Received: 18 November 2019 | Revised: 14 April 2020 | Accepted: 19 April 2020
DOI: 10.1002/mde.3175

RESEARCH ARTICLE

Accreditation in regulated markets

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We study firms that supply a vertically and horizontally differentiated service in a market with regulated prices. The incentives for seeking accreditation are more significant for sellers of below-average quality services relative to sellers of above-average quality services. For homogenous firms, profits are lower in equilibria where both firms seek accreditation relatively to equilibria where neither does. Private and social accreditation incentives typically differ. The welfare optimal reimbursement rate is independent of a firm's actual accreditation decision but dependent on the accreditation decision of the rival. Hence, policies that give extra financial support to firms that accredit are likely to promote inefficiency.

JEL CLASSIFICATION
D43; L11; L15; L51

1 | INTRODUCTION

According to van Damme (2004), "Accreditation is a particular form of quality assurance, with, as the distinctive characteristics, that it leads to the formal approval of an institution that has been found by a legitimate body to meet predetermined and agreed upon standards, eventually resulting in an accredited status granted by responsible authorities" (p. 129). There are two types of accreditation: output and process. Output accreditation means that accrediting bodies are able to determine the exact product or service quality. In some cases, however, such verifications are difficult, and we observe accrediting bodies that verify compliance with certain input standards (process accreditation) that may transform into product quality improvements.

Accreditation is a growth industry, but its importance varies across sectors. By 1995, ISO 9000 had been adopted by 101 countries, representing more than 500,000 certifications, as a national quality assurance standard (Anderson, Daly, & Johnson, 1999; Corbett, Montes, Kirsh, & Alvarez-Gil, 2002). In the United States, the industries with the highest number of certificates (ISO 9000) are "chemicals," "industrial and commercial machinery," and "electrical equipment." Accreditation expands rapidly in regulated industries such as health care and higher education. According to Lam et al. (2018), about 75% of U.S. hospital organizations were accredited by 2017. Of these, the majority (80%) was accredited by the Joint Commission. In 2017, the international branch of the Joint Commission (JCI) accredited over 1,000 organizations in more than 60 countries. The annual number of health care centers that become accredited by JCI increased from 1 in 1999 to 132 in 2016 (Mehta, Goldstein, & Makary, 2017). The World Health Organization identified 36 nationwide health care accreditation programs in 2000 (Greenfield & Braithwaite, 2009; Shaw, 2003; Shaw, 2006), and the annual number of international hospitals that became accredited nearly tripled between 2007 and 2011 (Woodhead, 2013).

The Council for Higher Education Accreditation, a nongovernmental organization, maintains an international directory that contains contact information of 467 accreditation bodies in 175 countries (http://www.chea.org). In 2009, almost 7,500 U.S. institutions in higher education were accredited by institutional accreditors (Woolston, 2012). By 2016, the number had increased to more than 8,000 encompassing over 23 million students (Taylor, 2018). In addition, there are programmatic accreditors that in sum have accredited 42.000 different U.S. educational programs (Eaton, 2015). Globalization and internationalization have also led to the rise of accreditation activities that cross national boundaries (Blanco Ramirez, 2015). As of 2015, U.S. accreditors review colleges and universities in 125 other countries (Eaton, 2015). Central and eastern European countries introduced accreditation into higher education after the fall of communism (Westerheijden, 2001). The pressure towards more quality assurance (including accreditation) for western European countries increased in response to the Bologna process (Westerheijden, 2001).

Various governmental interventions promote accreditation. EU requires that companies that produce-regulated products, such as medical devices, must adhere to ISO 9000 standards (Marquardt, 1992). Mandatory programs for hospitals are introduced in Croatia, France, Denmark, Italy, Scotland, and Australia (Mumford et al., 2015; Shaw, 2004). In addition, accreditation is often a requirement for public (federal) reimbursement. U.S. hospitals use accreditation to become providers in the Medicare program (Pawlson & O'Kane, 2002; Sprague, 2005). Mandatory accreditation is also observed for higher education, but accreditation as a requirement for public or federal funds such as grants and student aid is more common (Eaton, 2006; Haug, 2003).

The direct effects from accreditation are typically changes in costs and possibly quality. The literature refers to two types of cost changes: (a) costs associated with changing production processes (compliance costs) and (b) costs that arise in connection with outside consulting services, documentation, staff-training, and audit fees. The costs of accreditation can be substantial and may differ across firms (Anderson et al., 1999). For health care organizations, there are several literature surveys, including Shaw (2001, 2003, 2006); Braithwaite et al. (2006); Greenfield and Braithwaite (2008); Mumford, Forde, Greenfield, and Hinchcliff (2013); and Brubakk, Vist, Bukholm, Barach, and Tjomsland (2015) that all find no convincing evidence on accreditation causing product quality improvements. Similar conclusions are reached by Griffith, Knutzen, and Alexander (2002) and Barker, Flynn, Pepper, Bates, and Mikeal (2002). We were not able to identify any systematic reviews on educational organizations. Some works confirm that there is little systematic research on the effects from accreditation (Nigsch & Schenker-Wicki, 2013; Volkwein, Lattuca, Harper, & Domingo, 2007). A few studies confirm positive and significant effects from accreditation on educational quality (Nigsch & Schenker-Wicki, 2013; Volkwein et al., 2007). From above, it follows that empirical studies within health and education show ambiguous evidence regarding quality improvements. The scarcity of convincing evidence must be interpreted in view of the inherent difficulties in study design. The lack of control groups creates problems in establishing causality as well as measuring the overall impact from accreditation (Mumford et al., 2013).

The prevalence of accreditation means that it becomes important to understand such institutions. In this paper, we propose a model to analyze the following questions: (a) why some firms voluntary seek accreditation whereas others do not?, (b) what are the welfare effects from accreditation?, and (c) how should optimal accreditation incentives be designed? These are questions that are of interest for industries and sectors in which firms and organizations face public regulations. We focus primarily on welfare optimal accreditation policies such as direct regulation (mandatory accreditation versus banning accreditation) and indirect regulation (via funding mechanisms).

We pursue the above issues by applying a model with a Hotelling structure for profit-seeking firms. Our modeling includes various features that appear as important in relation to accreditation decisions. First, the decision to accredit, or not, is binary one, and we portray accreditation as a confirmation of compliance to certain predefined output quality standards (output accreditation) or input standards (process accreditation). Second, the process of becoming accredited (fulfilling quality standards) is costly. Third, output quality (both for accredited and nonaccredited firms) is not perfectly observable to consumers. The consumers do not observe service quality (credence goods), but they have prior beliefs about the distribution of quality and the quality effects that arise from accreditation. Fourth, the firms compete for consumers that care about location (horizontal differentiation) and quality (vertical differentiation). Furthermore, the firms play a simultaneous game when deciding on whether to become accredited or not and are fully informed about its own and the rival's costs, quality levels, accreditation status, and the consumers' beliefs about quality. Our main contribution is the use of a Hotelling model to study accreditation in regulated markets that allows for the analysis of policy measures such as mandatory accreditation and funding aimed at encouraging accreditation (preferential pricing).

The economic literature on the demand for accreditation is scarce. One exception is Grepperud, Matiesen, and Pedersen (2019) that apply an oligopoly model to analyze how substitutable and complementary goods (product differentiation) and type of competition (Cournot and Bertrand) affect accreditation incentives in simultaneous and nonsimultaneous games. The firms are unregulated and make their accreditation decisions in a competitive environment where prices and quantities are endogenous. They find that high accreditation rates could follow from fierce competition in markets for substitutable goods and by a high degree of coordination in markets for complementary goods.

Works on optimal quality regulation, third-party disclosure, and self-disclosure (see, e.g., Dranove and Jin (2010) for a survey) are to some extent relevant for our study. As concerning optimal quality regulation, Spence (1975) shows that a monopolist sets the optimal quality level (marginal revenue equal to marginal cost), whereas welfare optimality requires information on the consumers' average valuation of quality. Hence, in an unregulated market, quality could be too high or too low compared with the welfare optimal level. Works on third-party disclosure study the behavior of accrediting bodies (the supply-side of the market) and derive optimal quality disclosure rules and optimal accreditation fees (Albano & Lizzeri, 2001; Lizzeri, 1999). The literature on self-disclosure assumes that quality is unobservable to consumers, but firms may voluntarily reveal their true quality type in a credible way. Grossman and Hart (1980) and Milgrom (1981) show, in the absence of disclosure costs, that all firms will disclose their true type (full disclosure). Jovanovic (1982) and Dye and Sridhar (1995) find that disclosure costs produce partial disclosure.

There is also a body of literature on the relationship between competition and quality both for exogenous and endogenous prices. Ma and Burgess (1993) study firms that choose prices and quality and Brekke, Nuscheler, and Straume (2006) study firms that choose quality and locations under price regulation. A common assumption is that quality is observable but noncontractible. In a paper by Gravelle and Sivey (2010), however, quality is observable with a noise. Here, consumers receive imperfect signals about quality from each producer. Our work is concerned with credence goods where consumers have expectations about the distribution of the quality across producers. The decision to seek accreditation is assumed to provide additional quality information to the market.

We restrict ourselves to discuss accreditation for firms that face regulated prices. This means that the firms are unable to cover the extra costs that arise from accreditation by obtaining higher prices. An environment where competing institutions face price regulations is reasonable for organizations or institutions that are funded by the public, such as kindergartens, nursing homes, hospitals, schools, colleges, and universities. Such institutions typically compete for pupils, students, and patients. For instance, most European health care systems apply prospective reimbursement systems (DRG-based financing) and Medicare and Medicaid use similar systems. Universities are often funded (at least partly) by public grants that depend on the number of produced candidates and tuition fees paid by students. Traditionally, the public funding of organizations within health care and education has been independent of their accreditation behavior.

Section 2 presents the basic model and identifies the conditions for various equilibria as well as the quality beliefs of consumers. Section 3 discusses the equilibria that may arise in the case of homogeneous and heterogeneous firms. We find that the incentives for experiencing equilibria where both firms seek accreditation are substantial and especially so in the case of homogeneous firms. Section 4 considers the welfare optimality of accreditation decisions for homogenous firms. We find that social and private incentives typically deviate. In Section 5, we discuss the welfare properties of regulatory accreditation policies. First, we identify the conditions for when mandatory accreditation and a ban on accreditation are optimal. Second, we show, among others that the social optimal reimbursement rate is contingent upon the rival's accreditation decision. Section 6 compares our findings to other works and discusses possible extensions. Finally, Section 7 summarizes our main conclusions.

2 | THE MARKET, THE EQUILIBRIA, AND CONSUMER BELIEFS

We consider a market with regulated prices where two profit-maximizing firms (i = 1,2) compete for a given number of customers. The firms are reimbursed by a uniform reimbursement rate, P, and user fees paid by consumers, z (tuitions or copayments). Both firms have constant marginal costs that vary depending on being accredited or not. The production unit cost of firm i, if not accredited, is c_i, whereas if being accredited, the unit cost equals $c_i+\tau_i$, where τ_i reflect the change in the unit cost that occurs in response to meeting accreditation standards (accreditation unit costs). The fixed accreditation cost, F_i, reflects audit fees and various implementation costs in connection with documentation and staff-training. Now, by letting sales be represented by x_i, the firm profit, π_i, equals the profit margin multiplied with sales, subtracted fixed costs:

$$\pi_i = (P+z-c_i-\tau_i)x_i - F_i \geq 0 \quad i = 1,2, \tag{1}$$

where $F_i = \tau_i = 0$, if the firm does not accredit, whereas it is positive if accreditation takes place. There are no capacity problems. The profit margins are positive to ensure a market equilibrium: $P+z - c_i - \tau_i \geq 0$. The firms know each other's type (quality and costs), and they are informed about market demand. Furthermore, the firms have end-point locations along a line segment ranging from *0* to *1* where Firm 1 is located at zero and Firm 2 at one (exogenous horizontal differentiation). This assumption is in line with the literature on monopolistic competition.

The consumers are identical in all respects except for location (uniformly distributed on the line segment). The net utility of a consumer increases with lower travel costs (i.e., location closer to a firm), a higher expected quality of the services provided by firm i, V_i^j, which again depends on the firm being accredited ($j = A$) or not ($j = N$) and lower user fees (z). Given this, the net utility for a consumer located at $d \in [0,1]$ that use services from Firm 1 and 2, respectively, become:

$$U_1 = V_1^j - td - z \quad \text{and} \quad U_2 = V_2^j - t(1-d) - z \quad j = A,N. \tag{2}$$

In 2, t is the disutility per distance unit, d is the distance between the customer and Firm 1, and td represents travel costs if being served by Firm 1. It also follows from 2 that there is a one-to-one relationship between utility and quality. Moreover, we see that U_1 and U_2 strictly decrease with t. The participation constraint is $U_i \geq \bar{U} = 0, i = 1,2$; thus, the net utility for a consumer served by any firm is higher than zero; thus, both firms face a positive demand. The consumers are heterogeneous with respect to their horizontal preferences but homogenous with respect to their vertical preferences, that is, their quality valuations are similar. The expected quality level of services provided by Firm 1 and Firm 2, in the initial state (both firms being nonaccredited), are V_1 and V_2, respectively. Now, we use 2 and let $\bar{d}$ be the solution to

$V_1^N - td - z = V_2^N - (1-d)t - z$, which yields

$$\bar{d} \equiv d^1(N_1,N_2) = \frac{V_1^N - V_2^N + t}{2t} = \frac{V_1 - V_2 + t}{2t} = \frac{\Delta V}{2t} + \frac{1}{2}. \tag{3a}$$

Expression 3a defines the identity of the customer that is indifferent between the two firms when both firms are nonaccredited. $\bar{d}$ can be interpreted as Firm 1's market share when both firms stay nonaccredited (the initial state); thus, firm sales, x_i, can be replaced by the market share in the various states. Moreover, we have defined $\Delta V \equiv V_1 - V_2$ as the difference in initial quality between Firms 1 and 2, in the following denoted the quality-differential.

From 3a, we observe that the market share of Firm 1 in the initial state, $\bar{d}$, decreases with the disutility per distance unit, t, and increasing with the quality-differential, ΔV. Furthermore, we assume that the firms, via their accreditation decision, may increase own expected quality that raises the willingness to pay for their product. Let the expected increase in quality from being accredited be represented by b_i, where $b_i > 0$, and we denote $\Delta b \equiv b_1 - b_2$ as the relative quality-addition. For the case where Firm 1 accredits, and Firm 2 does not, the market share for Firm 1 is given by 3b. The market share for Firm 1, when Firm 2 accredits and Firm 1 does not, is given by 3c. The case where both firms accredit is given by 3d:

$$d^1(A_1, N_2) = \bar{d} + \frac{b_1}{2t}, \tag{3b}$$

$$d^1(N_1, A_2) = \bar{d} - \frac{b_2}{2t}, \tag{3c}$$

$$d^1(A_1, A_2) = \bar{d} + \frac{\Delta b}{2t}. \tag{3d}$$

We observe from 3b–3d that the market shares for Firm 1, when accreditation occurs, are described as functions of the market shares in the initial state, $\bar{d}$, and the quality-additions: b_i and Δb. To ensure that all possible outcomes induce positive market shares for both firms, that is, $0 < d^1(H_1, K_2) < 1$, where $H_1 = \{A_1, N_1\}$ and $K_2 = \{A_2, N_2\}$, we restrict ourselves to cases where the following inequalities are satisfied:

$$-t < \Delta V < t, -t < \Delta V + b_1 < t, -t < \Delta V - b_2 < t, -t < \Delta V + \Delta b < t. \tag{3e}$$

The inequalities in 3e mean that the possible differences in qualities are limited by the size of the disutility per distance, t. Hence, horizontal differentiation never dominates the vertical differentiation in the market. The conditions in 3e also ensure that the two firms are active in the market given the outcomes defined by 3a–3d.

Now, we can deduce the conditions for the various types of Nash equilibria. First, it is seen that a Nash equilibrium of type N_1N_2 requires that $\pi_1(N_1, N_2) > \pi_1(A_1, N_2)$ and $\pi_2(N_1, N_2) > \pi_2(N_1, A_2)$, which, by using 1–3 above, can be expressed as follows:

$$P < c_1 - z + \tau_1 + \frac{\tau_1(t + \Delta V) + 2tF_1}{b_1} \equiv Y_1 \text{ and } P < c_2 - z + \tau_2 + \frac{\tau_2(t - \Delta V) + 2tF_2}{b_2} \equiv Y_2. \tag{4}$$

$N_2) > \pi_1(N_1, N_2)$ and $\pi_2(A_1, N_2) > \pi_2(A_1, A_2)$, which again gives

$$P > Y_1 \text{ and } P < c_2 - z - \tau_2\frac{\Delta b}{b_2} + \frac{\tau_2(t - \Delta V) + 2tF_2}{b_2} = Y_2 - \tau_2\frac{b_1}{b_2} \equiv y_2. \tag{5}$$

Moreover, the conditions for a Nash-equilibrium of type N_1A_2 are $\pi_1(N_1, A_2) > \pi_1(A_1, A_2)$ and $\pi_2(N_1, A_2) > \pi_2(N_1, N_2)$, which yield

$$P < c_1 - z + \tau_1\frac{\Delta b}{b_1} + \frac{\tau_1(t + \Delta V) + 2tF_1}{b_1} = Y_1 - \tau_1\frac{b_2}{b_1} \equiv y_1 \text{ and } P > Y_2. \tag{6}$$

$A_2) > \pi_1(N_1, A_2)$ and $\pi_2(A_1, A_2) > \pi_2(A_1, N_2)$, which yields

$$P > y_1 \text{ and } P > y_2. \tag{7}$$

The conditions in 4–7 refer to changes in profit margins and market shares that arise from being accredited relatively to being nonaccredited. The type of equilibria arrived at depends on the reimbursement rate, P, user charges, z, production unit costs, c_i, accreditation costs (variable, τ_i, and fixed, F_i), the initial quality-differential, ΔV, quality-additions, b_i, the relative quality-addition, Δb, and the disutility per distance unit, t. We observe four threshold values (Y_1, y_1,Y_2,y_2) that define the equilibria. Firm-specific threshold values imply incentives that differ across firms. According to 4–7, firm i seeks accreditation if $P > y_i$ given that $P > y_j$ is satisfied for firm j, and, additionally, seeks accreditation for $P > Y_i$ if $P < y_j$ is satisfied for firm j. Hence, the relevant equilibrium condition for a firm depends on the relevant condition of the rival. Note that

$$Y_1 - y_1 = \tau_1\frac{b_2}{b_1} \text{ and } Y_2 - y_2 = \tau_2\frac{b_1}{b_2}. \tag{8}$$

We see from 8 that the difference in threshold values, for each firm, is a function of the firm's own accreditation unit cost and the ratio between own quality-addition and the quality-addition of the rival. The presence of the latter confirms that the two firms need not have a dominant strategy.

We will now study possible consumer beliefs about the distribution of quality in the initial state as well as the expected quality effects that arise from becoming accredited. For the sake of simplicity, assume there initially exist two quality levels, high quality, H, and low quality, L, commonly known to all consumers, where $H > L$. In the eyes of the consumers, the probability for Firm 1, being a high-quality producer (H) is q_1, whereas the same probability for Firm 2 is q_2. From these assumptions, we get

$$V_i = q_i H + (1 - q_i)L > 0 \quad i = 1, 2, \tag{9}$$

$$\Delta V = V_1 - V_2 = (q_1 - q_2)(H - L) \geq 0. \tag{10}$$

The expression in 9 defines the expected quality of firm i in the initial state (nonaccredited), whereas expression 10 defines the quality-differential. Suppose now that the consumers' quality beliefs about the quality of the service provided by the two firms differ. To simplify, and without loss of generality, we restrict our reasoning to cases where $q_1 \geq q_2$. This means that the consumers expect the quality of Firm 1 to be equal to or higher than the quality of Firm 2 in the initial state. This means that the quality differential (see 10) is zero or positive: $\Delta V \geq 0$. A possible explanation for quality expectations that are biased in favor of Firm 1, $q_1 > q_2$, might be former consumer experiences and recommendations given by better informed agents (e.g., general practitioners, former patients, graduated candidates, and employees). Another reason might be that consumers rely on other information sources (e.g., reputation effects) or observe other dimensions of quality (noncredence aspects) that are believed to be positively correlated with unobservable quality dimensions (credence good dimensions).

The consumers understand that the effects from accreditation might depend on the type of accreditation in question (output or process accreditation and the strictness of the imposed standards). For output accreditation, the accrediting body is able to determine whether the quality of a product exceeds a given predetermined accreditation standard or not. For process accreditation, however, such verifications are difficult due to additional informational imperfections. In this case, the accrediting body is only able to verify that a firm complies with certain predetermined input and process standards, which may, or may not, transform into output quality improvements.

Consider output accreditation, where *S* refers to the accreditation standard (the output quality standard) that is common for both firms. The level of *S* is decisive for the effect that accreditation has on expected quality. A first possibility is where $H > \hat{S} > L$, which assumes that accreditation acts as a guarantee against low-performing firms. This implies that the output quality of accrediting firms is raised to a minimum level, $\hat{S}$, with certainty (this type is denoted *OL*). For *OL*, the quality addition and the relative quality-addition become

$$b_i^{OL} \equiv (1-q_i)\left(\hat{S}-L\right) > 0, \tag{11}$$

$$\Delta b^{OL} \equiv b_1 - b_2 = (q_2 - q_1)\left(\hat{S}-L\right) \le 0. \tag{12}$$

From 10 to 12, we observe that the perceptions about the initial distribution of quality and the effects on the expected quality from accreditation are determined by three parameters (q_1, q_2, and $\hat{S}$) and the initial quality levels (*H* and *L*). Expressions 10–12 are mutually dependent via q_1, q_2, and *L*. The quality-differential (see 10) increases with the difference in the perceived probabilities for being a high-quality firm and the difference between the high-quality level and the low-quality level (*H-L*). The quality-additions (see 11) increase with the perceived probabilities of being a low-quality firm and the difference between the standard and the low-quality level ($\hat{S}-L$). The relative quality-addition (see 12), increases with the difference in the probabilities for being a high-quality firm and the difference between the standard and the low-quality level ($\hat{S}$-*L*). Furthermore, the quality-differential and the relative quality-addition differ across the two firms when $q_1 > q_2$.

Another possibility is that the accreditation standard is higher than the quality level provided initially by both firms: $\bar{S} > H > L$ (this type is denoted *OH*). If this is the case, we arrive at the following expressions for the quality addition and the relative quality-addition (for *OH*)

$$b_i^{OH} \equiv \left(\bar{S}-L\right) - q_i(H-L) > 0, \tag{13}$$

$$\Delta b^{OH} \equiv b_1 - b_2 = (q_2 - q_1)(H-L) \le 0. \tag{14}$$

A comparison of 13 and 14 with 11 and 12 shows that the difference between *OH* and *OL* is that 13 and 14 are influenced by the level *H* rather than the accreditation standard.

Consider process accreditation. Now, there is no well-defined output quality standard. In addition, there is an inherent uncertainty associated with the quality effects from accreditation. Hence, for consumers, the quality effects from accreditation are more uncertain than those that follows from output accreditation. Appendix A presents possible ways to describe the effects of process accreditation for $H > \hat{S} > L$ and for $\hat{S} > H > L$. From Appendix A, it follows that in a regime with a low predetermined input standard, it is still likely that the relative quality addition, Δb, is negative (see A2 in Appendix A). However, in the regime with a high predetermined input standard, Δb might be both positive and negative (see A4 in Appendix A). This finding illustrates that the outcome of process accreditation is less predictable than the outcome of output accreditation, because for output accreditation $\Delta b \le 0$ holds for predetermined standards that are both low and high (see 12 and 14).

3 | ACCREDITATION IN MARKETS

3.1 | The case of homogeneous firms

The case of homogeneous firms is characterized by firms that have identical costs, where the consumers perceive the firms to have the same initial quality, and where the accreditation decision is expected to give the same increase in quality; that is, $c_1 = c_2 = c$, $\tau_1 = \tau_2 = \tau$, $F_1 = F_2 = F$, $b_1 = b_2 = b$ and $V_1 = V_2 = V$. Given these assumptions, we get from 3a that the two firms' initial market shares are identical and defined by $\bar{d} = \frac{1}{2}$. If both firms choose to accredit, they are neutralizing each other's effort in increasing own market size. The threshold values in 4–7 become $Y_1 = Y_2 = Y = c - z + \tau + \frac{t(\tau+2F)}{b}$ and $y_1 = y_2 = y = c - z + \frac{t(\tau+2F)}{b}$. Hence, the Nash equilibria for homogenous firms are determined by two threshold values, *Y* and *y*, where $Y - y = \tau$. Because the difference in the threshold values is independent of the quality-addition of the rival, the firms have dominating strategies. Figure 1 presents the two possible equilibria (symmetric equilibria). From this figure, we observe that for $P < y$, we have an N_1N_2 equilibrium, whereas for $P > Y$, we have an A_1A_2 equilibrium. This means that a sufficiently high price, *P*, or profit margin ($P + z - c$), *ceteris paribus*, produces A_1A_2 as equilibrium. A sufficiently low reimbursement rate or profit margin produces N_1N_2 as equilibrium. An intermediate case arises for $y < P < Y$, yielding the two symmetric equilibria (N_1N_2 and A_1A_2), here denoted as the multiple symmetric equilibria case.

By comparing the profit following from N_1,N_2 and A_1,A_2, we arrive at the following expression

$$\pi(N_1,N_2) - \pi(A_1,A_2) = (P+Z-c)\frac{t}{2t} - (P+Z-c-\tau)\frac{t}{2t} + F = \frac{\tau}{2} + F > 0. \tag{15}$$

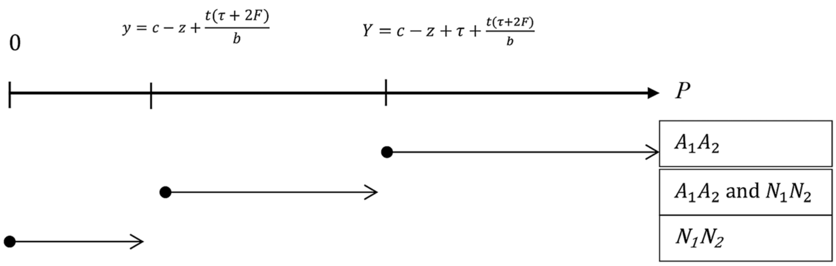

FIGURE 1 Homogeneous firms (voluntary accreditation incentives)

15 means that for positive accreditation costs, A_1A_2 always yields lower profits for both firms relatively to N_1N_2. Thus, for $P > Y$, we have a Prisoners' dilemma game going on. Our findings confirm that there are considerable forces at play; thus, homogeneous firms may end up as being accredited despite of a suboptimal profit outcome for both. The mutual fear of the rival capturing a higher market share via accreditation can be said to "force" both firms to undertake a costly accreditation investment.We see from the threshold values, y and Y, that the interval that defines the A_1A_2 equilibria increases with a higher profit margin (a higher P, a higher z, and lower c), lower accreditation costs (τ and F) and a lower t (a higher degree of competition). By replacing b with the two accreditation types defined in 11 and 13, it follows that the same interval will increase for a reduced low-quality level, L, higher accreditation standards, $\hat{S}$ and $\bar{S}$, a lower probability for being a high-quality firm, q_i, (OL, OH), and a reduced high-quality level H (OH). Notice that the threshold values become closer as the accreditation unit cost in, τ, approaches zero.

RESULT 1: In the case of homogeneous firms, the equilibria are defined by dominating strategies. Equilibria where both firms seek accreditation yield less profit for each firm relatively to equilibria where both firms stay non-accredited. The interval that defines the equilibria where both firms are accredited, increases with a higher profit margin, lower accreditation costs, a higher degree of market competition (lower t), and higher expected quality additions from becoming accredited.

3.2 | The case of heterogeneous firms

Firms may differ with respect to technology and because consumers perceive them as being different in quality. For heterogeneous firms, the equilibria are determined by four threshold values, Y_1,Y_2,y_1,y_2, because now $Y_1 \neq Y_2$ and $y_1 \neq y_2$. The increase in the number of thresholds relatively to the case of homogenous firms follows because $c_1 \neq c_2$, $\tau_1 \neq \tau_2$, $F_1 \neq F_2$, $b_1 \neq b_2$, and/or $V_1 \neq V_2$, possibly leading to $\Delta V \neq 0$ and/or $\Delta b \neq 0$. The possible rankings in the case of heterogeneous firms are

$$(I) Y_1 > y_1 > Y_2 > y_2, (II)\, Y_1 > Y_2 > y_1 > y_2, (III), Y_1 > Y_2 > y_2 > y_1,$$
$$(IV) Y_2 > Y_1 > y_1 > y_2, (V), Y_2 > Y_1 > y_2 > y_1, (VI) Y_2 > y_2 > Y_1 > y_1.$$

Using 4–7, we find that each ranking produces the two symmetric equilibria (N_1N_2 and A_1A_2). However, Ranking I and VI differ from Rankings II–V in several respects. For I and VI, asymmetric equilibria might occur whereas multiple symmetric equilibria do not. For I, only an asymmetric equilibria of type N_1A_2 is possible. For VI, only an asymmetric equilibrium of type A_1N_2 is possible. Moreover, for Rankings II–V, multiple symmetric equilibria (N_1N_2/A_1A_2) may occur whereas asymmetric equilibria do not. This means that Rankings II–V produce games that have similarities with the ones identified for symmetric markets. Rankings I and VI also differ from II–V in that both threshold values, for a given firm, are ranked higher or lower than the two threshold values that are relevant for the rival. This observation suggests that asymmetric equilibria are possible only if the two firms differ to a significant degree (significant cost and quality differences and/or a significant variation in the quality improvements from accreditation). A final observation, relevant for all rankings, is that the two symmetric equilibria occur when the reimbursement rate (or the profit margin) is sufficiently low (N_1N_2) or sufficiently high (A_1A_2), whereas the multiple symmetric equilibria (N_1N_2/A_1A_2) and the asymmetric ones (N_1A_2 or A_1N_2) occur for intermediate levels of the threshold values (for reimbursement rates lying between the threshold value ranked as number two and three).

The intervals that define the various equilibria for heterogeneous firms depend on the ranking of the threshold values. This property can be utilized to study the effects from a change in the model parameters. First, we observe from 4 to 7 that all four thresholds increase with a higher t (a lower degree of competition) and a higher z. Second, as concerning technology, we observe that Y_1 and y_1 increase with higher Firm 1 costs (a higher c_1, a higher F_1, and a higher τ_1) and Y_2 and y_2 increase with higher Firm 2 costs (a higher c_2, a higher F_2, and a higher τ_2). Because the interval that defines equilibria of type A_1A_2 becomes wider the lower y_1 and/or lower y_2 (see 7), the same interval becomes wider for a higher degree of competition, higher profit margins, and lower costs.

As concerning consumer expectations, we observe that Y_1 and y_1 increase with a higher ΔV, whereas Y_2 and y_2 decrease ($\Delta V = V_1 - V_2 > 0$). Lower Y_1 and y_1 push towards equilibria where Firm 1 seeks accreditation whereas higher Y_2 and y_2 push towards equilibria where Firm 2 stays nonaccredited. These effects may appear somewhat contraintuitive but follow because the lower the initial difference in quality, the lower is the market share of the firm perceived to have the highest expected quality (Firm 1). Furthermore, the lower the market share, the lower is the increase in the variable costs that follow from becoming accredited. From 11 to 14, we observe that the firm with the lowest expected initial quality level (the lowest q_i) experiences the highest increase in the expected quality from becoming accredited.

This finding is a direct result of regulated reimbursement rates because now, firms are not compensated by a higher rate in response to becoming accredited (only by a market share increase**)**. Finally, we observe that y_1 decreases and y_2 increases for a higher Δb (in absolute terms) where $\Delta b = b_1 - b_2 < 0$. A lower y_1 pushes towards equilibria where Firm 1 is accredited whereas a higher y_2 pushes towards equilibria where Firm 2 stays nonaccredited. Such effects arise because a higher Δb (in absolute terms) increases the difference in expected firm quality in favor of Firm 1. This means that the accreditation benefits, in terms of market share changes, when both firms are accredited, are more advantageous for Firm 2 and more adverse for Firm 1.

Above, we discussed the role of consumer expectations, ΔV and Δb. In doing so, we ignored that the expectations are interlinked via the quality parameters for specific consumer beliefs, for example, *OL* and *OH*. Table 1 presents the signs of the partial effects from the quality parameters on the threshold values for the two types of output accreditation, *OL* and *OH*. For type *OL*, we see that a reduction in the low-quality level (L) and an increase in the accreditation standard ($\hat{S}$) increase all four thresholds. An increase in the high-quality level (H) has indeterminate effects. Moreover, the higher the probability for a firm being considered a high-quality firm, q_i, and the lower the probability for the rival being considered a high-quality firm, q_j, the higher the thresholds values. In Appendix C, we show that if the firms only differ in the consumers' anticipation of supplying high quality, that is, the q-levels, the firm with the lowest q has the lowest values of Y and y. This means that the accreditation incentive is lowest for the firm that consumers expect has the highest initial quality level. For type *OH*, we find much the same effects, but now, the influence of a higher L on the threshold values is indeterminate.

The Rankings in I and in VI differ from Rankings II–V and the ranking that is valid for homogenous firms. This is because asymmetric equilibria may occur. For this reason, we discuss these two rankings in more detail (see Figures 2 and 3). Suppose a higher probability for Firm 2 being a high-quality firm. From Figure 2 (Ranking I), it follows that only Y_2 and y_1 have an impact on the intervals that define the three possible equilibria. From Table 1, we know that a higher q_2 increases Y_2 both for *OL* and *OH*. This means that the interval that defines an equilibrium of type N_1N_2 becomes wider at the expense of equilibria of type N_1A_2. From Table 1, we know that a higher q_2 reduces y_1 both for *OL* and *OH*. This implies that the interval that defines an equilibrium of type A_1A_2 becomes wider at the expense of N_1A_2. Thus, a higher q_2 pushes Firm 2 towards choosing accreditation and Firm 1 towards choosing nonaccreditation. A similar reasoning can be performed in relation to Ranking VI (Figure 3). Now Y_1 and y_2 are the thresholds that impact the intervals that define the equilibria. From Table 1, it follows that a higher q_2 decreases Y_1 and increases y_2 for *OL* and *OH*. As a consequence, the interval for A_1N_2 in Figure 3 becomes wider at the expense of N_1N_2 and A_1A_2 (*OL* and *OH*).

TABLE 1 The partial effects from quality parameters and quality categories on the threshold values (output accreditation: *OL* and *OH*)

	Type *OL*				Type *OH*			
	Y_1	y_1	Y_2	y_2	Y_1	y_1	Y_2	y_2
q_1	+	+	–	–	+	+	–	0
q_2	–	–	+	+	–	0	+	+
H	+	+	–	–	+	+	+	+
L	+	+	+	+	?	?	?	?
$\hat{S}$	–	–	–	–				
$\bar{S}$					–	–	–	–

RESULT 2: In markets with heterogeneous firms, all equilibria types (symmetric and asymmetric) may occur. The interval that defines equilibria where both firms become accredited increases with higher profit margins, $P+z - c_i$, lower accreditation costs, τ_i and F_i, and, a higher degree of market competition (a lower t). For the two types of output accreditation, the same interval increases for stricter accreditation standards ($\hat{S}$ or $\bar{S}$) and a lower initial high-quality level (H), while the effects from the perceived probabilities of being a high-quality firm (q_i and q_j) and a higher low-quality level (L) are generally indeterminate.

Now, we study the existence conditions for the two asymmetric equilibria: A_1N_2 and N_1A_2. To simplify the forthcoming discussion, fixed costs are set equal to zero ($F_1 = F_2 = 0$). We start by presenting the existence condition for A_1N_2. From the conditions described in 5, we arrive at the following inequality:

$$c_2 - c_1 + \frac{\tau_2}{b_2}[t - (\Delta V + \Delta b)] - \frac{\tau_1}{b_1}[b_1 + t + \Delta V] > 0. \quad (16)$$

Suppose the firms differ with respect to the accreditation unit costs ($\tau_1 \neq \tau_2$), but are equal in all other respects ($c_1 = c_2 = c, b_1 = b_2 = b$ and $q_1 = q_2 = q \Longrightarrow \Delta V = \Delta b = 0$), then 16 becomes

$$\frac{\tau_2 - \tau_1}{\tau_1} > \frac{b}{t}. \quad (16a)$$

16a says that the asymmetric equilibrium, where Firm 1 accredits and Firm 2 does not, that is, A_1N_2 might occur when the accreditation unit cost for Firm 2 is sufficiently high relatively to that of Firm 1. The left hand side of 16a, $\frac{\tau_2 - \tau_1}{\tau_1}$, measures the relative accreditation unit cost difference, whereas the right hand side, b/t, measures the increase in the willingness to pay for accreditation among consumers divided by the disutility per distance unit. In other words, an explanation for the occurrence of A_1N_2 is that Firm 1 has accreditation unit costs that are sufficiently low relative to Firm 2. Suppose now that the firms differ with respect to production unit costs ($c_1 \neq c_2$), but are equal in all other respects ($\tau_1 = \tau_2 = \tau, b_1 = b_2 = b$ and $q_1 = q_2 = q$), then 16 becomes

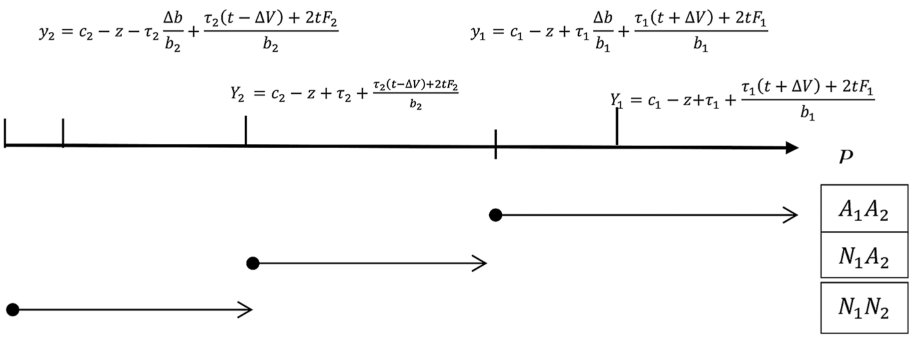

FIGURE 2 Equilibria in the case of heterogeneous firms (Ranking I)

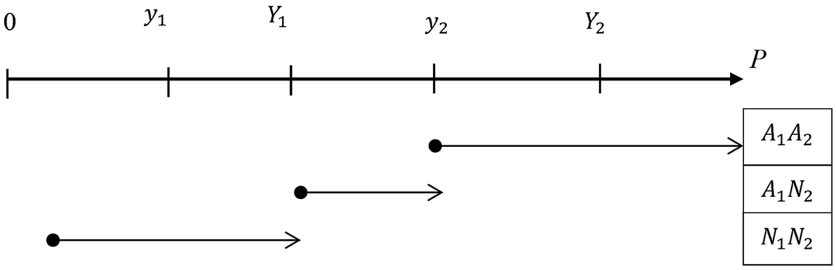

FIGURE 3 Equilibria in the case of heterogeneous firms (Ranking VI)

$$c_2 > c_1 + \tau. \tag{16b}$$

16b means that an asymmetric equilibrium of type A_1N_2 might follow from the production unit cost of Firm 2 being higher than the sum of the production unit cost and the accreditation unit cost of Firm 1. Finally, suppose that the firms only differ when it comes to the q's, that is, $q_1 > q_2 \Rightarrow \Delta V > 0$, $\tau_1 = \tau_2 = \tau$ and $c_1 = c_2$. Then, 16 can be written as

$$\frac{\tau}{b_1 b_2}[\Delta b(t - b_1) - (b_1 + b_2)\Delta V - b_1 b_2] > 0. \tag{16c}$$

It follows that the second and the third terms within the parenthesis, $(b_1+b_2)\Delta V$ and $b_1 b_2$, are positive, meaning that these terms are negative. For OL and OH, the first term is nonpositive due to $t > b_1$ (see 3e) and $\Delta b \leq 0$ (see 12 and 14). This means that A_1N_2 is unlikely to appear in this special case.

If we do the same analysis for the equilibrium where Firm 1 does not accredit whereas Firm 2 does, that is, N_1A_2, using the conditions in 6, we end up with the following inequality

$$c_2 - c_1 + \frac{\tau_2}{b_2}[b_2 + t - \Delta V] - \frac{\tau_1}{b_1}[\Delta b + t + \Delta V] < 0 \tag{17}$$

This leads to $\frac{\tau_1 - \tau_2}{\tau_2} > \frac{b}{t}$ and $c_1 > c_2 + \tau$, which are inequalities that are similar to the cases discussed in relation to 16a and 16b above. The interpretation is that N_1A_2 might appear because of cost differences that are opposite of what is described above. However, more interesting is the case where the firms only differ with respect to the q's, that is, $q_1 > q_2 \Longrightarrow \Delta V > 0$ and $\Delta b < 0, \tau_1 = \tau_2 = \tau$ and $c_1 = c_2$. Now, 17 can be rewritten as

$$\frac{\tau}{b_1 b_2}[\Delta b(t - b_2) - (b_1 + b_2)\Delta V + b_1 b_2] < 0. \tag{17a}$$

We observe that the two first terms within the parenthesis of 17a is negative when $\Delta V > 0$ and $\Delta b < 0$ (output accreditation). The inequality in 17a is satisfied if these two terms dominate the positive third term. Again, this implies that if q_1 is sufficiently higher than q_2, and the accreditation unit cost and production unit cost are equal for the firms, the equilibrium where Firm 1 chooses to stay nonaccredited, whereas Firm 2 chooses to accredit, is possible.

The intuition behind the above findings is provided by identifying two effects, one positive and one negative that arise from becoming accredited. The positive effect is the increase in the market share (the increase in sales) that follows from accreditation that again increases profits. The increase in profits is equal to the profit margin, being the price subtracted production unit costs and accreditation unit cost, multiplied with the increase in sales. This positive effect increases with a higher increase in sales and the lower the two unit costs. However, becoming accredited also impacts the profit margin for the initial sales (the sales before becoming accredited). This effect represents a negative profit-effect because the costs of producing the initial sales, when being accredited, become higher due to the introduction of the accreditation unit cost. This negative effect is lower, the lower the accreditation unit cost. In addition, this effect depends on the size of the initial sales—the higher the initial sales, the more significant is the negative effect. For $q_1 > q_2$, Firm 1 will have higher initial sales than Firm 2. For Firm 1, now choosing to accredit, the negative effect will be more significant, compared with the effect that follow for Firm 2 if choosing to accredit. From the signaling literature it follows, given that quality is inversely related to signaling costs, that it is possible to differentiate credibly between high-quality and low-quality producers (see Riley, 2001; Spence, 1973, 1974). Our discussion in relation to 16ab supports such a conclusion because a sufficiently high difference in accreditation unit cost between the two firms will induce the most efficient firm (Firm 1) to accredit, whereas the less efficient one (Firm 2) will not. However, the result related to 17a illustrates an effect that works in the opposite direction, and this effect arises from the negative profit-effect described above. This is an effect that is not present in the signaling literature (see Section 6 for more on this issue).

Finally, our model can be used to analyze the effects from consumers that become better informed about quality (the accuracy of information). The assumption that consumers have partly relevant quality expectations for $q_1 > q_2$ implies that Firm 1 is a true high-quality producer and Firm 2 is a true low-quality producer. In this situation, improved information (more accurate information) follows from a higher $\Delta q = q_1 - q_2 > 0$ (a higher q_1 and/or a lower q_2). Consider now the rankings presented in Figures 2 and 3. From Table 1, we know that improved information in association with output accreditation (*OL* and *OH*) causes an increase in y_1 and a decrease in Y_2 (Y_1 and y_2 also change, but they do not affect the equilibria intervals in Figure 2). From Figure 2, we observe that the interval that defines N_1A_2 increases at the expense of the intervals N_1N_2 and A_1A_2. Because the sum of the two intervals that defines the equilibria where one or both firms seek accreditation (N_1A_2+A_1A_2), becomes wider, we may conclude that more (accurate) information has strengthened the accreditation incentives and thereby, possibly, the average market output quality. Using the same reasoning for Ranking VI (Figure 3), we find for *OL* that both the intervals defining N_1N_2 and A_1A_2 increase at the expense of A_1N_2. This means that the sum of the intervals for which one or both firms seek accreditation (A_1N_2+A_1A_2) is reduced. From this, we can conclude that more (accurate) information weakens accreditation incentives, and this again causes a reduction in the average market product quality. For *OH*, we find that the interval that defines A_1N_2 becomes wider at the expense of N_1N_2.

For the five remaining rankings (Rankings II–VI), the conclusions with respect to the effects on accreditation decisions and output quality also work in opposite directions. If the firms prefer N_1N_2 to A_1A_2, in situations with a multiple symmetric equilibria (N_1N_2/A_1A_2; see footnote 18), we find for Rankings II and IV that higher information accuracy increases the interval that defines N_1N_2 at the expense of A_1A_2. Thus, accreditation incentives (and the expected market output quality) can be said to be weakened. For Rankings II and V, a higher information accuracy increases the interval that defines A_1A_2 at the expense of N_1N_2; thus, we arrive at the opposite conclusion.

RESULT 3: Given $c_1 < c_2$ and/or $\tau_1 < \tau_2$, such differences could explain that Firm 1 will choose to accredit while Firm 2 will not, i.e. that A_1N_2 exists. If there are no such differences, and we have output accreditation with the following consumer beliefs;$H > \hat{S} > L$ or $\bar{S} > H > L$, an asymmetric equilibrium, where the firm expected to have the highest quality does not accredit while the firm with the lowest expected quality chooses to accredit, i.e. that N_1A_2, might exist. An increase in the accreditation standard ($\hat{S}$ or $\bar{S}$), and a decrease in the low-quality level (L), will increase the accreditation incentives for both firms. An increase in the high-quality category (H) has opposite effects on the accreditation incentives for the two firms. Furthermore, accreditation incentives become lower, the higher the perceived probability for a firm to be considered a high-quality firm, and the higher the perceived probability of the rival firm being considered a high-quality firm. Finally, more accurate information about the firms' true initial qualities, may both strengthen and weaken the incentives for firms to seek accreditation.

4 | WELFARE ANALYSIS

In this section, we analyze the social effectiveness of accreditation. In order to simplify our reasoning, we restrict ourselves to consider identical firms, that is, the homogenous case in Section 3.1. In such a case, because only symmetric equilibria exist, it is sufficient to compare the welfare that arises from A_1,A_2 with the welfare of N_1,N_2. This follows because if it is welfare improving (reducing) for one firm to be accredited, it has to be the same for identical firms. Moreover, it is assumed that the quality-additions that follow from accreditation reflect true quality improvements. There are two consumer groups, defined by the firm they are served by. We first calculate the difference between the sums of the utility of the two groups across the two equilibria. From this, we arrive at the following expression

$$U_1(A_1,A_2)+U_2(A_1,A_2)-U_1(N_1,N_2)-U_2(N_1,N_2)=b_1+b_2=2b. \quad (18)$$

Equation 15 defines the profit loss that arises from (A_1, A_2) relatively to (N_1, N_2). Using this, we arrive at the following expression for the difference in the sum of profits across the two equilibria

$$\pi_1(A_1,A_2)+\pi_2(A_1,A_2)-\pi_1(N_1,N_2)-\pi_2(N_1,N_2)=-2\left(\frac{\tau}{2}+F\right)=-(\tau+2F). \quad (19)$$

N_2), we must compare the overall utility benefits, defined by 18, with the overall profit losses, defined by 19. This means that (A_1, A_2) is welfare improving (reducing) compared to (N_1, N_2) when the following inequality holds

$$2b>(<)\tau+2F \text{ or } b>(<)\frac{\tau}{2}+F. \quad (20)$$

Given that the consumers' total willingness to pay for the quality-addition, *2b*, is higher (lower) than the sum of the overall accreditation unit cost, τ, and the overall fixed costs, 2*F*, the decision to seek accreditation (staying nonaccredited) is welfare improving. In order to compare this welfare criteria with the symmetric Nash equilibria defined in 4 and 7 above, we rewrite 4 and 7 as follows:

$$N_1N_2: \quad b < \frac{\tau t + 2tF}{m - \tau} \equiv E, \tag{21}$$

$$A_1A_2: \quad b > \frac{\tau t + 2tF}{m} \equiv e, \tag{22}$$

where $m = P + z - c$ and $E > e$ because $\tau > 0$.

To evaluate the equilibria, we must compare E, e and the social accreditation costs $(\frac{\tau}{2} + F)$ with the quality-additions. Because $E > e$, there are three possible rankings:

$$(\text{Case 1})\ E > e > \frac{\tau}{2} + F \quad \text{if} \quad 2t - m > 0, \tag{23}$$

$$(\text{Case 2})\ E > \frac{\tau}{2} + F > e \quad \text{if} \quad 0 < 2t - m + \tau < 2t - m, \tag{24}$$

$$(\text{Case 3})\ \frac{\tau}{2} + F > E > e \quad \text{if} \quad m - \tau - 2t > 0. \tag{25}$$

The three cases (Cases 1–3) are presented in Figures 4–6, respectively. The upper lines in the figures refer to the interval where accreditation is socially optimal (the absence of a line refers to the case where nonaccreditation is socially optimal). Below the upper line in the figures, we present the market equilibria where the line refers to the interval with symmetric equilibria where both accredit, the dotted line refers to multiple symmetric equilibria (N_1N_2/A_1A_2), whereas the interval without any line refers to symmetric equilibria (both stay non-accredited). From the conditions that belong to each case, it follows that Case 1 describe situations where the disutility of distance (degree of competition) is high relatively to the profit margin. This induces too weak accreditation incentives from a social point of view. Case 3 reflects a situation where the profit margin is higher than the disutility of distance (degree of competition), thus the private accreditation incentives are too significant. As for the multiple equilibria, N_1N_2 yields higher profits than A_1A_2; thus, it seems reasonable to assume that the dotted lines in Figures 4–6 represent N_1N_2 equilibria. If so, the market yields a socially inefficient outcome when $E > b > \frac{\tau}{2} + F$ (Case 1 and Case 2) and when $\frac{\tau}{2} + F > b > E$ (Case 3).

Figures 4–6 identify the presence of inefficient incentives in the sense that homogenous firms may (a) seek accreditation when it is socially inefficient or (b) stay nonaccredited when it is social inefficient. The discrete nature of the accreditation decision implies, in spite of private and social incentives not being perfectly aligned, that the private decision coincides with the socially optimal one for some intervals of b. We also observe that socially efficient outcomes are always achieved, when the quality-addition (willingness to pay), b, is very low or very high. For intermediate values, the private and the social accreditation decision typically differ.

More generally, when the firms are heterogeneous, the Nash equilibria in 4–7 must be evaluated and compared in a welfare perspective. Hence, the welfare analysis in the heterogeneous case becomes more complex. This is because of the possibility that some of the asymmetric equilibria might be welfare-dominant. Another question that is relevant for the more general case relates to the allocation of production across the two firms. From a welfare point of

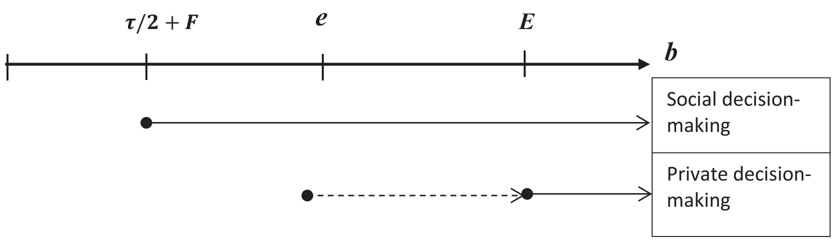

FIGURE 4 Social and private accreditation incentives: homogenous firms and Case 1

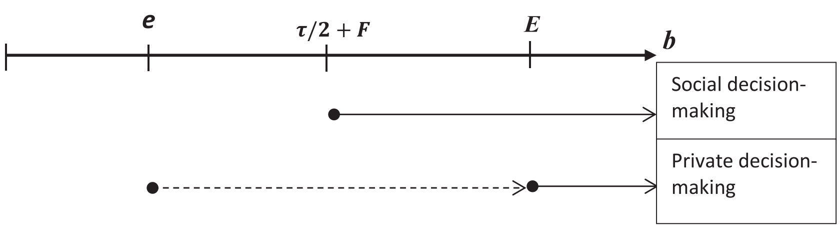

FIGURE 5 Social and private accreditation incentives: homogeneous firms and Case 2

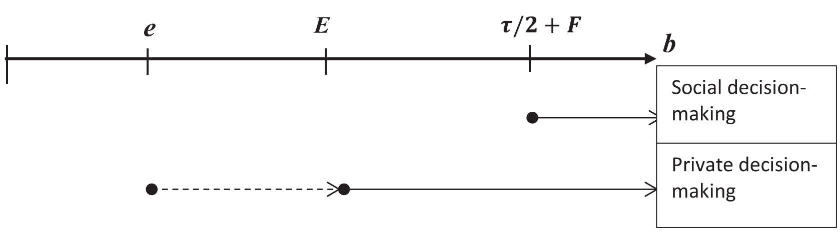

FIGURE 6 Social and private accreditation incentives: homogeneous firms and Case 3

view, it will always will be preferable to concentrate production in the firm with the lowest production costs, that is, the lowest levels of τ_i and c_i. The difference between private and social accreditation incentives, as revealed in the homogenous case, however, will still be present for the general case.

RESULT 4: Both for homogeneous and heterogeneous firms, private and social accreditation incentives are not perfectly aligned. This implies that firms may seek accreditation when it is socially inefficient, and stay non-accredited when it is social efficient. Hence, there is a potential for introducing a public policy to induce socially optimal accreditation behaviors among firms.

5 | REGULATORY INTERVENTIONS

In regulated markets, accreditation policy interventions are common. In health care and in higher education, there are examples of public authorities that practice direct regulation such as mandatory accreditation. Indirect regulation, like financial incentives that are to encourage accreditation is also present, either through a general budget raise (a higher fixed budget) or through a higher reimbursement rate if becoming accredited (preferential pricing). For the sake of simplicity, we restrict our forthcoming discussion to the case of homogeneous firms. First, we discuss mandatory accreditation (direct regulation); thereafter, we discuss indirect regulation (preferential pricing).

In Case 1 (see 23 and Figure 4), mandatory accreditation is optimal if $\frac{\tau}{2}+F<b<E$ (the multiple symmetric equilibrium is N_1N_2) or $\frac{\tau}{2}+F<b<e$ (the multiple symmetric equilibrium is A_1A_2). For Case 2 (see 24 and Figure 5), mandatory accreditation is socially preferable if $\frac{\tau}{2}+F<b<E$ (multiple symmetric equilibrium is N_1N_2). We also notice that a ban against accreditation is optimal for Case 2 when $\frac{\tau}{2}+F<b<e$. In this case, the private incentives produce a multiple equilibrium equal to A_1A_2. For Case *3* as well (see 25 and Figure 6), the authorities could improve welfare by banning accreditation when $E<b<\frac{\tau}{2}+F$ (multiple equilibrium is A_1A_2) and $e<b<\frac{\tau}{2}+F$ (multiple equilibrium is A_1A_2). This finding illustrates that mandatory accreditation can both improve welfare and decrease welfare. In situations where firms are homogeneous, and there are high profit margins relatively to the degree of competition, mandatory accreditation will typically be socially preferable. However, in markets with low profit margins, relatively to the degree of competition, it is less likely that mandatory accreditation is optimal.

Indirect regulation includes budget transfers, user charges, or reimbursement rates that are contingent upon the firms' actual accreditation choices (preferential pricing). Below, we give an example by studying optimal reimbursement rates. Comparing the social criteria in 20 with the two possible Nash equilibria in 21 and 22 above, we can identify the rates that align private and social incentives. First, by using 20 and 21, calculating the price p^H that makes E equal to $\frac{\tau}{2}+F$, defines the following value

$$p^H = c - z + \tau + 2t. \tag{26}$$

Next, by using 20 and 22, calculating the price p^L that makes e equal to $\frac{\tau}{2}+F$, defines the following value

$$p^L = c - z + 2t. \tag{27}$$

Finally, suppose now that the firms' actual reimbursement rates are designed as

$$P_1(N_1,N_2) = P_1(A_1,N_2) = P_2(N_1,N_2) = P_2(N_1,A_2) = p^H = c - z + \tau + 2t \tag{28}$$

and

$$P_1(A_1,A_2) = P_1(N_1,A_2) = P_2(A_1,A_2) = P_2(A_1,N_2) = p^L = c - z + 2t. \tag{29}$$

Using the reasoning behind the Nash equilibria defined in 4 and 7, where the values of P vary as described in 28 and 29, leads to the Nash equilibrium (A_1, A_2) in cases where $b>\frac{\tau}{2}+F$ and the Nash equilibrium (N_1,N_2) when $b<\frac{\tau}{2}+F$. This means that the reimbursement scheme defined by 28 and 29 ensure that the private incentives, leading to the two possible Nash-equilibria, correspond to the social preferable outcomes, depending on whether $b>\frac{\tau}{2}+F$ or $b<\frac{\tau}{2}+F$.

The optimal scheme is characterized by two different reimbursement rates, where both rates are independent of a firm's actual choice of accreditation, but dependent on the rival's choice. It is seen that if the rival stays nonaccredited, the firm obtains the high reimbursement rate, p^H, whereas the payment becomes low if the rival chooses to accredit, that is, p^L. The difference between the rates is τ. Hence, this particular scheme strengthens the incentives for the firms to stay nonaccredited. As we have seen in Section 3.2, the accreditation incentives for a given level of P are too strong, and the optimal reimbursement scheme prevents the firms from getting involved in the inefficient fighting for market shares (or from entering the Prisoners' dilemma game). Moreover, it is seen that both payments are increasing in the production unit cost, c, and the travel cost for the consumers, t, and decreasing in the user charge, z. Finally, it is seen that the extra payment if the rival's stay nonaccredited, $p^H - p^L = \tau$, is increasing as the accreditation unit cost becomes higher.

The above discussions show that it is not optimal for public authorities to reward those firms who accredit and/or punish those who do not accredit. However, such a practice of preferential pricing is often observed in connection with accreditation. Our proposed optimal reimbursement scheme is characterized by no dependency between the actual choice made by the firm regarding accreditation, but dependent on the rival's decision. The firm is to be rewarded if the rival stays nonaccredited. In a way the regime described in 28 and 29 is analogous to the socially preferable characteristics of Groves mechanisms for instance found in second price seal bid auctions, where the winner, reporting the lowest price (or valuation), obtains a price that is independent of its reported value, but dependent on the reported second lowest price, see for instance Rasmusen (1989).

RESULT 5: Direct regulation as mandatory accreditation can both improve welfare and decrease welfare, depending on the overall market situation. An indirect regulation, as designing an optimal reimbursement scheme for each firm, can be characterized by regulatory prices that are independent of the firm's own accreditation choice, but are contingent upon the accreditation decisions of the rival. The reimbursement rate is highest when the rival stays nonaccredited, reducing the firm's incentives to take part in an inefficient competition for market shares.

6 | DISCUSSION

In this section, we first compare our findings with the conclusions of works considered relevant. Second, we identify what the welfare implications are from consumer misperceptions (a false belief in quality improvements from accreditation) and accreditation leading to "true" cost-efficiency improvements. Finally, we discuss possible extensions (multi-party approaches and dynamic modeling). The literature on signaling begins with Spence's (1973) work on job-market signaling where low-ability workers find signaling (education) more costly than high-ability workers (Gibbons, 1992). Spence (1973) asked whether, in a competitive marketplace, sellers of above-average quality products could "signal" this fact by taking some costly action, and if the uninformed buyers could use this costly action as a way to "screen" for quality (Riley, 2001; Spence, 1974). However, for signaling to differentiate credibly between high and low quality suppliers, it must be advantageous for the high-quality ones. In basic market signaling models, this is accomplished by assuming that the cost of signaling is inversely related to supplier's quality (Kirmani & Rao, 2000; Riley, 2001).

In our model, accreditation represents a signaling device because being observable to the consumers (communicating about some unobservable element), whereas the signaling costs are the accreditation unit costs and the fixed accreditation costs. In Section 3.2, we showed the existence of equilibria for which low-quality firms choose not to signal (e.g., stay nonaccredited), whereas high-quality firms choose to signal (e.g., accreditation). We find that such asymmetric equilibria become more likely the lower the signaling costs of the high-quality firm and the higher the signaling costs of the low-quality firm. This is because lower (higher) accreditation costs, ceteris paribus, increases (reduces) the firms' profit margin. Our conclusion is analogous to the conclusion arrived at in the signaling literature. However, in contrast, to the signaling literature, we identify an additional effect implying that the opportunity to signal (seek accreditation) needs not to represent a comparative advantage for (true) high quality firms. This is because of the negative profit-effect described in Section 3. Firms exposed to relatively high quality expectations will have a higher initial market share, and such a market share advantage, ceteris paribus, will imply higher variable production costs if the firm seeks accreditation. This means that we cannot rule out equilibria where high-quality firms (with low signaling costs) choose not to signal (e.g., stay nonaccredited) whereas low-quality firms (with high signaling costs) choose to signal (e.g., accreditation). This finding points to a trade-off between the incentives that arise from lower accreditation costs and those that arise from higher quality expectations. The first effect promotes accreditation whereas the latter effect does the opposite. For instance, more precise information, brought to the market about the distribution of quality (becoming accredited), could in fact reduce the probability for true high-quality firms to seek accreditation. In reality, one often observes that firms that initially have a strong position in a market less frequently seek accreditation, for instance well-established and reputable universities and hospitals. Perhaps, this mechanism could contribute in explaining why many reputable hospitals and universities do not seek accreditation.

Grepperud et al. (2019) discusses how oligopolistic competition (duopoly) may affect the incentives for firms to seek accreditation. This work, however, is a more general than ours because studying the role of product differentiation (substitutable and complementary goods) and type of competition (various Cournot and Bertrand games). Furthermore, this work assumes that market size and prices are endogenous. Our model, in contrast, is one of monopolistic competition with substitutable goods, regulated prices, and a given market size, thus producing a zero-sum game where the parties compete for market shares. For substitutable goods, for example, the two studies yield the same type of results. Grepperud et al. (2019) finds that the closer to perfect substitutes, the higher the accreditation incentives for firms engaging in Cournot and Bertrand competition. In our model, the same conclusion follows from a reduction in the disutility per distance, that is, a lower t. A difference between the two models, however, is that in our set-up, due to a given market size, a more aggressive "race for accreditation" is experienced. Additionally, in Grepperud et al. (2019), in contrast to our analysis, the net benefits from becoming accredited are typically higher because the price is sensitive to a higher product quality (a higher demand).

The welfare analysis presented in Section 4 presupposes that accreditation induces "true" product quality improvements. Literature surveys concerned with quality improvements from hospital accreditation (see the introduction), however, do not identify much convincing evidence on such improvements. The question then becomes whether consumers and third-party payers are irrational (naïve), or not, because ignoring such evidence. However, the credence good properties of health care services and higher educational services suggest that third-party payers and consumers (patients or students) might be unable to observe quality both before and after purchase. For this reason, consumers may overvalue the effects from accreditation. In this perspective, consumers can be considered as rational decision-makers (given their beliefs) because their misperceptions are not adjusted over time due to the lack of improved (updated) information. In such situations, consumers are left with trusting the information provided by an independent third-party (accreditation body).

Grepperud et al. (2019) undertakes a welfare analysis for the case where accreditation does not yield any "true" increase in product quality but where the consumers falsely believe in such improvements (consumer misperceptions). In this case, as long as accreditation costs are positive, any equilibria that contain one or more firms that seek accreditation will represent a socially undesirable outcome. This conclusion is relevant for our analysis as well. Some researchers have argued that accreditation may lead to higher productivity and lower production costs due to improved processes causing a better use of resources and lower service failure (Motwani, Kumar, & Cheng, 1996). To the extent cost-efficiency improvements are taking place, ceteris paribus, such effects pull in the direction of accreditation improving its position in welfare terms. However, at the same time, we know from our analysis (see Section 3.2.) that the lower the production costs, the stronger the firm incentives for seeking accreditation. This means that the overall impact on social welfare from cost-efficiency improvements need not necessarily be positive.

In the following, we will discuss two possible model extensions—multi-party games and dynamic games. As is common for a class of Hotelling models, we have assumed two firms with end-point locations along a line segment. A higher number of parties in such a market will produce two important effects. First, due to a given market size, the market will be shared among more producers. Second, the average distance, between the consumers and the nearest producer, will be shorter (a lower *d*). It seems likely that both effects will increase the degree of market competition, thus increasing the firms' incentives to seek accreditation.

As concerning dynamic extensions, there are several options. One possibility is to introduce a model with sequential decision making, that is, one firm acts as a first-mover, whereas the rival, after observing the first mover's accreditation decision, thereafter decides on his accreditation decision (second-mover). In situations where both firms have dominant strategies, such an approach will not add anything new compared with the results presented in Section 3. This result holds for both homogenous and heterogenous firms. In the absence of dominant strategies, however, a model with sequential decision making might change some conclusions. In situations where both firms have a first-mover advantage, there might be a race for becoming the leader. If so, the conclusions arrived at in Section 3, however, are expected to prevail.

Another dynamic extension would be to relax the assumption of the initial quality levels being exogenous (given by history), by allowing firms to invest in quality prior to playing the accreditation game (an extended time horizon). A reasonable modeling approach, being much in line with our model, would be to assume that (a) quality is not perfectly observable by consumers and (b) accreditation enables consumers to assess the true quality with a higher degree of certainty. Such a dynamic extension makes possible an analysis of possible interactions between quality—and accreditation choices, and such interactions are likely to uncover additional effects. For example, the introduction of an additional stage of competition (Stage 1), ceteris paribus, will create a more competitive environment that may strengthen accreditation incentives. Another mechanism that may turn out to be important is the linkage between quality levels and accreditation costs. The quality investment undertaken in the first stage may influence the accreditation decision at the second stage because the significance of accreditation costs typically will depend on the quality levels. A model extension along the lines described above is an interesting avenue for future research.

7 | CONCLUSIONS

We have chosen a simple market model that includes vertical and horizontal differentiation, fixed locations, and fixed prices to analyze accreditation incentives. Regulated markets, as those modeled here, are common for instance in health care and education. We portray accreditation as a third-party verification of compliance to certain predefined output standard (output accreditation) or to certain input—and process standards (process accreditation). In the case of process accreditation, unlike output accreditation, there is no exact verification of the product quality level, implying that accreditation in general need not give quality improvements. However, we have assumed that accreditation of both types raises the expected product quality in the eyes of the consumers, where output accreditation gives more accurate information relatively to process accreditation.

The driving force in the model presented is the competition for defending or increasing own market shares. When the reimbursement rate, the user charges, and the quality-additions related to accreditation become higher, and the production unit costs, accreditation costs, and consumers' distance costs become lower, the probability for equilibria of the type where all firms choose to accredit, increases. For homogenous firms, the firms prefer equilibria of the type where both stay nonaccredited compared with those where both choose to accredit. Hence, the accreditation instrument creates a Prisoner's dilemma game.

One finding is that both players, independent of own choices, are better off if the rival stays nonaccredited. Furthermore, the incentives for seeking accreditation depend on profit margins and market shares. The market shares are functions of strategic interactions (own and rival choices) and depend on *ex ante* perceived differences in quality, changes in the perceived quality from becoming accredited, and the disutility of distance (the degree of market competition). We have identified the conditions for various Nash-equilibria. In the case of homogeneous firms, both types of equilibria are possible (both stay nonaccredited and both become accredited). Moreover, there is a possibility of a multiple Nash equilibria where both stay nonaccredited and both choose to accredit. When analyzing the case of heterogeneous firms, we find that if the differences between the firms regarding costs and/or quality improvements from accreditation are sufficiently high, a separation in choices is likely. A firm with lower production costs and accreditation costs, compared with the rival, is encouraged to seek accreditation whereas the rival is not. Furthermore, by specifying the consumers' beliefs, we have identified equilibria characterized by the firms, likely to have the lowest initial quality level, to choose accreditation, whereas other firms stay nonaccredited.

From a welfare point of view, the condition for accreditation to be preferable is that accreditation raises the true quality and that the increase in utility that follow from a higher quality will exceed the accreditation costs. Hence, a general policy of mandatory accreditation cannot be welfare optimal. The use of reimbursement rates that align private incentives with the social ones can be applied to reduce deviations between private and social accreditation incentives. Such a reimbursement scheme should reflect the accreditation decision made by rival. If the rival stays nonaccredited, the firm is honored by a reimbursement rate that is higher than if the rival seeks accreditation, and the difference is equal to the accreditation unit cost (τ). Furthermore, the reimbursement rates are increasing in the disutility of distance (t) and the production unit cost (c), and decreasing in the user charge (z). The optimal reimbursement scheme is designed in a way that weakens the firms' accreditation incentives. These findings confirm that the type of financial incentives often discussed and sometimes observed in relation to accreditation in regulated markets, such as preferential pricing (favorable economic terms in response to becoming accredited), will increase private accreditation incentives, in this way increasing the gap between the private and the social accreditation incentives.

Based on the high and still growing prevalence of accreditation in markets with regulated prices, both more theoretical and empirical research on the possible private and social gains and costs that follow from accreditation is in demand. In particular, such research should focus on the causal links between becoming accredited and product quality improvements.

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ENDNOTES

[1]The distinction of concepts is discussed in van Damme (2004). The American approach to accreditation is close to quality assurance (schemes that have the objective of assessing, monitoring, and maintaining/improving quality), whereas approval or certification are lying closest to what is meant by accreditation elsewhere. Bohigas and Heaton (2000) define accreditation as a process by which an agency evaluates and recognizes an organization meeting certain requirements. To become accredited requires an organization to demonstrate that it employs a specific set of management practices or fulfill certain pre-specified standards (Griffith et al., 2002)

[2]According to Haug (2003), accreditation of higher education provides an authorized message about quality aimed at students, employers, and public authorities.

[3]By 2005 almost one half of the U.S. health maintenance organizations was accredited (Jin, 2005).

[4]The National Association for the Education of Young Children (NAEYC) accredits approximately 8,000 early care and education programs throughout the United States with an equivalent number being in the process of seeking accreditation (Whitebook, Sakai, & Howes, 2010).

[5]The proportion of accredited US business education programs increased from 11% (1988) to 42% (2007; Corcoran, 2007).

[6]The number of countries in 2005 was 98 (Eaton, 2006).

[7]Nearly all European countries have set in place a national system or agency for the purpose of quality evaluation, quality assurance, and accreditation (Haug, 2003).

[8]There are examples of hospital payments systems that link accreditation to reimbursement (Duckett, 1995; El-Jardali, 2007). Ng, Leung, Johnston, and Cowling (2013) and Shaw (2004) recommend financial incentives as drivers for hospital accreditation. Eager, Sansoni, Loggie, Elsworthy, and McNamee (2013) apply the term "quality structures pricing models" on accreditation programs that link accreditation standards to funding.

[9]Some literature, however, confirms that hospital accreditation may lead to changes in internal processes. A systematic literature survey by Greenfield and Braithwaite (2008) identified consistent positive associations in two, out of, the 10 areas being investigated ("promoting change" and "professional development"). Chen, Rathore, Radford, and Krumholz (2003) find that hospitals rapidly increase compliance with standards in the months prior to external assessments.

[10]Lejeune and Vas (2009) have analyzed the effects of EQUIS accreditation with quantitative survey data and found that accreditations positively influence organizational culture and effectiveness. Volkwein et al., (2007) find that the introduction of new EC2000 accreditations standards improved engineering programs in terms of student experiences and student outcomes. Nigsch and Schenker-Wicki (2013) find that international accreditations help business schools to improve their research performance.

[11]Additionally, Grepperud (2015) discusses the relationship between hospital motivation and the incentives for hospital accreditation in a nonstrategic setting.

[12]See Gaynor (2007) for a survey of theoretical and empirical evidence.

[13]See also Brekke, Siciliani, and Straume (2011), Matsumura and Matsushima (2007), and Wolinsky (1997).

[14]*Ex ante* there could exist two equally sized pools of firms. The consumers know that the first pool consists of at least as many high quality firms as the other pool. Following the reasoning in Rasmusen (1989), using "Nature" as an actor, this means that we implicitly assume that Nature draws two competing firms, one from each pool, and the consumers do not observe the actual quality supplied by the selected firms.

[15]For a similar reasoning, see Gravelle and Masiero (2009) and Gravelle and Sivey (2010).

[16]Note that even though we have modeled uncertainty for the consumers regarding the quality supplied by the firms, it is still possible to use the Nash equilibrium concept (instead of a Bayesian equilibrium concept) in analyzing the possible outcomes of the accreditation game. The firms are supposed to be perfectly informed about each other's quality levels. The consumers have prior beliefs concerning the firms' probabilities for supplying high and low quality, implying that there is no information updating concerning these probabilities during the game, see for instance Rasmusen (1989) for a discussion of informational structures of games and the relevance of practicing different equilibrium concepts.

[17]In the following, we denote equilibria where both firms make the same accreditation choice as symmetric equilibria, whereas we use asymmetric equilibria when the two firms make different accreditation choices.

[18]If we use a kind of "focal point" argument here, we may suggest that because the firms prefer N_1N_2 to A_1A_2, the most likely outcome in cases where $y < P < Y$ is N_1N_2.

[19]The partial effects from τ_1 and τ_2 are presented in Appendix B.

[20]The firms' valuation of the various equilibria now becomes more complex. For instance, in this case of heterogeneous firms, it is not always true that both firms prefer the outcome where no one accredits, to the outcome, where both firms accredit, as it is when assuming firm homogeneity (leading to the Prisoners' dilemma situation).

[21]The results presented in Table 1 are available from Appendix C.

[22]However, as discussed in Section 2 and Appendix A, for the case of "strict" process accreditation, Δb could be positive, and if the first term dominates the second and the third terms in the parenthesis in 16c, this result could be changed.

[23]Implicitly, we have assumed an additive welfare function where the Kaldor-Hicks criteria holds. This implies that utility (profit) gains (losses) for one group of consumers (firms) might be compared to utility (profit) losses (gains) for another group of consumers (firms). As long as the total welfare is higher for one outcome compared to the other, this means that the first one is socially preferred.

[24]In the case of heterogeneous firms, it might be welfare improving to move production from the firm with the highest costs (and/or lowest quality) to the firm with the lowest costs (and/or highest quality). Such effects must be considered when undertaking a welfare analysis of heterogeneous firms. In doing so, the welfare that arises the asymmetric equilibria must be calculated and ranked, that is, the profits and utilities belonging to 5 and 6.

[25]Kirmani and Rao (2000) discusses interesting ways of signaling quality in markets and develops a typology that classifies signals and discuss the available empirical evidence on the signaling properties of several marketing variables.

[26]Terlaak and King (2006) discusses the role of certification as a signaling device and uses ISO 9000 Quality Management Standard to develop their arguments. They argue that certification may represent an attempt to communicate about desirable organizational attributes to parties that cannot observe them directly and propose that certification provides a competitive advantage whether or not the standard actually improves the organization's operational performance.

[27]Applying a Hotelling model seems relevant when travel costs are important, as is the case for purchasers of health care services and educational services. In a Hoteling model, in contrast to oligopolistic competition, homogenous firms are different in the eyes of consumers because the location of both firms and consumers differ.

[28]Besides Motwani et al. (1996), we are not aware of other works that mention that production costs may be reduced as a consequence of accreditation. The study by Motwani et al. (1996) does not provide any evidence for the existence of such cost-reducing effects.

[29]Increasing the number of firms will most likely have an effect parallel to reducing t in our model. An adequate way of analyzing the effects from an increasing the number of firms would be to use a spatial framework (the circular city).

[30]Also in the opposite case, where both firms have a second mover advantage, the players might choose an awaiting behavior that finally ends up in simultaneous moves as described in Section 3. For a discussion on first and second mover advantages, see Gar-Ol (1985).

[31]Our paper is set in regulatory context meaning that we study accreditation as a short or medium term decision. An additional long-term decision that could be studied is the location decision of the firms. However, for health care organizations and educational institution, such choices are likely to be influenced by the geographical preferences of public authorities.

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How to cite this article: Grepperud S, Pedersen PA. Accreditation in regulated markets. *Manage Decis Econ*. 2020; 1–18. https://doi.org/10.1002/mde.3175

APPENDIX A.: MODELING PROCESS ACCREDITATION

In the case of process accreditation, there is no well-defined output quality standard, and there is an inherent uncertainty associated with the quality effects that arise from becoming accredited. A simple, but possible, formulation of quality additions and the relative quality addition for this type is (in the following denoted *PL*)

$$b_i^{PL} \equiv (1-q_i)s\left(\hat{S}-L\right) > 0, \tag{A1}$$

$$\Delta b^{PL} \equiv b_1 - b_2 = -(q_1-q_2)s\left(\hat{S}-L\right)] < 0, \tag{A2}$$

where $\hat{S}$ now refers to the expected quality level for firms that comply with the predetermined input standards where $H > \hat{S} > L$ and s is the probability of achieving this particular output quality level. Process accreditation with somewhat higher quality expectations (in the following denoted *PH*) can be formulated as follows:

$$b_i^{PH} \equiv q_i r(\bar{S}-H) + (1-q_i)s(\bar{S}-L) > 0, \tag{A3}$$

$$\Delta b^{PH} \equiv b_1 - b_2 = (q_1-q_2)\left[r(\bar{S}-H) - s(\bar{S}-L)\right] \geq (<)0. \tag{A4}$$

Now we have a situation where $\bar{S}$ refers to the expected quality level for firms that comply with the predetermined input standards where $\bar{S} > H > L$ and where the parameters r and s refer to the probability of achieving this particular quality levels for high and low-quality firms, respectively. It follows from A4 that $\Delta b^{PH} > (<0) \Rightarrow r(\bar{S}-H) \geq (<) s(\bar{S}-L)$. If $r \leq s$, it is easily seen that $\Delta b^{PH} < 0$ also in this case.

APPENDIX B.: PARTIAL EFFECTS FROM A CHANGE IN VARIABLE ACCREDITATION COSTS

It follows from 4–7 that the following changes in the threshold values for marginal changes in the variable accreditation costs

$$\frac{\partial Y_1}{\partial \tau_1} = 1 + \frac{t+\Delta V}{b_1} > 0, \ \frac{\partial y_1}{\partial \tau_1} = \frac{\partial Y_1}{\partial \tau_1} - \frac{b_2}{b_1} = \frac{t+\Delta V+\Delta b}{b_1} > 0, \frac{\partial Y_1}{\partial \tau_2} = \frac{\partial y_1}{\partial \tau_2} = 0, \tag{A5}$$

$$\frac{\partial Y_2}{\partial \tau_2} = 1 + \frac{t-\Delta V}{b_2} > 0, \ \frac{\partial y_2}{\partial \tau_2} = \frac{\partial Y_2}{\partial \tau_2} - \frac{b_1}{b_2} = \frac{t-\Delta V-\Delta b}{b_2} > 0, \ \frac{\partial Y_2}{\partial \tau_1} = \frac{\partial y_2}{\partial \tau_1} = 0, \tag{A6}$$

where we have used that $\Delta V < t$ and $\Delta V + \Delta b < t$ when both firms are supposed to operate in all cases.

APPENDIX C.: COMPARATIVE STATICS GIVEN OUTPUT ACCREDITATION (CASE *OL* and *OH*), SEE Table 1

1 The case *OL*

For Firm 1, the partial effects following from *OL* ($\hat{S}$) become as follows

$$\frac{\partial Y_1}{\partial q_1} = \frac{[t\tau_1 + 2tF_1 + (1-q_2)\tau_1(H-L)]}{(1-q_1)^2\left(\hat{S}-L\right)} > 0; \ \frac{\partial Y_1}{\partial q_2}$$
$$= -\frac{[\tau_1(H-L)]}{(1-q_1)\left(\hat{S}-L\right)} < 0; \ \frac{\partial Y_1}{\partial H}$$
$$= \frac{[\tau_1(q_1-q_2)]}{(1-q_1)\left(\hat{S}-L\right)} > 0 \quad \frac{\partial Y_1}{\partial L}$$
$$= \frac{\left[2tF_1 + \tau_1\left(t + (q_1-q_2)\left(H-\hat{S}\right)\right)\right]}{(1-q_1)\left(\hat{S}-L\right)^2} > 0, \quad \frac{\partial Y_1}{\partial \hat{S}}$$
$$= -\frac{[2tF_1 + \tau_1(t + (q_1-q_2)(H-L))]}{(1-q_1)\left(\hat{S}-L\right)^2} < 0 \quad \frac{\partial y_1}{\partial q_1}$$
$$= \frac{[t\tau_1 + 2tF_1 + (1-q_2)\tau_1(H-S)]}{(1-q_1)^2\left(\hat{S}-L\right)} > 0; \ \frac{\partial y_1}{\partial q_2}$$
$$= \frac{\tau_1}{(1-q_1)}\left(1 - \frac{(H-L)}{\left(\hat{S}-L\right)}\right) < 0; \ \frac{\partial y_1}{\partial H}$$
$$= \frac{[\tau_1(q_1-q_2)]}{(1-q_1)\left(\hat{S}-L\right)} > 0; \ \frac{\partial y_1}{\partial L}$$
$$= \frac{\left[2tF_1 + \tau_1\left(t + (q_1-q_2)\left(H-\hat{S}\right)\right)\right]}{(1-q_1)\left(\hat{S}-L\right)^2} > 0; \ \frac{\partial y_1}{\partial \hat{S}}$$
$$= -\frac{[2tF_1 + \tau_1(t + (q_1-q_2)(H-L))]}{(1-q_1)\left(\hat{S}-L\right)^2} < 0.$$

The same effects for Firm 2 in the case of OL ($\hat{S}$) are

$$\frac{\partial Y_2}{\partial q_2}=\frac{[t\tau_2+2tF_2+(1-q_1)\tau_2(H-L)]}{(1-q_2)^2\left(\hat{S}-L\right)}>0,\ \frac{\partial Y_2}{\partial q_1}=-\frac{[\tau_2(H-L)]}{(1-q_2)\left(\hat{S}-L\right)}<0;\ \frac{\partial Y_2}{\partial H}=-\frac{[\tau_2(q_1-q_2)]}{(1-q_2)\left(\hat{S}-L\right)}<0;\ \frac{\partial Y_2}{\partial L}=\frac{\left[2tF_2+\tau_2\left(t-(q_1-q_2)\left(H-\hat{S}\right)\right)\right]}{(1-q_2)\left(\hat{S}-L\right)^2}>0;\ \frac{\partial Y_2}{\partial \hat{S}}=-\frac{[2tF_2+\tau_2(t-(q_1-q_2)(H-L))]}{(1-q_2)\left(\hat{S}-L\right)^2}<0\ \frac{\partial y_2}{\partial q_2}=\frac{\left[t\tau_2+2tF_2+(1-q_1)\tau_2\left(H-\hat{S}\right)\right]}{(1-q_2)^2\left(\hat{S}-L\right)}>0\ \frac{\partial y_2}{\partial q_1}=\frac{\tau_2}{(1-q_2)}\left(1-\frac{(H-L)}{\left(\hat{S}-L\right)}\right)<0,\ \frac{\partial y_1}{\partial H}=-\frac{[\tau_2(q_1-q_2)]}{(1-q_2)\left(\hat{S}-L\right)}<0\ \frac{\partial y_2}{\partial L}=\frac{\left[2tF_2+\tau_2\left(t-(q_1-q_2)\left(H-\hat{S}\right)\right)\right]}{(1-q_2)\left(\hat{S}-L\right)^2}>0;\ \frac{\partial y_2}{\partial \hat{S}}=-\frac{[2tF_2+\tau_2(t-(q_1-q_2)(H-L))]}{(1-q_2)\left(\hat{S}-L\right)^2}<0.$$

2 The case OH

For Firm 1, the partial effects following from OH ($\bar{S}$) become as follows:

$$\frac{\partial Y_1}{\partial q_1}=\frac{T}{N^2}(H-L)>0;\ \frac{\partial Y_1}{\partial q_2}=-\frac{\tau_1}{N}(H-L)<0;\ \frac{\partial Y_1}{\partial H}=\frac{\tau_1\left[(q_1-q_2)\left(\bar{S}-L\right)+q_1t\right]+2tF_1q_1}{N^2}>0\ \frac{\partial Y_1}{\partial L}=\frac{(1-q_1)t(\tau_1+2F_1)-\tau_1(q_1-q_2)(\bar{S}-L)}{N^2}\geq(<)0;\ \frac{\partial Y_1}{\partial \bar{S}}=-\frac{[\tau_1(t+(q_1-q_2)(H-L)+2tF_1]}{N^2}<0;\ \frac{\partial y_1}{\partial q_1}=\left(\frac{T}{N^2}+\frac{\tau_1 b_2}{N^2}\right)(H-L)>0;\ \frac{\partial y_1}{\partial q_2}=0;\frac{\partial y_1}{\partial H}=\frac{q_1t(2F_1+\tau_1)}{N^2}>0;\ \frac{\partial y_1}{\partial L}=\frac{(1-q_1)t(\tau_1+2F_1)-\tau_1(q_1-q_2)(H-L)}{N^2}\geq(<)0;\frac{\partial y_1}{\partial \bar{S}}=-\frac{[\tau_1(t+2tF_1)]}{N^2}<0,$$

where $T=\tau_1\left(\bar{S}-L-q_2(H-L)+t\right)+2tF_1$ and $b_1=N=\bar{S}-L-q_1(H-L)$.

The same effects for Firm 2 following from OH ($\bar{S}$) are

$$\frac{\partial Y_2}{\partial q_2}=\frac{D(H-L)}{G^2}>0,\ \frac{\partial Y_2}{\partial q_1}=-\frac{[\tau_2(H-L)]}{G}<0;\ \frac{\partial Y_2}{\partial H}=\frac{\tau_1\left[(q_1-q_2)\left(\bar{S}-L\right)+q_2t\right]+2tF_2q_2}{G^2}>0;\frac{\partial Y_2}{\partial L}=\frac{(1-q_2)t(\tau_2+2F_2)-\tau_2\left(q_1-q_2\right)(\bar{S}-L)}{G^2}\geq(<)0;\ \frac{\partial Y_2}{\partial \bar{S}}=-\frac{[\tau_1(t+(q_1-q_2)(H-L)+2tF_1]}{N^2}<0\ \frac{\partial y_2}{\partial q_2}=\left(\frac{D}{G^2}+\frac{\tau_2 b_1}{G^2}\right)(H-L)>0;\frac{\partial y_2}{\partial q_1}=0;\ \frac{\partial y_2}{\partial H}=\frac{q_2t(2F_2+\tau_2)}{G^2}>0;\ \frac{\partial y_2}{\partial L}=\frac{(1-q_2)t(\tau_2+2F_2)-\tau_2(q_1-q_2)(H-L)}{G^2}\geq(<)0;\ \frac{\partial y_2}{\partial \bar{S}}=-\frac{[\tau_2(t+2tF_2)]}{G^2}<0,$$

where $D=\tau_2\left(\bar{S}-L-q_1(H-L)+t\right)+2tF_2$ and $G=\bar{S}-L-q_2(H-L)$.