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Viability and Welfare Implications

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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 (e.g., certification) that ensure quality and origin of the goods. These costly standards can be adopted by a group of producers of high-quality goods. We study the formation of such a group that we model as a club. We first investigate under what circumstances a club of a given size is desirable for producers, and for society. We then analyze the optimal size of the club when there exists a direct barrier to entry, and when there is no barrier.

We find that for intermediate values of certification costs, the industry and a club of a given size of certified producers have divergent incentives. Furthermore, if barriers to entry are allowed, an optimal size of club exists, which allows some revelation of information. In the absence of barrier to entry, it is less likely that a club will emerge.

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, the quality cannot be assessed before the goods are purchased (experience goods) whereas for other goods, consumers will never be able to assess the goods' quality (credence goods).[1] 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 generally do not fully reveal information to consumers. Indeed, if high-quality goods are certified, it does not necessarily mean that all 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.

Our analysis focuses on this type of certification (i.e., geographical indications), and we consider that a group of producers of high-quality goods can get it. The size of the group is endogenously determined, as we model the group as a club where letting one more producer join reduces the average certification cost but also reduces the profit for each producer. Hence, we consider certification that can fully (if the size of the club is the entire group of high-quality producers) or partially (if only a subset of high-quality producers gets the certification) reveal information to consumers. We first investigate how different degrees of information revelation affect producers, the industry, and society in general, knowing that any system is costly to implement. We then determine the optimal size of the club in the presence of a direct barrier to entry, and when barriers are not allowed.

We consider a simple model of vertical differentiation[2] in which firms produce goods of given quality: high or low. Consumers do not know the quality of the good unless they get more information through certification. At the outset, high-quality producers can decide to form a group to obtain a geographical indication, and share the associated cost. Each producer must respect precise and well-defined quality requirements.

We model geographical indications as club goods (non-rival, congestible, and excludable),

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[1] Nelson (1970) and Darbi and Karni (1973) introduced this categorization of goods.

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

and therefore an optimal size of the club can be defined. The size of the club can be the entire group of high-quality producers, a subset of the high-quality producers, or null, when none of them decide to get the label-G. Consumers can thus either learn perfectly the quality if all of the high-quality producers get a certification, learn imperfectly the quality when not all of them get a certification, or learn nothing when there is no certification. We first consider these different scenarios - (*i*) no certification, (*ii*) the certification fully reveals the quality, and (*iii*) the certification only reveals products of high quality - and then compare the welfare changes.

In general, we find that complete (or partial) revelation of information benefits 1) high-quality producers, because they can gain 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 price for their output; and 2) consumers with middle willingness to pay, who benefit in the benchmark case of sometimes receiving high-quality products for a moderate price.

We investigate under what 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. Not surprisingly, if the certification costs are identical under all scenarios, or if the full revelation certification is smaller than the partial revelation certification cost, a regime that fully discloses the quality makes society better off. For intermediate values of certification cost, 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.

For a given club size, the incentives of the producers within the club to obtain a certification are divergent from those of the entire industry. In other words, the industry may prefer no certification. We show that the industry may be better off under partial revelation of information rather than full revelation for some values of certification cost. These results may explain the hesitancy of the U.S. cattle industry to endorse full traceability for cattle.

We then investigate the optimal size of the club, given an existing barrier to entry and no barrier to entry. We find that letting the club deter entry allows for more revelation of

information. In other words, if the government allows a club to prevent entry of producers once the optimal size has been reached, it is socially improving, as more revelation of information occurs.

The paper is organized as follows. Section 2 presents the related literature as well as the legal aspects of geographical indications. The model is presented in section 3. Section 4 gives the details of the production stage under different scenarios. Section 5 focuses on the determination of the optimal size of the club and the existence of an equilibrium. In section 6 we derive the optimal certification choice by producers. Section 7 concludes.

2 Certification: literature and legal aspects

2.1 Related literature

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 asymmetric information affects the allocation and distribution of resources. 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 (Bagwell and Riordan, 1991). Therefore, there exists a separating equilibrium in which prices signal quality of the good. However, it is not always possible to signal quality through 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 through prices.

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. It is then interesting to know what amount of information should be revealed by the certification intermediaries and how this information affects surplus (Lizzeri, 1999). Albano and Lizzeri (2001) study the optimal degree of information revelation and how the information revealed by the intermediary affects the production of quality. In our paper, qualities are given and we do not allow for strategic revelation of information by the certification intermediary. We assume 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 therefore consumers who value the good the most consume the high-quality good. We do not question either whether self-certification or public intervention is better. Auriol and Schillizzi (2003) show that a public agency may benefit from economies of scale when the fixed costs for certification are high.

Labels can be private or public.[3] 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 in most cases a per-unit or an ad valorem fee is 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 paper is close to that of Marette and Crespi (2003). These authors 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 a cartel to examine the actions of sellers who join a cartel. They investigate different structures of certification costs (shared 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; rather, 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 the optimal size of a club as the result of a trade-off between allowing more producers to join the club, which reduces the average cost, and reducing the number of club members, which increases the profit of each producer (on club goods, see Scotchmer, 2002).

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[3]See Bergès-Sennou, Bontems and Réquillart (2004) for a survey on private labels, Crespi and Marette (2003) for a survey on public labels, and Marette (2005) for a survey on common labeling.

2.2 Geographical indications

In Europe, geographical indications (GIs), generally combined with national labels (e.g., "label rouge" in France), ensure quality and origin of goods. The definition from the World Trade Organization (WTO) is as follows:

> "Geographical indications are defined, for the purposes of the Agreement, as indications which identify a good as originating in the territory of a Member, or a region or locality in that territory, where a given quality, reputation or other characteristic of the good is essentially attributable to its geographical origin (Article 22.1)."

Therefore, quality, reputation, or other characteristics of a good can each be a sufficient basis for eligibility as a GI. Hence, GIs define who can make a particular product, where the product is to be made, and what ingredients and techniques are to be used to ensure origin and authenticity. The geographical link must occur in at least one of the stages of production, processing, or preparation. Some well-known examples of GIs are Parmesan cheese, Champagne wine, and Roquefort cheese.

European countries seek to extend GIs to most countries worldwide, as defined in the TRIPs agreements. However, the U.S., Canada, and Australia, among other countries, are reluctant to adopt such protection (Addor and Grazioli, 2002). Hayes, Lence and Babcock (2005) analyze possible reasons for U.S. opposition. According to them, a few large U.S. food companies are threatened by the E.U. proposal and therefore oppose GIs.

In Europe, to obtain a GI a group of producers must first define the product according to precise specifications. The application, including the specifications, is studied on a national level and thereafter transmitted to the European Commission. If it meets the requirements, a first publication in the Official Journal of the European Communities will inform those in the Union who are interested. If there are no objections, the European Commission publishes the protected product name in the Official Journal of the European Communities.

Therefore, GIs are not limited to any particular firm. There is no monopoly right in the hands of a single firm, but rather it is a collective right. There is no owner of a GI; within the E.U., the indication is owned by the States. In theory, all producers in a specific geographical area should have the right to use the GI if their products meet the stipulated requirements

for use of the indication. Administration and control of GIs are shared by public and private parties. It is not possible to break the link between the product and its geographic origin. The protection should be given to any producer who can show the link between his product and the geographical origin. In some systems registration is required (Addor and Grazioli, 2002; Rangnekar, 2004).

Our contribution is an attempt at understanding and explaining the reasons for U.S. opposition. We explicitly model GIs as club goods, and we analyze the optimal size of the club. All firms that respect the quality requirements should be able to use a GI. However, producers within the club can make it harder for producers who are trying to join the club to comply with the requirements of the GI. It is not uncommon to observe that few producers are able to use a GI (e.g., Roquefort). The group can always claim that the quality of the product of a potential entrant is not good enough or does not respect some specifications. For instance, the group could argue that to get the GI a potential entrant needs to buy some land from the area to be able to claim the geographic link. In economic terms, it means that the group can create a direct barrier to entry with the imposition of an entry cost. Once the optimal size of the club is reached, the producers within the group can create a barrier to entry that will make entry unprofitable for one more producer. We study that setting in detail. However, the government can be in a position of preventing direct barriers to entry, and it can force the club to accept more firms as long as their products comply with the rule. In this case, more producers join the group, as they benefit from doing so. We also analyze this possibility.

3   The model

We consider an industry with $m > 2$ firms that produce goods of two different qualities: high, s_h, and low, s_l, where $s_h > s_l$. We assume that qualities are given and that a fraction α of the firms produce high quality, whereas a fraction $(1 - \alpha)$ produce low quality. To simplify we also assume that the marginal cost of production is zero.

Consumers do not know the quality of the good (it can be either a credence good or an experience good), while producers know the quality of their own good. There is asymmetric information unless consumers get more information. This can happen if some (or all) of the high-quality producers obtain a certification, in which case consumers learn that certified goods

are of high quality.

To be more specific on the demand side, we consider N consumers, each of which 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 0 and 1, and thus $F(\theta)$ is the fraction of consumers with a taste parameter of less than θ. We can therefore 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. His utility is $\widehat{\theta}s - p = 0$, and therefore $\widehat{\theta} = p/s$. Consumers with $\theta > \widehat{\theta}$ buy the good, and we can derive the demand function $D(p) = (1 - p/s)$. The inverse demand is

$$p(Q) = [1 - Q]s, \tag{1}$$

where Q represents the total quantity.

With 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 (respectively, p_l) is the price for the high- (respectively, low-) quality good. Hence, $\widetilde{\theta} = (p_h - p_l)/(s_h - s_l)$. Consumers who choose not to buy the high quality buy either 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

$$p_h(Q_h, Q_l) = [1 - Q_h)]s_h - Q_l s_l, \tag{2}$$

$$p_l(Q_h, Q_l) = [1 - (Q_h + Q_l)]s_l, \tag{3}$$

where Q_h (respectively, Q_l) represents the total quantity of high- (respectively, low-) quality good.

At the outset of the game, a governmental agency gives high-quality producers the choice to adopt a label that reveals only high quality. If only a fraction of the high-quality producers get the label, consumers cannot determine whether a non-labeled good is of low quality. High-quality producers choose the size of the group that will get the label. Thus, if the size is zero, there is no revelation of information, as none of the firms adopt a label. The other extreme case is when the size of the group is exactly the total number of high-quality producers, and thus there is full revelation of information to consumers. For any group size in between, consumers are partially informed about the quality.

We denote this kind of label *label-G*, as it can be the case of geographical indication (GI): goods with a GI are identifiable 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 full revelation case corresponds to the simpler case of certification. For instance, consider a monopoly that can produce either a high-quality good or a low-quality good. The quality is unknown by consumers, and we assume that with a 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 the high-quality producer will certify his good whereas the 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 goods are of low quality. In our setting, this will happen if all the αm 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.

The timing of the game is as follows:

- First, producers decide whether or not to get a label-G and determine the optimal size of the group, n_g^*, of producers that will get the protection.

- Second, producers observe whether a label has been adopted and by how many firms. Then, all the firms compete in quantity.

We consider the following scenarios: (i) no certification; (ii) the certification fully reveals the quality of the good; (iii) the certification reveals only high-quality goods, when the size of the club is positive but smaller than αm.

4 Production stage

In this section, we first define the Cournot equilibrium for each possible scenario, and then we compare the results under the different regimes for a given size of club.

4.1 No certification regime

Consider first that producers cannot get a certification or do not want to get it (i.e., the size of the club is null, $n_g = 0$), and thus consumers do not have extra information concerning the quality of the good. Consumers' expectation of the quality is

$$s^a = \alpha s_h + (1 - \alpha)s_l.$$

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.

Each firm chooses the quantity that maximizes its payoff

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

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 therefore

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

that gives the best response function of each firm

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

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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[4]

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

The consumer surplus can be defined as

$$S^a = \int_{\tilde{\theta}^a}^{1} (\theta s^a - p^*) d\theta = \frac{s^a m^2}{2(m+1)^2},$$

and the total welfare as

$$W^a = m\Pi^* - \alpha m F_h + S^a = \frac{m s^a}{(1+m)^2} + \frac{s^a m^2}{2(1+m)^2}.$$

4.2 Full revelation certification regime

The other polar case is when all of the high-quality producers get a certification and pay a fixed cost C to allow consumers to be fully informed of the quality. This corresponds to the case where the size of the club is exactly the size of the group of high-quality producers, $n_g = \alpha m$. This can happen if, for example, there is a mandatory label and all of the high-quality producers must get the label. 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. Demands are defined by equations (2) and (3).

We relegate in the appendix the maximization programs and their resolutions. The quantities offered respectively by each high-quality producer and low-quality producer are

$$q_h^* = \frac{s_h + (1-\alpha)m(s_h - s_l)}{(1+m)s_h + (1-\alpha)\alpha m^2 (s_h - s_l)}, \qquad (4)$$

$$q_l^* = \frac{s_h}{(1+m)s_h + (1-\alpha)\alpha m^2 (s_h - s_l)}. \qquad (5)$$

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

The prices are $p_h^* = s_h q_h^*$, and $p_l^* = s_l q_l^*$, and the gross profits are

$$\Pi_h^* = s_h(q_h^*)^2,$$
$$\Pi_l^* = s_l(q_l^*)^2.$$

Each high-quality producer gets the net profit

$$\Pi_h^* - \frac{C}{\alpha m} \geq 0.$$

Consumers' surplus S is defined in the appendix, and the total welfare is

$$W = \alpha m \Pi_h^* + (1 - \alpha)m \Pi_l^* - C + S.$$

4.3 Label-G regime

Consider now that $n_g > 0$ producers of high quality decide to form a group and get a well-established label (consumers have no doubt about the veracity of the information provided) at a total cost of C_g, which can be different from C. The mandatory labelling can be less costly if the government already has a system of inspection to monitor producers and make sure they comply with the rules. The label-G regime requires the creation of new groups of inspectors and so on. Because only high-quality producers can be part of the group, $n_g < \alpha m$ and thus consumers who buy the label-G good know that it is 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. For now we consider that with a given club size, entry is prevented, as no more high-quality producers can get into the club. In the next section we discuss whether there exists such an equilibrium and if so under what conditions.

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, $(1 - \alpha)m$ produce low quality, whereas $(\alpha m - n_g)$ produce high quality. Hence, some consumers choose to buy the high known quality, and others choose not to and thus buy a good of expected quality

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

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, and p is the price of the non-label-G good. Demands and maximization

programs are also defined in the appendix. The quantities offered respectively by each label-G producer and non-label-G producer are

$$q_g^* = \frac{s_h + (1 - \alpha)(s_h - s_l)}{(1 + m)s_h + m(1 - \alpha)n_g(s_h - s_l)}, \tag{6}$$

$$q_a^* = \frac{s_h}{(1 + m)s_h + m(1 - \alpha)n_g(s_h - s_l)}. \tag{7}$$

These optimal quantities are decreasing in n_g. The optimal prices are $p_g^* = s_h q_g^*$ and $p_a^* = s_g^a q_a^*$. A label-G producer produces more than a non-label-G producer (i.e., $q_g^* > q_a^*$), and therefore 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 the 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

$$\Pi_g^* = s_h(q_g^*)^2, \tag{8}$$

$$\Pi_a^* = s_g^a(q_a^*)^2,$$

and the net payoff of each label-G producer is

$$\Pi_g^* - \frac{C_g}{n_g} \geq 0. \tag{9}$$

Furthermore, each non-label-G high-quality producer gets $\Pi_a^* \geq 0$.

Consumers' surplus $S^g(n_g)$ is defined in the appendix and is increasing with n_g. For a given n_g the social welfare is

$$W^g = n_g \Pi_g^* + (m - n_g)\Pi_a^* - C_g + S^g(n_g).$$

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

4.4 Comparison of the different regimes

For a given size of club n_g, we compare the different regimes. We start with a comparison of the quantities, prices, and profits, and then we compare the different regimes depending on the different costs of label-G.

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4.4.1 Quantities, prices, and gross profits

In terms of output, in a full-revelation regime, a certified high- (non-certified low-) quality producer produces more (less) than any producer in a non-certification regime. 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. A label-G (non-label-G) producer produces more (less) than a producer in a non-certification regime and a label-G (non-label-G) producer produces more (more) than a high- (low-) quality producer in the full-revelation regime (i.e., $q_g^* \geq q_h^* > q^* > q_a^* \geq q_l^*$).

In terms of prices, the price charged by high- (low-) quality producers is higher (lower) than the price charged under the non-certification regime because high-quality producers can charge a higher price for their high-quality goods. The price charged for the label-G (non-label-G) product is higher (lower) than the price charged in a non-certification regime, and the price charged for the label-G (non-label-G) product is higher (higher) than the price charged for the high- (low-) quality product in a full-revelation regime (i.e., $p_g^* \geq p_h^* > p^* > p_a^* \geq p_l^*$).

In terms of gross profits, a label-G (non-label-G) producer gets a higher (lower) profit than a producer in a non-certification regime, and 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., $\Pi_g^* \geq \Pi_h^* > \Pi^* > \Pi_a^* \geq \Pi_l^*$).

4.4.2 Non-certification, full-revelation, and label-G regimes

For a given club size, we study under what conditions a label-G regime will be adopted, and whether the industry and society are better off. Our discussion depends on both the label-G and the full-certification costs, C_g and C.

Producers and consumers can be separated into two groups: those who benefit from revelation of information and those who do not. In the former group are the certified high-quality producers, some of the consumers with a low willingness to pay who did not buy the good of unknown quality but can now buy the less expensive non-labeled good, and the consumers with high willingness to pay who are willing to pay a premium for the high-quality good. On the other hand, those who lose from the revelation of information are high-quality producers who do not get the label, low-quality producers, and consumers with middle willingness to pay: before

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they had a probability α of getting a high-quality good, now they have a lower probability of getting it.

As we are mainly interested in determining who benefits from the label-G regime, we focus our analysis on four different groups of agents: (*i*) the label-G producers (i.e., the label-G high-quality producers), (*ii*) all the high-quality producers, (*iii*) the entire industry, and (*iv*) society. We consider under what circumstances each of these groups is better off under a label-G regime compared to the full-revelation regime or the non-certification regime.

If n_g high-quality producers can obtain a label-G, they are better off under the label-G regime as long as the label-G cost is not too high, i.e., $C_g < \Gamma_g$ where Γ_g is defined in the appendix. For low enough full-certification cost C, the label-G regime has to be compared with the full-certification regime, and the total gain in profits (i.e., $n_g(\Pi_g^* - \Pi_h^*)$) must outweigh the difference in costs (i.e., $C_g - C$). For higher values of C, both the label-G regime and the non-certification regime must be compared, and again the total gain in profit (i.e., $n_g(\Pi_g^* - \Pi^*)$) must be compared to the cost associated with label-G, C_g.

At the level of the entire group of high-quality producers, the label-G regime is appealing less often, as not all of the high-quality producers get in the club, and therefore some of them cannot enjoy the benefit of the label-G regime. The entire group of high-quality producers is better off with the label-G regime only if $C_g < \Gamma_1$ where Γ_1 is defined in the appendix. The set of parameters for which the entire group of high-quality producers prefers the label-G regime is smaller than the set for which only the label-G high-quality producers prefer the label-G regime (i.e., $\Gamma_1 < \Gamma_g$). The fraction of the high-quality producers that get the label-G gain from identifying themselves (thus the total gain in profit is either $n_g(\Pi_g^* - \Pi_h^*)$ or $n_g(\Pi_g^* - \Pi^*)$), whereas the rest of the high-quality producers that cannot get the label lose from not being identified (and therefore the total loss in profit is either $(\alpha m - n_g)(\Pi_h^* - \Pi_a^*)$ or $(\alpha m - n_g)(\Pi_h^* - \Pi^*)$).

Industry-wise, all the producers prefer the label-G regime as long as $C_g < \Gamma_2$ where Γ_2 is defined in the appendix. The set of parameters for which the entire industry is better off with the label-G regime is even smaller (i.e., $\Gamma_2 < \Gamma_g$). For low enough full-certification cost C, the label-G regime has to be compared with the full-revelation regime. In this case, the label-G regime makes the label-G producers better off (their total gain in profit is $n_g(\Pi_g^* - \Pi_h^*)$) and the low-quality producers better off (their total gain in profit is $(1 - \alpha)m(\Pi_a^* - \Pi_l^*)$) whereas non-

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label-G high-quality producers are worse off (their total loss in profit is $(\alpha m - n_g)(\Pi_h^* - \Pi_a^*)$). Hence, the entire industry prefers less label-G than the label-G group but they prefer more label-G than the high-quality producers group. For high enough full-certification cost C, the label-G regime only makes label-G producers better off (their total gain is $n_g(\Pi_g^* - \Pi^*)$) whereas both low-quality producers and non-label-G high-quality producers are worse off (their total loss is $(m - n_g)(\Pi^* - \Pi_a^*)$).

Because consumers' surplus is increasing with n_g and $n_g = 0$ (respectively, $n_g = \alpha m$) corresponds to the non-certification (respectively, full-revelation) regime, consumers are worse (respectively, better) off in the case of label-G compared to the full-revelation (respectively, non-certification) regime (i.e., $S^a < S^g < S$). The entire society is better off under the label-G regime as long as $C_g < \Gamma_3$ where Γ_3 is defined in the appendix. Besides the effect of the label-G on the entire industry described above, at the society level we need to add the effect on consumers. Thus, for low enough full-certification cost, the label-G regime does not benefit consumers, as they are better off under full revelation (i.e., $S^g < S$). Thus, overall the label-G regime makes consumers and non-label-G producers worse off. For higher full-certification costs, the label-G regime benefits consumers ($S^g > S^a$) and label-G producers. The rest of the producers are worse off.

We can posit the following set of results. All the proofs are given in the appendix.

Proposition 1: *If $C_g \geq C$, society is never better off under the label-G regime.*

Not surprisingly, if full certification is less costly than label-G, from the society viewpoint more revelation of information is always better. At the level of the entire society, consumers benefit from full revelation and this effect outweighs the loss for the low-quality producers.

Proposition 2: *For a given intermediate value of the full-certification cost C and*

- *for very high values of the label-G cost, the high-quality producers are better off under full revelation whereas the industry is worse off.*

- *for intermediate values of C_g, label-G producers are better off under the label-G regime, whereas the entire industry is worse off. The high-quality producers can be better or worse off.*

- *for low values of C_g, label-G producers and the industry are better off under the label-G regime, whereas high-quality producers can be better or worse off.*

Unless it is very expensive to collectively get a label-G, the high-quality producers who get it are made better off. However, this is no longer the case for the entire industry or the entire set of high-quality producers. Indeed, for some values of the label-G cost, the entire industry can be worse off, as the benefit from the revelation of the quality does not outweigh the label-G cost plus the loss incurred by the low-quality producers.

Corollary 1: *For intermediate values of both certification costs, the incentives of the label-G producers and the industry are divergent.*

If the entire industry can lobby the decision of the government to offer such a label-G regime, then there is room for doing so here. In the case of the refusal to adopt GIs in the U.S., it seems that some companies are trying to convince the government to reject the GI altogether (Hayes, Lence, and Babcock, 2005).

From the previous results, we can derive the following corollaries.

Corollary 2: *For intermediate values of C_g, there is under-provision of certification from the society viewpoint.*

Indeed, label-G producers are those who make the decision to adopt the label-G, and thus they prefer to reveal less information, i.e., not to choose full certification for a certain constellation of parameters.

If we now consider that it is possible that $C > C_g$, and if furthermore full revelation is not an option, as it is too costly, for intermediate values of C_g there is an over-provision of label-G compared to what makes society better off. This happens if the loss incurred by non-label-G producers (i.e., $(m - n_g)(\Pi^* - \Pi_a^*)$) is higher than the consumers' benefit from more revelation of information (i.e., $S^g - S^a$). This actually happens when the club size is small enough.

Corollary 3: *For very high full-certification cost, for intermediate values of the label-G cost, and for a small given club size, there is over-provision of label-G. Label-G high-quality producers are better off under label-G whereas society and the entire industry are worse off.*

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Thus, because a group of high-quality producers decide on whether to adopt a label, there are too many label-G producers from a social viewpoint.

For label-G certification costs close enough to full-revelation cost, society would prefer more full-revelation certification to be adopted. However, high-quality producers are worse off and thus prefer to adopt label-G.

We represent the different choices in a graph (C, C_g).

For small club size
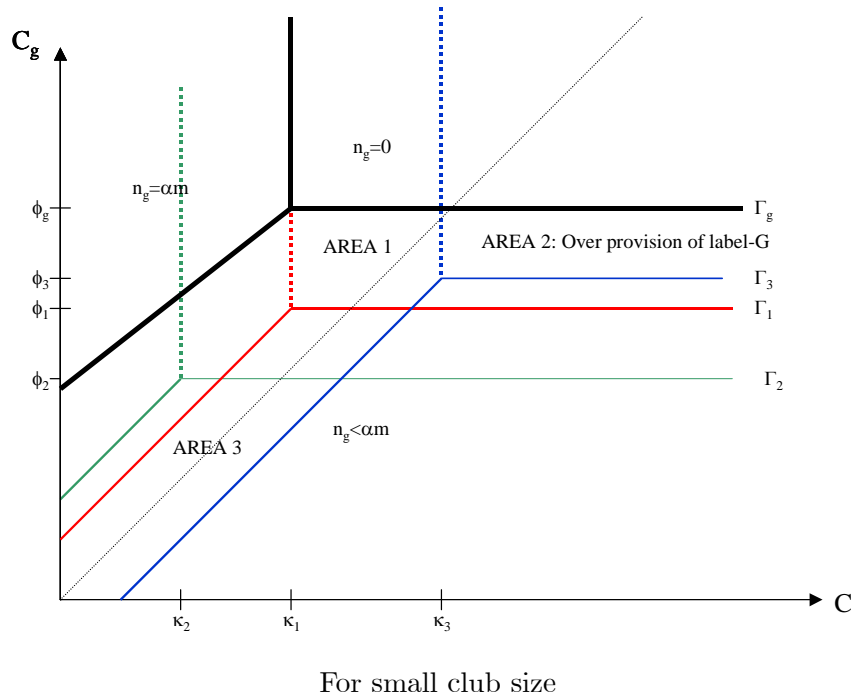
For values of C_g smaller than Γ_i, $i = g$ for label-G high-quality producers, $i = 1$ for all the high-quality producers, $i = 2$ for the industry, and $i = 3$ for society, the label-G regime is preferred. For values of C_g bigger than Γ_i and bigger than κ_i, no certification is preferred, whereas full revelation is preferred for values of $C_g < \kappa_i$. Thus, we can isolate three areas of interest. Area 1 is where high-quality producers and the industry prefer no certification at all, whereas label-G producers and society would be better off under the label-G regime and full-revelation certification, respectively. This arises for relatively high C_g. In area 2, high-quality producers and society would prefer no certification at all, but label-G producers still benefit from the label-G regime. Then, area 3 corresponds to the area where label-G high-

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quality producers, other high-quality producers, and the entire industry are better off with a label-G regime, whereas society would be better off with a full-revelation certification. If both certifications costs were identical, for low costs, there is under-provision of information. Indeed, high-quality producers are better off with a label-G regime, whereas society would prefer full revelation.

For a bigger club size, the graph is slightly different, and if both certifications were to cost the same, for low cost there is efficient provision of information (i.e., both high-quality producers and society are better off with a certification that fully reveals information), whereas for high cost values there is under-provision of information.

5 Optimal size of the club

We now turn to the first decision of the high-quality producers. Once they decide whether or not to adopt a label, they must decide upon the optimal size of the group of producers that will get the label. We define the group as a club. Indeed, GIs can be seen as club goods that are non-rival but congestible (many firms can have access to this kind of protection but if too many of them have access to it, it will decrease the profit of each of them) and excludable (those who do not have the label are excluded to benefit from it). Therefore, each producer derives benefit from joining the club, but the arrival of new members will reduce the benefit.

We first define the optimal size of the club. The net benefit of each member of the club is defined by equation (9). Hence, the optimal size of the club is the solution to the following maximization program:

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

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

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

which we re-write as

$$n_g \left| \frac{d\Pi_g^*(n_g)}{dn_g} \right| = \frac{C_g}{n_g}. \tag{10}$$

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 of equation (10). 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 as $n_g^* < \alpha m$.

Thus, when a label-G is available, a club will be formed, and not all the high-quality producers can get into 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 rest of the high-quality producers have no opportunity to signal their quality.

Using equation (8), the first-order condition becomes

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

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

$$\begin{cases} \underset{n_g}{Max}\{n_g\Pi_g^*(n_g) - C_g + (m - n_g)\Pi_a^*(n_g)\}, \\ \text{with } n_g \leq \alpha m. \end{cases}$$

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 viewpoint, too few high-quality producers are part of the club that holds the label-G.

Lemma 1: *If a club can be formed, its size is suboptimal from the industry viewpoint.*

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 the label-G regime.

So far, we have only defined the optimal size of the club that some producers of high-quality will join. But is this a Nash equilibrium?

We need to make sure that no deviation will occur, and therefore that each high-quality producer inside and outside of the club has no incentive to deviate. To see that, even though most of our discussion is in term of continuous values for the size of the club, we now consider discrete sizes. A high-quality producer inside of the club does not deviate if

$$\Pi_g^*(n_g^*) - \frac{C_g}{n_g^*} \geq \Pi_a^*(n_g^* - 1).$$

A high-quality producer outside of the club chooses not to get into the club if

$$\Pi_a^*(n_g^*) \geq \Pi_g^*(n_g^* + 1) - \frac{C_g}{n_g^* + 1}.$$

Those two inequalities cannot hold simultaneously, and thus n_g^* cannot be an equilibrium. Indeed, a high-quality producer inside of the club has no incentive to deviate as long as C_g is small enough, whereas a producer outside of the club has an incentive to get into the club.

There exists, however, an equilibrium $\overline{n}_g - 1$ such that none of the producers deviate. It is such that

$$\Pi_g^*(\overline{n}_g) - \frac{C_g}{\overline{n}_g} = \Pi_a^*(\overline{n}_g).$$

At $\overline{n}_g$, a producer outside of the club prefers not to join, whereas a producer inside prefers to leave the club. At $\overline{n}_g - 1$ a producer outside the club gets less from joining the club, whereas a producer inside the club has no incentive to exit. This is an equilibrium. Furthermore, this equilibrium exists only if $C_g > \alpha m(\Pi_h^* - \Pi_l^*)$ (see appendix). However, if $C_g < \alpha m(\Pi_h^* - \Pi^*)$, the equilibrium is the entire group of high-quality producers, αm.

Proposition 3: *Under a free-entry condition, there is no equilibrium with a club of optimal size. However, under certain cost conditions, a club of bigger size may exist.*

If, however, the government lets the club set a barrier to entry, the optimal size of the club can be reached. The barrier can be such that any producer who wants to join the club after the optimal size has been reached needs to pay an extra fixed cost. This fee can be set at exactly $\Pi_g^*(n_g^*) - \frac{C_g}{n_g^*}$. For instance, because of the geographic restraint, if one more producer decides to use the label-G, he has to buy some land inside the geographical area. Note that this behavior may be prohibited by law.

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6   Certification Choice

In this section we determine the equilibrium of the game. So far, we have defined who benefits from certification that does not completely reveal information for a given size of club. Then, we have defined the optimal size of the club, and defined whether it can be an equilibrium or not. We now put together those two parts. We consider two cases; in the first one, entry can be deterred by members of the club, and in the second case, entry cannot be deterred, and therefore the optimal size of the club cannot be an equilibrium.

6.1   Barrier to Entry

We assume that *ex ante* the optimal size of the club is defined, and that any extra producer who wants to get into the club has to pay an extra fee, corresponding to the profit earned by each member of the club (or it could be less than that). We can now define the optimal choice of certification.

As before, we need to determine the areas where label-G producers are better off if they get a label. However, here we need to account for the fact that the optimal size of the club is endogenous and thus n_g^* depends on C_g. Label-G producers are better off under the label-G regime if $C_g < \Gamma_g(C_g)$ where Γ_g is now a function of C_g (see appendix). We show that there exists a value of C_g such that $C_g = \Gamma_g(C_g)$. Let $\overline{C}_g(C)$ denote this value. It is first increasing with C and then it is a constant. Therefore, for any certification cost $C_g \leq \overline{C}_g(C)$, n_g^* high-quality producers join the club. However, for $C_g > \overline{C}_g(C)$, no high-quality producers join the club. We can thus posit the following proposition:

Proposition 4: *If the club can create a barrier to entry,*

- *for low certification costs, there exists a positive optimal size of the club, i.e., $n_g^* \in (0, \alpha m)$,*

- *for higher certification costs, there is no club.*

6.2   No barrier to entry

We now consider the case in which it is prohibited by law to prevent entry. Entry in the club is only restricted by the certification costs. The only equilibrium in this case is $(\overline{n}_g - 1)$ if

$C_g > \alpha m(\Pi_h^* - \Pi_l^*)$. If $C_g < \alpha m(\Pi_h^* - \Pi^*)$, the equilibrium is the total number of high-quality producers, αm.

If $\overline{n}_g$ exists, because Π_a^* is strictly decreasing in n_g, and the inequality $\Pi^* > \Pi_g^*(\overline{n}_g) - \frac{C_g}{\overline{n}_g}$ is always satisfied, the high-quality producers prefer not to choose a certification, and thus $n_g = 0$. On the other hand, if $C_g < \alpha m(\Pi_h^* - \Pi^*)$, the only optimal size is the entire group of high-quality producers, αm. Then, for values of $C_g \in [\alpha m(\Pi_h^* - \Pi^*), \alpha m(\Pi_h^* - \Pi_l^*)]$, high-quality producers choose not to label.

Proposition 5: *A club with free entry with a size strictly higher than 0 and strictly smaller than αm is not viable.*

This is actually consistent with the literature on club goods, where there is a problem of stability of the equilibrium (see Scotchmer, 2002).

Let $\overline{C}$ denote the value of C_g such that $C_g = \alpha m(\Pi_h^* - \Pi^*)$. For any certification cost $C_g \leq \overline{C}$, all the high-quality producers join the club. For $C_g > \overline{C}$, no high-quality producers join the club. We can thus posit the following proposition:

Proposition 6: *If the club cannot create a barrier to entry,*

- *for low enough certification costs, all the high-quality producers join the club,*

- *for high certification costs, there is no club.*

Furthermore, $\overline{C} < \overline{C}_g$ where $\overline{C}_g$ correspond to the constant value of $\overline{C}_g(C)$. For values of $C_g \in (\overline{C}, \overline{C}_g)$, by letting the club create a barrier to entry, the government allows for more revelation of information. Indeed, in the absence of barrier to entry, for these values of the certification costs, no club will be formed. However, if entry is prevented, there will be some revelation of information, and a club with less than all of the high-quality producers will be formed.

Proposition 7: *for values of $C_g \in (\overline{C}, \overline{C}_g)$,*

- *in the absence of barrier to entry, there is no label,*

- *if entry is deterred, a group n_g^* of high-quality producers gets a label-G.*

Allowing producers to restrict entry permits some revelation of information.

7 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, 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 consumers with high willingness to pay and with low willingness to pay gain from certification. Those with high willingness to pay benefit by being able to buy a high-quality product with certainty. Those with low willingness to pay benefit from lower prices for low-quality production. Those with moderate willingness to pay may lose from certification because they now have to pay a high price for a high-quality product whereas without certification they had a chance at obtaining a high-quality product at a moderate price. We also model a certification program that fully reveals the high-quality product but not the low-quality product with similar welfare consequences, and 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 with 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.

References

[1] Addor, F. and A. Grazioli. "Geographical Indications Beyond Wine and Spirits," *The Journal of World Intellectual Property*, *5*:865–897 (2002).

[2] Akerlof, G. "The Market for Lemons: Quality Uncertainty and the Market Mechanism," *Quarterly Journal of Economics*, *84(1)*:488–500 (1970).

[3] Albano, G. and A. Lizzeri. "Strategic Certification and Provision of Quality," *International Economic Review*, *42*:267–283 (2001).

[4] Auriol, E. and S. Schillizzi. "Quality Signaling Through Certification. Theory and an Application to Agricultural Seed Markets," *IDEI mimeo*, *165* (2003).

[5] Bagwell, K. and M. Riordan. "High and Declining Prices Signal Product Quality," *American Economic Review*, *81*:224–269 (1991).

[6] Bergès-Sennou F., P. Bontems and V. Réquillart. "Economics of Private Labels: A Survey of Literature," *Journal of Agricultural and Food Industrial Organization*, *2* (2004).

[7] Biglaiser, G. "Middlemen as Experts," *RAND Journal of Economics*, *24*:212–223 (1993).

[8] Biglaiser, G. and J. Friedman. "Middlemen as Guarantors of Quality," *International Journal of Industrial Organization*, *12*:509–531 (1994).

[9] Crespi, J. and S. Marette. "How Should Food Safety Certification Be Financed," *American Journal of Agricultural Economics*, *83(4)*:852–861 (2001).

[10] Darbi, M.R. and E. Karni. "Free Competition and the Optimal Amount of Fraud," *Journal of Law and Economics*, *16*:67–88 (1973).

[11] Gabszewicz, J.J and J.F. Thisse. "Price Competition, Quality and Income Disparities," *Journal of Economic Theory*, *20*:340–359 (1979).

[12] Hayes D., S. Lence and B. Babcock. "Geographic Indications and Farmer-Owned Brands: Why Do the U.S. and E.U. Disagree?," *Eurochoices*, *4*:28–35 (2005).

[13] Lizzeri, A. "Information Revelation and Certification Intermediaries," *RAND Journal of Economics*, *30*:214–231 (1999).

[14] Marette, S. "The Collective-Quality Promotion in the Agribusiness Sector: An Overview," *working paper* (2005).

[15] Marette, S. and J. Crespi. "Can Quality Certification Lead to Stable Cartels?," *Review of Industrial Organization*, *23*:43–64 (2003).

[16] Milgrom, P. and J. Roberts. "Price and Advertising Signals of Product Quality," *Journal of Political Economy*, *94*:796–821 (1986).

[17] Mussa, M. and S. Rosen. "Monopoly and Product Quality," *Journal of Economic Theory*, *18*:301–317 (1978).

[18] Nelson, P. "Information and Consumer Behavior," *Journal of Political Economy*, *78*:311–329 (1970).

[19] Rangnekar, D. "The Socio-Economics of Geographical Indications: A Review of Empirical Evidence from Europe," *UNCTAD-ISTSD Project on IPRs and Sustainable Development* (2004).

[20] Scotchmer, S. *Local Public Good and Clubs*, chapter 29, 1998–2036. Handbook of Public Economics, 2002.

Appendix

Full-certification regime

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

$$\underset{q_{ih}}{Max}\{([1 - q_{ih} - (\alpha m - 1)q_h]s_h - s_l m(1 - \alpha)q_l)q_{ih} - \frac{C}{\alpha m}\},$$

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

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

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

The best-response function of each high-quality firm is

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

and of each low-quality firm is

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

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

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

Thus, solving for these two equations, we find (4) and (5).

Consumer surplus is given by

$$S = \int_{\hat{\theta}}^{\tilde{\theta}} (\theta s_l - p_l^*)d\theta + \int_{\tilde{\theta}}^{1} (\theta s_h - p_h^*)d\theta = m s_h \frac{N}{2D^2},$$

where $N = \alpha^4 m^3 (s_h - s_l)^2 - 2\alpha^3 (s_h - s_l)^2 (1 + m)m^2 + \alpha^2 (s_h - s_l) m(s_h + m^2 (s_h - s_l) + 2m (s_h - 2s_l)) + 2\alpha s_l (-s_h(1 - s_l) + m^2 (s_h - s_l)) + s_h s_l(2 - 2s_l + m)$ and $D = (1 + m)s_h + (1 - \alpha)\alpha m^2(s_h - s_l)$.

We can now compare S and S^a, where $S^a = (\alpha s_h + (1 - \alpha)s_l)m^2/2 (m + 1)^2$. First, we calculate that

$$S - S^a = -\frac{(1 - \alpha) m}{2D^2 (m + 1)^2}\Phi(\alpha)$$

where $\Phi(\alpha) = -\alpha^4 m^5 (s_h - s_l)^3 + \alpha^3 m^3 (s_h - s_l)^2 (s_h (2m + 1) + 2m^2 (s_h - s_l))$

$-\alpha^2 m^2 (s_h - s_l)^2 (m^3(s_h - s_l) + s_h(3m + 2m^2 + 2)) + \alpha s_h m (s_h - s_l) (m + 1) (2ms_l - ms_h - s_h) -$

$2s_l s_h^2 (m + 1)^2 (1 - s_l)$. To show that $S - S^a > 0$ we need to show that $\Phi(\alpha) < 0$ for $\alpha \in [0, 1]$. For $\alpha = 0$, $\Phi(0) < 0$, $\Phi'(0) < 0$, and $\Phi''(0) < 0$. Further because $\Phi'(\alpha)$ has no real roots between $[0, 1]$, $\Phi(\alpha)$ has no real roots between $[0, 1]$ either, and is negative on $[0, 1]$. Hence, if $\Phi(\alpha) < 0$ for $\alpha \in [0, 1]$, $S > S^a$.

Label-G regime

The inverse demand functions for the label-G good and the non-label-G good are

$$p_g(Q_g, Q_a) = [1 - Q_g]s_h - s_g^a Q_a,$$
$$p_a(Q_g, Q_a) = [1 - Q_g - Q_a]s_g^a,$$

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

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

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

and of each firm j is

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

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

$$q_j(q_g, q_a) = \frac{1 - (m - n_g - 1)q_a - n_g q_g}{2}.$$

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 (respectively, outside) the group, q_g (respectively,

q_a) to the quantity offered by each firm outside (respectively, inside) the group q_a (respectively, q_g) is

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

Thus, solving for these two equations, we find (6) and (7).

The total consumer's surplus is

$$
S^g(n_g) = \int_{\widetilde{\theta}_a}^{\widetilde{\theta}_g} (\theta s_g^a - p_a^*) d\theta + \int_{\widetilde{\theta}_g}^{1} (\theta s_h - p_g^*) d\theta
$$

$$
= \frac{2mn(s_h - s_l)(1-\alpha)(\alpha s_h + (1-\alpha)s_l) + mn^2(s_h - s_l)^2(1-\alpha)^2 + s_h(m(\alpha s_h + (1-\alpha)s_l) - n(1-\alpha)(s_h - s_l))}{2D_n^2} ms_h.
$$

where $D_n = s_h(1 + m) + mn(1 - \alpha)(s_h - s_l)$. The derivative of the surplus is

$$
\frac{\partial S^g(n_g)}{\partial n_g} = \frac{2ms_h(\alpha s_h + (1-\alpha)s_l) + 3mns_h(s_h - s_l)(1-\alpha) + 2m^2 n(s_h - s_l)^2(1-\alpha)^2 - s_h^2(1+m)}{2D_n^3} (1-\alpha)(s_h - s_l) ms_h,
$$

which is strictly positive. Furthermore, when $n_g = 0$, the consumer's surplus is the surplus in case of no certification (i.e., $S^g(0) = S^a$), whereas when $n_g = \alpha m$ and for $\alpha = 0.5$, it is the case when the quality is perfectly known (i.e., $S^g(\frac{1}{2}m) = S$).

Comparison of the different regimes

Label-G producers are better off under the full-revelation regime versus the non-certification regime if $\alpha m \Pi_h^* - C > \alpha m \Pi^*$, or equivalently $C < \kappa_1 \equiv \alpha m(\Pi_h^* - \Pi^*)$ (this is actually the same for all of the high-quality producers). Thus, as long as $C > \kappa_1$, we need to compare the label-G regime and the non-certification regime. Thus, label-G producers are better off under the label-G regime rather than the non-certification regime as long as $n_g \Pi_g^* - C_g > n_g \Pi^*$, which is equivalent to $C_g < \phi_g \equiv n_g(\Pi_g^* - \Pi^*)$. For $C < \kappa_1$, they are better off under label-G versus full certification if $n_g \Pi_g^* - C_g > n_g \Pi_h^* - \frac{n_g}{\alpha m} C$ or equivalently $C_g < \varphi_g + \frac{n_g}{\alpha m} C$ where $\varphi_g \equiv n_g(\Pi_g^* - \Pi_h^*)$. Hence, overall, label-G makes them better off as long as $C_g < \Gamma_g = \min\{\phi_g, \varphi_g + \frac{n_g}{\alpha m} C\}$.

If $C > \kappa_1$ high-quality producers are better off under the non-certification regime (compared to the full-revelation regime). Furthermore, they are better off under the label-G regime if $n_g \Pi_g^* + (\alpha m - n_g)\Pi_a^* - C_g > \alpha m \Pi^*$ or $C_g < \phi_1$ where $\phi_1 \equiv \phi_g - (\alpha m - n_g)(\Pi^* - \Pi_a^*)$. However, if $C < \kappa_1$, they are better off under label-G (versus full certification) if $n_g \Pi_g^* + (\alpha m - n_g)\Pi_a^* - C_g >$

$\alpha m \Pi_h^* - C$ or $C_g < \varphi_1 + C$ where $\varphi_1 \equiv \varphi_g - (\alpha m - n_g)(\Pi_g^* - \Pi_a^*)$. Thus, high-quality producers prefer the label-G regime as long as $C_g < \Gamma_1 = \min\{\phi_1, \varphi_1 + C\}$. As $\phi_1 < \phi_g$ and $\varphi_1 < \varphi_g$, the set of parameters is smaller.

The label-G regime can only be appealing if $\varphi_1 > 0$. If not, the label-G regime is never preferred by high-quality producers.

Furthermore, φ_1 is an increasing and then decreasing function of n_g, with $\varphi_1(0) < 0$ and $\varphi_1(\alpha m) = 0$. Thus, there exists a value $n_1 < \alpha m$ such that $\varphi_1(n_1) = 0$. Thus $\varphi_1 > 0$ implies that $n_g > n_1$.

At the level of the industry, all the producers prefer the full-certification regime over the non-certification regime as long as $\alpha m \Pi_h^* - C + (1 - \alpha) m \Pi_l^* > m \Pi^*$ or $C < \kappa_2$ where $\kappa_2 \equiv \kappa_1 - (1 - \alpha) m (\Pi^* - \Pi_l^*) < \kappa_1$. For $C > \kappa_2$, the entire industry is better off with label-G as long as $n_g \Pi_g^* + (m - n_g) \Pi_a^* - C_g > m \Pi^*$ or $C_g < \phi_2$ where $\phi_2 = \phi_1 - (1 - \alpha) m (\Pi^* - \Pi_a^*) < \phi_1$. On the other hand, for $C < \kappa_2$, the entire industry is better off under label-G if $n_g \Pi_g^* + (m - n_g) \Pi_a^* - C_g > \alpha m \Pi_h^* - C + (1 - \alpha) m \Pi_l^*$ or $C_g < \varphi_2 + C$ where $\varphi_2 = \varphi_1 + (1 - \alpha) m (\Pi_a^* - \Pi_l^*)$. Thus, as long as $C_g < \Gamma_2 = \min\{\phi_2, \varphi_2 + C\}$ the entire industry is better off.

The function φ_2 is first increasing and then decreasing with n_g with $\varphi_2(0) < 0$ and $\varphi_2(\alpha m) = 0$. There exists a value $n_2 < \alpha m$ such that $\varphi_2(n_2) = 0$ with $n_2 < n_1$.

From the society viewpoint, the entire society is better off under full revelation versus non-revelation for $\alpha m \Pi_h^* - C + (1 - \alpha) m \Pi_l^* + S > m \Pi^* + S^a$ or $C < \kappa_3$ where $\kappa_3 = \kappa_2 + S - S^a > \kappa_2$. For values of $C > \kappa_3$, society can benefit from the label-G regime if $n_g \Pi_g^* + (m - n_g) \Pi_a^* - C_g + S^g > m \Pi^* + S^a$ or $C_g < \phi_3$ where $\phi_3 = \phi_2 + S^g - S^a$. For $C < \kappa_3$, society is better off under label-G if $n_g \Pi_g^* + (m - n_g) \Pi_a^* - C_g + S^g > \alpha m \Pi_h^* - C + (1 - \alpha) m \Pi_l^* + S$ or $C_g < \varphi_3 + C$ where $\varphi_3 \equiv \varphi_2 + S^g - S$. Thus label-G is preferred for $C_g < \Gamma_3 = \min\{\phi_3, \varphi_3 + C\}$.

Further, we show that $\kappa_3 > \phi_3$ and that $\varphi_3 < 0$. To prove that the first equation holds true, we calculate $\kappa_3 - \phi_3 = -(m\alpha - n_g)(1 - \alpha)(s_h - s_l) m s_h^2 \Psi / (2 D^2 D_n^2)$ where $\Psi(\alpha) = \alpha^3 m^3 (s_h - s_l)^2 (n - m - 2)$

$\quad + \alpha^2 m^2 (s_h - s_l) \left(s_l \left(2n - 4m - 2m^2 + 3mn \right) + s_h \left(4m - 2n + 2m^2 - 3mn + 1 \right) \right)$

$\quad - \alpha m (s_h - s_l) \left(s_l m \left(4n - 2m + 3mn - m^2 \right) - s_h (m + 1) \left(m + n + 3mn - m^2 + 4 \right) \right)$

$\quad + s_h s_l m \left(6m + n + 4mn + 2m^2 + 2m^2 n + 4 \right) - s_l^2 n m^2 (m + 2) - s_h^2 (m + 1)^2 (2m + mn + 3) .$

The difference $\kappa_3 - \phi_3$ is positive if $\Psi(\alpha) < 0$, and therefore we need to study the function $\Psi(\alpha)$. First, note that $\Psi(0) < 0$, $\Psi(1) < 0$, and $\Psi'(\alpha) > 0$ for $\alpha \in [0, 1]$. Hence, the function $\Psi(\alpha) < 0$

which proves that $\kappa_3 > \phi_3$.

We now show that $\varphi_3 < 0$. Here again we calculate φ_3 as being $(m\alpha - n_g)(1 - \alpha)(s_h - s_l)ms_h^2\Psi_3/(2D^2D_n^2)$ where $\Psi_3(\alpha) = \alpha^3m^3(s_h - s_l)^2(n - m - 2)$

$$+\alpha^2m^2(s_h - s_l)(s_l(2n - 4m + 3mn - 2m^2) + s_h(4m - 2n - 3mn + 2m^2 + 1))$$

$$-\alpha m(s_h - s_l)(s_lm(4n - 2m + 3mn - m^2) - s_h(m + 1)(m + n + 3mn - m^2 + 4))$$

$$+s_hs_lm(6m + n + 4mn + 2m^2 + 2m^2n + 4) - s_h^2(m + 1)^2(2m + mn + 3) - s_l^2nm^2(m + 2).$$

We now analyze the function $\Psi_3(\alpha)$, and we show that $\Psi_3(0) < 0$, $\Psi_3(1) < 0$ and $\Psi_3'(\alpha) > 0$ for $\alpha \in [0, 1]$. Therefore, $\Psi_3(\alpha) < 0$ for $\alpha \in [0, 1]$, which proves that $\varphi_3 < 0$. Hence, as long as $C < C_g$, the label-G is never preferred by the entire society.

We now show that $\kappa_2 > 0$. Recall that $\kappa_2 \equiv \alpha m(\Pi_h^* - \Pi^*) - (1 - \alpha)m(\Pi^* - \Pi_l^*) > 0$ that can be re-written as $\kappa_2 = (s_h - s_l)(1 - \alpha)m\alpha\Psi_2/[D(m + 1)]^2$ where $\Psi_2(\alpha) = \alpha^3m^3(s_h - s_l)^2 - \alpha^2m^3(s_h - s_l)(s_h - 2s_l) - \alpha m(s_h - s_l)(3s_h + 4ms_h + m^2s_h + m^2s_l) + s_h(m + 1)(2s_h + m(3 + m)(s_h - s_l))$.

We can easily calculate that $\kappa_2(0) = 0 = \kappa_2(1)$. We now need to study κ_2 for $\alpha \in [0, 1]$. To do so, we study the function $\Psi_2(\alpha)$. Indeed if we show that $\Psi_2(\alpha) > 0$, then $\kappa_2 > 0$. First, for the extreme values of α, $\Psi_2(0) > 0$ and $\Psi_2(1) = 2s_h^2(1 + m) > 0$. The derivative of $\Psi_2(\alpha)$ is such that $\Psi_2'(\alpha)|_{\alpha=0} < 0$ and $\Psi_2'(\alpha)|_{\alpha=1} < 0$, and furthermore the values of α such that $\Psi_2'(\alpha) = 0$ are outside of $[0, 1]$, that gives $\Psi_2'(\alpha) < 0$ for $\alpha \in (0, 1)$. Hence, the function $\Psi_2(\alpha)$ is strictly decreasing but positive for $\alpha \in (0, 1)$ and we can conclude that $\kappa_2 > 0$.

Using the same kind of reasoning we can also prove that $\kappa_3 > \kappa_1$. Indeed,

$$\kappa_3 - \kappa_1 = -\frac{(1-\alpha)(s_h-s_l)m}{2((m+1)D_n)^2}\Psi_4$$

where $\Psi_4 = \alpha^42m^4(s_h - s_l)^2 - \alpha^3m^4(s_h - s_l)((m + 4)(s_h - s_l) - 2s_l)$

$$+\alpha^2(-m^2(s_h - s_l)(s_h(4 + 3m) + 2m^2s_l - 2m^2(s_h - s_l)(2 + m)))$$

$$-\alpha m^2(m^2s_l^2(2 + m) + s_h^2(2m^2 - m + m^3 - 2) + s_hs_l(6 + 5m - 4m^2 - 2m^3))$$

$$+s_h(m + 1)(2s_h + 3ms_h + m^2s_h + 2m^2s_l).$$ We study the function Ψ_4, and show that it is negative over $\alpha \in [0, 1]$.

Proof of Proposition 1

It is equivalent to show that $\varphi_3 < 0$ (proof provided above).

Proof of Proposition 2

Intermediate values of the full-certification cost corresponds to $C \in (\kappa_2, \kappa_1)$. Very high values of the label-G costs correspond to $C_g > \phi_g$, intermediate corresponds to $C_g \in (\phi_2, \varphi_g + \frac{n_g}{\alpha m}C)$, whereas low values correspond to $C_g < \phi_2$.

For intermediate values of C_g, high-quality producers are better (worse) off if $C_g < \Gamma_1$ ($C_g > \Gamma_1$).

For low values of C_g, high-quality producers are better (worse) off under the label-G regime only if $C_g < \Gamma_1$ ($C_g > \Gamma_1$).

Proof of Corollary 2

For intermediate values of label-G costs, i.e., $\Gamma_g > C_g \geq C$, there is under-provision of certification from the society viewpoint.

Proof of Corollary 3

For high full-revelation certification cost, i.e., $C > \kappa_3$, and for intermediate values of the label-G cost, $C_g \in [\phi_3, \phi_g]$, there is over-provision of label-G. Label-G high-quality producers are better off under label-G whereas society and the entire industry are worse off.

Club size and equilibrium (Proposition 3)

An equilibrium $\overline{n}_g - 1$ exists only if $C_g > \alpha m(\Pi_h^* - \Pi_l^*)$. Indeed, the function $\Pi_g^*(n_g) - \frac{C_g}{n_g} \equiv F(n_g)$ is first increasing and then decreasing with n_g, reaching an optimal value at n_g^* and $F(\alpha m) = \Pi_h^* - \frac{C_g}{\alpha m}$. The function $\Pi_a^*(n_g)$ is strictly decreasing with $\Pi_a^*(0) = \Pi^*$ and $\Pi_a^*(\alpha m) = \Pi_l^*$. Thus, either $F(n_g)$ and $\Pi_a^*(n_g)$ never cross, cross once, or cross twice. If $\Pi_l^* > \Pi_g^*(n_g) - \frac{C_g}{n_g}$ for any n_g, the two functions never cross and thus there is no equilibrium. On the other hand, if $\Pi_h^* - \frac{C_g}{\alpha m} > \Pi^*$, they cross once, but this is in the increasing part of $F(n_g)$ and this is not an equilibrium either. Indeed, denote n the value of n_g such that $F(n) = \Pi_a^*(n)$. If one more producer enters the club, his payoff increases to $F(n+1)$, and this is enough to show it is not an equilibrium. If $\Pi_l^* > \Pi_h^* - \frac{C_g}{\alpha m}$ or equivalently $C_g > \alpha m(\Pi_h^* - \Pi_l^*)$, the two functions cross twice: once in the increasing part of $F(n_g)$ and another time in its decreasing part at $\overline{n}_g$. Therefore $\overline{n}_g - 1$ is the equilibrium, as none of the producers have an incentive to deviate from this point.

Label-G choice in the presence of barrier to entry (Proposition 4)

A group of high-quality producers will decide to form a club of size n_g^* if it is worthwhile to do it, in other words, as long as $C_g < \Gamma_g(C_g)$ where $\Gamma_g(C_g) = \min\{\phi_g(C_g), \varphi_g(C_g) + \frac{n_g^*(C_g)}{\alpha m}C\}$ with $\phi_g(C_g) = n_g^*(C_g)(\Pi_g^*(C_g) - \Pi^*)$ and $\varphi_g(C_g) = n_g^*(C_g)(\Pi_g^*(C_g) - \Pi_h^*)$. There exists a value of C_g, denoted $\overline{C}_g$, for which $C_g = \phi_g(C_g)$. There exists also a value of C_g for which $C_g = \varphi_g(C_g) + \frac{n_g^*(C_g)}{\alpha m}C$ that we denote $\overline{C}_g(C)$. As long as $C_g < \overline{C}_g(C)$, a club will be formed of size n_g^*. For higher values, none of the high-quality producers decide to form a club.

Label-G choice in the absence of barrier to entry (Propositions 5 and 6)

As long as $C_g > \alpha m(\Pi_h^* - \Pi_l^*)$, the only equilibrium is a club of size $(\overline{n}_g - 1)$. However, this size is not chosen, as high-quality producers can get a higher payoff if they do not get a label, as $\Pi^* > \Pi_g^*(\overline{n}_g) - \frac{C_g}{\overline{n}_g}$ is always satisfied. Therefore, for $C_g > \alpha m(\Pi_h^* - \Pi^*)$, there is no club, whereas for $C_g < \alpha m(\Pi_h^* - \Pi^*)$, all of the high-quality producers join the club.

Proof of Proposition 7

Let $\overline{C}$ denote the value of C_g such that $C_g = \alpha m(\Pi_h^* - \Pi^*)$. The value of C_g such that $C_g = \phi_g(C_g)$ (denoted $\overline{C}_g$) is necessarily higher than $\overline{C}$. Therefore, there exist values of C_g, i.e., $C_g \in [\overline{C}, \overline{C}_g]$, for which allowing the club to create a barrier to entry allows for some revelation of information.