Producers' choice of certification

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Abstract

Consumers are in general less informed than producers about the quality of agricultural goods. To reduce the information gap, consumers can rely on standards (labels, certifications, geographic indications) that insure quality and origin of the goods. However, these standards do not always fully reveal information. Some of them may just signal that the good is more likely to be of high quality. We investigate what kind of standards are most desirable for producers, and for society in general knowing that any system is costly to implement. One of our findings is that for intermediate values of certification costs, certification that fully reveals information makes high quality producers better off, but make the entire industry worse off. In this case, the benefit from the revelation of the quality does not outweigh certification costs and the loss incurred by low quality producers. Furthermore, the industry may be better off under partial revelation of information rather than full revelation for some values of the certification costs.

Keywords: Asymmetric information, certification, clubs, quality.

JEL classification: L11 (Market structure); L15 (information and product quality); D82 (asymmetric and private information); D71 (Clubs).

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1 Introduction

Consumers are in general less informed than producers about the quality of agricultural goods. For some goods, cannot be assessed before being purchased (experience goods) whereas for other goods consumers will never be able to assess their quality (credence goods). To reduce the information gap consumers can rely on standards (labels, geographical indications, certifications) that are granted or regulated by a governmental agency. These standards are used to infer quality and origin of goods. However they do not always fully reveal information to consumers. Indeed, if high-quality goods are certified, it does not necessarily mean that all the non-certified goods are of low quality. For instance, a geographical indication provides consumers with the information that the good has been produced within a certain geographic area, and insures a certain quality. However, producers who do not have this geographical indication may produce a good of equal quality. In general certified goods signal high quality, but it can just give an indication that it is more likely that the good is of high quality. One can think of trademarks that do not necessarily insure that the good is of good quality but help consumers identify the brand name.[3] Hence there exists a variety of standards or certifications that can fully or partially reveal information to consumers. We investigate how different degrees of information revelation affect producers, the industry, and social welfare in general knowing that any system is costly to implement.

Asymmetric information between sellers and consumers has been widely studied in the economic literature. Starting with the seminal work of Akerlof (1970), studies have shown how it affects the allocation and distribution of resources. Bagwell and Riordan (1991) show that when it is more costly to produce high quality than low quality, high quality producers have an incentive to produce less and thus increase their price to signal their high quality. Thus there exists a separating equilibrium in which prices signal quality of the good. However, it is not always possible to signal quality by prices, especially when marginal costs of production are identical. In case of repeated purchases, Milgrom and Roberts (1986) show that producers can signal their high quality by negative price distortion.

Another way of allowing uninformed consumers to become better informed is to introduce a certification intermediary. Biglaiser (1993) and Biglaiser and Friedman (1994) investigate how middlemen can partially mitigate the problem due to asymmetric information. Lizzeri (1999) investigates what amount of information should be revealed by the certification intermediaries, and how this information affects the surplus. In a recent paper, Albano and Lizzeri (2001) study what is the optimal degree of information revelation, and how the information revealed by the

[3] Rangnekar (2004) compares and contrasts geographical indications and trademarks.

intermediary affects the production of quality. In our paper, we consider that qualities are given and we do not consider a strategic revelation of information by the certification intermediary. We consider that the information conveyed by the intermediary is accurate and that it completely reveals the quality of the good. Unlike in Lizzeri (1999) where consumers have identical tastes, we consider that consumers differ in their taste and thus consumers who value the most the good consume the high quality good.

Our paper is close to Marette and Crespi (2003)'s. They investigate whether cartels (producer associations that use common labels and trademarks) improve overall welfare. They consider that producers can collude in quantity and use the concept of sequential formation of cartel to examine the actions of sellers who join a cartel. They investigate different structures of certification costs (share cost versus non-shared cost) and analyze whether the signalling effect (through certification) offsets the collusive effect. The authors show that if cartels are allowed and there exists a third party certification, a stable cartel may emerge. Our analysis is different from theirs on several grounds. We do not allow for collusion on quantity, we consider that an association of producers can be formed to get a common label, but they compete in quantity afterwards. They can, however, reduce competition by not allowing too many producers in the group. Our formation of the association is a club formation. We define an optimal size of a club, knowing that letting one more producer in the club reduces the total cost, but also reduces the profit for each producer (on club goods, see Scotchmer, 2002). We investigate under what kinds of circumstances producers may prefer to rely on a certification regime that does not fully reveal information, and whether this certification regime can be welfare improving.

Labels can be private or public.[4] Public labeling can be done directly by a public agency that controls the entire labeling process, or through a third party middleman (producer association) that certifies the goods according to some rules imposed by a regulator. In our model we consider the latter case: a third certification intermediary has the power to certify. Another important question is to define who should pay for labeling. Crespi and Marette (2001) show that a per-unit or an ad valorem fee is in most cases preferred. We do not have the ambition of answering such a question. Rather we consider that the cost of labeling is shared by all the producers that get the label.

Our model is related to the literature on imperfect competition, and we consider a simple model of vertical differentiation[5] in which firms produce goods of given quality: high or low. The

[4] See Bergès-Sennou, Bontems and Réquillart (2004) for a survey on private labels, and Crespi and Marette (2003) for a survey on public labels.

[5] Models of vertical differentiation were first developed in the context of monopoly (Mussa and Rosen, 1978) and a duopoly (Gabszewics and Thisse, 1979). The focus was on the optimal choice of product qualities.

industry is composed of half high quality producers and half low quality producers. Consumers do not know the quality of the good unless they get more information through certification. They can either learn perfectly the quality if all the high quality producers get a certification, or learn imperfectly the quality when not all the high quality producers get a certification. We consider different scenarios and then compare the welfare changes relative to a benchmark when there is no certification. We examine the following scenarios: (*i*) the certification fully reveals the quality and, (*ii*) the certification only reveals when a product is of high quality.

In scenario (*ii*) we consider that producers can decide to form a group (a club) that will apply for the certification. This is what we observe with geographical indications: a certain number of high quality producers decide to form a group in which each member must respect a precise and well-defined control of quality. Geographical indications can be seen as club goods (non rival, congestible and excludable), and thus an optimal size of the club can be defined.

In general, complete (or partial) revelation of information benefits 1) high quality producers, because they can profit from revealing that they produce high quality; 2) consumers with low willingness to pay, who will find that their consumption of low-quality products will cost them less; and 3) consumers with high willingness to pay who will find that they are more likely to get what they pay for. Welfare losses can be expected for 1) low quality producers who lose from the revelation of information because they are now identified as being of low quality so they will receive a lower quality for their output; and 2) consumers with middle willingness to pay who benefit in the benchmark case of sometimes receiving high quality production for a moderate price.

Not surprisingly, if the certification costs are identical under all scenarios, a regime that fully discloses the quality makes society better off. However, this is no longer true if the costs vary across certification schemes. Furthermore, for intermediate values of certification costs, a certification that fully reveals information makes high quality producers better off, but it will result in lower industry welfare. In this case, the benefit from the revelation of the quality does not outweigh the cost and the loss incurred by low-quality producers. We show that the industry may be better off under partial revelation of information rather than full revelation for some constellations of certification costs. These results may explain the hesitancy of the U.S. cattle industry to endorse full traceability for cattle.

The paper is organized as follows. The model is presented in section 2. Section 3 gives the details of the production stage under the four different scenario we consider. Section 4 focuses on the certification choice by producers. In section 5, we investigate, from a normative viewpoint, what certification a benevolent agency should allow. Section 6 concludes.

2 The model

We consider an industry with $m > 2$ firms that produce goods of two different qualities: high, s_h and low, s_l. We assume that firms do not choose their quality level and that half of them (i.e., $m/2$) produce high quality, and half produce low quality. Let c_h (c_l) denote the marginal cost of production of a high (low) quality, where $c_h \geq c_l$. To simplify, we first assume that $c_h = c_l = 0$. Furthermore, there is a fixed cost incurred by the firms $F_h > F_l = 0$.

Consumers don't know the quality of the good (it can be either a credence good or a search good), while producers know the quality of their own good. There is asymmetric information unless consumers get more information. This can happen if the producers obtain a label or get certified in which case consumers either know that only high quality is provided.

To be more specific on the demand side, we consider N consumers, each of them consumes either 0 or 1 unit of the good. We normalize $N = 1$. Each consumer has the following preferences

$$U = \begin{cases} \theta s - p \text{ if he buys the good of quality } s \text{ and pays } p \\ 0 \text{ otherwise} \end{cases}$$

where θ is a taste parameter, and s represents the quality of the good. We assume that θ is distributed according to a uniform distribution between $\underline{\theta} = 0$ and $\overline{\theta} = 1$, where $F(0) = 0$ and $F(+\infty) = 1$. Thus, $F(\theta)$ is the fraction of consumers with a taste parameter of less than θ. We can thus define the demand function. If there were only one quality, there exists a consumer $\widehat{\theta}$ who is indifferent between buying the good of quality s or not buying it, and thus his utility is

$$\widehat{\theta}s - p = 0.$$

Then, the demand is

$$D(p) = 1 - \frac{p}{s}.$$

If there are two different levels of quality, and $\frac{s_h}{p_h} < \frac{s_l}{p_l}$ (quality-adjusted price is higher for low quality), there exists a consumer $\widetilde{\theta}$ who is indifferent between consuming the high quality good or the low quality good and thus

$$\widetilde{\theta}s_h - p_h = \widetilde{\theta}s_l - p_l,$$

where p_h (p_l) is the price for high (low) quality good. Hence

$$\widetilde{\theta} = \frac{p_h - p_l}{s_h - s_l}$$

defines the demand for high quality. However, consumers who choose not to buy the high quality, will buy the low quality or nothing. Thus, there exists an indifferent consumer such that

$$\widehat{\theta}s_l - p_l = 0.$$

The demands for high quality and low quality are thus

$$\begin{aligned} D_h(p_l, p_h) &= 1 - \frac{p_h - p_l}{s_h - s_l}, \\ D_l(p_l, p_h) &= \frac{p_h - p_l}{s_h - s_l} - \frac{p_l}{s_l}. \end{aligned}$$

We can easily derive the inverse demand functions

$$\begin{aligned} p_h(Q_h, Q_l) &= [1 - Q_h)]s_h - Q_l s_l, \\ p_l(Q_h, Q_l) &= [1 - (Q_h + Q_l)]s_l, \end{aligned}$$

where Q_h (Q_l) represents the total quantity of high (low) quality good produced.

At the outset of the game, the governmental agency offers two certifications or labels: one that fully reveals the quality of the good (full revelation case) and one that only reveals high quality goods, but cannot allow consumer to determine if the non-labeled good is of low quality.

The full revelation case corresponds to the simpler case of certification. For instance, consider a monopoly that can either produce a high quality good or a low quality good. The quality is unknown by consumers, and with probability $1/2$ the good is of high quality. Thus, if it is not too costly to certify the good, there exits a separating equilibrium in which high quality producer will certify his good whereas low quality producer never does certify his good. Thus, consumers learn the quality of the good as certified goods are of high quality whereas non-certified good are of low quality. In our setting, this will happen if all the $m/2$ producers of high quality decide to adopt the certification. However, if only a fraction of the high quality producers adopts the label, when buying a labeled good, consumers know that it is a high quality good, but they don't know the quality of a non-labeled good. Indeed, among the non-labeled goods, some are of low quality (actually they represent the biggest proportion), but some are of high quality. We denote this kind of label label-G, as for instance it an be the case of geographical indications (GI): goods with a GI can be identified as high quality goods, whereas goods without a GI may also be of high quality. It may be the case that more high quality producers want to get the label, but cannot.

The timing of the game is the following:

- First, producers decide whether or not to get a label. If they get a label-G, they decide the optimal size of the group of producers that will get the protection;
- Second, producers observe what label has been adopted and by how many firms. Then, all the firms compete in quantity.

We consider the following scenarios: (i) there is no certification (benchmark case); (ii) the certification fully reveals the quality of the good; (iii) the certification reveals only high quality goods (label-G case).

3 Production stage: equilibrium, profit and welfare

By backward induction, we first define the Cournot equilibrium for each possible scenario and then we define the label decision.

3.1 Benchmark: No certification, unknown quality

Consider first that producers cannot get a certification and thus consumers do not have extra information concerning the quality of the good. Consumers' expectation of the quality is

$$s^a = \frac{1}{2}(s_h + s_l).$$

There exists a consumer $\widetilde{\theta}^a$ who is indifferent between buying the good of expected quality s^a and not buying it,

$$\widetilde{\theta}^a s^a - p = 0,$$

and thus the inverse demand function for the good of quality s^a is

$$p(Q) = [1 - Q]s^a,$$

where Q is the total quantity produced.

Each firm chooses the quantity that maximizes its payoff

$$\underset{q_i}{Max}\{p(q_i, q_{-i})q_i - F_i\}$$

where $q_i + q_{-i} = Q$. Because they have the same marginal cost, firms are symmetric and thus $q_{-i} = (m-1)q$. The maximization program is thus

$$\underset{q_i}{Max}\{[1 - q_i - (m-1)q]s^a q_i - F_i\}$$

that gives the best response function of each firm

$$q_i(q) = \frac{[1-(m-1)q]s^a}{2s^a}.$$

Using the fact that firms are symmetric, we can set $q_i = q$ and thus the optimal output level for each firm is

$$q^* = \frac{1}{(1+m)},$$

the price is

$$p^* = \frac{s^a}{1+m},$$

and each firm gets a gross profit

$$\Pi^* = \frac{s^a}{(1+m)^2},$$

from which high quality producers have to pay a fixed cost F_h.

In this very simple setting, because marginal costs are identical, if firms had to choose their quality, they will all produce low quality good. Consumers anticipate this correctly and thus they are only willing to pay $(s_l + cm)/(1+m)$. This leads to a market failure. But here qualities are given.

Consumer surplus is

$$CS^a = \int_{\widetilde{\theta}^a}^{1} (\theta s^a - p^*) d\theta = \frac{s^a m^2}{2\left(m+1\right)^2}.$$

Hence, the total welfare is

$$\begin{aligned} W^a &= m\Pi^* - \frac{m}{2} F_h + CS^a, \\ W^a &= \frac{m s^a}{(1+m)^2} + \frac{s^a m^2}{2\left(m+1\right)^2} - \frac{m}{2} F_h, \end{aligned}$$

that we will be able to compare with the different scenario in order to provide welfare implications.

3.2 Certification that completely reveals quality

Imagine that all the $m/2$ high quality producers decide to pay C to allow consumers to be fully informed of the quality. Consumers know that certified goods are of high quality, whereas non-certified goods are of low quality. Thus, depending on their willingness to pay, they buy the high quality good or the low quality good. There exists a consumer who is indifferent between buying low and high quality, whose parameter taste is $\widetilde{\theta} = (p_h - p_l)/(s_h - s_l)$ and a consumer who is indifferent between buying the low quality good or nothing whose parameter taste is $\widehat{\theta} = p_l/s_l$. Thus the inverse demand functions are

$$\begin{aligned} p_h(Q_h, Q_l) &= [1 - Q_h]s_h - s_l Q_l, \\ p_l(Q_h, Q_l) &= [1 - Q_h - Q_l]s_l. \end{aligned}$$

Each high quality firm i chooses q_{ih} that solves

$$\underset{q_{hi}}{Max}\{([1 - q_{hi} - (\frac{m}{2} - 1)q_h]s_h - s_l(m - \frac{m}{2})q_l)q_{hi} - F_h - \frac{C}{\frac{m}{2}}\}$$

where q_h (q_l) is the quantity sold by each other high quality (low quality) producer.

Each low quality firm j chooses q_{jl} that solves

$$\underset{q_{jl}}{Max}\{([1 - q_{jl} - (\frac{m}{2} - 1)q_l - \frac{m}{2}q_h]s_l)q_{jl}\}$$

The best response function of each high quality firm is

$$q_{ih}(q_h, q_l) = \frac{[1 - (\frac{m}{2} - 1)q_l]s_h - s_l(m - \frac{m}{2})q_l}{2s_h}$$

and of each low quality firm is

$$q_j(q_g, q_a) = \frac{[1 - (m - \frac{m}{2} - 1)q_l - \frac{m}{2}q_h]}{2}.$$

Because high (low) quality firms are identical, $q_{ih} = q_h$ and $q_{jl} = q_l$ and thus the best response function of each high quality (low quality) firm, q_h (q_l) to the quantity offered by each low (high) quality firm q_l (q_h) is

$$\begin{aligned} q_h(q_l) &= \frac{s_h - s_l\frac{m}{2}q_l}{(1 + \frac{m}{2})s_h} \\ q_l(q_h) &= \frac{1 - \frac{m}{2}q_h}{(1 + \frac{m}{2})} \end{aligned}$$

The quantities offered respectively by each high quality producer and low quality producer are

$$\begin{aligned} q_h^* &= \frac{s_h + \frac{m}{2}(s_h - s_l)}{(1 + m)s_h + \frac{m^2}{4}(s_h - s_l)} \\ q_l^* &= \frac{s_h}{(1 + m)s_h + \frac{m^2}{4}(s_h - s_l)} \end{aligned}$$

the prices are

$$\begin{aligned} p_h^* &= s_h q_h^* \\ p_l^* &= s_l q_l^* \end{aligned}$$

and the gross profits are

$$\begin{aligned} \Pi_h^* &= s_h(q_h^*)^2, \\ \Pi_l^* &= s_l(q_l^*)^2. \end{aligned}$$

Each high quality producer gets the net profit

$$\Pi_h^* - F_h - \frac{C}{\frac{1}{2}m}.$$

Consumers' surplus is

$$
\begin{aligned}
CS_l + CS_h &= \int_{\widehat{\theta}}^{\widetilde{\theta}} (\theta s_l - p_l^*) d\theta + \int_{\widetilde{\theta}}^{1} (\theta s_h - p_h^*) d\theta, \\
&= \frac{4m(s_h^2 - s_l^2) + m^2(s_h - s_l)^2 + 12 s_h s_l + 4 s_h^2}{32((1+m)s_h + \frac{m^2}{4}(s_h - s_l))^2} m^2 s_h.
\end{aligned}
$$

And the total welfare is

$$
W = \frac{m}{2}\Pi_h^* + \frac{m}{2}\Pi_l^* - \frac{m}{2}F_h - C + CS_l + CS_h
$$

We now compare the non-certification regime and the certification regime. In term of output, a certified high (non-certified low) quality producer produces more (less) than any producer in a non-certification regime (i.e., $q_l^* < q^* < q_h^*$). In the non-certification regime, the production is based on the average quality, which is the only quality consumers are aware of. Whereas in a certification regime, production is based on the true value of the quality. In term of prices, the price charged by high (low) quality producers is higher (lower) than the price charged under non-certification regime (i.e., $p_l^* < p^* < p_h^*$) because high quality producers can charge a higher price for their high quality goods.

In term of profit, a high quality producer benefits from certification as long as the certification cost is not too high (i.e., $C < \frac{1}{2}m(\Pi_h^* - \Pi^*) \equiv C_1$). On the other hand, none of the low quality producers benefits from certification (i.e., $\Pi_l^* < \Pi^*$).

We then define two groups of individuals (producers and consumers): those who benefit from certification and those who do not benefit. Those who benefit from the revelation of information are (*i*) high quality producers, as long as the certification cost is not too high; (*ii*) consumers with a low willingness to pay who did not buy the unknown quality and they can now buy the low quality; (*iii*) consumers with high willingness to pay: they are willing to pay more for a high quality and they get it if they pay a premium. On the other hand, those who lose from the revelation of information are: (*i*) low quality producers; (*ii*) consumers with middle willingness to pay: before they had a probability 1/2 of getting a high quality good, now they can just afford the low quality good.

However, overall consumers benefit from certification (i.e., $CS_l + CS_h > CS^a$) as long as $m > 2(1+\sqrt{2})$ (sufficient condition). From the industry viewpoint, the industry benefits as long as the cost of certification is not too high (i.e., $C < \frac{m}{2}(\Pi_h^* - \Pi^*) - \frac{m}{2}(\Pi^* - \Pi_l^*) \equiv C_2$).

In term of welfare, as long as the cost of certification is not too high (i.e., $C < \frac{m}{2}(\Pi_h^* - \Pi^*) - \frac{m}{2}(\Pi^* - \Pi_l^*) + CS_l + CS_h - CS^a \equiv C_3$) society is better off under certification rather than non-certification (i.e., $W > W^a$). It is straightforward to show that $C_1 > C_2$ and $C_3 > C_2$.

However, $C_3 > C_1$ only if the industry is large enough (i.e., $m > \widetilde{m}$, where $\widetilde{m}$ is defined in the appendix).

Following the previous analysis of the certification versus non-certification regimes, we can posit the following result:

Result: For intermediate values of the certification cost, $C_2 < C < C_1$, producers of high quality are better off when the quality is known whereas the entire industry is worse off. Furthermore, if the industry is large enough, society is better off.

For intermediate values of the certification cost, the benefit from the revelation of the quality does not outweigh the cost plus the loss incurred by the low quality producers. However, as consumers are better off under certification, the gain from consumers' surplus is higher than the loss incurred by low quality producers if the certification cost is not too high and the industry is large enough. Hence, society is better off under certification if certification is not too costly. Full revelation of the quality to consumers increases total welfare so long as it is not too costly to reveal the quality and that there are enough firms in the industry.

3.3 Certification that only reveals high quality

Consider now that n_g producers of high quality decide to form a group and get a certification (a label that is well-established and thus consumers have no doubt about the veracity of the information provided) at a total cost of C_g. We call this label *label-G*. Because only high quality producers can be part of the group, $n_g \leq m/2$ and thus consumers who buy the good with the label know that they buy a high quality good. There is no collusion, no cartel formation, just a club that producers can join to get the benefit of signalling their type. Entry is prevented.

The remaining $(m - n_g)$ producers do not belong to the group and thus if consumers buy from them, they don't know the quality of the good. Among those producers, $m/2$ produce low quality, whereas $(m/2 - n_g)$ produce high quality good. Hence, some consumers can afford to buy the high known quality, and other cannot afford this quality and thus buy a good of expected quality

$$s_g^a = \frac{\frac{1}{2}ms_l + (\frac{1}{2}m - n_g)s_h}{m - n_g} = \frac{ms^a - n_g s_h}{m - n_g} < s^a < s_h.$$

There exists an indifferent consumer $\widetilde{\theta}_g$ such that

$$\widetilde{\theta}_g s_h - p_g = \widetilde{\theta}_g s_g^a - p,$$

where p_g is the price of the label-G good, p the price of non-label-G good. The inverse demand functions for the label-G good and the non-label-G good are

$$\begin{aligned} p_g(Q_g, Q_a) &= [1 - Q_g]s_h - s_g^a Q_a, \\ p_a(Q_g, Q_a) &= [1 - Q_g - Q_a]s_g^a, \end{aligned}$$

where Q_g represents the total quantity of label-G good produced, and Q_a the total quantity of good of unknown value.

Let firm i denote one of the label-G good producers, with $i = 1, ..., n_g$, firm j one of the non-label-G producers, with $j = 1, ..., m - n_g$. The maximization program of each firm i is

$$\underset{q_i}{Max}\{([1 - q_i - (n_g - 1)q_g]s_h - s_g^a(m - n_g)q_a)q_i - F_h - \frac{C_g}{n_g}\},$$

and of each firm j is

$$\underset{q_j}{Max}\{([1 - q_j - (m - n_g - 1)q - n_g q_g]s_g^a)q_j - F_j\}.$$

The best response function of each firm within the label-G group is

$$q_i(q_g, q_a) = \frac{[1 - (n_g - 1)q_g]s_h - s_g^a(m - n_g)q_a}{2s_h},$$

and outside of the group is

$$q_j(q_g, q_a) = \frac{[1 - (m - n_g - 1)q_a - n_g q_g]s_g^a}{2s_g^a}.$$

As firms are identical within the group or outside of the group, $q_i = q_g$ and $q_j = q_a$ and thus the best response function of each firm inside (outside) the group, q_g (q_a) to the quantity offered by each firm outside (inside) the group q_a (q_g) is

$$\begin{aligned} q_g(q_a) &= \frac{s_h - s_g^a(m - n_g)q_a}{(1 + n_g)s_h}, \\ q_a(q_g) &= \frac{s_g^a - s_g^a n_g q_g}{(1 + m - n_g)s_g^a}, \end{aligned}$$

The quantities offered respectively by each label-G producer and non-label-G producer are

$$\begin{aligned} q_g^* &= \frac{s_h + \frac{m}{2}(s_h - s_l)}{(1 + m)s_h + \frac{m}{2}n_g(s_h - s_l)}, \\ q_a^* &= \frac{s_h}{(1 + m)s_h + \frac{m}{2}n_g(s_h - s_l)}. \end{aligned}$$

Those optimal quantities are decreasing in n_g.

We can derive the optimal prices

$$\begin{aligned} p_g^* &= s_h q_g^*, \\ p_a^* &= s_g^a q_a^*. \end{aligned}$$

A label-G producer produces more than a non-label-G producer (i.e., $q_g^* > q_a^*$), and thus the price charged by the label-G producers is higher than the non-label-G price (i.e., $p_g^* > p_a^*$). Because there is complete resolution of uncertainty concerning the quality of the good in case of label-G, demand is higher and thus producers produce more.

The gross payoffs of each label-G producer and each non-label-G producer are also simplified to

$$\begin{aligned} \Pi_g^* &= s_h (q_g^*)^2, \\ \Pi_a^* &= s_g^a (q_a^*)^2, \end{aligned}$$

and the net payoff of each label-G producer is

$$\Pi_g^* - F_h - \frac{C_g}{n_g}.$$

Consumers' surplus is

$$\begin{aligned} CS_g &= CS_g^a + CS_h = \int_{\widetilde{\theta}_a}^{\widetilde{\theta}_g} (\theta s_g^a - p_a^*) d\theta + \int_{\widetilde{\theta}_g}^{1} (\theta s_h - p_g^*) d\theta \\ &= \frac{2mn_g(s_h^2 - s_l^2) + mn_g^2(s_h - s_l)^2 + 2s_h(s_l(m+n_g) + s_h(m-n_g))}{8((1+m)s_h + \frac{m}{2} n_g (s_h - s_l))^2} ms_h. \end{aligned}$$

Furthermore, CS_g is an increasing function with n_g if $n_g > 2/3$ and $m > 1$ (sufficient conditions).

For a given n_g the social welfare is

$$W_g = n_g \Pi_g^* + (m - n_g)\Pi_a^* - \frac{m}{2} F_h - C_g + CS_g$$

The label-G regime is in fact an intermediate case. Indeed, the two extreme regimes are the non-certification regime (for $n_g = 0$) and the full revelation regime (for $n_g = m/2$). Because $q_g^*(n_g)$ and $q_a^*(n_g)$ are decreasing functions of n_g, it is easy to compare the different regimes.

A label-G (non-label-G) producer produces more (less) than a producer in a non-certification regime (i.e., $q_g^* > q^* > q_a^*$), and thus the price charged for the label-G (non-label-G) product is higher (lower) than the price charged in a non-certification regime (i.e., $p_g^* > p^* > p_a^*$). In terms of profits, a label-G (non-label-G) producer gets a higher (lower) profit than a producer in a non-certification regime (i.e., $\Pi_g^* > \Pi^* > \Pi_a^*$).

We now compare the label-G regime with the full-certification regime. A label-G (non-label-G) producer produces more (more) than a high (low) quality producer in the full-revelation regime (i.e., $q_g^* \geq q_h^* > q_a^* \geq q_l^*$). Therefore, the price charged for the label-G (non-label-G) product is higher (higher) than the price charged for high (low) quality product in a full-revelation regime (i.e., $p_g^* \geq p_h^* > p_a^* \geq p_l^*$). Profit wise, a label-G (non-label-G) producer obtains a higher (higher) profit than a high (low) quality producer in a non-certification regime (i.e., $\Pi_g^* \geq \Pi_h^* > \Pi_a^* \geq \Pi_l^*$).

As in the previous section, we separate firms and consumers in two groups: those who benefit from the label-G regime and those who don't. In the former group, we have (*i*) some high quality producers that get a higher gross profit. They benefit as long as $\Pi_g^* - \Pi_h^* > \frac{C_g}{n_g} - \frac{C}{\frac{1}{2}m}$; and (*ii*) consumers with low willingness to pay and high willingness to pay. In the latter group, low quality producers are still losing, but do not lose as much as in the full-revelation regime; consumers with a low willingness to pay have to pay more than in the full-revelation regime.

At the industry level, label-G regime makes the entire industry better off (compared to full revelation) when the certification cost is small enough, i.e., $C_g < \phi(n_g) + C$ where

$$\phi(n_g) = n_g(\Pi_g^* - \Pi_h^*) - (\frac{m}{2} - n_g)(\Pi_h^* - \Pi_a^*) + \frac{m}{2}(\Pi_a^* - \Pi_l^*).$$

The sign of $\phi(n_g)$ depends on the size of the label-G club, i.e., the number of high quality producers that adopt label-G. To see this, not that the first term represents the benefit of adopting the label-G for the certified high-quality producers; the second term represents the loss incurred by the non-certified high quality producers (that would have been signaled as high quality producer in a full revelation regime); and the third term represents the benefit for the low quality producers. Overall, $\phi(n_g) > 0$ if the size of the club is big enough (i.e., if $n_g > \widehat{n}_g$).

If $\phi(n_g) > 0$, $C_g \leq C$ is enough to insure that the industry is better off under the label-G regime. However, if $\phi(n_g) < 0$, the condition $C_g < \phi(n_g) + C$ must be satisfied for the industry to be better off.

Because consumers' surplus is increasing with n_g and, $n_g = 0$ (respectively, $n_g = m/2$) corresponds to the non-certification (respectively, full revelation) regime, consumers are worse (respectively, better) off in case of label-G compared to the full revelation (respectively, non-certification) regime (i.e., $CS^a < CS_g < CS_l + CS_h$).

The social welfare is an increasing function of n_g. Indeed, the derivative of the social welfare under label-G regime can be written as:

$$\frac{\partial W_g}{\partial n_g} = (\Pi^*_g - \Pi^*_a) + (m - n_g)(\frac{d\Pi^*_a}{dn_g} - \frac{d\Pi^*_g}{dn_g}) - m\frac{d\Pi^*_g}{dn_g} + \frac{dCS_g}{dn_g}.$$

This derivative is positive as $\frac{d(\Pi^*_a - \Pi^*_g)}{dn_g} > 0$. Furthermore, when $n_g = 0$, $W_g(0) = W^a - C_g$ and when $n_g = \frac{m}{2}$, $W_g(\frac{m}{2}) = W - C_g + C$. There exists $\widetilde{n}_g$ (respectively, $\widetilde{\widetilde{n}}_g$) such that $W_g(\widetilde{n}_g) = W^a - C_g$ (respectively, $W_g(\widetilde{\widetilde{n}}_g) = W - C_g + C$) and thus, for any $n_g > \widetilde{n}_g$ (respectively, $n_g > \widetilde{\widetilde{n}}_g$), $W_g(n_g) > W^a$ (respectively, $W_g(n_g) > W$). The social welfare is higher under label-G regime rather than non certification (respectively full revelation) regime so long as the size of the group is not too small, and / or the label-G cost is not too high.

To be more precise, social welfare is higher under the label-G regime than under full revelation if $C_g < \phi(n_g) + C + CS_g - (CS_l + CS_h)$.

Welfare under label-G regime is higher than under no certification regime (i.e., $W_g > W$) if the certification is not too big. The entire society is better off when there is some revelation of information compared to no revelation at all so long as the costs of revealing information is not too high.

If the label-G cost is small enough compared to the full-certification cost, and for a large enough size of the group, welfare under label-G regime can be higher than under full-revelation.

Result: For intermediate values of the label-G cost, i.e., $C_g \in (\phi(n_g) + C + CS_g - (CS_l + CS_h), \phi(n_g) + C)$, a label-G regime makes the industry better off whereas society is worse off.

High quality producers benefit from label-G regime so long as $C_g < n_g\Pi^*_g - \frac{m}{2}\Pi^*_h + C$. Furthermore, $n_g\Pi^*_g - \frac{m}{2}\Pi^*_h + C < \phi(n_g) + C$ is always satisfied as it is equivalent to $(\frac{m}{2} - n_g)\Pi^*_a + \frac{m}{2}(\Pi^*_a - \Pi^*_l) > 0$.

We can thus posit the following result:

Result: So long as $C_g \in (n_g\Pi^*_g - \frac{m}{2}\Pi^*_h + C, \phi(n_g) + C)$, high quality producers are worse off under a label-G regime, but the total industry is better off.

This is because low quality producers are always better off under the label-G regime compared to the full revelation regime, and because high quality producers are the only one to pay for the certification.

4 Producer's choice of certification and optimal size

We now turn to the first decision of the producers. First, they must decide which certification to adopt, and thus once a label has been chosen, whether or not to label their product (i.e., to join the club). We define the optimal size of the group that will get the label as a club. Each producers will derive benefit from joining the club, but the arrival of new members will reduce the benefit.

4.1 Optimal size of the club

We now define the optimal size of the club. The net benefit of each member of the club is $(\Pi_g^*(n_g) - F_h - \frac{C_g}{n_g})$. Thus, the optimal size of the club n_g is solution of the following maximization program

$$\begin{cases} \underset{n_g}{Max}\{\Pi_g^*(n_g) - F_h - \frac{C_g}{n_g}\} \\ \text{with } n_g \leq \frac{m}{2} \end{cases}$$

Because $\Pi_g^*(n_g)$ is decreasing and convex in n_g, we may have several solutions. If we assume a positive interior solution, n_g must satisfy

$$\frac{d\Pi_g^*(n_g)}{dn_g} + \frac{C_g}{n_g^2} = 0.$$

We re-write this equation as

$$n_g \left| \frac{d\Pi_g^*(n_g)}{dn_g} \right| = \frac{C_g}{n_g}.$$

Consider that there are n_g producers in the club. If a new member enters, the total costs imposed on the existing members is represented by the term on the left-hand side. On the right-hand side, the benefit from a new member is the amount received in additional membership. At the optimum, the total cost imposed on existing members must be equal to the benefit from a new member.

Let n_g^* be the optimal size of the label-G group. In the label-G regime, not all high quality producers will adopt the label because $n_g^* < \frac{m}{2}$.

Thus, when a label-G is available, a club will be formed, and not all the high quality producer can get in the club. Which firms join the club cannot be determined without specification about firms heterogeneity. But, if we assume that firms are heterogeneous with respect to their "eagerness" to join the club, the most eager producers join the club, and the other high quality producer won't have the opportunity of signaling their quality.

We can rewrite the first order condition as

$$2s_h q_g^*(n_g)\frac{dq_g^*(n_g)}{dn_g} + \frac{C_g}{n_g^2} = 0.$$

Imagine now that the entire industry can decide the size of the club. In other words, this is no longer a club, but all producers jointly decide how many of them can get the label-G. The optimization problem becomes

$$\begin{cases} \underset{n_g}{Max}\{n_g\Pi_g^*(n_g) - \frac{m}{2}F_h - C_g + (m-n_g)\Pi_a^*(n_g)\} \\ \text{with } n_g \leq \frac{m}{2} \end{cases}$$

The optimal size n_g^{**} is solution of

$$\Pi_g^*(n_g) - \Pi_a^*(n_g) + n_g\frac{d\Pi_g^*(n_g)}{dn_g} + (m-n_g)\frac{d\Pi_a^*(n_g)}{dn_g} = 0$$

The size of the club is suboptimal: from the industry view point, too few high quality producers are part of the club that hold the label-G.

If the label-G cost is small enough compared to the full certification cost, at the optimal level of the industry, n_g^{**}, the label-G regime gives a higher welfare than the full certification regime. However, at the club level, n_g^*, the welfare is lower under label-G regime.

4.2 Choice of certification

Considering the equilibrium payoffs derived under each scenario, which certification will be chosen by high quality producers? According to the previous analysis, we can posit the following result:

Result: For low values of certification costs, high quality producers prefer to adopt certification (full revelation or label-G), and the industry is better off. For intermediate values of the certification cost, producers of high quality prefer a certification (full revelation or label-G) rather than no-certification, whereas the industry would prefer no certification.

Result: For a small difference in costs, i.e., $C_g - C < n_g^*\Pi_g^* - \frac{m}{2}\Pi_h^*$, high quality producers prefer to adopt label-G compared to the full revelation certification. For a bigger difference in costs, i.e., $C_g - C \in (n_g^*\Pi_g^* - \frac{m}{2}\Pi_h^*, \phi(n_g))$, high quality producers do not adopt the label-G whereas the industry would prefer a label-G over a certification that fully reveals the quality.

5 Socially optimal certification

From a normative viewpoint we investigate which certification should a benevolent planner offer, and at what cost. In fact, by choosing the right ranges of certification costs, the governmental agency can induce the producers to choose a certain certification.

When high quality producers have to choose between non-certification and certification (either full revelation or label-G), as long as the certification cost is not too high, they are better off under certification. The entire industry may be worse off (because low quality producers prefer the no-certification regime), while the entire society is better off as consumers benefit from the revelation of information. However, things are different when high quality producers have to choose between a full-revelation certification and a label-G. Indeed, there exist intermediate values of difference in costs $(C_g - C)$ for which high quality producers are better off if they adopt a label-G regime compare to full revelation whereas society is worse off. Thus, from a social viewpoint, by increasing the label-G cost, or by decreasing the full revelation certification cost (and thus decreasing the difference $C_g - C$), the government can force high quality producers to adopt a full revelation certification rather than a label-G.

Result: By decreasing the difference in certification costs, the government can induce high quality producers to choose a certification that fully reveal the quality rather than a label-G that does not fully reveal the quality.

6 Conclusion

Advances in information technologies and logistics continue to lower the costs of providing new food products to consumers. These advances have increased the incentive for some growers and processors to implement new certification programs to help them differentiate their output. We analyze the welfare consequences of such certification programs on heterogeneous producers and consumers, and society. Certification costs play a key role in determining the distributional benefits. Relative to the baseline case of no certification program, we find that under a certification program that fully reveals quality, producers of high quality output will benefit and producers of low quality output will lose from certification programs. The level of certification costs determine whether the gains to high quality producers offset the losses to low quality producers. Both high willingness to pay and low willingness to pay consumers gain from certification. High willingness to pay consumer benefit by being able to buy high quality product with certainty. Low willingness to pay consumers benefit from lower prices for low quality production. Moderate willingness to pay consumers may lose from certification because they now have to pay a high price for high quality product whereas without certification they had a chance at obtaining high quality product at a moderate price. We also model a certification program that fully reveals high quality product but not low quality. We show that it has similar welfare consequences, with certification costs again playing a key role in determining the distributional benefits.

The results of this paper provide insight into why producer groups often cannot agree on new certification programs that provide consumers with increased information. For example, U.S. cattle producers continue to resist implementation of a full traceability system that would provide consumers knowledge about an animal's age, breed, and where it was bred, fed, and processed. We show that the current system that allows mixing of heterogeneous product into a common commodity pool benefits low quality producers and perhaps the industry as a whole. Even if certification costs are low enough so that the entire industry would benefit from de-commoditization, producers of low quality cattle could form a blocking coalition preventing implementation of welfare-increasing certification rules.

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