The effect of accreditation regulation on the credibility of voluntary certification*

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Abstract

Voluntary certification can mitigate market inefficiencies due to asymmetric information if certifiers are credible. Many countries establish accreditation bodies to monitor and license them. This paper theoretically analyses how the establishment and regulation of accreditation bodies affect certifiers' incentives for fraud and welfare. I provide motivating evidence based on increased certification after the international recognition of the Uruguayan accreditation body. I then analyze public-perfect equilibria in an infinitely repeated game of a mass of buyers, a monopolist supplier, a monopolist auditing company, and one or more accreditation bodies. I show that a necessary condition for a welfare-improving effect of accreditation bodies' existence is that buyers are sufficiently sophisticated or that accreditation is compulsory. The model highlights that accreditation bodies should not be profit-maximizing companies whenever buyers are naive. It shows that developing and small economies should establish their own national accreditation body only if they cannot find a foreign accreditation body of sufficiently high quality and sufficiently low transportation cost. These results are broadly in line with international practice. However, the model also suggests that developing economies likely need even higher quality accreditation bodies than advanced economies.

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1 Introduction

Due to adverse selection and moral hazard, asymmetric information about quality attributes causes inefficiencies in many markets (Akerlof, 1970; Arrow, 1963). Credible quality signaling is particularly challenging in the case of *credence attributes*, which can only be revealed at a high cost through inspection of the production process or testing technologies (Darby and Karni, 1973). Examples are pesticide residues in food or ethical treatment of workers abroad. Buyers learn about credence attributes only with a very low probability, based on some level of public monitoring, for instance, through governmental or non-governmental organizations, investigative journalists, or researchers.

This paper theoretically studies the potential of *accreditation* to increase the credibility of signaling credence qualities through third-party certification. While third-party certification is the external assessment and disclosure of a firm's compliance with a quality standard through inspection of production processes or tests of products,[1] accreditation is the external assessment and disclosure of the third party's competence to certify. Accreditation can improve a certifier's incentives to assess and disclose firms' compliance rigorously and truthfully. It typically involves inspections, is based on international accreditation standards, and is often conducted by public authorities (IAF, 2018a).

This paper's core is a model that explains the effect of the establishment and competition regulation of accreditation bodies on the credibility of the certification of voluntary credence standards. I provide motivating evidence from Uruguay to illustrate the potential role of establishing an internationally recognized national accreditation body in spreading certification.

In the model, atomistic buyers, a certifier, and zero to two accreditation bodies play a repeated game with an infinite horizon. The supplier is a new entrant in each stage game to focus the analysis on cases where truthful signaling without certification is not incentive compatible. I consider a monopolist certifier as I want to concentrate on the market structure in which incentive compatibility of truthful certification is most likely. The baseline model without accreditation then reproduces a result from the literature: Even a monopolist certifier may not have sufficient incentives to assess and disclose the

[1] Certifiers are independent of the owners and typically also from the developers of the standard. Standards can be set at many different levels. See Figure 3 in Appendix 8.1 for an overview. The organizations that set a standard usually own it. That means they charge license fees when a certifier certifies according to the standard.

supplier's compliance truthfully if they do not care enough about the future or if the probability that fraud becomes known to buyers is too low (Strausz, 2005).

My contribution is the introduction of accreditation, a second layer of monitoring. Obtaining accreditation has two opposing effects for the certifier's incentives to cheat: On the one hand, it requires them to spend a certain fraction of the truthful monitoring cost to demonstrate their competence. The fraction they need to spend is a proxy of the accreditation quality since it reduces their incentives to cheat. On the other hand, accreditation requires the payment of a fee to the accreditation body in each period, which reduces future profits and thus reduces potential loss in future profits from cheating. The fee is increasing in the quality of accreditation. The optimal level of accreditation quality depends on the strengths of the two opposing effects for the certifier's incentives.

Based on this model, I derive the following conclusions. First, accreditation can only prevent certifiers from cheating if buyers are sophisticated enough to demand accreditation from certifiers or if accreditation is compulsory. Second, assuming sophisticated buyers, I show that a profit-maximizing accreditation body reduces fraud in the certification market whenever a welfare-maximizing accreditation body can do so. This result does not hold if buyers naively trust in any accreditation. Third, under a few plausible assumptions, the model suggests that the optimal accreditation quality is, on average, higher in developing than advanced economies. Fourth, it shows that developing and small economies should only establish their own national accreditation body if they cannot find a foreign accreditation body of sufficiently high quality and sufficiently low transportation cost.

The theoretical analysis is motivated by an empirical analysis of the association of the availability of an internationally recognized national accreditation body with the share of companies that seek certification. Using data from the World Bank Enterprise Surveys, I compare changes in certification rates in Uruguay and Nicaragua before and after the official international recognition of Uruguay's national accreditation body. The results suggest that the availability of globally recognized national accreditation is associated with increased certification rates. Increased certification rates might be driven by increased credibility of certification through accreditation, such that this case illustrates the potential of accreditation highlighted in the model. However, the setting does not allow to establish causality with certainty.

The questions analyzed in this paper are policy-relevant for the following reasons. Demand for accreditation is increasing globally, partly driven by downstream buyers preferring to buy products certified by an accredited certifier (Heras-Saizarbitoria and Boiral, 2019). Many developing countries still have to decide whether to establish their national accreditation body. International organizations such as UNIDO have supported some such endeavors (UNIDO et al., 2017). Donors have to choose in which cases to contribute. Finally, the regulation of accreditation bodies started only about fifteen years ago, and it may still need refinements, particularly concerning the degree to which private accreditation bodies are allowed. Approaches differ by country, from little regulation in the United States to a restriction to a single accreditation body appointed by the state in the European Union and China.

The paper is organized as follows. I first give an overview of the literature on certification and outline in what ways I contribute to it. Section 2 provides an overview of the organization of accreditation worldwide and motivating evidence about its relevance. Section 3 presents the baseline model in which no accreditation is available. In section 4, the model is extended to account for certification. I analyze first the case of a monopoly accreditation body and second, Bertrand competition among different accreditation bodies. Section 5 shows how the results of section 4 change if buyers do not understand the value of accreditation. In section 6, I adapt the results to account for the case where buyers only trust accredited certification. Section 7 summarises and gives an outlook on potential extensions to this paper.

Literature and contribution

This paper contributes to the literature on the economics of certification. The syntheses of Dranove and Jin (2010) and Bonroy and Constantatos (2014) provide helpful overviews. Many papers cover companies' decisions to seek certification between cost and benefits. However, fewer models endogenize the choices of the certifying company (henceforth the *certifier*) (Farhi et al., 2013), as I do in this paper.

This paper focuses on the certifiers' choice between honest and fraudulent certification. I concentrate on for-profit certifiers.[2] I follow former papers regarding the certifier as a

[2]For many standards, such as ISO management system standards, certifiers are typically for-profit companies. Two of the biggest players are Bureau Veritas and SGS. For ethical standards, such as Fairtrade, certifiers are typically non-profit companies.

black box (Bolton et al., 2012; Giannakas, 2002; Strausz, 2005).[3] I do not model certifiers' public choices, such as the limited disclosure of inspection results, which Lizzeri (1999), Farhi et al. (2013), Stahl and Strausz (2017) and Kastl et al. (2018) have analyzed. I instead adopt a result of Lizzeri (1999) as an assumption. Lizzeri (1999) shows that, under monopoly and oligopoly certifiers, there exists an equilibrium in which the certifiers only publish the names of successful applicants. This equilibrium is in line with the practice of most certifiers: Certifiers typically do not disclose unsuccessful applicants and grant applicants sufficient time to correct undetected nonconformities.[4] Hence, any certification applicant in my model obtains certification if they pay the necessary cost. Thus, the model focuses on the firm's moral hazard rather than adverse selection.

Many certification models, including the papers cited above, assume full commitment of the certifier to the disclosure rule. That implies that the information the consumer obtains is limited but correct (Giannakas, 2002). The papers that investigate the credibility of certifiers are almost entirely based on reputation building.[5] Ratings of financial products are the most-studied examples of certification (Bar-Isaac and Shapiro, 2011; Bolton et al., 2012; Faure-Grimaud et al., 2009; Mathis et al., 2009; Opp et al., 2013; Skreta and Veldkamp, 2009). Reputation building plays a crucial role in this industry since investors can systematically observe the overall accuracy of credit rating agencies ex-post. Nevertheless, various scandals have brought attention to severe conflicts of interest in this industry (Bolton et al., 2012). The literature on certification in financial markets finds that increased competition exacerbates asymmetric information (Faure-Grimaud et al., 2009; Skreta and Veldkamp, 2009). Without a particular focus on the financial

[3] I do not analyze potential principal-agent issues between the certifier as a company and its agents. The certifiers' agents are (1) employed or contracted auditors and (2) the employees that evaluate the auditors' inspection reports and make the certification decisions. These agents can be subject to moral hazard, adverse selection, or corruption. However, a sufficiently committed certifier can implement mechanisms that minimize such issues. For example, they could send multiple auditors to each client or double-check auditors' reports. In an RCT on environmental audits in India, Duflo et al. (2013) also show that introducing (1) random auditor assignment, (2) flat payment by companies to the auditors, (3) random backchecks of reports through an upstream agency, and (4) linking salaries of auditors to backcheck results, altogether improve auditing accuracy. Moreover, due to the lack of systematic asymmetric information between top management and the employees evaluating inspection reports, I do not suspect many difficulties for the company to implement their policies on report evaluations and certification decisions.

[4] There are, however, standards for which certifiers have to publish inspection reports, as MSC Fisheries (Auld and Gulbrandsen, 2010). One explanation for this might be the separation of standard setting and certification. The standard setters, who often also prescribe disclosure rules, have different incentives than the certifiers. Ways of modeling those can be found in Swinnen et al. (2015).

[5] This literature took off most significantly with the contributions of Biglaiser (1993); Biglaiser and Friedman (1994).

market, Strausz (2005) obtains an even more striking result: He shows that, under low discount rates, collusion can only be deterred if certification fees are above the monopoly price. He obtains this result even though he assumes that customers perfectly observe quality after their purchase. The finding implies that there can be fraudulent certification even under a monopoly certifier. My model builds on that idea and analyses whether accreditation can prevent fraudulent certification.

There is significant evidence of incorrect certification, especially for credence goods. For example, the exploratory study of Heras-Saizarbitoria and Boiral (2019) shows large-scale fake certifications of the ISO 9001 management system standards in China. The study finds that fraudulent certification exists even for accredited certifiers. Heras-Saizarbitoria and Boiral (2019) finds this problem mainly for certifiers accredited by private accreditation bodies which are not internationally recognized.[6] My model, therefore, distinguishes between welfare-maximizing and profit-maximizing accreditation bodies. This distinction allows me to give some suggestive explanations on the findings of Heras-Saizarbitoria and Boiral (2019).[7]

2 Context and motivating evidence

2.1 The regulation of accreditation

This section explains the functioning and regulation of accreditation to motivate some critical assumptions made in the model.

Accreditation bodies are only widely recognized if they work according to ISO standard 17011.[8] This standard defines an *accreditation body* as an "authoritative body that

[6] I will explain the role and system of international recognition of accreditation bodies in section 2.2.

[7] Cases of fraud in certification have been observed even in advanced economies. Examples are the Anderson-Enron accounting scandal and the case in which Sony Pictures was fined for having certified their films based on invented reviews (Strausz, 2005). Strausz (2005) claims that these cases are out-of-equilibrium events that were sufficiently punished to deter systematic fraud in the market. However, other cases cast doubt on that and show the difficulties of monitoring certification. TÜV Rheinland, for example, was accused of misreporting construction safety in the garment factories of Rana Plaza whose collapse in 2013 cost the lives of over 1100 workers (OECD NCP, 2018). In 2013, a French court held the company liable for falsely certifying ruptured breast implants (Van Leeuwen, 2017). Despite such incidences, TÜV Rheinland's revenues have been steadily growing in the subsequent years, what implies that their reputation was not strongly affected by the accusations (TÜV Rheinland AG, 2015, 2016, 2017).

[8] See Heras-Saizarbitoria and Boiral (2019); ISO (2017). ISO 17011 has been internationally harmonized and developed by the International Organization for Standardization (ISO). It describes how accreditation bodies should be organized and work.

performs accreditation" (ISO, 2017). This authority is typically derived from the government (ISO, 2017). It can also be derived from designation by private standard owners.[9] Accreditation is the attestation that a certifier is competent to assess firms' conformity with specific standards, typically based on ISO standards for certifiers. (ISO, 2017).[10] These standards are not very detailed, so accreditation bodies still have some discretion in their assessments of certifiers.[11] This is why this paper allows the quality of accreditation to vary between different bodies.

The state often regulates accreditation. In the European Union, each member state can only have one accreditation body appointed by the state.[12] For voluntary standards, private certification bodies are not prevented from seeking accreditation from non-European bodies.[13] Other advanced economies such as the USA allow activities of accreditation bodies that the state did not appoint even with-in the USA (NIST 2018).[14] Also, many emerging and developing countries, such as Argentina, India, and Kenya, do not regulate their accreditation markets a lot.[15] Stricter regulations, similar to Europe, apply, for example, in China and Colombia.[16][17] These varying regulations motivate analyzing

[9]This is, for example, the case for Assurance Services International, which sustainability standards such as Marine Stewardship Council designated as their sole accreditation body (Auld and Gulbrandsen, 2010; MSC, 2019).

[10]There are ISO standards for various types of certifiers, for example, ISO 17065 for certifiers of products, processes, and services, and ISO 17021 for certifiers of management systems. Accreditation attests to their competence by checking compliance with these standards. They include organizational requirements favoring impartiality and thoroughness in the certification process. For example, accredited certifiers and their subsidiaries must be independent of all companies involved in the value chain of certified products or processes (ISO, 2012).

[11]Standard ISO 17065:2012 has about 25 pages, ISO 17021 about 35.

[12]If certifiers in Europe want to get accredited by a European accreditation body, they must refer to the accreditation body of their headquarters' state (Reg. (EC) No 765/2008). If that accreditation body did not offer the required service, they could refer the certifier to the accreditation body appointed by another EU member state. The EU has taken measures against continued activities of other private accreditation bodies (European Commission, 2017; Ref. Ares, 2014).

[13]The British BSI Group, for example, is accredited by the US accreditation body ANAB (ANAB 2018). These accreditations will not be recognized by the European states (European Commission, 2014).

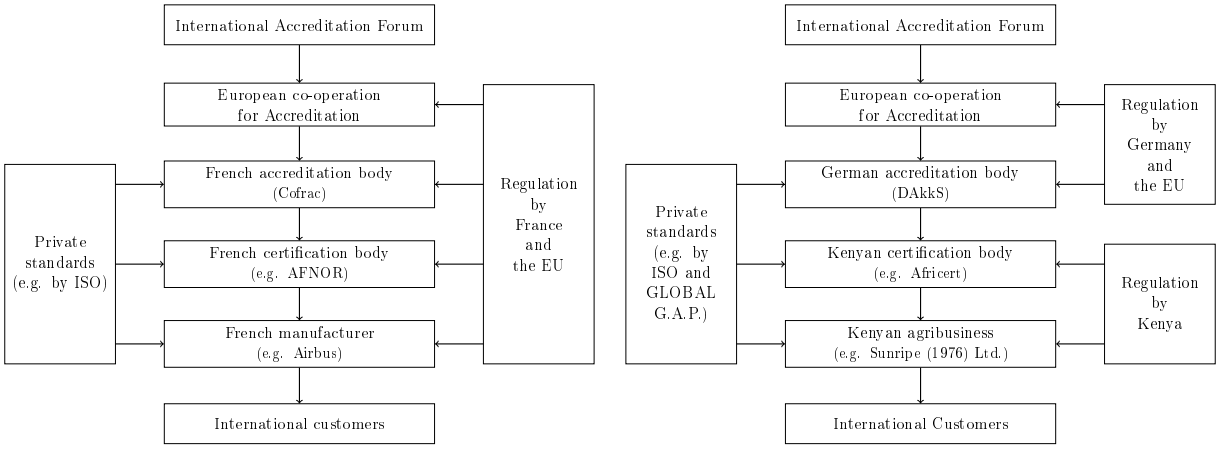
[14]Also, some private accreditation bodies specialized in particular standards and transnationally active are based in the USA, such as the International Organic Accreditation Service (IOAS). Such bodies build their credibility on their reputation and creation through NGOs but are also increasingly integrated with the international peer-evaluation system (IOAS, 2018).

[15]See AfriCert (2017); Competition Appellate Tribunal (2014); Eguino (2018).

[16]See CNAS (2012); UNIDO et al. (2017).

[17]What the accreditation bodies in most economies have in common is that they are created with the support of the state (Quality Council of India, 2015; UNIDO et al., 2017). An important reason for such cooperation is that accreditation activities are often not profitable in their first years of business but have positive externalities for the credibility of quality assurance and thus for the development of an economy (Eguino, 2018; UNIDO et al., 2017). Many states use accreditation bodies also to support the controls of public regulations (UNIDO et al., 2017). In the long term, many accreditation bodies try to become financially independent, as dependence on public resources can also affect their credibility

both the case of monopoly accreditation and competition among foreign and national accreditation bodies.



(a) In manufacturing in France with national accreditation **(b)** In agriculture in Kenya with foreign accreditation

Figure 1: Value chains of recognition, accreditation, certification and product sale

Notes: Downward arrows symbolize directions of supply of services or products, from the IAF "supplying" international recognition of a regional accreditation group to companies supplying products to their international customers. Arrows from the left symbolize the influence of private standards, arrows from the right the influence of public regulation.

Figure 1a serves as an illustration of the accreditation and certification system. It shows a typical case in advanced economies: The certified company (Airbus), the certifier (AFNOR), and the accreditation body (Cofrac) are all based in the same country.[18] In developing countries, certifiers are often accredited by foreign accreditation bodies as shown in Figure 1b: The German accreditation body DAkkS accredited the Kenyan certifier AfriCert to certify farms according to the GLOBALG.A.P. standard.

2.2 Motivating evidence: The role of internally recognized national accreditation bodies

In this section, I provide motivating evidence of the role of national accreditation bodies in increasing demand for certification, which might be related to increased credibility. I expect to see increased demand for *internationally recognized* certification not directly after establishing the accreditation body but after the international recognition of that body through peer review. In a peer review, accreditation bodies from other countries

negatively (UNIDO et al., 2017).

[18] See AFNOR Group (2018); Cofrac (2018).

check compliance with the ISO standard 17011 through regional or international associations, such as the European co-operation for Accreditation and the International Accreditation Forum in Figure 1.[19] In international trade, this likely increases the recognition of certifiers accredited by the peer-reviewed body. In the following, I test whether the international recognition of the Uruguayan accreditation body through peer review is associated with increased certification demand. Here, *certification demand* is the decision of companies to obtain internationally recognized certification, not the demand for products from certified companies.

2.2.1 Empirical specification

I use a difference-in-differences (DD) estimator, which compares changes in the certification status y_{ict} of companies affected by that recognition to changes in the certification status of companies unaffected by this recognition. I consider a Linear Probability Model with two-way fixed effects:

$$y_{ict} = \alpha_i + \beta Post_t + \delta \, Treated_i \times Post_t + \varepsilon_{it} \tag{1}$$

i indicates the company and t the period. $Treated$ is a dummy variable that is one if the company is located in Uruguay, the country whose accreditation body became internationally recognized through peer review in 2011 (International Accreditation Forum, 2018b). Since the international recognition affected all certifiers in Uruguay, it likely also affected all companies in Uruguay. The control group consists of companies located in Nicaragua, whose trend in certification is approximately parallel to that of Uruguay prior to 2011, as I show in the results from a placebo test comparing 2006 and 2010 in Table 3 in the Appendix. Both Nicaragua and Uruguay have had national accreditation bodies since the 1990s, but the international community has not peer-reviewed and recognized Nicaragua's accreditation body until today. $Post$ is a dummy that takes on the value one if the observation is from the period after 2011 and zero otherwise.

[19] Figure 4 in Appendix 8.2 shows the countries which have officially gained international or regional recognition in that way. Membership in a regional accreditation group, such as the African Accreditation Cooperation (AFRAC) or the European co-operation for Accreditation, facilitates the recognition of an accreditation body in the limited geographical scope of that organization. The International Accreditation Forum, in turn, reviews the regional groups. That review gives their members certain credibility, even internationally (IAF, 2018a; 2018b).

2.2.2 Data

I use panel data from the World Bank Enterprise Surveys, which are representative samples of private firms (World Bank, 2017). The survey covers Nicaraguan firms in 2006, 2010, and 2016 and Uruguayan firms in 2006, 2010 and 2017. I use 2016/2017 as the period after the treatment, 2010 as the period prior to the treatment, and 2006 to test for a parallel trend from 2006 to 2010 in Table 3. Table 2 in the Appendix shows descriptive statistics of the data. The table illustrates that the difference in the share of firms with internationally recognized certification between Nicaragua and Uruguay changed after the treatment, but the differences in other observables did not change much.

2.2.3 Results and discussion

Table 1 presents the main results. Column (1) follows specification 1, and column (2) additionally controls for two company-level variables: the percentage of the firm owned by private domestic individuals, companies, or organizations; and the years of experience in the company's sector the top manager has. The reported standard errors are robust to heteroskedasticity. Both specifications result in a positive DD estimate that is significant at a 1% significance level. The international recognition of the Uruguayan accreditation body is associated with a 21 percentage point increase in the likelihood that a company in Uruguay has internationally recognized certification, compared to Nicaragua.

These results suggest that the international recognition of the Uruguayan accreditation body positively affected the likelihood of Uruguayan companies being certified. If companies choose certification rationally and under the common trend assumption, this points to an increased net benefit of certification for companies due to the availability of internationally recognized accreditation at a reduced cost through a national accreditation body. This increase might be due to risen credibility of certification by certifiers previously not accredited by an internationally recognized accreditation body or due to the reduced cost of certification by certifiers previously accredited by a foreign, more expensive accreditation body.

However, the result is only suggestive. Firstly, the small sample reduces reliability in the regression output. Secondly, the data for the post-treatment period come from two different years: 2016 for Nicaragua and 2017 for Uruguay. If many companies obtained

Table 1: Main results

	(1)	(2)
Treated x Post	0.210***	0.211***
	(3.89)	(3.89)
Post	-0.183***	-0.181***
	(-4.88)	(-4.78)
Constant	0.241***	0.295**
	(12.65)	(3.20)
Observations	464	464
Controls	No	Yes
Company FE	Yes	Yes
F-stat.	12.17***	6.18***

Notes: Estimates from regression of specification 1 in column (1), adding company controls in column (2) (percentage of domestic shareholders and the years of sector experience of the top manager). t statistics in parentheses, robust to heteroskedasticity. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

certification in 2017 for some reason, I overestimate the result. Thirdly, more favorable development in Uruguay compared to Nicaragua from 2010 to 2016/2017 in dimensions not caused by the treatment might explain the rise in certification demand. However, GDP per capita growth between 2010 and 2016 has been, on average, higher in Nicaragua than in Uruguay (World Bank, 2019).

3 The baseline model

The extensive-form game of my model is shown in Figure 2. Time is discrete. The horizon is infinite. There are three players.

The players are a buyer or a mass 1 of identical buyers, a supplier, and a certifier. The certifier is a monopolist.[20] Buyers are atomistic. The buyers and the certifier are long-lived players. The supplier is short-lived. All players are risk-neutral.

Remark. By assuming that the supplier is short-lived, I abstract from the case where the supplier can build a reputation. This assumption allows me to focus on the incentives of the certifier since it implies that the supplier cannot credibly signal quality without credible certification.

[20]This is a simplification of the theoretical insight that reputation mechanisms can only work if prices are above marginal cost (Darby and Karni, 1973) and the empirical observation that certification markets are oligopolistic: A few big players such as SGS and Bureau Veritas are dominant (Galland, 2017)

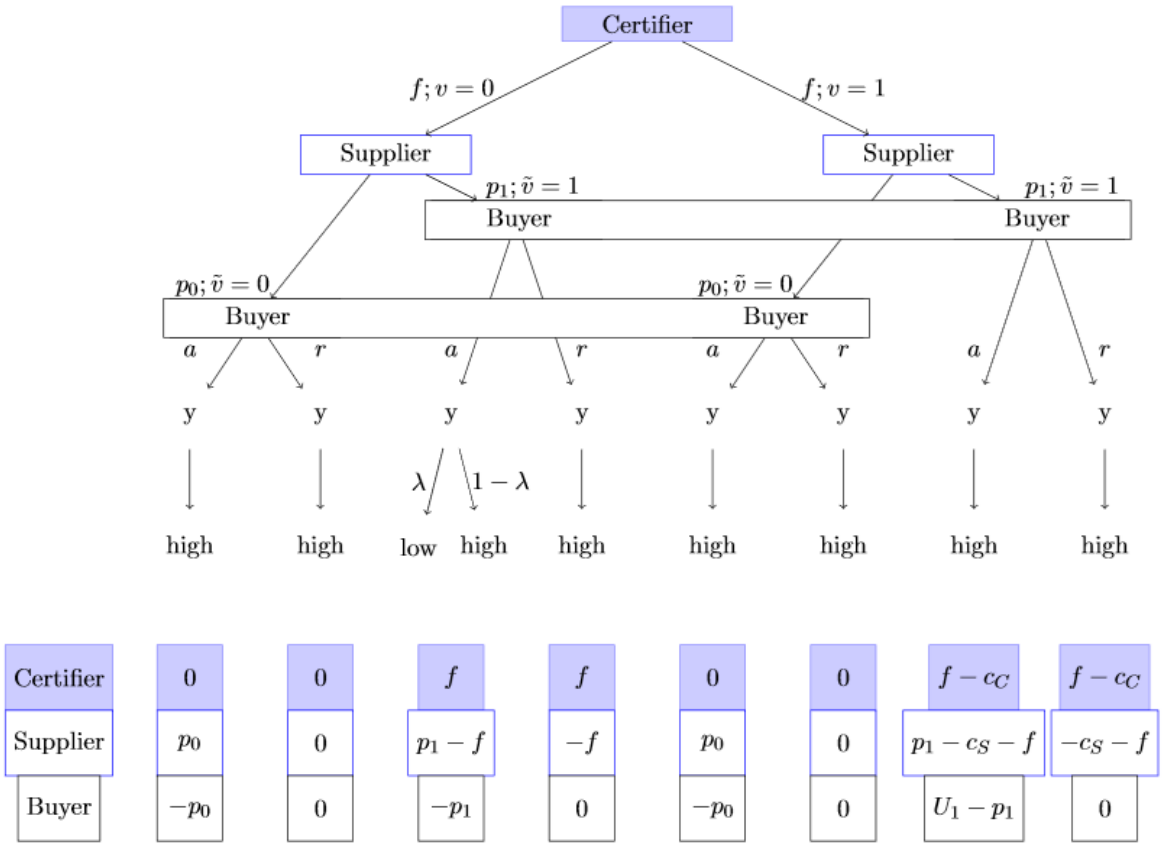


Figure 2: The baseline model

The action sets are the following: The certifier offers a certification contract (v, f). $f \in \mathbb{R}_+$ is the fee for which they certify the supplier. $v \in \{0, 1\}$ is the quality level that the certifier verifies. The certifier tells the public that the supplier has high quality 1 whenever their quality exceeds v.[21] In other words, the certifier grants a high-quality label $\tilde{v} = 1$. If $v = 1$, the certifier verifies that the supplier produces high quality. If $v = 0$, the certifier does not verify high quality and provides a fake certificate. The certifier's cost of monitoring a true quality level v is (vc_C), which is 0 if the certifier cheats and $c_C \in \mathbb{R}_{++}$ otherwise.[22] The supplier chooses if they accept or reject the certification

[21] Third-party certification is typically not a one-shot check if a producer complies with a standard. Rather, the certifier notes non-conformities and sets a time frame within which the producer has to correct those non-conformities (ISO, 2012, 2015a). Thus, compliance is rather a matter of moral hazard than adverse selection. In other words, I apply the empirical observation, and theoretical result of Lizzeri (1999) that certifiers usually do not publish rejected applications.

[22] These costs do not only include the cost of actual auditing but also the cost of acquiring and maintaining the competence and infrastructure which are needed to certify correctly.

contract. In other words, they choose a quality label $\tilde{v}$:

$$\tilde{v} = \begin{cases} 1 & \text{if the supplier accepts the certification contract} \\ 0 & \text{otherwise} \end{cases}$$

Accepting a certification contract (v, f) to obtain a high-quality label $\tilde{v} = 1$ requires investing in product quality v at cost (vc_S). This cost is 0 if the certifier cheats and $c_S \in \mathbb{R}_{++}$ otherwise. The supplier further chooses a price $p_{\tilde{v}} \in \mathbb{R}_+$ at which they offer a product of quality label $\tilde{v}$ to the buyers. The buyers accept or reject.

Remark. I assume that possible quality levels are exogenous and discrete not only for simplicity. It also allows focusing on the certification of quality standards which an independent standard-setting organization fixed and an individual company cannot influence.[23] Buyers may view the quality of complying with such a standard as binary: A company truly follows ISO 9001 or not, a product is Fairtrade or not.[24] This is also why I assume that the certifier only certifies high quality $\tilde{v} = 1$. The definition of the high-quality level as 1 is without loss of generality. Certification is always a positive signal; setting it at some level $\bar{v} > 0$ would not affect the qualitative results.

The players' information is as follows. At the end of each period $t \geq 1$, there is a public signal about honesty y: The signal can be high or low. The signal is always high if nobody cheats, i.e., if the supplier did not get certified or if the certifier's effort level was one:

$$\text{If } \tilde{v} = 0 \text{ or } v = 1, y = "high"$$

If the certifier cheats, the signal is sometimes high and sometimes low:

$$\text{If } v = 0 \text{ and } \tilde{v} = 1, y = \begin{cases} \text{"high" with probability } 1 - \lambda \\ \text{"low" with probability } \lambda \end{cases}$$

Thus, λ is the probability of detecting fraudulent certification or the level of public monitoring.

The game is common knowledge. Thus, all players know the history of public signals,

[23] See Appendix 8.1, Figure 3 for a complete overview of standard setters. I focus here on large standard-setting organizations where an individual company has little influence on the standard.

[24] Unless due to intrinsic motivation, the supplier has no incentive to comply only with some Fairtrade criteria since this does not lead to certification and price premia.

the players, the action sets, the information sets, the timing, and the payoffs (see below). The certifier and the supplier observe all actions chosen. The buyers observe the quality label $\tilde{v}$, not the certification contract (v, f). Thus, the buyers do not observe whether the certifier cheats or not. They also do not observe their stage payoff.

The Timing of the stage game is:

Stage 1: The certifier offers a certification contract (v, f).

Stage 2: The supplier accepts or rejects the certification contract (choose quality label $\tilde{v}$) and offers the product at a price $p_{\tilde{v}}$ to the buyers.

Stage 3: The buyers purchase the product or not.

The payoffs of each stage game are as follows.

The valuation of the buyers is

$$U_v = \begin{cases} U_1 > c_S + c_C & \text{if } v = 1 \\ U_0 = 0 & \text{if } v = 0 \end{cases}$$

Thus, the buyers obtain a surplus S_B from buying a product of quality v at price $p_{\tilde{v}}$:

$$S_B = U_v - p_{\tilde{v}}$$

Remark. The most straightforward way is to see the buyers as final consumers who draw utility U_v from the true quality v, not the quality label $\tilde{v}$. The idea is that the true quality affects the buyers' well-being but that the buyers cannot attribute this effect to the product. One can think of long-term health or environmental impacts that affect well-being through the aggregate level of environmental protection. Alternatively, the buyers could also be firms that obtain an unaccounted benefit U_v if their supplier has implemented a meta-standard. The most widespread meta-standards are the ISO 9000 management system standards. One objective of these standards is to increase the effectiveness of firms, both in product and service quality (ISO, 2015b). Implementing such a management system can facilitate interaction with buyers and increase the profits from that interaction in the long term. The buyers cannot always directly observe such benefits in a given period and may later be unable to attribute it to the certification. [25]

[25] It is also possible to extend the model to account for a retailer with a long-term relationship with final consumers. However, this would require the model to be adapted so that the retailer gains some profit which they would lose if they lost their customers. Alternatively, I would need to assume that they are honest and, to some extent, altruistic: Then they would disvalue a low-quality product through

The supplier obtains a surplus S_S from selling a product with quality label $\tilde{v}$ at price $p_{\tilde{v}}$:

$$S_S = \begin{cases} p_{\tilde{v}} & \text{if } \tilde{v} = 0 \\ p_{\tilde{v}} - vc_S - f & \text{if } \tilde{v} = 1 \text{ under certification contract } (v, f) \end{cases}$$

The certifier obtains a surplus S_C from a contract (v, f):

$$S_C = f - (vc_C)$$

The long-time payoffs of the certifier and the buyers are the discounted sums of the expectation of stage game payoffs for infinitely many periods. Their common discount factor is $\delta \in [0, 1]$.

As a tiebreaking rule, I assume that all players prefer high quality: In case two actions or strategies lead to the same payoff, each player favors the action or strategy that leads to an equilibrium that ensures high quality.

Social optimum Assume a utilitarian social planner can determine all actions. The total welfare W in each stage game is

$$W = S_B + S_S + S_C = U_v - v(c_S + c_C) = \begin{cases} U_1 - (c_S + c_C) > 0 & \text{if } v = 1 \\ 0 & \text{if } v = 0 \end{cases} \tag{2}$$

Recall that the action sets do not contain the possibility that the supplier provides high quality without certification. In other words, it is not possible that $v = 1$ and $\tilde{v} = 0$ simultaneously. I assume that as a shortcut to account ex-ante for the fact that the short-lived supplier would never have the incentive to play these actions. If they would, this would have been the first best since it would give welfare $W = U_1 - c_S$.

Assuming this is impossible, the social planner's solution to the remaining problem is to induce certification and a truly high-quality level ($v = 1$) in each period $t \geq 1$. Thus, without accreditation, the social planner's (second best) solution is achieved by any "High-Quality Equilibrium" defined as follows:

Definition 1. *Any equilibrium in which the true quality level is $v = 1$ in each period $t \geq 1$ is a "High-Quality Equilibrium."*

observing negative effects on their customers in the long run (see Kitzmueller and Shimshack (2012) on the role of intrinsically motivated agents in businesses).

Throughout the paper, I illustrate the model and results with the same numerical specification, separate from the general results:

Illustration. Assume that the buyers' valuation equals the true quality of the product $U_v = v$ and that $c_S = c_C = \frac{1}{4}v^2$. Then, total welfare is

$$W = v - \frac{1}{4}v^2 - \frac{1}{4}v^2 = \begin{cases} \frac{1}{2} & \text{if } v = 1 \\ 0 & \text{if } v = 0 \end{cases}$$

□

Equilibrium I only look for public-perfect equilibria and restrict myself to subgame perfection. The focus on public-perfect equilibria means I do not consider any private strategies, i.e., strategies in which actions are taken conditional on private information (Mailath and Samuelson, 2006). This focus is justified in Appendix 8.3 in the proof of Lemma 2.

Without repeated interaction, the certifier has a dominant incentive to cheat. This incentive comes from two sources: First, verifying the true quality $v = 1$ would incur monitoring cost c_C. By cheating, the certifier saves these costs, a moral hazard problem. Second, cheating allows the certifier to extract a higher surplus from the supplier since the supplier saves the cost c_S, a form of corruption. Thus, in a one-shot game, a certifier can only lose from truthful certification:

Lemma 1. *No High-Quality Equilibrium exists in the one-period game.*

Proof. See Appendix 8.3.1. □

This result easily extends to any finite horizon. At the infinite horizon, the buyers can play the following grim trigger strategy: If there were only high signals in the past, they buy the product at any price $p_{\tilde{v}} \leq U_{\tilde{v}}$ for a product of quality label $\tilde{v}$. Otherwise, their willingness to pay is zero. This grim trigger strategy allows the buyers to enforce a High-Quality Equilibrium if the certifier's discount factor is significant enough:

Lemma 2. *If no accreditation is available, the buyers enforce a High-Quality Equilibrium if and only if*

$$\delta \geq \underline{\delta}_{NA} \equiv \frac{1}{\lambda(\frac{U_1}{\bar{c}} - 1) + 1} \tag{3}$$

where $\bar{c} = c_S + c_C$.

The discount factor threshold $\underline{\delta}_{NA}$ from Lemma 2 is the incentive compatibility threshold of the certifier without accreditation.

Proof. See Appendix 8.3.2. □

The interpretation of Lemma 2 is as follows: If the discount factor δ is lower than the incentive compatibility threshold $\underline{\delta}_{NA}$, the certifier is too "impatient" or uncertain about the future and prefers to obtain a higher profit today by cheating, even though this might lower future profit if they are detected. The incentive compatibility threshold decreases in λ, the probability of a low signal if the certifier cheats. In other words, if the signal quality increases, a lower level of patience or certainty of future profits is sufficient to prevent cheating. Thus, increasing public monitoring could facilitate the achievement of the social optimum.
$\underline{\delta}_{NA}$ also decreases the buyers' willingness to pay for high quality U_1. However, it is increasing in the certifier's and the supplier's cost $\bar{c}$ of providing true quality $v = 1$. This result implies that the higher the net value of true quality certification, the easier it can be achieved.

Illustration. In the numerical example, ($U_v = v$, $c_S = c_C = \frac{1}{4}v^2$), Lemma 2 implies that the buyers enforce a High-Quality Equilibrium if and only if $\delta \geq \frac{1}{\lambda+1}$. □

The following sections extend the model to see whether the buyers can enforce a High-Quality Equilibrium more often if the certifier can get accredited. I also analyze under which type of accreditation body welfare is maximized and whether the state should favor monopoly or competition.

4 Model: Accreditation and sophisticated buyers

This section extends the baseline model to account for the possibility of accreditation, assuming that buyers are sophisticated. *Sophisticated* means that they can judge the accreditation quality. Accreditation forces the certifier to have a certain minimum level of rigor, i.e., to invest at least a fraction of their monitoring cost. This investment lowers the profit the certifier gains from cheating, such that there are cases in which the buyers can only enforce the High-Quality Equilibrium under accreditation.

4.1 Monopoly accreditation

As in the baseline model, time is discrete, and the horizon is infinite. There are four players now.

An additional player enters the game: the accreditation body. The accreditation body faces no competition, is long-lived, and is risk neutral. I will first derive a general result and then distinguish three cases: The accreditation body can be (1) a national accreditation body that maximizes total national welfare (or is regulated to do so), (2) a foreign accreditation body that maximizes total welfare of their foreign country, or (3) a profit-maximizing accreditation body. The other players are the same as in the baseline model.

The action sets are extended in the following way: The accreditation body offers an accreditation contract (β, g) where $g \in \mathbb{R}_+$ is the accreditation fee and $\beta \in [0, 1]$ is the fraction of the certifier's monitoring cost c_C whose investment the accreditation body ensures. This specification reflects that accreditation bodies only inspect a sample of certifiers' activities and can thus only ensure competent certification for a fraction of the certifier's activity. I call β the accreditation quality since the effect of accreditation is increasing in β, as we will see. The certifier chooses whether to get accredited or not. The rest of the certifier's action set stays the same. The action sets of the supplier and the buyers stay the same.

The players' information stays the same, except that they have some additional information: All players observe the type of the accreditation body, the accreditation contract (β, g), and whether the certifier gets accredited or not. Throughout this section, this also holds for the buyers. I call the buyers *sophisticated buyers* whenever this information is relevant.

Definition 2. *A "sophisticated buyer" knows the game, the type of the accreditation body, the accreditation contract (β, g), and whether the certifier gets accredited or not.*

The accreditation body has complete information.

The timing is as follows: Before the repeated interaction starts, the accreditation body chooses the accreditation fee g and the quality of accreditation β. Then, each stage game only changes in stage 1:

Stage 1: The certifier chooses to get accredited or not and offers a certification contract

(v, f).

Stage 2: The supplier accepts or rejects the certification contract and offers to sell the product at price $p_{\tilde{v}}$.

Stage 3: The buyers accept or reject.

The payoffs of each stage game are as follows. The surplus of the buyers S_B and the surplus of the supplier S_S from trading a product of quality v at a price $p_{\tilde{v}}$ stay the same as in the baseline model. The certifier's surplus is:

$$S_C = \begin{cases} f - (vc_C) & \text{if they are not accredited} \\ f - \beta c_C - g - v(1-\beta)c_C & \text{if they are accredited} \end{cases}$$

The interpretation follows: Once the certifier gets accredited, they must invest βc_C. The decision to monitor high quality $v = 1$ only determines whether they incur the additional monitoring cost $(1-\beta)c_C$.

The accreditation body incurs a cost $\left(\frac{(\beta c_C)^2}{2} + K + t\right)$, where $t \in \mathbb{R}_+$ are the transportation cost and $K \in \mathbb{R}_+$ are the fixed establishment of the cost for each accreditation body.[26] $\frac{(\beta c_C)^2}{2}$ are the actual monitoring cost of accreditation. They are an increasing, convex function of the quality of accreditation β.[27] The surplus of the accreditation body, S_A, is then:

$$S_A = g - \left(\frac{(\beta c_C)^2}{2} + K + t\right)$$

The long-time payoffs of the accreditation body, the certifier, and the buyers are the discounted sums of the expectation of stage game payoffs for infinitely many stage games. Their common discount factor is δ. I assume the same tiebreaking rule as in the baseline model.

[26] The role of these variable will be clarified in sections 4.1.1 and 4.1.2. Since I have only one certifier per country in the model, the fact that K is a fixed cost does not play a role. It will, however, play a role when I introduce international trade of accreditation in section 4.1.2.

[27] The convexity of the monitoring cost of accreditation is justified by the fact that βc_C captures the accreditation quality. While the cost of checking a small fraction of the certifier's cost c_C, such as basic infrastructure and qualifications, the cost increase with a rising slope when it comes to checking not easily observable effort cost such as rigorousness in audits.

Social optimum Assume a utilitarian social planner determines all actions played. In each stage game, total welfare $W = S_B + S_S + S_C + S_A$ and thus

$$W = \begin{cases} U_1 - (\bar{c} + K) > 0 & \text{if v=1 \& the certifier is not accredited} \\ -K & \text{if v=0 \& the certifier is not accredited} \\ U_1 - (\bar{c} + \frac{(\beta c_C)^2}{2} + K + t) & \text{if v=1 \& the certifier is accredited} \\ -(\frac{(\beta c_C)^2}{2} + K + t) & \text{if v=0 \& the certifier is accredited} \end{cases} \tag{4}$$

where $\bar{c} = c_S + c_C$. The entrance of an accreditation body creates an establishment cost of K even if the certifier does not demand the body's services. I make the following assumption:

Assumption 1. *Any High-Quality Equilibrium yields strictly positive social welfare:*

$$U_1 - \left(\bar{c} + \frac{(\beta c_C)^2}{2} + K + t\right) > 0 \quad \forall \beta \in [0, 1]$$

That suggests that the entrance of the accreditation body improves welfare if and only if buyers cannot achieve a High-Quality Equilibrium without accreditation but can do so with accreditation. I will specify this result further below.

Illustration. In my numerical example, the total welfare under the presence of a single accreditation body is

$$W = \begin{cases} \frac{1}{2} - K & \text{if } v = 1 \text{ and the certifier is not accredited} \\ -K & \text{if } v = 0 \text{ and the certifier is not accredited} \\ \frac{1}{2} - \left(\frac{\beta^2}{32} + K + t\right) & \text{if } v = 1 \text{ and the certifier is accredited} \\ -\left(\frac{\beta^2}{32} + K + t\right) & \text{if } v = 0 \text{ and the certifier is accredited} \end{cases} \tag{5}$$

Assumption 1 implies positive welfare in a High-Quality Equilibrium even for $\beta = 1$. In the numerical example, Assumption 1 can thus only hold if:

$$(K + t) < \frac{15}{32} \tag{6}$$

□

Equilibrium Throughout the analysis, I focus on the conditions under which the buyers can enforce a High-Quality Equilibrium by playing a grim trigger strategy since this is

the best possible strategy for the buyers, as shown in the baseline model. If the certifier never obtains accreditation, it is as if it is unavailable. Then, the buyers can enforce a High-Quality Equilibrium if and only if $\delta \geq \underline{\delta}_{NA}$, as shown in Lemma 2. If the certifier obtains accreditation, the incentive compatibility threshold changes:

Lemma 3. *If the certifier obtains accreditation in each period, the buyers can enforce a High-Quality Equilibrium if and only if*

$$\delta \geq \underline{\delta}_A \equiv \frac{1}{\lambda\left(\frac{U_1-\bar{c}-g}{\bar{c}-\beta c_C}\right)+1} \tag{7}$$

$\underline{\delta}_A$ is the incentive compatibility constraint when the certifier gets accredited in each period.

Proof. See Appendix 8.4.1. □

Recall that the buyers are sophisticated: they know the game, observe the accreditation contract (β, g), and whether the certifier obtains accreditation. This assumption implies that they know when truthful monitoring is incentive compatible. They can play a grim trigger strategy that forces the certifier to take the accreditation decision, which leads to a High-Quality Equilibrium if it exists:

Proposition 1. *If accreditation is available, sophisticated buyers enforce a High-Quality Equilibrium if and only if*

$$\delta \geq \min\{\underline{\delta}_A, \underline{\delta}_{NA}\} \tag{8}$$

Proof. See Appendix 8.4.2. □

Since accreditation is costly, it is only welfare improving if it enables a High-Quality Equilibrium that was not possible before:

Corollary 1. *Given sophisticated buyers, the entrance of an accreditation body improves welfare if and only if $\underline{\delta}_{NA} > \delta \geq \underline{\delta}_A$.*

A necessary condition for that is $\underline{\delta}_{NA} > \underline{\delta}_A$. This is equivalent to

$$g < \frac{\beta c_C(U_1 - \bar{c})}{\bar{c}} \tag{9}$$

This corollary shows that accreditation can only be welfare-improving if two conditions hold: The quality of accreditation β must be high enough. The accreditation fee g must be low enough. Thus, the choice of these variables is crucial. It is likely to vary with the objective of the accreditation body. In the following, I analyze the choices of different accreditation bodies and compare the effects.

Illustration. In my numerical example, $\underline{\delta}_A$, the threshold for enforceability of a High-Quality Equilibrium from Lemma 3 becomes the following:

$$\underline{\delta}_A = \frac{1}{\lambda\left(\frac{1-2g}{1-\beta/2}\right)+1} \tag{10}$$

Then, $\underline{\delta}_{NA} > \underline{\delta}_A$ requires $g < \frac{\beta}{4}$ □

4.1.1 National welfare maximizing accreditation body

In this section, I assume that the only available accreditation body is a national accreditation body (denoted by subscript n). I assume that a national accreditation body offers an accreditation contract (β_n, g_n), which maximizes national welfare, where g_n is the accreditation fee and β_n is the accreditation quality. Accreditation under a national accreditation body does not incur transportation costs, so $t = 0$. However, the economy bears the cost $K \in \mathbb{R}_+$ of establishing the national accreditation body. Consequently, the accreditation contract (β_n, g_n) is the solution to the optimization problem defined in the following.

Definition 3. *The optimization problem of a welfare-maximizing accreditation body is:*

$$\max_{\beta,g} U - \bar{c} - \frac{(\beta c_C)^2}{2} - K$$

such that the Break Even constraint of the accreditation body is satisfied

$$g - \frac{(\beta c_C)^2}{2} - K \geq 0$$

and such that the Incentive Constraint holds:

$$\delta \geq \frac{\bar{c} - \beta c_C}{\lambda(U - \bar{c} - g) + (\bar{c} - \beta c_C)} \iff g \leq U - \bar{c} - \frac{1-\delta}{\delta\lambda}(\bar{c} - \beta c_C)$$

Remark. For simplicity, I assume that all players reside in the same economy, i.e., contribute to national welfare. I will discuss this assumption and possible extensions in the conclusion.

The solution to the problem in Definition 3 is $(\beta_n, g_n) = (K, 0)$, whenever the accreditation body cannot achieve a welfare-improving contract (see Appendix 8.4.3). The condition and solution for the case where it can improve welfare are as follows:

Proposition 2. *Under sophisticated buyers, the entrance of the national accreditation body improves welfare, if and only if (A1)*

$$\delta < \underline{\delta}_{NA} = \frac{1}{\lambda\left(\frac{U_1}{\bar{c}} - 1\right) + 1} \tag{11}$$

and (A2)

$$\delta \geq min\left\{\frac{1}{\lambda c_C + 1}; \frac{1}{\lambda \frac{1}{c_S}\left(U_1 - \bar{c} - \frac{c_C^2}{2} - K\right) + 1}\right\} \tag{12}$$

The accreditation contract is then (β_n, g_n) *where*

$$\beta_n = \frac{1-\delta}{\delta\lambda c_C} - \frac{1}{c_C}\sqrt{2\left(U_1 - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c}\right) + \left(\frac{1-\delta}{\delta\lambda}\right)^2} \tag{13}$$

and

$$g_n = \frac{(\beta_n c_C)^2}{2} + K \tag{14}$$

Proof. See Appendix 8.4.3. □

This proposition covers a particular case of Corollary 1. It is the best case of the corollary since it shows under which conditions a welfare-maximizing accreditation body can provide the conditions for a High-Quality Equilibrium when buyers cannot achieve it without accreditation. Assumption (A1) is simply the condition that a High-Quality Equilibrium cannot be achieved without accreditation. Assumption (A2) is needed so that an accreditation body can provide the conditions for a High-Quality Equilibrium. Note that a necessary condition for the combination of (A1) and (A2) is:

$$\frac{U_1}{\bar{c}} - 1 < \max\{c_C; \frac{1}{c_S}(U_1 - \bar{c} - \frac{c_C^2}{2} - K)\} \tag{15}$$

The interpretation is as follows: The establishment of the accreditation body can only be welfare improving if either the certifier's monitoring cost c_C are high enough, or if otherwise the buyers' valuation U_1 is high enough, but if the cost of the supplier c_S and the establishment cost of the accreditation body K are low enough. If the monitoring cost c_C is high, the cost saved by cheating would be high without accreditation but are much smaller under accreditation due to the sunk fraction $\beta_n c_C$. If the certifier's monitoring cost c_C is low, the effect of accreditation can still be sufficiently high if its establishment is not too costly and its net benefit high enough.

Illustration. In my numerical example, the necessary condition (15) translates into: $1 < \max\{\frac{1}{4}; \frac{15}{8} - 4K)\} \iff K < \frac{7}{32}$. Note that this condition also implies that welfare under a High-Quality Equilibrium and a national accreditation body is strictly positive (compare condition (6) in the Illustration of Assumption 1). To make the illustration more concrete, I assume that $\lambda = \frac{1}{10}$. That means I assume one out of ten fraudulent certificates is detected. Then, assumption (A1) in Proposition 2 ($\delta < \underline{\delta}_{NA}$) implies that $\delta < \frac{10}{11}$. Assumption (A2) implies that $\delta \geq \frac{80}{95-32K}$. Assume $K = \frac{1}{8}$ (such that condition (15) is satisfied, then (A1) and (A2) require that $\delta \in [\frac{80}{91}, \frac{10}{11})]$. $\delta = \frac{19}{22}$ would satisfy this requirement, for example. The lower K, the larger the interval of discount factors under which accreditation is welfare improving. Given the above assumptions, the optimal quality of accreditation $\beta_n \approx 0.781$, according to Proposition 2. The welfare gain through accreditation is then $\frac{1}{2} - \frac{\beta_n^2}{2} - \frac{1}{8} \approx 0.356$, since welfare would be zero without accreditation, since $\delta < \underline{\delta}_{NA}$. □

The illustration shows that the margin at which accreditation improves welfare might be smaller than expected. However, rigorous calibration and empirical testing of the model would be necessary to obtain a precise idea. Moreover, the model so far does not take into account scale effects. Scale effects will lower the participation of each accreditation fee to the overall establishment cost of K, and, as noted above, lower accreditation fees will make the case of welfare-improving accreditation more frequent.

Note that the optimal quality of accreditation β_n is decreasing in the buyers' valuation of high quality U_1, increasing in the establishment cost K as well as the supplier's and the certifier's cost of high quality c_S and c_C (and thus also $\bar{c}$). The larger the buyers' valuation of high quality and the lower the cost of high quality, the closer we are to the case

where the High-Quality Equilibrium is enforced even without accreditation. Proposition 2 further implies:

Corollary 2. *If the entrance of a national accreditation body improves welfare, the optimal quality of accreditation β_n decreases in the level of public monitoring λ and the discount factor δ.*

Proof. See Appendix 8.4.4 □

The interpretation is as follows: The level of public monitoring and accreditation are imperfect substitutes. If λ goes up, i.e., if a higher fraction of cheating certifiers are detected, the threat of punishment for cheating increases. Hence, it relaxes the Incentive Constraint and, thus, the required accreditation quality to deter cheating. The same holds for the discount factor: A very long-lived or more patient certifier will disvalue the long-term threat of punishment more than a relatively short-lived or impatient certifier. A welfare-maximizing accreditation body can anticipate that and decrease the quality of accreditation β_n to save cost while still achieving the High-Quality Equilibrium.

4.1.2 Foreign welfare maximizing accreditation body

In this section, I assume that the entrance of a national accreditation body would be welfare-improving according to Proposition 2, but that the only available accreditation body is a foreign accreditation body. A foreign accreditation body is the national accreditation body of another country. The case of a foreign accreditation body is important since many small and developing countries do not have accreditation bodies but instead rely on foreign bodies.[28] This section will show under which conditions this is well-advised.

I make the following assumption:

[28]The Kenyan certifier AfriCert, for example, is accredited by the German accreditation body DAkkS to certify farms according to the GLOBALG.A.P. standard, as Figure 1b illustrates. AfriCert has become one of the dominant players in agricultural certification in Sub-Sahara Africa (AfriCert, 2017; Fletcher, 2011). The German development agency GIZ supported their establishment, arguing that local certification would be more affordable and accessible for small-scale farmers than certification by international companies (Fletcher, 2011; Pannhausen and Untied, 2010). In the first years of its establishment and accreditation, AfriCert was not financially viable, but in 2012, it provided its investors with an internal rate of return of more than 30% (Fletcher, 2011).

Assumption 2. *If a foreign accreditation body is the only available accreditation body in a given country, they offer an accreditation contract*

$$(\beta_f, g_f) = \left(\beta_f, \frac{(\beta_f c_C)^2}{2} + t\right)$$

where β_f is the solution to the welfare maximization problem from Definition 3 under the parameters $U_v = U_{vf} \in \mathbb{R}_+$, $c_C = c_{Cf} \in \mathbb{R}_+$, $c_S = c_{Sf} \in \mathbb{R}_+$, $\delta = \delta_f \in [0,1]$, $\lambda = \lambda_f \in [0,1]$ and $K = K_f$. $g_f \in \mathbb{R}_+$ is the accreditation fee and $t \in \mathbb{R}_+$ are the transportation cost.

This assumption implies that the foreign accreditation body sets the quality of accreditation β_f by solving the same optimization problem as the national accreditation body but based on the data of their country of origin. It further means that the foreign accreditation body keeps the accreditation quality β_f constant when providing accreditation abroad.[29] I make this assumption due to empirical indications that national accreditation bodies typically follow the same regulations when accrediting abroad.[30]

Assumption 2 also implies that the foreign accreditation body still prices at cost when providing services cross-country by adapting the accreditation fee by accounting for c_C. Pricing at a cost even abroad is common practice among national accreditation bodies.[31]. However, I assume that the economy in which the foreign accreditation body resides already paid the fixed establishment cost of K. I do so because national accreditation bodies are usually established to break even without providing service abroad and typically do so only after years of experience at home. Providing services abroad incurs transportation costs of t instead.

I assume that the existence of the foreign accreditation body in its home country is welfare improving.[32] Then, Proposition 2 and Assumption 2 imply that

$$\beta_f = \frac{1-\delta_f}{\delta_f \lambda_f c_{Cf}} - \frac{1}{c_C f}\sqrt{2\left(U_{1f} - \bar{c}_f - \frac{1-\delta_f}{\delta_f \lambda_f}\bar{c}_f - K_f\right) + \left(\frac{1-\delta_f}{\delta_f \lambda_f}\right)^2} \tag{16}$$

[29] A corresponding case is national accreditation bodies created for the accreditation of certification of ISO standards, but later competing with the international accreditation body IOAS in the accreditation of certification of organic products.

[30] See, for example, the regulations of the Dutch Accreditation Council (RvA) (2013).

[31] This is, for example, the case for the German and the Dutch accreditation body Dutch Accreditation Council (RvA) (2013); Kirmes (2019)

[32] Otherwise, the existence of that body would not be socially desirable

The home country of the foreign accreditation body can be a more advanced economy (denoted by subscript a) or a more developing country (denoted by subscript d).[33] I make the following assumptions:

Assumption 3. .

(1) $c_{Cd} > c_C > c_{Ca}$ *(2)* $c_{Sd} \geq cS \geq c_{Sa}$ *(3)* $U_{vd} \leq U_v \leq U_{va}$

(4) $\lambda_d \leq \lambda \leq \lambda_a$ *(5)* $\delta_d \leq \delta \leq \delta_a$ *(6)* $K_d \geq K \geq K_a$

This assumption should be understood as follows. Assumption 3 (1) means that the certifier's cost of effectively monitoring the supplier (c_C) is lower in more advanced economies and higher in more developing countries, for example, due to the use of technology such as satellite imagery, but also due to institutional embeddedness and infrastructure. Assumption 3 (2) implies that truthful implementation of high quality is less costly in a more advanced economy and costlier in more developing economies. I expect this to be the case since products in more advanced economies are already of higher quality on average. Also, many compulsory quality standards in advanced economies, such as CE Marking in the EU, are still voluntary in developing countries. Assumption 3 (3) is made since most international quality standards are more known in advanced economies than in developing economies (UNIDO et al., 2017). Hence, buyers' valuation for them is likely to be higher in advanced economies than in developing economies. Moreover, higher wealth in advanced economies likely leads to higher ability and, thus, higher willingness to pay for high quality. Assumption 3 (4) means that the level of public monitoring in developing countries is likely lower than in advanced economies. A lower level of monitoring implies that the probability of detecting fraudulent certification is lower. There are many indications for that: developing countries are, on average, faced with lower freedom of the press, lower internet connectivity, lower resources for NGOs, state investigations, media, and research, higher levels of corruption, and lower levels of education than advanced economies.[34] Assumption 3 (5) says that certifiers and buyers are less patient or long-lived in developing countries than in more advanced economies. I assume that for two reasons: First, financial constraints typically reduce companies' and individuals' patience. Second, developing countries are, on average, faced with more political instability and a lower level of the rule of law than advanced economies

[33] A proxy for being more advanced or more developing can be income per capita.

[34] See Auriol and Picard (2006); Freedom House (2017a,b); Hanushek and Wößmann (2007); Olken and Pande (2012); Transparency International (2018)

(Institute for Economics and Peace, 2019; World Justice Project, 2019). Assumption 3 (6) means that establishing an accreditation body is more costly for developing than for more advanced economies. I assume that since establishing an accreditation body requires specialized expertise, more developing countries often have to fly in from abroad (UNIDO et al., 2017).

The following result is immediate:

Proposition 3. *Under the assumptions of Proposition 2, Assumption 2 and 3, the optimal quality of accreditation decreases with an economy's development:*

$$\beta_d \geq \beta \geq \beta_a \tag{17}$$

Where β is the optimal quality of accreditation in the reference country, β_d is the optimal quality of accreditation in a more developing economy, and β_a is the optimal quality of accreditation in a more advanced economy.

This proposition does not align with the widespread impression that accreditation bodies from developing countries are less rigorous. Indeed, the actual accreditation quality is likely weaker than the optimal level due to capacity constraints. Political economy and industrial policies also play an essential role and can lead to non-welfare maximizing accreditation regulation. Therefore, I will not continue the interpretation by distinguishing between a foreign accreditation body from a more developing or advanced economy. Instead, I will distinguish between a foreign accreditation body with a higher or a lower accreditation quality β_f. Nevertheless, the above analysis has illustrated that it is far from certain that accreditation bodies from more advanced economies have a higher quality of accreditation. Even though the precise determination of an optimal accreditation quality β seems far from reality, I expect that a benevolent regulator or accreditation body manager is aware of some of the issues I mentioned in the context of Assumption 3. Hence, it is not unreasonable to expect them to audit certifiers more carefully than accreditation bodies from advanced economies would do.

Replacing a national accreditation body with a foreign accreditation body affects the outcome. Recall that the quality of accreditation β_n is the minimum β for which the Incentive Constraint of the certifier is satisfied. Thus, the Incentive Constraint will no longer be satisfied under a foreign accreditation body with a lower accreditation quality.

Suppose the quality of accreditation β_f of the foreign accreditation body is higher than that of the national body. In that case, the Incentive Constraint is still satisfied if the difference between β_n is small enough. If β_f is too high, the cost will exceed the benefit, and the Incentive Constraint will no longer be satisfied.

Proposition 4. *Under Assumption 2 and sophisticated buyers, it is welfare-improving to let certifiers obtain accreditation with a foreign accreditation body rather than establishing a national accreditation body if and only if*
(1) the quality of accreditation of the foreign accreditation body β_f is at least as high as β_n, the optimal quality of the national accreditation body,
(2) $\beta_f \leq \frac{1-\delta}{\delta\lambda c_C} + \frac{1}{c_C}\sqrt{2(U - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} - K) + (\frac{1-\delta}{\delta\lambda})^2}$
(3) the establishment cost of a national accreditation body K is higher than the sum of the transport cost t and the additional variable accreditation cost $\frac{c_C^2}{2}(\beta_f^2 - \beta_n^2)$:

$$K \geq \frac{c_C^2}{2}(\beta_f^2 - \beta_n^2) + t \tag{18}$$

Proof. See Appendix 8.4.5 □

Thus, relying on a welfare-maximizing accreditation body of a similar economy (with a similar quality of accreditation) can be welfare-improving if the establishment cost of a national accreditation body K is high enough, transportation cost t low enough, and the quality of accreditation of the foreign body is not lower but not too high either. If the economy cannot find a foreign accreditation body satisfying these conditions, it should establish its own national accreditation body.
Proposition 4 thus explains why some small countries have cooperation agreements with other countries to use their accreditation services UNIDO et al. (2017). Other countries have formed regional accreditation groups, such as the Southern African Development Community Accreditation Service (SADCAS) and the CARICOM Regional Organisation for Standards and Quality in the Caribbean (CROSQ, 2014; UNIDO et al., 2017).

4.1.3 Profit maximizing accreditation body

I now assume that the only available accreditation body is profit maximizing. Such accreditation bodies exist but are usually not internationally recognized (International

Accreditation Forum, 2018a).[35]

I assume the profit-maximizing accreditation body faces the same cost function as the national accreditation body but chooses the accreditation quality β_p to maximize profit. Given sophisticated buyers, the profit-maximizing accreditation body must still satisfy the Incentive Constraint. Otherwise, the buyers would not accept to buy a certified product ($\tilde{v} = 1$) at a positive price $p_{\tilde{v}} > 0$ if the certifier is accredited, such that the certifier would not demand accreditation.[36]

Thus, the profit-maximizing accreditation body's problem is:

$$\max_{\beta,g} g - \frac{(\beta c_C)^2}{2} - K \tag{19}$$

s.t. the Individual Rationality constraint of the certifier

$$U - \bar{c} - g \geq 0 \tag{20}$$

and s.t. the Incentive Constraint holds:

$$g \leq U - \bar{c} - \frac{1-\delta}{\delta\lambda}(\bar{c} - \beta_p c_C) \tag{21}$$

Note that under the Incentive Constraint, the Individual Rationality constraint of the certifier is slack. The solution to the problem is:

$$\beta_p = \min\left\{\frac{1-\delta}{\delta\lambda c_C}; 1\right\} \tag{22}$$

$$g_p = \min\left\{U - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} + \left(\frac{1-\delta}{\delta\lambda}\right)^2; U - \bar{c} - \frac{1-\delta}{\delta\lambda}c_S\right\} \tag{23}$$

where the subscript p denotes the solution as "profit-maximizing".

The profit maximizing accreditation body offers this contract (β_p, g_p) if and only if $g_p - \frac{(\beta_p c_C)^2}{2} - K \geq 0$. This is the case whenever assumption (A2) of Proposition 2 is given.[37]

This directly implies the following result:

Proposition 5. *Under sophisticated buyers, the entrance of a profit-maximizing accreditation*

[35] Heras-Saizarbitoria and Boiral (2019) describe the importance of such accreditation bodies in China.

[36] See the proof of Proposition 1.

[37] Compare conditions 33 and 39 in the proof of Proposition 2 in Appendix 8.4.3.

body improves welfare, whenever the entrance of a national accreditation body would have been welfare improving (according to Proposition 2), but does not occur.

Note that the profit-maximizing accreditation body always offers a quality of accreditation β_p that is at least as high as the quality β_n, which a national accreditation body would offer under the assumptions of Proposition 2. Whenever $\beta_n < \beta_p$, the cost of accreditation under the profit-maximizing accreditation body is higher. In these cases, welfare under the profit-maximizing accreditation body is lower than under a national body.

Illustration. Under the assumptions I made in my numerical example, entering a national accreditation body would improve welfare and yield a total welfare of $W \approx 0.356$. If there were no national accreditation body, but only a profit-maximizing one, total welfare would be lower: The profit maximizing accreditation body sets $\beta_p = \min\left\{\frac{1-\delta}{\delta\lambda c_C}; 1\right\} = \min\left\{\frac{120}{19}; 1\right\} = 1$. Hence, total welfare is $\frac{11}{32} \approx 0.344$. The welfare loss is 0.012.
As an extension of the model, I could think about the possibility that a profit-maximizing accreditation body is more efficient so that, for example, their establishment cost of K is lower than those of the national body. Then using a profit-maximizing instead of a welfare-maximizing accreditation body might increase welfare. □

4.2 Accreditation competition

So far, I assumed that only one accreditation body could offer its services in the model's economy. In this section, I analyze how the above results would change if there were competition among different accreditation bodies.

4.2.1 Foreign versus national welfare maximizing

Assume we are in the case that the entrance of a national accreditation body is welfare improving according to Proposition 2.[38] Recall that sophisticated buyers will not accept accreditation that does not induce incentive compatibility of a High-Quality Equilibrium. If the foreign accreditation quality β_f is instead such that the buyers can enforce a High-Quality Equilibrium, they accept both foreign and national accreditation. This result corresponds to conditions (1) and (2) in Proposition 4. The certifier then chooses the

[38] Otherwise, no accreditation body can improve welfare since the national accreditation body sets the optimal quality of accreditation.

accreditation body with the lower fee. This is the foreign accreditation body if and only if

$$\frac{\beta_n^2 c_C^2}{2} + K \geq \frac{\beta_f^2 c_C^2}{2} + t \tag{24}$$

This condition corresponds to condition (3) in Proposition 4. Under these conditions, there is no demand for accreditation from the national body, and the establishment costs K of the national body are sunk costs. Thus, welfare would be higher if the national body did not exist in the first place, as in Proposition 4.

In any other case, there is no demand for foreign accreditation. In all cases, society is better off under monopoly accreditation, in some cases (Proposition 4) with a foreign accreditation body, and others with their own.

4.2.2 Profit maximizing versus welfare maximizing

When competing with a national accreditation body, the profit-maximizing body must also price at cost. Thus, the profit-maximizing body will set the same accreditation quality as the national body to satisfy the Incentive Constraint. The national and the profit-maximizing accreditation bodies' accreditation contracts are then identical. The buyers and the certifier are indifferent. Sophisticated buyers enforce a High-Quality Equilibrium if and only if they would have done so under monopoly accreditation.

However, total welfare is lower since society spends double the cost of establishing accreditation bodies. Thus, society is better off with monopoly accreditation under a national or foreign accreditation body, according to Proposition 4.

If welfare-maximizing accreditation bodies did not exist, total welfare might be higher under the competition of two profit-maximizing accreditation bodies than under a monopoly profit-maximizing accreditation body.

5 Model: Accreditation and unsophisticated buyers

So far, I assumed that the buyers were sophisticated according to Definition 2. In most empirical cases, this assumption will not hold. It might be that some very institutionalized buyers spend many resources to understand the certification and accreditation market. They could then get an idea of the accreditation quality from different accreditation

bodies.[39] However, many such professional buyers do not have sufficient knowledge to distinguish between effective and ineffective certification and accreditation (Heras-Saizarbitoria and Boiral, 2019). Therefore, I will now relax the assumption of sophisticated buyers. Instead, I assume that the buyers are unsophisticated according to the following definition:

Definition 4. *Unsophisticated buyers know the game, except for the certifier's and the supplier's costs. They know the type of the accreditation body and whether the certifier gets accredited or not but do not observe the accreditation contract* (β, g).

With this definition, the analysis still focuses on a case in which the buyers have a good level of knowledge about certification, which is unlikely for final consumers, but more reasonable for institutionalized professional buyers.

The rest of the game stays the same as in the above sections. In the following, I will analyze how the above results change under unsophisticated buyers and how the state should intervene. The first result says that with unsophisticated buyers, Proposition 1 does no longer hold:

Proposition 6. *Even if accreditation is available, unsophisticated buyers enforce a High-Quality Equilibrium if and only if* $\delta \geq \underline{\delta}_{NA}$.

Proof. See Appendix 8.5.1. □

This proposition directly implies the following:

Corollary 3. *If buyers are unsophisticated and there is no regulation of the accreditation market, there is no demand for accreditation.*

Note that this holds even when demand for accreditation by a national accreditation body would improve welfare, in which case sophisticated buyers would demand accreditation. With unsophisticated buyers, a national accreditation body or the state establishing it has to make an effort to inform buyers about the effect of accreditation. In other words, they must educate unsophisticated buyers to transform them into sophisticated buyers. Such education does not necessarily need to be the state's responsibility. Industry associations, media, and accreditation bodies could also do it. Another option would be to make accreditation compulsory.

[39] This is a more plausible assumption if I extend the model such that the buyers are long-lived downstream firms that have to ensure a High-Quality Equilibrium to keep their reputation towards their consumers.

6 Model: Accreditation bias

So far, I have assumed that buyers are either sophisticated or unsophisticated (Definitions 2 and 4). Another critical case is when buyers cannot judge if accreditation is incentive compatible in a specific case but prefer accreditation. This preference can, for example, be due to a belief created by marketing or because governments in other countries have made accreditation compulsory. To be precise, I define such a bias as follows:

Definition 5. *"Buyers with accreditation bias" know the game, except the certifier's and the supplier's cost. They know the type of the accreditation body and whether the certifier gets accredited but do not observe the accreditation contract* (β, g)*. They believe that accreditation is always welfare improving, i.e., that* $\underline{\delta}_{NA} > \delta \geq \underline{\delta}_A$

The rest of the game stays the same as in the above sections. In the following, I analyze how the above results change under buyers with accreditation bias and how the state should intervene.

6.1 Monopoly accreditation

Lemma 4. *Buyers with accreditation bias enforce a High-Quality Equilibrium if and only if* $\delta \geq \underline{\delta}_A$.

Proof. See Appendix 8.6.1. □

Lemma 4 means that Proposition 1 does no longer hold. It further implies that the entrance of a national accreditation body is welfare-improving whenever $\delta \geq \underline{\delta}_A$. That means that Proposition 2 holds even if assumption (A1) in the proposition is not satisfied: Buyers with accreditation bias have no willingness to pay for certified products when the certifier is not accredited. Thus, total welfare is zero if no accreditation body is available. Hence, the entrance of the national accreditation body improves welfare whenever it induces the certifier not to cheat.

Proposition 4 still trivially holds: When transportation costs for a foreign accreditation body are much lower than the establishment cost of a national body, and if the foreign body is as effective as the national one, it is still better to invite their services instead of establishing a national body.

The outcome under a profit-maximizing accreditation body changes when buyers have accreditation bias:

Proposition 7. *Under a monopoly profit-maximizing accreditation body, buyers with accreditation bias cannot enforce a High-Quality Equilibrium whenever*

$$\delta < \min\{\underline{\delta}_{NA}; \frac{1}{\lambda 2(1-c_S)+1}\}$$

Proof. See Appendix 8.6.2. □

Note that Proposition 7 only establishes a sufficient condition for the non-existence of a High Equilibrium. In contrast, I could not derive a sufficient condition for the existence as in the previous sections. Proposition 7 implies that Proposition 5 does no longer apply:

Corollary 4. *With buyers with accreditation bias, the entrance of a profit-maximizing accreditation body does not always improve welfare when a national accreditation body would have improved welfare but did not enter.*

Consequently, a profit-maximizing accreditation is no longer a good replacement for a national accreditation body since the buyers' naive beliefs allow the profit-maximizing body to extract profit with zero-quality accreditation.

Illustration. Under the assumptions I made in my numerical example so far, the condition in Proposition 7 would come down to: $\delta < \min\{\frac{10}{11}; \frac{20}{23}\} = \frac{20}{23}$. Thus, the case under accreditation bias, where the entrance of a national body would improve welfare, but the entrance of a profit-maximizing body would not, is $\delta \in [\frac{80}{91}; \frac{20}{23}]$. The discount factor employed in the illustration so far ($\frac{19}{22}$) would satisfy this condition. □

6.2 Accreditation competition

Buyers with accreditation bias cannot distinguish accreditation bodies with a quality β which ensures a High-Quality Equilibrium from those with a lower quality. Thus, competition between a national accreditation body and a foreign accreditation body with lower quality and fees would prevent a High-Quality Equilibrium. It would then be welfare improving to prevent such accreditation bodies from offering their service in one's country.

If they compete, a profit-maximizing body can no longer set a higher accreditation fee than the national body. They solve the following problem:

$$\max_{\beta,g} g - \frac{(\beta c_C)^2}{2} \tag{25}$$

Such that the profit-maximizing accreditation body can compete with the national body:

$$g_p \leq g_n \tag{26}$$

Thus, the accreditation fee of the profit-maximizer is the same as the national body's fee g_n (defined in Proposition 2). Their accreditation quality β is zero. Their long-term profit is then

$$\sum_{t=0}^{\infty} \delta^t (1-\lambda)^t \left(g - \frac{(\beta c_C)^2}{2} \right) = \frac{g_n}{1-\delta(1-\lambda)} > 0 \tag{27}$$

Consequently, buyers cannot enforce the High-Quality Equilibrium whenever they can without accreditation, that is, if $\delta < \underline{\delta}_{NA}$. If that does not hold, the regulator should forbid competition with a profit-maximizing accreditation body or inform buyers sufficiently to eliminate their accreditation bias, at least for profit-maximizing accreditation bodies.

7 Discussion and Conclusion

This paper studied the effect of accreditation on the credibility of certification. I derived the conditions under which accreditation ensures certifiers' credibility by deterring fraud. The distinction between sophisticated, unsophisticated buyers and buyers with accreditation bias emphasized one fundamental condition: Buyers must be sufficiently informed to demand accreditation from certifiers, or accreditation must be compulsory.[40] That can explain why voluntary Business-to-Business and Business-to-Consumer standards are usually regulated differently. Accreditation of certifiers of voluntary Business-to-Business standards like the ISO 9000 management system standards is not compulsory. Instead, firms learn about accreditation, for example, through industry associations and consultants (Heras-Saizarbitoria and Boiral, 2019). Owners of Business-to-Consumer standards usually make accreditation of certifiers compulsory. An example is the Marine Stewardship

[40] See Corollary 3.

Council (MSC). Most consumers who buy products with the MSC label[41] do not know about accreditation. They typically do not even know who certifies the producer's compliance with the MSC standard. Imagine consumers learned about fraudulent MSC certification. Then, MSC would lose its reputation even if only one certifier cheated. By forcing the certifier to obtain accreditation, the MSC may prevent this from happening. To verify this mechanism, it would be helpful to extend my model to account for the role of standard owners. Moreover, adapting the model to allow for a mix of different buyer types would be useful. Especially for Business-to-Business standards, it is likely that some firms have enough insider knowledge to judge the quality of accreditation bodies while the majority have not. I could model this heterogeneity by allowing a fraction of sophisticated buyers among mostly unsophisticated buyers.

Such an extension would also allow better to evaluate the outcome under a profit-maximizing accreditation body. With sophisticated buyers, the model has shown that a profit-maximizer reduces fraud in the certification market whenever a welfare-maximizing accreditation body could do so but is not available.[42] If buyers naively trust in any accreditation, this result does not remain valid.[43] This can explain some of the certification fraud documented by Heras-Saizarbitoria and Boiral (2019) In future work, it would be interesting to analyze what fraction of sophisticated buyers is necessary to give accreditation bodies the right incentives. In any case, welfare is lower under a profit-maximizing accreditation body: If they deter the certifier from cheating, they do so with a higher accreditation quality than needed. Such excessive quality creates unnecessary social costs. The model thus explains that some countries have banned accreditation bodies not appointed by the state.[44] Where unappointed accreditation bodies are not banned, they usually operate as non-profits to be internally recognized (ISO, 2017). This situation may result from a mix of sophisticated buyers and buyers with accreditation bias: Sophisticated buyers might know that the presence of buyers with accreditation bias could incentivize for-profit bodies to cheat. This knowledge could decrease demand such that accreditation bodies prefer a non-profit status even when not state-regulated or altruistic.[45]

[41] See Figure 5 in Appendix 8.7.

[42] See Proposition 5.

[43] See Proposition 7.

[44] This is, for example, the case in the European Union (Reg. (EC) No 765/2008).

[45] Glaeser and Shleifer (2001) explain that even non-altruistic companies in a sector like accreditation may prefer to operate as non-profits since this gives them lower incentives to cheat and thus a better reputation among buyers.

I could improve the model also by allowing for buyers with heterogeneous private valuations. In addition, I might consider buyers as retailers with long-term relations to final consumers. Such an assumption would require adapting the model so that the retailer gains some profit which they would lose if they lost their reputation. The retailer would then observe the stage game payoff and act similarly to the certifier: They would pay for certification and accreditation only when consumers were sophisticated enough to require them. Therefore, I expect the model's results will not change qualitatively. More fruitful might be an extension of the model that includes imperfect competition of certifiers. The restriction to a single certifier and supplier does not account for the scale effects of accreditation, which might increase the effectiveness of accreditation.

An important result of this paper is that the optimal accreditation quality is, on average, higher in developing than advanced economies.[46] In other words, accreditation bodies in developing countries should exert more effort to monitor certifiers. However, establishing accreditation bodies in developing countries can be particularly challenging and costly (UNIDO et al., 2017). Therefore, my model suggests that developing and small economies should only establish their own national accreditation body if they cannot find a foreign accreditation body of sufficiently high quality and sufficiently low transportation cost.[47] This explains the creation of regional accreditation bodies in Southern Africa and the Caribic.[48]

The model's results on national and foreign accreditation bodies relied on the assumption that these bodies are welfare-maximizing. I assumed that they maximize the welfare of their own economy and that all players reside in their economy. In international trade, buyers often do not reside in the same country as the producer, the certifier, and the accreditation body.[49] Then buyers would not contribute to national welfare. This situation would not change the results of my model since I modeled the case of atomistic buyers.[50] Extending the model to buyers with market power would allow me to analyze further the incentives of welfare-maximizing accreditation bodies. National bodies might no longer want to provide sufficient accreditation quality. The same argument would

[46] See Proposition 3.

[47] See Proposition 4.

[48] These are the Southern African Development Community Accreditation Service (SADCAS) and the CARICOM Regional Organisation for Standards and Quality in the Caribbean (CROSQ, 2014; UNIDO et al., 2017).

[49] See for example Figure 1b in Appendix 8.2).

[50] Hence, the buyers made zero surplus.

apply if they could lower their quality when accrediting abroad.[51] The model could then be extended to account for the role of reputation building of accreditation bodies and the political economy of international peer reviews.[52]

My model also indicates that, even if accreditation bodies have the right incentives and buyers are sophisticated, accreditation cannot always prevent certification fraud.[53] This can be an additional explanation for the fact that there are cases of fraudulent certifiers accredited by national bodies.

The econometric analysis of the effect of the international recognition of the Uruguayan accreditation body suggests that national accreditation bodies positively affect the demand and supply of certification. However, the result of the difference-in-differences analysis is only correct if no significant omitted factors changed the certification market in Uruguay compared to the control country Nicaragua between 2010 and 2016. To be sure of that, more qualitative and quantitative investigation is required.[54]

To conclude, this paper provides a solid starting point to understand the effects of accreditation and its regulation. It shows that the intervention of states or standard owners in the certification and accreditation market is often justified. However, the globalization of supply chains and the certification market can render a national focus on accreditation inefficient. More research is needed to find optimal ways of combining public and private as well as national and international endeavors in accreditation.

[51] This would require relaxing Assumption 2.

[52] An interesting question in such a setup would be whether national accreditation bodies have the right incentives to monitor other accreditation bodies rigorously.

[53] See Proposition 2.

[54] It would be helpful to conduct further difference-in-differences analyses for other country pairs to verify the external validity of the result. Finding the correct country pairs and data is a challenge. Not many panel data on certification demand are conducted parallelly for different countries before and after a change in accreditation regulation. Moreover, the countries need to have a common pre-trend in certification. I found relevant data for El Salvador and Ecuador, but they did not have a common pre-trend. A systematic analysis would require collecting relevant data from accreditation bodies worldwide.

8 Appendix

8.1 Introduction

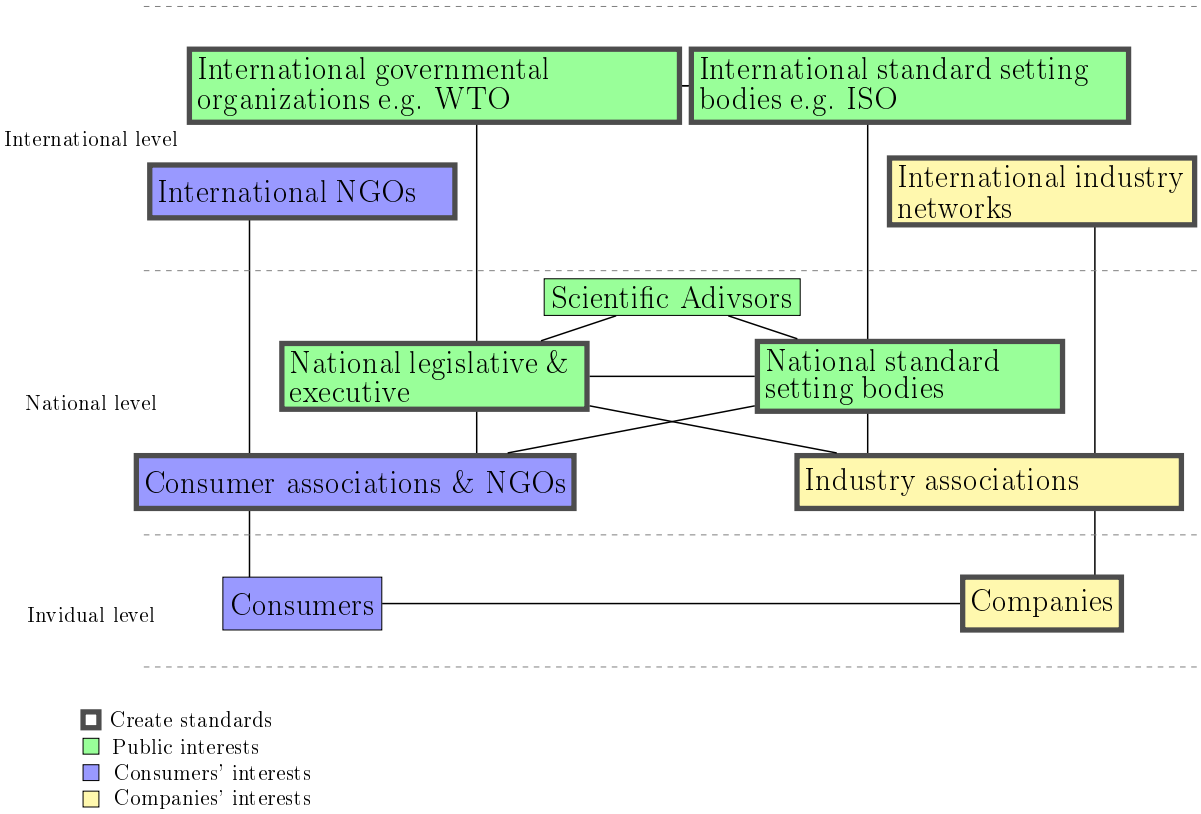


Figure 3: Public and private standard-setting processes

8.2 Context and motivating evidence

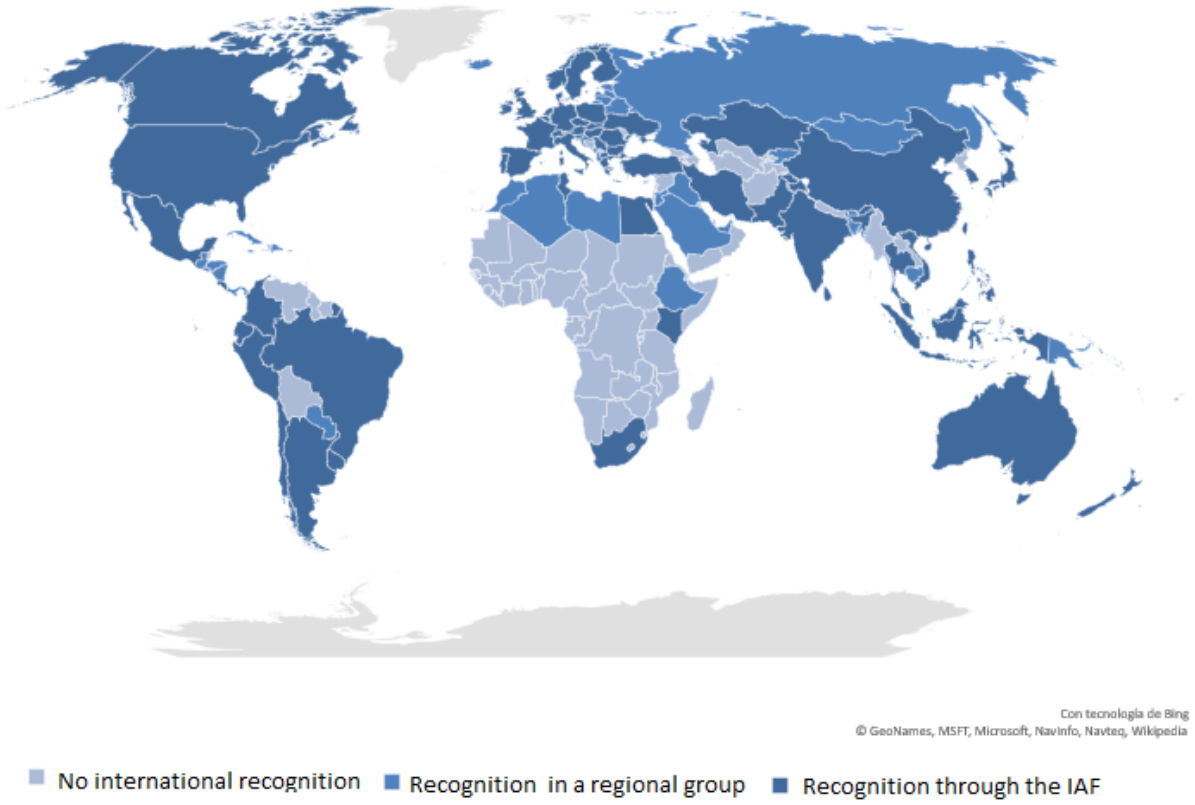


Figure 4: International and regional recognition of national accreditation bodies (Data: Websites of the IAF and the regional accreditation groups AFRAC, ARAC, EA, IAAC, PAC)

Table 2: Descriptive statistics of the treatment and control group

	Treatment group 2010		Difference in means *Treat.-Control*	
	Mean	SD	2010	2016/17
Dependent variable				
Internationally recognized certification	0.223	0.418	−0.035	0.175
Control variables				
% domestic shareholders	85.580	34.286	−0.944	−2.106
Years sector experience manager	24.554	13.358	2.645	3.692
	Treated		Control	
	2010	2017	2010	2016
Sample size	112	112	120	120

Table 3: Test of common trend

	(1)	(2)
Treated x (Year=2010)	0.0279	0.0305
	(0.35)	(0.38)
Year=2010	0.0213	0.0209
	(0.36)	(0.34)
Constant	0.191***	0.215
	(6.06)	(1.55)
Observations	340	340
Controls	No	Yes
Company FE	Yes	Yes
F-stat.	0.5	0.31

Notes: Estimates from regression of specification 1 in column (1), but with data from 2006 and 2010, using 2010 as the *Post*-treatment period, adding company controls in column (2) (percentage of domestic shareholders and the years of sector experience of the top manager). t statistics in parentheses, robust to heteroskedasticity. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

8.3 The baseline model

8.3.1 Proof of Lemma 1

I solve the game by backward induction:

No matter what the buyers play in stage 3, the supplier accepts a certification contract (v, f) in stage 2 if and only if their surplus is positive:

$$S_S \geq 0 \iff f \leq p_{\tilde{v}} - vc_S$$

In stage 1, the certifier offers $(0, p_{\tilde{v}})$ since $p_{\tilde{v}} - 0 - 0 > p_{\tilde{v}} - c_S - c_C$.

Thus, buyers cannot enforce true quality $v = 0$ and the social optimum in a one-shot game.

8.3.2 Proof of Lemma 2

Lemma 2 is proven in three steps by three additional Lemmas that are presented and proven below.

Lemma 5. *If $\delta \geq \underline{\delta}_{NA}$, the buyers can enforce a High-Quality Equilibrium by playing the following grim trigger strategy: If there were only high signals in the past, they buy the product at any price $p_{\tilde{v}} \leq U_{\tilde{v}}$ for a product of quality label $\tilde{v}$. Otherwise, their willingness to pay is zero.*

Proof. Let $\delta \geq \underline{\delta}_{NA}$. Assume the buyers play the grim trigger strategy described in Lemma 5. This assumption implies that their willingness to pay under certification ($\tilde{v} = 1$) equals their valuation U_1 for a product of true quality $v = 1$, whenever there were no low signals in the past. Otherwise, they do not trust a high-quality label $\tilde{v} = 1$. Thus, if there was any low signal in the past, the seller could not make any positive profit, neither without certification ($\tilde{v} = 0$) nor from obtaining a quality label $\tilde{v} = 1$. The only certification contract they would accept is thus $(v, f) = (0, 0)$, where the true quality level v is zero, and they obtain certification for free. Hence, all players make zero profit. If there were only high signals in the past, the stage game at period $t \geq 1$ is solved by backward induction as follows: In stage 3, the buyers are willing to pay any price $p_{\tilde{v}} \leq \tilde{v}$ for a product of quality label $\tilde{v}$. In Stage 2, if and only if $f \leq p_{\tilde{v}} - vc_S = U_1 - vc_S$, the seller accepts the certification contract and offers a product of quality label $\tilde{v} = 1$ for price $p_1 = U_1$. This contract gives them a payoff of $S_S \geq 0$. Otherwise, they can only offer a product of quality label $\tilde{v} = 0$ for price $p_0 = 0$. In Stage 1, the certifier offers a contract $(v, f) = (1, U_1 - c_S)$ if and only if there is no profitable one-shot deviation to the strategy of playing $(1, U_1 - c_S)$ each period.[55] The most profitable one-shot deviation of playing $(0, U_1)$ in period t is not profitable if and only if:

$$\sum_{t=0}^{\infty} \delta^t (U_1 - c_S - c_C) \geq U_1 + \delta(1 - \lambda) \sum_{t=0}^{\infty} \delta^t (U_1 - c_S - c_C) \tag{28}$$

This condition yields the condition given in 2.

The proof also shows why it is justified to limit attention to public strategies: The buyers have no private information and can hence only play a public strategy. Hence, the highest

[55] See Mailath and Samuelson (2006) for the one-shot deviation principle

price $p_{\tilde{v}}$, which the buyers would accept to pay, depends only on public information. Consequently, the payoffs of the certifier and the supplier depend only on the history of public signals, such that their relevant behavior strategies should only depend on the public history so that their strategies are public. □

Lemma 6. *(a) The buyers can enforce a High-Quality Equilibrium only if $\delta \geq \underline{\delta}_{NA}$. (b) Only by playing a grim trigger strategy can the buyers enforce a High-Quality Equilibrium for any $\delta \geq \underline{\delta}_{NA}$*

Proof. Accepting prices $p_{\tilde{v}} > 0$, even after low signals in the past, would increase the expected long-term profit after a deviation and would thus increase the minimum discount factor that is required to achieve the social optimum such that it is larger than $\underline{\delta}_{NA}$. Note further that $\underline{\delta}_{NA}$ is decreasing in U_1, the willingness to pay for a certified product $\tilde{v} = 1$ if there have been only high signals in the past. Thus, the buyers would need to increase their willingness to pay to lower the minimum discount factor required to achieve the social optimum. Such an increase, however, would not be rational: the buyers would pay more than their valuation of a product of the highest true quality v. □

Lemma 7. *The buyers prefer a High-Quality Equilibrium over all other equilibria.*

Proof. The buyers make zero profit in any equilibrium since (1) they would never buy if they made a loss, and (2) the proof of Lemma 1 and 5 show that the certifier forces the supplier to extract all surplus from the buyers. Hence, the buyers obtain the same profit in all equilibria. Since I assumed that they then prefer high quality $v = 1$ in each period, they favor any equilibrium in which they buy a product of truly high quality. □

Lemma 5, 6 and 7 imply Lemma 2.

8.4 Model: Accreditation and sophisticated buyers

8.4.1 Proof of Lemma 3

The proof is analogous to the proof of Lemma 2, except that the condition that ensures that the certifier has no profitable deviation from offering a high-quality certification contract $(v, f) = (1, U_1 - c_S)$ changes:

$$\sum_{t=0}^{\infty} \delta^t (U_1 - c_S - c_C - g) \geq (U_1 - \beta c_C - g) + \delta(1-\lambda) \sum_{t=0}^{\infty} \delta^t (U_1 - c_S - c_C - g) \quad (29)$$

This yields the condition given in Lemma 3.

8.4.2 Proof of Proposition 1

Given the setup of the game, the buyers know the values of δ, $\underline{\delta}_A$, and $\underline{\delta}_{NA}$. Hence, they can enforce a High-Quality Equilibrium by playing the grim trigger strategy described in Lemma 5, with a slight adaption: If $\underline{\delta}_A > \delta \geq \underline{\delta}_{NA}$, they do not buy a certified product ($\tilde{v} = 1$) at a positive price $p_{\tilde{v}} > 0$ if the certifier is accredited. If $\underline{\delta}_{NA} > \delta \geq \underline{\delta}_A$, they do not buy a certified product ($\tilde{v} = 1$) at a positive price $p_{\tilde{v}} > 0$ if the certifier is not accredited. The certifier can only profit if they comply with the buyers' "conditions". Then, Proposition 2 and Lemma 3 apply, and the "if"-part of Proposition 1 follows. The proof of the "only if"-part is analogous to the proof of Lemma 6.

8.4.3 Proof of Proposition 2

It is easy to see that it is optimal to price at cost, i.e., to set $g_n = \frac{(\beta_n c_C)^2}{2} + K$.[56] Consequently, the Break Even constraint in Definition 3 is binding. Replacing the accreditation fee g_n in the Incentive Constraint, the remaining problem is to set β_n as low as possible but high enough to satisfy the Incentive Constraint. Let η be the Lagrange multiplier of the Incentive Constraint. Then the solution to this problem is

$$\beta_n = \eta \frac{1-\delta}{\delta\lambda c_C(1+\eta)} \tag{30}$$

If $U - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} - K \geq 0$, the Incentive Constraint is slack, $\eta = 0$ and thus $\beta_n = 0$. However, then $\delta \geq \underline{\delta}_{NA} \geq \underline{\delta}_A$ and the entrance of the accreditation body is not welfare improving (see Corollary 1).

Assume instead:

$$U - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} - K < 0 \tag{31}$$

This assumption corresponds to (A1) in Proposition 2. Then the Incentive Constraint is not slack at $\beta = 0$. Then $\eta > 0$ and the optimal quality of accreditation is the lowest

[56] This is done in many countries, for example in Germany (Deutsche Akkreditierungsstelle, 2017). In most countries and all EU member states, accreditation bodies are at least non-profit organizations (European co-operation for Accreditation (EA), 2019).

$\beta_n \in [0,1]$ that satisfies the Incentive Constraint:

$$U - \bar{c} - \frac{1-\delta}{\delta\lambda}(\bar{c} - \beta_n c_C) - \frac{(\beta_n c_C)^2}{2} - K \geq 0 \tag{32}$$

The derivative of the left-hand side of this quadratic inequality with respect to β_n is:

$$\frac{1-\delta}{\delta\lambda}c_C - \beta_n c_C^2 \begin{cases} \geq 0 & \forall \beta_n \leq \frac{1-\delta}{\delta\lambda c_C} \\ < 0 & \forall \beta_n > \frac{1-\delta}{\delta\lambda c_C} \end{cases}$$

The second order condition is negative, so the maximum is achieved at $\frac{1-\delta}{\delta\lambda c_C}$, which is always positive.

Thus, I have to check two cases to see whether the accreditation body can achieve Incentive Compatibility (and thus a High-Quality Equilibrium):

If $\frac{1-\delta}{\delta\lambda} \leq c_C$, we are in Case 1 and need that the Incentive Constraint is satisfied at $\beta* = \frac{1-\delta}{\delta\lambda c_C}$, since the maximum is achieved at this point.

If $\frac{1-\delta}{\delta\lambda} > c_C$, we are in Case 2 and need that the Incentive Constraint is satisfied at $\beta* = 1$, since the maximum under our restriction $\beta \in [0,1]$ is achieved at this point.

Case 1: At $\beta* = \frac{1-\delta}{\delta\lambda c_C}$, the Incentive Constraint becomes:

$$2(U - \bar{c} - \frac{1-\delta}{\delta\lambda}(\bar{c} - K) + \frac{1-\delta}{\delta\lambda} - \frac{1}{2}\left(\frac{1-\delta}{\delta\lambda}\right) \geq 0$$

Case 2: At $\beta* = 1$, the Incentive Constraint becomes:

$$2(U - \bar{c} - \frac{1-\delta}{\delta\lambda}c_S - K) - c_C^2 \geq 0$$

In both cases, there is no solution to the problem in Definition 3 if the Incentive Constraint of the given case is not satisfied. The lack of a solution means that under accreditation, buyers cannot enforce a High-Quality Equilibrium: $\underline{\delta}_A > \delta$ and the entrance of the accreditation body is not welfare increasing.[57] To minimizes potential welfare loss, the optimal quality of accreditation is zero: $\beta_n = 0$.

Note that the slope of the left-hand side of the Incentive Constraint is positive for any $\beta \leq \beta_n$ in both Case 1 and 2. Given that the Incentive Constraint is satisfied in both cases,

[57] It can either be the case that a High-Quality Equilibrium can be achieved without accreditation (if $\delta \geq \underline{\delta}_A \iff U - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} \geq 0$) or that no High-Quality Equilibrium can be achieved in any case (if $\delta < \underline{\delta}_A$)

a solution $\beta \leq 1$ necessarily exists that binds the Incentive Constraint. The existence of such a solution implies

$$2(U - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} - K) + (\frac{1-\delta}{\delta\lambda})^2 \geq 0 \tag{33}$$

so that the possible solutions are

$$\beta_1 = \frac{1-\delta}{\delta\lambda c_C} + \frac{1}{c_C}\sqrt{2(U - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} - K) + (\frac{1-\delta}{\delta\lambda})^2} \tag{34}$$

$$\beta_2 = \frac{1-\delta}{\delta\lambda c_C} - \frac{1}{c_C}\sqrt{2(U - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} - K) + (\frac{1-\delta}{\delta\lambda})^2} \tag{35}$$

It is obvious that $\beta_1 < \beta*$ both in case 1 and that $\beta_1 > 1$ in case 2. I therefore therefore verify that $\beta_2 \geq 0$: Assumption (33) implies

$$\beta_2 \geq 0 \iff \frac{1-\delta}{\delta\lambda c_C} \geq \frac{1}{c_C}\sqrt{2(U - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} - K) + (\frac{1-\delta}{\delta\lambda})^2} \tag{36}$$

$$\iff \left(\frac{1-\delta}{\delta\lambda}\right) \geq 2(U - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} - K) + \left(\frac{1-\delta}{\delta\lambda}\right)^2 \tag{37}$$

$$0 \geq 2(U - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} - K) \tag{38}$$

This inequality is satisfied due to assumption (A1). Thus $\beta_2 \geq 0$.

Hence, there is a solution to Equation 32 if and only if $\beta_2 \leq 1$. Satisfaction of this inequality is trivial in case 1. Thus, there exists a solution in case 1 which only relies on assumption (A1) and $\frac{1-\delta}{\delta\lambda} \leq c_C$

In case 2, a solution exists if:

$$2(U - \bar{c} - \frac{1-\delta}{\delta\lambda}c_S - K) - c_C^2 \geq 0 \tag{39}$$

This inequality corresponds to the Incentive Constraint assumption (A2) in Proposition 2.

Thus, under assumptions (A1) and (A2) $\beta_n = \beta_2$ and the entrance of the national accreditation body is welfare improving according to Corollary 1. [58]

[58] If (A2) is not given, this problem has no solution. This means that under accreditation, no High-Quality Equilibrium can be achieved: $\underline{\delta}_A > \delta$ and the entrance of the accreditation body is not welfare increasing. The optimal accreditation quality is zero to minimize potential welfare loss: $\beta_n = 0$.)

We will have the following accreditation fee:

$$g_{n2} = \min\left\{ \left(\frac{1-\delta}{\delta\lambda}\right)^2 - \frac{1-\delta}{\delta\lambda}\sqrt{2(U-\bar{c}-\frac{1-\delta}{\delta\lambda}\bar{c}-K)+(\frac{1-\delta}{\delta\lambda})^2} + (U-\bar{c}-\frac{1-\delta}{\delta\lambda}\bar{c}-K); \frac{c_C^2}{2}+K \right\} \tag{40}$$

Finally I obtain way I write assumption (A2) in Proposition 2 in the following way: Recall that, next to assumption (A1), we need to be in case 1 or 2.

Case 1 requires:

$$\frac{1-\delta}{\delta\lambda} \leq c_C \Longleftrightarrow \delta \geq \frac{1}{\lambda c_C + 1}$$

Case 2 requires:

$$\delta < \frac{1}{\lambda c_C + 1}$$

and

$$2(U-\bar{c}-\frac{1-\delta}{\delta\lambda}c_S - K) - c_C^2 \geq 0 \Longleftrightarrow \delta \geq \frac{1}{\frac{\lambda}{c_S}(U-\bar{c}-\frac{c_C^2}{2}-K)+1}$$

8.4.4 Proof of Corollary 2

$$\frac{\partial\beta}{\partial\lambda} = -\frac{1-\delta}{c_C\delta\lambda^2}\left(1+\frac{\bar{c}-\frac{1-\delta}{\delta\lambda}}{\sqrt{2(U_1-\bar{c}-\frac{1-\delta}{\delta\lambda}\bar{c})+(\frac{1-\delta}{\delta\lambda})^2}}\right)$$

$$\frac{\partial\beta}{\partial\delta} = -\frac{1}{c_C\delta^2\lambda}\left(1+\frac{\bar{c}-\frac{1-\delta}{\delta\lambda}}{\sqrt{2(U_1-\bar{c}-\frac{1-\delta}{\delta\lambda}\bar{c})+(\frac{1-\delta}{\delta\lambda})^2}}\right)$$

It is easy to see that both derivatives are negative whenever $\bar{c} \geq \frac{1-\delta}{\delta\lambda} \Longleftrightarrow \lambda \geq \frac{1-\delta}{\delta\bar{c}}$. Note that this condition is satisfied whenever

$$\lambda \geq \frac{1-\delta}{\delta c_C} \Longleftrightarrow \delta \geq \delta \geq \frac{1}{\lambda c_C + 1}$$

If $\delta < \frac{1}{\lambda c_C+1}$, the derivatives are negative if and only if

$$\frac{1-\delta}{\delta\lambda} - \bar{c} < \sqrt{2(U_1-\bar{c}-\frac{1-\delta}{\delta\lambda}\bar{c})+(\frac{1-\delta}{\delta\lambda})^2} \Longleftrightarrow 2(U_1-\bar{c}) > \bar{c}^2$$

This is a necessary condition for

$$\delta \geq \frac{1}{\lambda\frac{1}{c_S}\left(U_1-\bar{c}-\frac{c_C^2}{2}-K\right)+1}$$

which must be satisfied under assumption (A2) in Proposition 2, whenever $\delta < \frac{1}{\lambda c_C + 1}$.

8.4.5 Proof of Proposition 4

As argued above, the Incentive Constraint that ensures a High-Quality Equilibrium is only satisfied if $\beta_f \geq \beta_n$. In the rare case that β_1, defined in Appendix 8.4.3 is lower than 1, Incentive Compatibility would not be achieved for qualities above quality level β_1. This result is shown in the proof of Proposition 2 in Appendix 8.4.3. Hence, the second condition is $\beta_f \leq \beta_1$, which holds trivially when $\beta_1 > 1$. If that is the case, total welfare under the foreign accreditation body is higher than under the national body if and only if:

$$U_1 - \left(\bar{c} + \frac{(\beta_f c_C)^2}{2} + t\right) > U_1 - \left(\bar{c} + \frac{(\beta_n c_C)^2}{2} + K\right) \tag{41}$$

This yields condition (3) in Proposition 4.

8.5 Model: Accreditation and unsophisticated buyers

8.5.1 Proof of Proposition 6

Unsophisticated buyers do not know whether accreditation or no accreditation provides the certifier with enough incentives not to cheat. Hence, their best possible strategy is the grim trigger strategy from Lemma 5, as I have shown in the baseline model. The certifier decides whether or not to obtain accreditation by comparing the long-term payoffs in both cases.

If $\underline{\delta}_{NA} > \delta \geq \underline{\delta}_A$, then always obtaining accreditation would induce a High-Quality Equilibrium but is not incentive compatible. The certifier would only obtain accreditation if they had no incentive to deviate to no accreditation and cheating, i.e., if:

$$\sum_{t=0}^{\infty} \delta^t (U_1 - \bar{c} - g) \geq U_1 + \delta(1-\lambda) \sum_{t=0}^{\infty} \delta^t (U_1 - \bar{c} - g) \iff \delta \geq \frac{\bar{c} + g}{\lambda(U_1 - \bar{c} - g) + (\bar{c} + g)} \geq \underline{\delta}_{NA} \tag{42}$$

This inequality is a contradiction to the assumption $\underline{\delta}_{NA} > \delta$.

If $\delta \geq \max\{\underline{\delta}_{NA}, \underline{\delta}_A\}$, the certifier has no incentive to cheat no matter if they are accredited or not.

If $\delta < \min\{\underline{\delta}_{NA}, \underline{\delta}_A\}$, the certifier has the incentive to cheat no matter if they are accredited or not.

If $\underline{\delta}_A > \delta \geq \underline{\delta}_{NA}$, then never obtaining accreditation induces a High-Quality Equilibrium, and there is no profitable deviation to accreditation:

$$\sum_{t=0}^{\infty} \delta^t (U_1 - \bar{c}) \geq (U_1 - \beta c_C - g) + \delta(1-\lambda) \sum_{t=0}^{\infty} \delta^t (U_1 - \bar{c} - g) \tag{43}$$

This is trivially implied by the condition for $\delta \geq \underline{\delta}_{NA}$

$$\sum_{t=0}^{\infty} \delta^t (U_1 - \bar{c}) \geq (U_1 - \beta c_C - g) + \delta(1-\lambda) \sum_{t=0}^{\infty} \delta^t (U_1 - \bar{c} - g) \tag{44}$$

8.6 Model: Accreditation bias

8.6.1 Proof of Lemma 4

Buyers with accreditation bias believe that $\underline{\delta}_{NA} > \delta \geq \underline{\delta}_A$. That means that they expect that a certifier that is not accredited will cheat. Thus, they accept to buy a certified product ($\tilde{v} = 1$) at a positive price $p_{\tilde{v}} > 0$ if and only if the certifier is accredited and there has been no low signal in the past. Thus, the certifier can only profit if they obtain accreditation. Hence, they will always seek accreditation, so they will not cheat if and only if $\delta \geq \underline{\delta}_A$.

8.6.2 Proof of Proposition 7

Buyers with accreditation bias are willing to buy a certified product ($\tilde{v} = 1$) at a positive price $p_{\tilde{v}} > 0$ whenever the certifier is accredited. A monopoly profit-maximizing accreditation body may then have an incentive to cheat. They will set the quality of accreditation β only so high that they ensure the Incentive Compatibility of the certifier (β_p) if they have no profitable deviation. The most profitable deviation would be to set $\beta = 0$. The only restriction on the accreditation fee g would then be the Individual Rationality constraint of the certifier: $U_1 - \bar{c} - g_p \geq 0$. Thus their deviation profit would be $U_1 - \bar{c}$.

In the following, I show that this deviation is profitable whenever $\delta < \min\{\underline{\delta}_{NA}; \frac{1}{\lambda 2(1-c_S)+1}\}$. This condition is sufficient, not necessary.

Recall β_p and g_p from section 4.1.3.

I first consider case 1 from the proof of Proposition 2 in Appendix 8.4.3, where

$$\frac{1-\delta}{\delta\lambda} \leq c_C$$

such that

$$(\beta_p, g_p) = \left(\frac{1-\delta}{\delta\lambda c_C}, U_1 - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} + \left(\frac{1-\delta}{\delta\lambda}\right)^2\right)$$

Then the deviation to $(0, U_1 - \bar{c})$ is profitable if and only if:

$$\sum_{t=0}^{\infty} \delta^t (U_1 - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} + \frac{1}{2}\left(\frac{1-\delta}{\delta\lambda}\right)^2) \geq U_1 - \bar{c} + \delta(1-\lambda)\sum_{t=0}^{\infty} \delta^t (U_1 - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} + \frac{1}{2}\left(\frac{1-\delta}{\delta\lambda}\right)^2) \tag{45}$$

This is equivalent to:

$$\delta\lambda\left(U - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} - K\right) - \frac{(1-\delta)^2}{\delta\lambda}\left(\bar{c} - \frac{1-\delta}{2\delta\lambda}\right) - (1-\delta)K + \frac{(1-\delta)^2}{2\delta\lambda} \geq 0$$

Whenever $\delta < \underline{\delta}_{NA}$, then $\left(U - \bar{c} - \frac{1-\delta}{\delta\lambda}\bar{c} - K\right) < 0$ (see Appendix 8.4.3). Then the above inequality cannot hold, whenever[59]

$$\frac{(1-\delta)^2}{\delta\lambda}\left(\bar{c} - \frac{1-\delta}{2\delta\lambda} - \frac{1}{2}\right) < 0$$

Since we are in the case $\frac{1-\delta}{\delta\lambda} \leq c_C$, a sufficient condition for that is:

$$c_S + \frac{1}{2}\left(\frac{1-\delta}{\delta\lambda} - 1\right) \geq 0 \Longleftrightarrow \delta < \frac{1}{\lambda 2(1-c_S)+1}$$

In the rest of the proof, I show that whenever the deviation would be profitable in case 1, it would also be profitable in Case 2 where

$$\frac{1-\delta}{\delta\lambda} < c_C$$

Note first that Incentive Constraint 45 can also be rewritten as:

$$\delta\lambda\left(U - \bar{c}\right) - (1 - \delta(1-\lambda))\left(\frac{1-\delta}{\delta\lambda}\left(\bar{c} - \frac{1-\delta}{2\delta\lambda}\right) + K\right) \geq 0$$

Note that to derive the sufficient conditions in Case 1 above, I used the fact that $\bar{c} - \frac{1-\delta}{2\delta\lambda} \geq$

[59] This is a sufficient, not a necessary condition.

$c_S + \frac{1-\delta}{2\delta\lambda}$. Using this implies that whenever the following condition is not satisfied, the Incentive Constraint 45 is not given either:

$$\delta\lambda\left(U-\bar{c}\right)-\left(1-\delta(1-\lambda)\right)\left(\frac{1-\delta}{\delta\lambda}\left(c_S+\frac{1-\delta}{2\delta\lambda}\right)+K\right)\geq 0$$

In Case 2, the deviation would not be profitable if

$$\delta\lambda\left(U-\bar{c}\right)-\left(1-\delta(1-\lambda)\right)\left(\frac{1-\delta}{\delta\lambda}c_S+\frac{c_C^2}{2}+K\right)\geq 0$$

Comparing the two constraints, we see that whenever $c_C \geq \frac{1-\delta}{\delta\lambda}$, the Incentive Constraint for Case 1 is easier to achieve and vice versa. This is precisely the case when we are in Case 1, and vice versa. Thus, the conditions sufficient for violating Incentive Compatibility in Case 1 are also sufficient in Case 2.

8.7 Conclusion

Figure 5: The label of the Marine Stewardship Council

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