role that certi…cation intermediaries play in information signalling. He points out that certi…ers may di¤er from generic gatekeepers, as they do not necessarily prevent …rms from selling in the market. Furthermore, certi…ers may signal their information without a formal pronouncement, but solely by means of their association with the primary actor (as in the case of underwriters). As such, certi…cation turns out to be less disruptive of markets and may exist in market settings where gatekeeping is infeasible. Our analysis, however, concentrates on the true gatekeeping function, as we assume that certi…cation is necessary to engage in a regulated activity. Yet, most of our analysis (but not the normative part) can be extended to the case in which the standard is not set up to deal with an externality but relates to product quality. In this case, …rms failing to win certi…cation would still be allowed to initiate the activity but would necessarily be relegated to the lower tail of the market.

Lizzeri (1997) investigates the optimal disclosure policy for pro…t maximizing certi…cation intermediaries. The author develops a sophisticated adverse selection model in which certi…ers may …nd out the …rm's type with perfect accuracy and without expense. They sell their services to producers of goods of unobservable quality, where 'service' means any kind of (veri…able) information disclosure. The author shows that, under some conditions, the equilibrium may entail no revelation and monopolistic pro…ts for the certi…ers. Albano and Lizzeri (1997) consider the choice of the optimal disclosure rule by a monopolistic certi…er, assuming moral hazard on the side of producers. They show that the certi…er will elect to provide noisy disclosures able to maximize buyers' surplus.

The role played by gatekeepers in tax enforcement has been investigated by Franzoni (1998). The present essay extends my previous work by focusing on the enforcement of generic regulations instead of income taxes. This means that individuals' decisions are not restricted to the amount of taxable income to report, but involve the choice of whether to start up an activity, and whether or not to comply with the regulation. Here, in contrast to Franzoni (1998), individuals have differing compliance costs and are distributed over a continuum. Further, the certification fee is assumed not to be refunded. This highlights a different aspect of gatekeeping, namely the possibility that high certification fees themselves constitute an entry barrier.[4]

Finally, a good deal of research has been carried out in the accounting literature with respect to financial audits, which allow third parties to provide 'reasonable assurance about whether the financial statements of an audited entity present fairly the financial position, results of operation, and cash flows in conformity with generally accepted accounting principles.' The audit market is known to be dominated by the Big 6, and hence seems to be better captured by imperfect competition models. Starting with De Angelo (1981), however, the bulk of the auditing literature has concentrated on price competition, disregarding auditors' capacity choice.[5] Financial audits can be likened to the verification technology adopted in this paper. An unqualified opinion (a full certification) usually represents a means of obtaining cheap resources on the capital market. Inaccurate audits do not end up with an externality as is assumed in this model, but rather with direct damage to the purchaser (the firm's financiers). The normative analysis of Section 4 is hence ill fitted for this kind of gatekeeping.

In very brief summary, Section 2 introduces the model and presents a full characterization of the equilibrium of the game; Section 3 illustrates how the parameters of the model affect the players' behaviour; Section 4 addresses the main policy issues attendant upon a certification system; finally, Section 5 provides a summary and some final remarks.

[4] Choi (1996) reports that ISO 9000 certification may cost from $15,000 to several hundred thousand dollars for mid-sized US companies. In view of the recent proliferation of certification intermediaries, the fees for the same sort of certification in Italy have plummeted, reaching an average level of 10 million lire (roughly $ 7,000).

[5] Auditors' expropriable wealth has represented one of the key variables for the explanation of their quality choice. See, for instance, Dye (1993). Doogar and Easley (1998) develop (and test) an interesting model in which auditors' cost functions depend on their "size" (endowment of a fixed production factor).

2 The model

Let us consider the problem of enforcement of a particular law or regulation placing special constraints on the firms that intend to engage in a particular activity. To get an idea of the situation, one may think of safety and environmental regulations prescribing that firms in a certain industry must comply with specified production standards.

Compliance with the regulation is costly. The actual cost of compliance to the firm depends on its type, as it may be more or less close to the prescribed standard. Compliance costs are assumed to be uniformly distributed on the interval $[0, 1]$.[6] The benefit to each firm from engaging in the activity subject to regulation is equal to b, with $b < 1$; the benefit from not engaging into the activity is normalized to 0. A firm that starts up the activity without abiding by the regulation is expected to produce social harm of amount h. For simplicity, we assume that firms are perfectly 'judgement proof' and that they cannot be sanctioned for the harm caused.[7] In the absence of specific impediments, all firms would start the activity, none would comply with the regulation, and social harm would result.

In an ideal situation with full information, though, only compliant firms would be allowed to enter the activity (as $h > b$), and hence only firms with a small compliance cost would do so. This situation can be fruitfully used a as a benchmark for analysis.

Remark 1 In the first best outcome, firms with compliance cost $c < b$ comply with the standard and engage in the activity. The other firms do not engage in the activity.

In the presence of asymmetric information, compliance is fostered by requiring entering firms to produce a certification. The certification service is provided by independent intermediaries, which compete à la Cournot. Once engaged, the certifier exerts effort to ascertain whether the firm respects the standard or not. If the certifier detects a compliance failure, it does not issue certification and the firm cannot start the activity. Conversely, if the certifier detects no failure, it gives its OK and the ac-

[6] The uniform distribution yields a linear certification demand function and simplifies the analysis of the market equilibrium.

[7] This means that neither a Pigouvian remedy (a sanction for non-compliance) nor a Coasian remedy (a liability rule) can be applied.

tivity is carried out. We assume that certi…ers cannot deny a compliance certi…cation when the …rm is e¤ectively compliant.

The probability that the certi…er will detect a non-compliant …rm depends on the level of e¤ort exerted. The e¤ort cost is assumed to be proportional to the 'quality' of the certi…cation, i.e. to be equal to sa; where s is the marginal detection cost and a the probability that a non-compliant …rm will be detected. By exerting a su¢ciently great e¤ort, the certi…er learns the …rm's compliance level with certainty. We assume that random events lead the …rm's actual compliance behaviour to become common knowledge with probability ® (e.g. through a government inspection, a change of ownership, or an accident). In that case, if the certi…cation proves to be erroneous, the certi…er is liable to a monetary penalty P:

The sequence of move in this game is the following:

1. …rms know their compliance cost and decide whether to engage in the regulated activity;

2. certi…ers compete on quantities in the certi…cation market;

3. …rms that enter the activity hire a certi…er to get a certi…cation of compliance;

4. upon engagement, certi…ers decide the level of e¤ort to exert;

5. …rms that fail to get a certi…cation cannot initiate the activity;

6. with probability ®; miscerti…cations are detected and sanctioned.

The game is solved through the Bayes-Nash equilibrium concept. We consider the …rm's problem …rst, then the certi…er's optimal choice of e¤ort. The results will allow us to derive the 'demand' for the certi…cation services, which will then be used to determine the market equilibrium.

Let us start from the problem faced by the single …rm. It has to make two decisions: i) whether to engage in the activity (and, hence, hire a certi…er), and ii) whether to comply with the regulation.

Take a …rm that intends to engage in the activity. It will prefer to comply with the regulation only if

b ¡ c > (1 ¡ a) b;

that is, only if the net bene…t from compliance is greater that the expected bene…t from non-compliance [recall that $(1 - a)$ is the probability of not being detected by the certifier]. For simplicity, we assume that random detection occurs after the firm has reaped the benefit from the activity and has produced expected social harm h.[8] Given the expected certification quality a; only firms with compliance costs

$$c \le ab \tag{1}$$

will comply.

Let us turn to the entry decision. Firms with a compliance cost below ab will enter the activity only if

$$b - c \ge p. \tag{2}$$

Firms with compliance cost above ab will make an attempt to start the activity (and risk being rejected by the certifier) only if

$$(1 - a)b \ge p. \tag{3}$$

Note that the benefit to compliant firms from participation is decreasing in c. If non-compliant firms make an attempt to enter, then the marginal type, i.e. the one indifferent between complying and not, will enter the activity too, and so will all firms with compliance costs less than ab.

The optimal behaviour of firms can be summarized as follows.

Lemma 1 If $(1 - a)b \ge p$; then all firms will seek to enter the activity. Only those with compliance cost $c < ab$ will comply with the regulation.

If $(1 - a)b < p$; then the activity will be started only by firms with compliance cost $c < b - p$; which will all comply with the regulation.

Let us now turn to the certifier's problem. N identical certifiers are operating in the certification market. Each decides his own certification capacity and, upon engagement, the amount of effort to devote to the discovery of the firm's compliance status.

The profit for each certifier i can be written as

$$\Pi_i = [p - s a_i - (1 - a_i) v_i \alpha P] Q_i;$$

[8] This assumption does not affect the qualitative features of our results.

which includes the certification fee p; less the detection cost sa_i; less the expected liability associated with a miscertification, times the number of tests performed, Q_i. v_i is a probability measure that represents the certifier's belief that its customers are non-compliant. Note that if the test reveals that the firm is non-compliant, the certifier has an incentive to deny certification.[9]

Let us consider the choice of detection effort. Differentiation with respect to the certification quality a_i yields

$$\frac{\partial \pi_i}{\partial a_i} = [-s + v_i \alpha P] \, Q_i.$$

Hence, depending on the probability that tested firms are non-compliant, the certifier's effort will be such that

$$\begin{cases} a_i^* = 0 & \text{if} \quad v_i < \frac{s}{\alpha P}; \\ a_i^* \in [0;1] & \text{if} \quad v_i = \frac{s}{\alpha P}; \\ a_i^* = 1 & \text{if} \quad v_i > \frac{s}{\alpha P}. \end{cases} \tag{4}$$

We assume that the expected liability associated with an erroneous certification is sufficient to motivate accurate testing at least when all firms are non-compliant: $\alpha P > s$.

The expected cost of each test is: $s\,a_i + (1 - a_i)\,v_i\,\alpha P$; and, hence, at the optimum:

$$\text{marginal certification cost} = \begin{cases} v_i \alpha P & \text{if} \quad v_i \le \frac{s}{\alpha P}; \\ s & \text{if} \quad v_i \ge \frac{s}{\alpha P}. \end{cases} \tag{5}$$

In order to calculate the optimal certification quantity provided by each certifier, we first need to derive the market 'demand' for certifications. In other terms, we must derive firms' behaviour as a function of the market price p and the expected certification quality provided by each certifier.

As a first step, one may want to establish whether, in equilibrium, certifiers may provide certifications of different quality. The following lemma makes sure that no differentiation can effectively arise ex post.

Lemma 2 In equilibrium, all certifiers will exert the same detection effort.

Proof: From eq.(4), we know that the certifier's effort is greater if the fraction of non-compliant firms among those it serves is larger. As non-compliant firms prefer

[9] Contingent fees are not admitted.

not to be detected, they will all demand the service of the certifier with the lowest expected quality. This means that non-compliant firms would all 'herd' towards the certifier with the smallest fraction of non-compliant firms unless this fraction is the same for all. As a result, in equilibrium, the mix between compliant and non-compliant firms, as well as the detection effort, will be the same for all certifiers.[10]

In equilibrium, we thus have $v_i = v$ and $a_i = a$ for all certifiers.

Let us now consider the firms and certifiers' behaviour given the market price p:

If the certification fee exceeds the private benefit from the activity, $p \geq b$; then clearly nobody enters the activity and $Q^D(p) = 0$:

If $p < b$; we have to consider firms' entry and non-compliance decisions together. We have two possible cases: either all non-compliant firms enter the market or only a fraction do.

Consider first the case in which all non-compliant types enter the activity. The fraction among those demanding certification will be $v = 1 - ab$ (from Lemma 1). If certifiers exerted no detection effort, no one would comply with the regulation and $v = 1$: Since $\alpha P > s$; certifiers would then exert full effort, $a^* = 1$; and non-compliant firms would prefer not to enter the activity. In equilibrium, the detection probability has to be such that the probability of non-compliance given engagement leaves each certifier indifferent about the level of effort: $a_i = \hat{a}$ for all i; with

$$(1 - \hat{a}b)\,\alpha P = s:$$

Hence,

$$\hat{a} = \frac{1}{b}\frac{\alpha P - s}{\alpha P}: \tag{6}$$

In equilibrium, firms with a compliance cost less than $\hat{c} \equiv \hat{a}b = \frac{\alpha P - s}{\alpha P}$ will comply, while the others will not. The demand for certification services is equal to 1.

Note that this equilibrium can occur only if non-compliant firms find it profitable

[10] This argument is based on the assumption that the certification price is unique. Yet it also extends to the case in which certifiers can quote different prices (in a model à la Kreps and Scheinkman 1983). In this case, it would be sufficient to recall that only non-compliant firms would be willing to pay a premium for low certification quality. Any certifier offering low quality would then face noncompliant firms only, and would be led to exert full effort.

to enter the activity, i.e. only if (from eq. 3): $\bar{a} \le \frac{b-p}{b}$; that is only if

$$p \le b - \bar{c}.$$

When the certification fee is high or $b < \bar{c}$, the previous inequality is not satisfied. Noncompliant types will not find it profitable to apply for certification unless the certification quality is set below $\bar{a}$. They will be indifferent between doing it and not if $a = \frac{b-p}{b}$. In turn, certifiers will be indifferent about detection effort if non-compliant firms randomize and enter with a probability x such that

$$\frac{x\,[1-(b-p)]}{x\,[1-(b-p)]+(b-p)}\,\alpha P = s.$$

In equilibrium, we will hence have

$$x^* = \frac{b-p}{1-b+p}\,\frac{s}{\alpha P - s}. \qquad (7)$$

In this case, the certification demand will be equal to

$$Q^D(p) = b-p+[1-(b-p)]\,x^* = \frac{\alpha P}{\alpha P - s}\,(b-p).$$

To sum up, the certification demand can be written as:

$$Q^D(p) = \begin{cases} 0 & \text{for } p \ge b \\ \frac{\alpha P}{\alpha P - s}(b-p) & \text{for } b-\bar{c} \le p < b \\ 1 & \text{for } p \le b-\bar{c} \text{ (if } b-\bar{c} > 0). \end{cases}$$

Figures 1 and 2 illustrate the certification demand on the assumption that $b < \bar{c}$ and $b > \bar{c}$, respectively.

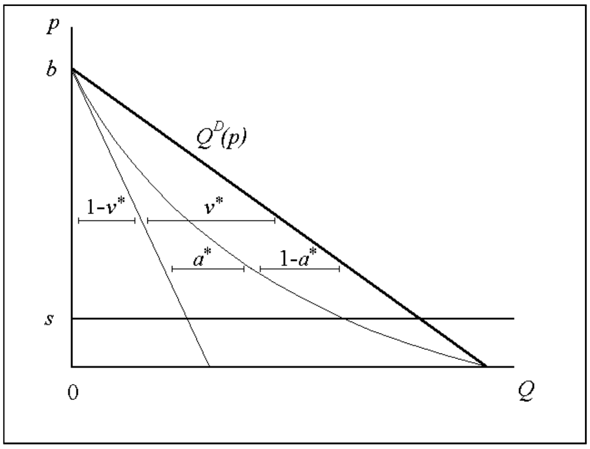

Figure 1. Unconstrained demand: $b < \bar{c}$.

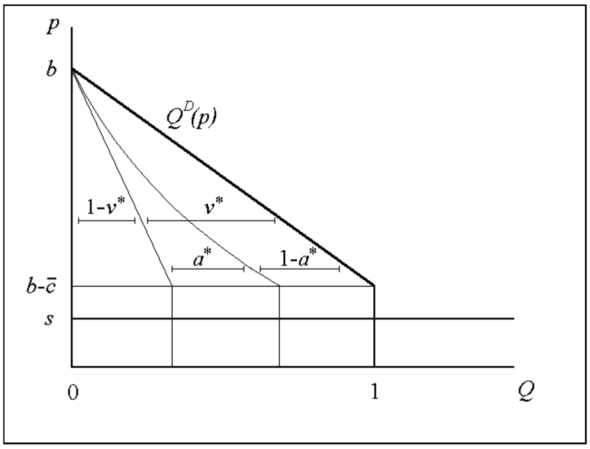

Figure 2. Constrained demand: $b > \bar{c}$.

The demand function together with the marginal certification cost determine the market configuration. Note that in any continuation equilibrium we have $v^* = \frac{s}{\alpha P}$. Hence, from eq.(5), the expected marginal certification cost for each certifier is equal to s. Further, it can be seen that the certifier's profit is independent of a_i:

$$\begin{aligned} \Pi_i^* &= [p(Q) - s a_i^* - (1 - a_i^*) v_i^* \alpha P] Q_i = [p(Q) - v_i^* \alpha P - a_i^* (s - v_i^* \alpha P)] = \\ &= [p(Q) - v_i^* \alpha P] Q_i = [p(Q) - s] Q_i. \end{aligned}$$

In the market, N symmetric certifiers compete in quantities. In order to account for the widest range of possible outcomes, we allow N to be non-integer: $N \in [1, \infty)$.

In order to get a complete solution to the market game, one has to make an assumption about the market price that occurs when $Q^D = 1$. The only assumption compatible with a subgame perfect equilibrium is that the price associated with full market coverage is the highest: $p = b - \hat{c}_1$. Otherwise, certifiers' payoffs would not be upper-hemicontinuous and there would be no equilibrium.

Through standard Cournot analysis (see the appendix), it can be established that the equilibrium market quantity is

$$\begin{cases} Q^* = \frac{N}{N+1}(b - s)\frac{\alpha P}{\alpha P - s} & \text{if } \frac{N}{N+1}(b - s)\frac{\alpha P}{\alpha P - s} \leq 1 \\ Q^* = 1 & \text{if } \frac{N}{N+1}(b - s)\frac{\alpha P}{\alpha P - s} > 1 \end{cases}$$

with

$$\begin{cases} p^* = s + \frac{1}{N+1} b & \text{if } \frac{N}{N+1}(b - s)\frac{\alpha P}{\alpha P - s} \leq 1 \\ p^* = b - \frac{\alpha P - s}{\alpha P} & \text{if } \frac{N}{N+1}(b - s)\frac{\alpha P}{\alpha P - s} > 1 \end{cases}$$

Recall that $Q^* = 1$ can occur in equilibrium only when $b - \hat{c}_1 \geq 0$; i.e. when certifiers' liability is relatively small: $P \leq \frac{s}{\alpha(1 - b)}$.

By nesting the equilibrium values into the players' best reply functions, we obtain a full characterization of the equilibrium.

Proposition 3 *The unique subgame perfect equilibrium is characterized as follows.*

If $\frac{N}{N+1}(b - s)\frac{\alpha P}{\alpha P - s} < 1$ (partial market coverage), then certifiers serve $Q^* = \frac{N}{N+1}(b - s)\frac{\alpha P}{\alpha P - s}$ firms for a fee $p^* = s + \frac{1}{N+1} b$. Firms with compliance cost c^*

$\frac{N}{N+1}(b-s)$ comply with the regulation and enter the activity, while the others do not comply and try to enter the activity with probability

$$x^* = \frac{s}{\alpha P - s}\frac{1}{\frac{N+1}{N}\frac{1}{b-s} - 1}.$$

A fraction

$$a^* = \frac{b - p^*}{b} = \frac{N+1}{N}\frac{b-s}{b}$$

of non-compliant firms are detected by their certifier and denied certification. Each certifier earns a profit equal to

$$\Pi_i^* = \left(\frac{1}{N+1}(b-s)\right)^2 \frac{\alpha P}{\alpha P - s}.$$

If $\frac{N}{N+1}(b-s)\frac{\alpha P}{\alpha P - s} > 1$ (full market coverage), then certifiers serve all firms, $Q^* = 1$; for a fee $p^* = b - \frac{\alpha P - s}{\alpha P}$. Firms with compliance cost $c^* \leq \frac{\alpha P - s}{\alpha P}$ comply with the regulation and enter the activity, while the others do not comply and try to enter the activity with probability 1. A fraction

$$a^* = \frac{1}{b}\frac{\alpha P - s}{\alpha P}$$

of non-compliant firms are detected by their certifier and denied certification. Each certifier earns a profit equal to

$$\Pi_i^* = \frac{1}{N}\left(b - \frac{\alpha P - s}{\alpha P}\right).$$

We have identified two types of equilibrium: in the first, the certification fee is high enough to discourage some firms from hiring a certifier and trying to enter the activity. In the second, all firms hire a certifier and try to enter. The second type can occur only when certifiers' liability is relatively small, $P \leq \frac{s}{\alpha(1-b)}$, and the number of operating certifiers is large, $N \geq \frac{\alpha P - s}{\alpha P(b-s) - (\alpha P - s)}$.

3 Equilibrium properties

In this section, we use Proposition 1 to assess how the equilibrium is affected by changes in the underlying parameters.

Number of certifiers

This variable is relevant only when the equilibrium entails partial coverage.

Suppose that the number of certifiers in the market increases. As competition intensifies, certifiers perform more tests for a lower price. Certifiers' profits decrease. Thanks to the reduction in the certification fee, more firms can afford to comply with the regulation. As this would reduce certifiers' incentive to exert effort in detection, a larger number of non-compliant firms try to initiate the activity. Further, the detection rate has to rise so as keep non-compliant firms indifferent between entering and not. As a result, the detection rate is higher.

As the number of certifiers grows to infinity, we have two possible outcomes. If $s > b - \bar{e}$; then the Cournot equilibrium converges to the Bertrand equilibrium. We have,

$$\lim_{N \to \infty} p^* = s \quad \text{and} \quad \lim_{N \to \infty} Q^* = (b - s) \frac{\alpha P}{\alpha P - s} < 1 :$$

At the limit, certifiers earn zero profits and serve all firms willing to pay at least the marginal certification cost s.

If $s < b - \bar{e}$; the perfect competition outcome is not approximated. In fact, we have

$$\lim_{N \to \infty} Q^* = 1 \text{ and } \lim_{N \to \infty} p^* = b - \bar{e}:$$

With quantity competition, the equilibrium price cannot drop below $b - \bar{e}$: At the limit, the profit per test equals $b - \bar{e} - s > 0$: Certifiers serve all firms and exhaust their certification capacity.

Certifiers' liability

Consider now an increase in certifiers' liability for miscertification. Let us start with the partial coverage equilibrium. As P increases, miscertification becomes more costly and certifiers have an incentive to increase the detection probability. Noncompliant firms offset this increased incentive by reducing their entry probability. The certification demand curve thus rotates to the left. In equilibrium, the certification fee will be the same, but the quantity of the tests will be lower. The detection probability will not be affected, as firms' incentives to comply are unaltered.

Let us now consider the full coverage equilibrium, recall that this equilibrium emerges only when P is relatively small. An increase in certifiers' liability increases their incentive to perform thorough tests. This factor is offset by a rise in the compliance level: some firms that were not compliant turn compliant. However, this means that both the equilibrium compliance cut-off level and the detection probability are lower. Somewhat paradoxically, therefore, an increase in certifiers' liability reduces their detection effort.

Detection cost

Let us consider the effect of an increase in the marginal detection cost s on the partial coverage equilibrium. Due to the decreased incentive for accurate testing, non-compliant firms try to enter the market with a higher probability: the certification demand curve rotates to the right. Since the marginal certification cost is now higher, the effect on the equilibrium quantity may be of either sign: Q^* increases if and only if $b > \alpha P$: Whatever the sign of the variation in Q^*; the effect on the certification fee is positive. Certifiers' profits decrease if and only if $b > 2\alpha P + s$: Since a higher fee discourages non-compliant firms from entering, the compliance cut-off is lowered and the detection probability decreases.

Consider the equilibrium with full market coverage. An increase in s reduces the certifiers' incentive for accurate testing. This leads a fraction of compliant firms to turn non-compliant, restoring certifiers' incentive. In equilibrium, the compliance cut-off c^* and the detection probability a^* will be lower. Faced with a lower detection probability, firms will be willing to pay more for certification, and both the certification fee and certifiers' profits will be higher.

Private benefit

When firms' private benefit from engaging in the regulated activity is greater, a higher detection rate is required to keep non-compliant firms out. In the partial coverage equilibrium, both the detection probability and the certification demand will be higher. As a result, the certification fee will be higher and the certification capacity will be lower. Thanks to the rise in the certification fee, certifiers' profits will be higher. More firms will prefer to comply.

In the full coverage equilibrium, non-compliant …rms cannot be kept out. The increase in the private bene…t does not a¤ect certi…ers' incentives and has no e¤ect on the compliance rate. Firms' additional incentive to comply are o¤set by a reduction in the detection probability. Finally, since …rms are willing to pay more for certi…cation, the fee will be higher.

The comparative statics is summarized by Tables 1 and 2.

Table 1. Direction of change: Partial coverage equilibirum

	Exhogenous parameters to be increased			
	Number of certi…ers	Certi…ers' liability	Detection cost	Private bene…t
Endogenous variable	N	P	s	b
Demand for certi…cation services	+	-	(1)	+
Ratio of non-compliant applicants	0	-	+	0
Certi…cation fee	-	0	+	+
Detection rate	+	0	-	+
Individual certi…er's pro…ts	-	-	(2)	+

(1) Positive if and only if b > ®P:
(2) Positive if and only if b > 2®P + s:

Table 2. Direction of change: Full coverage equilibrium

	Exhogenous parameters to be increased		
	Certi…ers' liability	Detection cost	Private bene…t
Endogenous variable	P	s	b
Ratio of non-compliant applicants	-	+	0
Certi…cation fee	-	+	+
Detection rate	+	-	-
Individual certi…er's pro…ts	-	+	+

4 Policy analysis

This section addresses two policy issues attendant upon the certification market: the optimal level of certifiers' liability and the quest for price regulation.

Social welfare is defined as the sum of net private benefits to firms from engaging in the regulated activity ('consumer surplus'), less detection costs, less social harm associated with non-compliance. As usual, no weight is attached to monetary transfers between parties.

We have

$$W = \underbrace{\int_0^{c^*} (b - c)\, dc + (1 - a^*)\, x^* \,(1 - c^*)}_{\text{net benefit from the activity}} - \underbrace{[c^* + x^*(1 - c^*)]\, s\, a^*}_{\text{detection costs}} - \underbrace{x^*(1 - a^*)(1 - c^*)\, h}_{\text{social harm}};$$

where the compliance threshold c^*; the entry probability x^* and the detection rate a^* are determined in equilibrium (Proposition 1).

Let us now consider the welfare effect of an increase in P: In the partial coverage equilibrium, the only relevant variable affected by P is x^*; which decreases. Social welfare is therefore greater, thanks to the reduction in the number of non-compliant firms entering the activity:

$$\frac{\partial W^{Part.}}{\partial P} = -(1 - a^*)(1 - c^*)(h - b)\frac{\partial x^*}{\partial P} > 0;$$

where '$Part.$' stands for 'partial coverage'. If certifiers' liability were stretched to infinity, we would get

$$\lim_{P \to \infty} W^{Part.} = \int_0^{c^*} (b - c)\, dG(c) - c^* s\, a^*;$$

with $a^* = \frac{N+1}{N}\frac{b-s}{b}$ and $c^* = \frac{N}{N+1}(b - s)$: We would still be far from the first best outcome (described in Remark 1): not all the potential gains from compliance would be reaped (some firms are put off by the certification fee) and costly detection would take place.

For low levels of certifiers' liability, the equilibrium entails full market coverage, and the effect of a variation in P is more complicated. In fact, an increase in P yields higher certification quality and induces a larger fraction of firms to comply:

$$\frac{dW^{Full}}{dP} = [(b - c^*)\, b + (h - b)(1 + b(1 - 2a^*)) - s]\frac{\partial a^*}{\partial P};$$

with $\frac{\partial a^*}{\partial P} = -\frac{s}{\alpha P^2}$.

Hence,

$$\frac{dW^{Full}}{dP} > 0 \iff s < (b - c^*)\,b + (h - b)\,(1 + b\,(1 - 2a^*)). \qquad (8)$$

Due to the attendant increase in detection costs, an increase in certifiers' liability is socially desirable only if the marginal detection cost is not too high. Note that eq.(8) is more likely to hold when a^* is high, i.e. when P is relatively small.

Let us now consider the effect of a variation in the number of operating firms. As the effect of an increase in N is a reduction in the certification fee, comparative statics can be used to assess the desirability of direct price regulation. Note that variations in N and p are relevant only when the equilibrium entails partial coverage.

To start with, let us rewrite the equilibrium variables in terms of Q. By substitution, we obtain $c^* = (1 - v)\,Q$; $x^*(1 - c^*) = vQ$; $p = b - (1 - v)\,Q$; and $a^* = (1 - v)\,\frac{1}{b}Q$. Hence,

$$W^{Part.} = \int_0^{(1-v)Q} (b - c)\,dc + b\,(1 - a^*)\,vQ - sa^*Q - h\,(1 - a^*)\,vQ, \qquad (9)$$

with

$$\begin{aligned}\frac{\partial W^{Part.}}{\partial Q} &= (1 - v^*)\,(b - (1 - v^*)\,Q) + bv^*(1 - a^*) - sa^* - h\,(1 - a^*)\,v^* \\ &\quad + \frac{\partial a^*}{\partial Q}\,[(h - b)\,v^* - s]\,Q = \\ &= (1 - v^*)\,p^* + v^*p^* - sa^* - h\,(1 - a^*)\,v^* + \frac{1 - v^*}{b}\,[(h - b)\,v^* - s]\,Q.\end{aligned}$$

Hence, through further simplification

$$\frac{\partial W^{Part.}}{\partial Q} = \underbrace{p^*}_{\text{increase in net benefit}} \; - \underbrace{sa^*}_{\text{increase in detection costs}} \; - \underbrace{(1 - a^*)\,v^*h}_{\substack{\text{increase in social harm} \\ \text{due to more non-compliant applicants}}} \; + \underbrace{a^*\,[(h - b)\,v - s]}_{\substack{\text{decrease in net social harm} \\ \text{and increase in detection costs} \\ \text{due to increased detection probability}}}.$$

An increase in certification capacity has four effects: 1) it increases the 'consumer surplus', as a greater share of the certification demand is satisfied; 2) it increases detection costs, 3) it increases social harm, as more non-compliant firms apply; and 4) it increases the detection probability and hence reduces social harm and increases detection costs.

This formulation highlights the features marking a difference between the certification market and conventional markets.

First, variations in certification capacity affect the amount of social harm attendant on non-compliance. This occurs through two means: the increase in the fraction of non-compliant applicants and the increase in the equilibrium detection probability. When deciding the amount of certification services to provide, firms disregard these effects because they do not affect their profits: the first relates to an externality, while the second is mediated by a variation in a, which does not enter into the firms' ex-ante payoff function.[11] The net effect is equal to $-h(1-a^*)v^* + a^*[(h-b)v^* - s]$ and may be of either sign.[12]

Second, firms perceived marginal certification cost, s, is greater than the real marginal social cost, as, as firms account their prospective liability payments as costs, while they are mere transfers.

In view of these two effects, the social optimum does not necessarily correspond to the point at which price equals marginal costs. This means, specifically, that an increase in competition in the industry, due to the entry of additional certifiers, is not necessarily socially desirable.

To specify, the perfect competition outcome with $p = s$ is not desirable if

$$\left.\frac{\partial W^{Part.}}{\partial Q}\right|_{p=s} = (1-a^*)s - h(1-a^*)v^* + a^*[(h-b)v^* - s] =$$
$$= \frac{s}{\alpha P}[-(1-a^*)(h-\alpha P) + a^*(h-b-\alpha P)]$$
$$= s + \left(1 - \frac{s}{b}\right)\frac{s}{\alpha P}[2h - b - 2\alpha P] < 0;$$

that is, if (upon simplification)

$$b(h-b-\alpha P) < s(2h-b-2\alpha P). \qquad (10)$$

[11] In view of the envelope theorem, the latter result applies whenever the detection cost function is weakly convex.

[12] Note that even if h were negligible, the net effect would not vanish. However, it would collapse to zero if s were negligible. In the latter case, the first best outcome would be achieved for $N \to \infty$.

Note, for instance, that inequality (10) holds (and perfect competition not desirable) when certifiers' liability is infinite and $b > 2s$:

Conversely, if $\left.\frac{\partial W^{Part.}}{\partial Q}\right|_{p=s} > 0$, a certification capacity greater than that arising from perfect competition is likely to be desirable. In particular, the government should subsidize a competitive certification industry if $\left.\frac{\partial W^{Part.}}{\partial Q}\right|_{p=s} > 0$ and $\frac{\partial^2 W^{Part.}}{\partial Q^2}$ 0; where

$$\frac{\partial^2 W^{Part.}}{\partial Q^2} = \frac{\partial}{\partial p}\left[\frac{\partial W^{Part.}}{\partial Q}\right]\frac{\partial p}{\partial Q} = -\left[1 - \frac{s}{\alpha P}\frac{1}{b}(2h - b - 2\alpha P)\right]\left(1 - \frac{s}{\alpha P}\right):$$

Both conditions are satisfied, for instance, when certifiers' liability is infinite and $b < 2s$:

The presence of the two 'additional' effects mentioned above makes welfare maximization a surprisingly complex problem, whose solution is strictly dependent on configuration of the parameters.

5 Final remarks

The model developed in this essay provides a theoretical analysis of imperfect competition in the market for certification services. It is based on the assumption that firms are required to produce evidence of compliance with a given standard in order to engage in a regulated activity. Our main result shows that the certification market can be analysed with the tools of ordinary oligopoly theory, as certifiers' effort of choice can be separated from their decision on capacity. When certifiers' liability is high, they serve only a fraction of the firms potentially interested. When liability and the marginal detection cost are low, certifiers serve all firms. In both cases, the fraction of non-compliant firms among those demanding a certificate is constant, and depends on the ratio between certifiers' expected liability and the marginal detection cost.

The model is deliberately sketchy about the exact content of the certification: only the normative analysis of Section 4 is based on the assumption that miscertifications lead to negative externalities. In fact, the model can be extended to quality certification, on the assumption that the upper, and most lucrative, tail of the market is served by certified firms only. In such a setup, firms' benefit from certification would supposedly relate inversely to the number to firms that obtain it, due to the increased competition in the downstream market.[13] The demand for certification services would then be bent downward, as firms' willingness to pay for certification would decrease more than proportionally to the number of applicants. The ratio between compliant and non-compliant applicants, whoever, wound not change, and the qualitative properties of our analysis would remain unaltered.

6 Appendix

Derivation of the Cournot equilibrium. Suppose first that $b < \hat{c}$ and consider the unconstrained demand function:

$$Q^D(p) = \begin{cases} 0 & \text{for } p \geq b \\ \frac{\alpha P}{\alpha P - s}(b - p) & \text{for } 0 \leq p < b \end{cases}.$$

The marginal certification cost is s.

The best reply function of firm i is obtained by maximizing the profit function:

$$\Pi_i = [p(Q) - s] Q_i,$$

with $p(Q) = b - \frac{\alpha P - s}{\alpha P} Q \equiv b - kQ$.

By setting marginal profits equal to zero, we get

$$Q_i^* = \frac{b - s - kQ_{-i}}{2k},$$

with $Q_{-i} \equiv Q - Q_i$. Since the equilibrium is symmetrical, we have $Q_i = Q/N$ and $Q_{-i} = \frac{(N-1)}{N} Q$. Hence

$$Q^* = \frac{N}{N+1} \frac{b - s}{k} = \frac{N}{N+1}(b - s)\frac{\alpha P}{\alpha P - s},$$

and

$$p^* = b - kQ^* = b - \frac{N}{N+1}(b - s).$$

[13] This effect may, however, be countered by an increase in final buyers' willingness to pay due to the higher average rate of compliance (to prescribed standards) of certified firms (as the detection rate increases with Q).

Suppose now that $b > \bar{c}$; and that the demand function takes the form

$$Q^D(p) = \begin{cases} 0 & \text{for} \quad p \geq b \\ \frac{\alpha P}{\alpha P - s}(b - p) & \text{for} \quad b - \bar{c} \leq p < b \\ 1 & \text{for} \quad p \leq b - \bar{c}. \end{cases}$$

If $s > \bar{c}$; the previous analysis carries through and the market is only partially served.

If $s < \bar{c}$; then competition among certifiers may drive the certification fee so low that the whole market is served. When deciding their capacity, certifiers know that the market demand cannot exceed 1: When the demand is effectively constrained, certifiers have no incentive to conduct additional tests. The constraint is binding when the number of certifiers is so high as to yield an unconstrained Cournot equilibrium quantity greater that 1:

$$\frac{N}{N+1}(b - s)\frac{\alpha P}{\alpha P - s} > 1.$$

Since the unconstrained equilibrium quantity cannot be completely sold, firms will not be able to meet their optimal production quantity. In theory, the equilibrium could be asymmetrical, as firms could be differently affected by the constraint. For simplicity, we restrict our attention to the symmetrical equilibrium in which all (identical) firms produce the same quantity, $Q_i^* = 1/N$: For a continuity argument, the equilibrium price has to be equal to $b - \bar{c}$: any other price (less than $b - \bar{c}$) would cause a discontinuity in the firms' payoff functions, thus yielding discontinuous best replies and non-existence of the equilibrium (as firms might prefer not to meet the constraint and produce an aggregate quantity equal to $1 - \varepsilon$; with ε infinitely small).

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