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Zohra Bouamra-Mechemache and Jad Chaaban

Abstract

This paper explores the impacts of Protected Designation of Origin (PDO) certification on the costs and profits of firms as well as consumers' and total welfare. The paper argues that PDO labels are different from other common labeling schemes, as they involve technological and capacity constraints that influence their economic efficiency. Using a theoretical model of endogenous quality choice, which incorporates vertical differentiation with the costs constraints linked to the PDO label, we explore the way producers can signal their quality either by certifying their product through PDO or by investing in a collective private common label. Results show that even if PDOs are efficient from a producer perspective, a society might be better off with less stringent techniques of quality signaling, relying on private collective certification.

KEYWORDS: public labeling, Protected Designation of Origin, collective trademark, capacity constraint

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1. Introduction: Public vs. private collective quality signaling

Groups of agro-food producers in Europe may have several alternatives to signal the quality of their products. Small individual producers may not be able to invest in quality products by themselves because it may be too costly, and accessing capital markets may be more difficult for them than for larger firms. For this, agri-food producers across the EU are increasingly forming unions either to voluntary certify their products through quality public labels or to promote collective trademarks through joint funding of R&D and/or advertising. The European Commission (EC) has in fact defined three labels to guarantee products' quality and enhance its credibility for consumers: Protected Designation of Origin (PDO), Protected Geographical Indication (PGI), and Traditional Specialty Guaranteed (TSG).

In this paper, we focus on PDO labels. By end of September 2008, the EU had 812 PDO-PGI labeled products[1], and this number is increasing every year. Numerous agricultural and food products benefit from PDO regulation (cheese, wines, meat, olive oils, fruits and vegetables, etc.). Consumers increasingly value the quality and the geographical characteristics of agricultural products as stressed by the overview of Marette (2005).[2] PDO-PGIs are mostly produced in Italy, France, Spain and Portugal that count for 70% of registered names (DG Agriculture and Rural Development,2008). The PDO regulation certifies that: (i) a given product originates in a defined region, place or country (that gives the name of the designation of origin), (ii) "its quality or characteristics are essentially or exclusively due to a particular geographical environment with its inherent natural and human factors, and (iii) the production, processing and preparation of which take place in the defined geographical area." (European Commission, 1992, Council Regulation (EEC) n°2081/92, article 2, para. 2). The PDO quality attributes thus concern not only raw materials and production but also the processing technology that has to be specific to the region. The PDO regulation induces technology constraints linked to a specific processing requirement and production area that have to be taken into account when dealing with PDO production issues. Some producers are also excluded because of the geographical area definition, and this tends to limit the production of this type of products. Moreover, the certification implies technological requirements that are most of the time not fulfilled above a production threshold (cf. Giraud-Héraud et al., 2003). When applying for PDO certification, the producers' organization commits

[1] http://ec.europa.eu/agriculture/events/qualityconference/index_en.htm.

[2] Give this, some empirical studies on Protected Designation of Origin (PDO) show that the PDO label is less valued than the brand of the product (cf. Bonnet and Simioni, 2001 and Hassan and Monier-Dilhan 2002 for the case of the French camembert cheese)

itself to this restrictive requirement, which will be subsequently controlled by the regulation authority.

Alternatively, producers could enhance the quality of their product through voluntary common actions (R&D and advertising) financed by joint funding. Agri-food producers across the EU are increasingly forming unions to promote collectively their products. Two examples of such producer organizations are the national inter-profession center of the dairy economy (CNIEL) for dairy products in France and the common brand Neuland for pig meat in Germany.

Public common labels have been found to be efficient to signal quality when some characteristics of a commodity cannot be observable by consumers before or after its purchase (cf. Shapiro, 1983 and Auriol and Schilizzi, 2003). The welfare analysis of public labeling has mainly focused on the tradeoff between the fixed cost of collective certification and the gains induced by better quality signals. Auriol and Schilizzi (2003) pointed out the importance of certification cost for market structure and determined the conditions for which a public certification is better than a private quality provision. A high certification cost leads to a highly concentrated market for certification and if it is too high, the market for quality collapses. Marette et al. (1999) have shown that the formation of groups of producers that certify high quality products are welfare improving when the cost of common labeling is high. Zago and Pick (2004) have shown that a public regulation may be detrimental to welfare in competitive markets when the quality difference is low and certification costs are high. This is because both consumers and the high quality producers benefit from the regulation but producers of the low quality good are worse-off. When the high quality producers have some market power, consumers are worse-off but the regulation favors producers.

The efficiency of common labels like the PDO has been widely analyzed in the literature, but there is to date no study that takes into account the possible differences between quality enhancement through a PDO label or a common trademark. We argue that PDO quality implies specific technological and possible capacity constraints, which might impact its efficiency. Existing literature on PDO including Chambolle and Giraud-Héraud (2003), Lence et *al.* (2007) and Moschni et *al*. (2008) all focus on fixed costs and the underlying investment in quality, without integrating variable cost differences related to publicly certified vs. privately promoted quality. These additional variable production costs might be related to the specific requirements imposed by the PDO label. We thus explore in this paper how the specificity of PDO labeling affects the producers' common quality and quality promotion choice as well as welfare tradeoffs. Our paper thus aims to critically evaluate the proliferation of PDO labels, by questioning the economic efficiency of these labels as compared to private

collective labeling schemes that might use less stringent technical requirements[3]. This would provide substantial insights into the debate concerning the effectiveness of public labeling schemes in creating value-added for agrifood producers.

The remainder of this paper is organized as follows: Section 2 presents the theoretical framework we use to analyze the trade-off faced by producers when choosing the way they signal the quality of their products. In this setting, producers have the choice to privately and collectively signal their level of quality through advertising/R&D, or to apply for a PDO certification. Section 3 shows how variable cost differences induced by the technology inherent to the PDO certification, in addition to potential production capacity constraints; affect the private producers' choice of signaling. Section 4 analyzes the implications for producers, consumers as well as total welfare, and Section 5 concludes the paper and presents some policy recommendations concerning PDO labeling in the European Union.

2. Modeling the choice of public PDO versus private collective advertising

We model in this section the tradeoff faced by a group of producers whose objective is to promote the quality of their product, by choosing either PDO certification or private common labeling. PDO certification differs from other voluntary quality promotion scheme as it carries specific technical requirements that do not apply to other labeling schemes. These requirements impose higher variable costs of production; while a private common label only requires fixed costs (in the form of joint advertising and R&D expenses).

2.1 The theoretical framework

We focus on the decision of a group of producers acting together on a voluntary basis in order to jointly certify their product's quality, either by public or private means. The group of producers is thus modeled as one single entity. It behaves collectively in choosing product quality (PDO or common label) and production levels. There is evidence from the literature (Marette, 2005, Colinet et al., 2006) that PDO producers are often grouped in producers' associations that may limit

[3] Article 4.2.e) in Council Regulation (EC) No 510/2006 of 20 March 2006 on the protection of geographical indications and designations of origin for agricultural products and foodstuffs, states that "…The product specification shall include at least:… a description of the method of obtaining the agricultural product or foodstuff and, if appropriate, the authentic and unvarying local methods as well as information concerning packaging, if the applicant group within the meaning of Article 5(1) so determines and gives reasons why the packaging must take place in the defined geographical area to safeguard quality or ensure the origin or ensure control". PDO certification imposes therefore a restriction on the processing technology.

competition within the PDO production. [4] Moreover, Hayes et al. (2004) shows how the characteristics of the PDO label allows a group of producers to control the quantity supplied. Note that in our framework the PDO or common label quality is endogenous. We assume that all producers commit to the level of quality chosen by the group of producers, defined in the product specification of the product's PDO legislation.

The two-stage decision game

The choice of the (potentially) high quality producers' organization is modeled as a two-stage game. In the first stage, the organization decides whether to engage in high quality production or not. If it decides not to do so, then it produces the low quality good within a perfectly competitive market. We assume that the low quality is exogenous and reflects the quality of the existing good on the market. It will thus affect the group of producers' strategy relative to the differentiation of its product compared to the existing one. If it chooses to engage in high quality, then the organization has two options: the first is to certify its quality by using the public PDO label; the second is to invest in a private common label. The second stage involves the choice of quantity and quality levels of the product.

The market

As reported by Gay and Gijsbers (2007), there exist several types of market organization for food quality assurance scheme (FQAS), from large size to small niche products and many PDOs have created niche markets for traditional products.[5] Given the diversity of market organizations PDO producers may face and the prevalence of niche markets, we choose to focus on niche markets where a set of competitive firms coexists with the group of producers and produces a

[4] When applying for a PDO certification, they have to be organized through a union, at least in France (Aragrande et al., 2006). By adopting a PDO label, the group of producers commits itself to specific technical requirements., We argue that the competition in some PDO markets is limited by the presence of binding production and technical constraints. This assumption may not be relevant in all PDO markets but we have evidence that it is actually the case at least for some markets studied in the literature. In the case of PDO Brie, producers are organized within an association called "Confrérie des Compagnons du Brie de Meaux", whose official goal is to promote PDO Brie. However, given its structure and small size (only 8 producers); it acts de facto as a cartel controlling the PDO Brie produce, thus limiting competitive behaviour. This is very much similar to the structure of the Comté cheese, which is also better documented: Colinet et al. (2006) show that production of Comté cheese is internally regulated by the Intra-Chain Gruyere and Comté Committee (CIGC) who manage the production of the industry through the sale of rights to produce. In the Roquefort case, a system of three class pricing quota for milk with the first class quota used for the production of Roquefort has also been implemented, which allows for Roquefort production control. We thus choose to focus on the latter market organization.

[5] This is also true for Common Label like Neuland for pig meat in Germany.

standard low quality good.[6] This assumption is supported by the definition of the relevant market considered by the competition authority in France for competition issues related to PDO products. The relevant market for Roquefort, Cantal and Reblechon for instance coincided with that of the PDO region (Gay and Gijsbers, 2007).

Demand

Consumers in our model choose between two varieties: A standard quality good or a differentiated one. Their preferences are represented by a Mussa-Rosen (1978) utility function: The utility of a consumer of type θ who purchases a unit of quality s at price p is given by $U(\theta,s)=\theta s-p$, where θ is also the willingness to pay for quality and is distributed uniformly on the interval $[0,1]$ as in Bagwell and Riordan (1991). The number of consumers is thus normalized to one and demand functions are linear in price and quality. When both varieties are produced, the inverse demands for the low quality good and for the high quality one, respectively denoted by $D_l(p_l,p_h)$ and $D_h(p_l,p_h)$ with p_l and p_h denoting the prices of the low and of the high quality goods, are determined as follows:

$$D_l(p_l,p_h)=\frac{p_h-p_l}{s_h-s_l}-\frac{p_l}{s_l}=\frac{p_h}{s_h-s_l}, \qquad D_h(p_l,p_h)=1-\frac{p_h-p_l}{s_h-s_l}=1-\frac{p_h}{s_h-s_l}. \tag{1}$$

where s_h is the endogenous high quality level and s_l is the low quality level. The quality s_h can therefore be seen as a minimum quality standard that the group of producers set in a binding way for all members of the group. We assume that the marginal cost for the low quality good is equal to zero. The market is therefore fully covered, and the price of the low quality product is normalized to $p_l = 0$. We can derive the inverse demand function

$P_h(x_h,s_l,s_h)$ of the high quality good as $P_h(x_h,s_l,s_h)=(s_h-s_l)(1-x_h)$, (2)

where x_h denotes the demand function for the high quality.

[6] The assumption made on market organization may not apply for all PDOs. For instance, we do not consider market structures where PDO producers may face the competition of national brands. Chambolle and Gérand-Héraud (2005) have analyzed such a setting where a certified firm competes with a brand strategic firm in a vertical differentiation framework where quality affects investment cost but not variable cost. We do not deal with markets where producers adopt a national brand strategy in addition to the PDO label. Historically, brand strategy comes after the introduction of PDOs often through the acquisition of PDO firms by large groups. Empirical analyses on the level of competition between brands within a PDO market are quite few. A study (Collinet el al., 2006) exists on the demand for Comté (using a AIDS model on cheese based on Secodip panel consumption data). It shows that among the hard cheese group in which Comté belongs, the level of price elasticity reflects more the competition between the main category of products (Emmenthal –Guryère and other hard cheese non PDO cheese) rather than within the PDO Comte market.

Supply

The cost of quality is modeled in the literature on common labeling as acting either on fixed cost or on the variable cost of production. When only fixed costs are required to produce a better quality product, prices are affected only through price differentiation. On the other hand, if quality costs enter the variable production cost function, then increasing quality implies also higher unit costs that affect the price and the demand for the high quality (Crampes and Hollander, 1995).[7]

Empirical results from Bouamra-Mechemache and Chaaban (2010) have shown that PDO products' variable costs are on average 40 percent higher than non-PDO products in the French Brie cheese industry. The cost disadvantage PDO producers face is linked to the technical requirements of the PDO label: The PDO technology is more labor-intensive and requires usage of a better quality thus more expensive milk. This situation is not unique to the Brie cheese sector. Recent research on the Comté cheese (Colinet et al., 2006) has shown that producers of this PDO cheese face a higher farm milk price because of the specific input quality requirement. They show that three quarters of the average production cost of unripened Comté are milk purchases and that labor cost accounts for 40% of total processing cost of milk into Comté. A case study of PDO Parmigiano Reggiano (Arfini et al., 2006) confirms this statement. The study also reports that the milk price in the Italian PDO Parmigiano Reggiano area is 20% higher than the standard milk price. Parmigiano Reggiano farmers face higher production cost than Grana Padano farms due to strict cattle feeding regulation.

Evidence of higher prices for raw agricultural input (higher quality input) can also be found in other food industries. For instance, the Spanish PDO Dehasa de Extremadura Iberian ham faces higher marginal cost of production due to prolonged pig pasturing and high feeding cost, with a traditional production process including large compulsory maturing processes (Collado et al, 2006). This is also true for Spanish Baena PDO olive oil (Clavero et al., 2006) where only olives in perfect conditions under the requested varieties are used to produce PDO extra virgin olive oil, which implies an olive separation process that can increase the cost of harvesting. These studies support the assumption that PDO modeling should include a quality dependent variable production cost. The quality standard generated by the PDO certification is tightly linked to a specific and binding production process, which is apparently causing higher production costs. These costs will play a central role in determining the choice of quality producers have for their products and the way to promote it.

[7] Moreover, in this kind of quality choice modeling, duopoly firms will always choose to offer distinct qualities at equilibrium (Motta, 1993 and Ronnen, 1991).

We assume that the cost function for the PDO good is given by $C(s_h, q_h) = c(s_h)q_h$ with $c(s_h) = as_h^2$ where s_h and q_h respectively denote the quality for the PDO good and the quantity produced.[8] We assume positive and increasing marginal cost, $c'(s_h) > 0$ and $c''(s_h) > 0$ for producing the PDO quality s_h. The high cost of quality argument is similar in spirit to that employed in Lehmann-Grube (1997) and the literature cited there. We also follow Marette et al. (1999) and assume that PDO certification costs the producers' organization a fixed fee *C*.

If the producers' organization opts for investing in a private common label, then it mainly incurs a cost of quality promotion that enters its fixed rather than its variable costs. The costs are modeled as $F(s_h) = bs_h^2$, where *b* is a cost parameter. Hence, the tradeoff the producers' organizations faces depends on the interplay between the variable cost parameter under PDO (*a*) and the fixed cost parameter under private common labeling (*b*). If the organization produces the PDO certified good, the organization's profits are given by:

$$\pi_h^{PDO}(x_h, s_l, s_h, C) = (P_h(x_h, s_l, s_h) - c(s_h))x_h - C = x_h(c(s_h) + (s_h - s_l)(1 - x_h)) - C \quad (3)$$

If the organization opts for common labeling (CL), profits are given by:

$$\pi_h^{CL}(x_h, s_l, s_h) = P_h(x_h, s_l, s_h)x_h - F(s_h) = (s_h - s_l)x_h(1 - x_h) - bs_h^2. \quad (4)$$

We first analyze the case of PDO public certification. After that, we study the private common labeling scheme and discuss the optimal choice between the two options.

2.2. Public certification

If the group of producers chooses to certify, it chooses the quality level and then, given the quality level of the low quality good and of the certified good, it chooses the quantity it will produce. Firms producing the low quality good produce the residual demanded quantity determined by the price charged by the group of producers. The demand facing the low quality firms is therefore given by:

$X_l(x_h) = 1 - x_h$.

[8] The literature on quality modeling generally uses this quadratic specification to take into account the fact that production cost increases with quality.

The optimal production of the certified good is obtained by maximizing the producers' organization profits with respect to x_h for a given level of quality s_h. This yields the last stage quantities:

$$x_h^{PDO}(s_l, s_h) = \frac{1}{2}(1 - \frac{as_h^2}{s_h - s_l}); \qquad x_l^{PDO}(s_l, s_h) = \frac{1}{2}(1 + \frac{as_h^2}{s_h - s_l}). \tag{5}$$

The sub-game equilibrium price for the certified good is:

$$p_h(s_l, s_h) = \frac{1}{2}(s_h - s_l + as_h^2).$$ [9]

To derive the optimal quality s_h^* when the group of producers decides to certify its product, we substitute the subgame quantity (5) into the profit equation (3) and maximize (3) with respect to s_h.[10] This gives:

$$s_h^{PDO*} = \frac{1}{6a}(1 + 4as_l + \sqrt{1 - 4as_l + (4as_l)^2}) \tag{6}$$

where $s_l < \frac{1}{4a}$. Demand for the PDO certified quality exists only if the cost of the low quality is not too high relative to the cost of producing the certified good. If the cost is higher, then the producers' organization will not benefit from enough product differentiation from their PDO product in order to cover their higher cost of production and will prefer producing the market standard quality good. We can also show that the optimal PDO certified quality is an increasing function of the low quality level and a decreasing function of the variable cost parameter.[11]

From (5) and (6), we can derive the optimal demand for the PDO good (x_h^{PDO*}) and for the low quality good (x_l^{PDO*}):

[9] This price is higher for a higher quality level of the certified good, and decreases for higher levels of quality for the low quality good. The price is therefore a function of vertical quality differentiation, and is also increasing with the variable cost of producing the better-quality certified good.

[10] Details of the derivation are available upon request.

[11] $\frac{\partial s_h}{\partial s_l} = \frac{1}{2+8as_l(4as_l-1)+(1-8as_l)\sqrt{1-4as_l+(4as_l)^2}} > 0$; $\frac{\partial s_h}{\partial a} = \frac{2as_l - 1 - \sqrt{1-4as_l+(4as_l)^2}}{6a^2\sqrt{1-4as_l+(4as_l)^2}} < 0$.

$$x_h^{PDO*}(s_l) = \frac{1}{3}(2 - 4as_l - \sqrt{1 - 4as_l + (4as_l)^2})$$
$$x_l^{PDO*}(s_l) = \frac{1}{3}(2 + 4as_l + \sqrt{1 - 4as_l + (4as_l)^2}) \quad (7)$$

where $s_l < \frac{1}{4a}$.

As illustrated in Figure 1, the optimal quantity of production under PDO decreases with the variable cost of producing quality (a) for a given level of the low quality. The effect of *a* (everything else being constant) can be derived from equation (5). The higher the quality achieved through an increase in a, the lower the production of the PDO good. The quality specifications imposed by the PDO regulation can thus be considered as a lever to reduce the quantity produced.[12] The PDO quantity is also linked to the level of quality differentiation vis-à-vis the generic product. The higher the quality of the standard good, the more the producers' organization has to increase the quality of the PDO product to increase demand. However, by doing so, the organization also increases its cost (for a given variable cost of producing quality) which reduces the optimal PDO quantity.

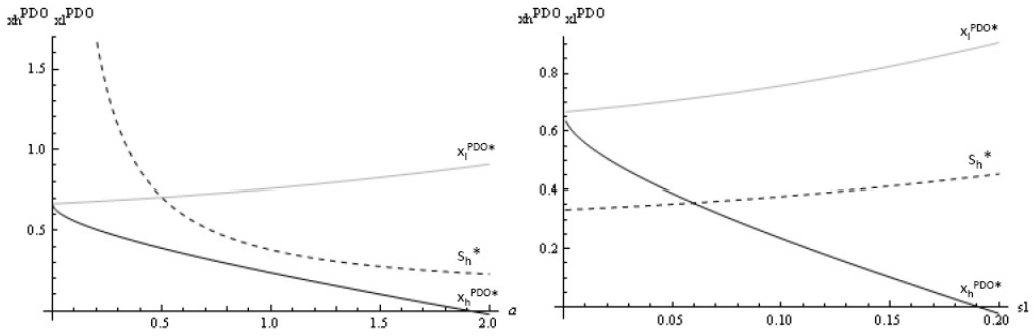


Figure 1: Impact of variable costs of producing quality and the level of low quality on optimal quantities.

[12] As pointed by a referee, this negative effect of quality requirements on the quantity produced could also be the objective a cartel will try to reach, and this has been somehow criticized as a hidden objective of the PDO regulation.

The optimal price of the certified good is:

$$p_h^{PDO*}(s_l) = \frac{1}{9a}[1 - as_l + 4a^2 s_l^2 + (1 + 4as_l)\sqrt{1 - 4as_l + (4as_l)^2}]$$

Using (6) and (7), we get the maximum profit under PDO certification as a function of the low quality level, the variable cost of quality and the certification fixed cost:

$$\pi_h^{PDO*}(s_l, a, C) = \frac{1}{54a} - \frac{s_l}{27}(3 + 12as_l - 32a^2 s_l^2) + \frac{1}{54a}[1 - 4as_l + (4as_l)^2]^{\frac{3}{2}} - C.$$

PDO certification will be profitable for the producers' organization if the market standard quality is not too high relative to the variable costs it has to incur to produce the PDO quality and if the certification costs are lower than a threshold *f*, such that:

$$C \leq f(s_l, a) = \tfrac{1}{54a} - \tfrac{s_l}{27}(3 + 12as_l - 32a^2 s_l^2) + \tfrac{1}{54a}[1 - 4as_l + (4as_l)^2]^{\frac{3}{2}} \ .$$

This result is different from Marette et al.'s (1999) where the function *f* was monotonic with the level of high quality, considered exogenous. In our framework, quality is endogenous.

Note that if the producers' organization has the power to delimit the production zone, then the geographical area will be chosen such that the optimal quantity x_h^{PDO*} is reached.[13] If the regulator chooses a geographical constraint that is more restrictive (compared to the optimal level of production for the producers' organization), PDO certification becomes less likely under sufficiently high certification costs, and the producers' organization may not engage in the PDO label.

2.3. Private common labeling

Assume now that instead of opting for a PDO certified quality, the group of producers opts for investing in R&D and/or to advertise its good such that it can produce a product of higher quality by incurring a fixed cost of quality rather than variable cost. In this case, it is not restricted in quantity and does not pay for a

[13] For instance, as argued by an anonymous referee, this is what was happening in the Champagne area in France, with the push to expand the regulated area when demand is high and to reduce it when demand is low. Acting this way may limit entry and competition.

public certification cost. However, it now faces a fixed cost that will depend on the level of the chosen quality.

The equilibrium quantities are now independent of the quality levels. The group of producers gets half of the market share ($x_h^{CL*} = \frac{1}{2}$), leaving half of the market for the low quality ($x_l^{CL*} = \frac{1}{2}$). The producers' organization produces more under the private common label (*CL*) than under PDO certification, because it does not incur the PDO-imposed extra variable cost of quality. The equilibrium price for the common private label product is:

$$p_h^{CL}(s_l, s_h) = \frac{1}{2}(s_h - s_l). \tag{9}$$

For a given level of quality s_h, the price of the common label is lower than under PDO certification, as now the marginal cost of producing the high quality good is lower (normalized to zero in our setting). The price under the private label only depends on the vertical differentiation between the high and the low quality good; while under PDO certification the variable cost linked to PDO quality *a* affected the pricing of the product.

Replacing x_h^{CL*}, x_l^{CL*} and $p_h^{CL}(s_l, s_h)$ in equation (9) and maximizing, we obtain the unique equilibrium for the level of the high quality product under the private common label:

$$s_h^{CL*} = \frac{1}{8b} \tag{10}$$

which is a decreasing function of the fixed cost of quality parameter. Contrary to the PDO certification case, the optimal private label quality does not depend on the level of the low quality product. From equations (9) and (10), we derive the corresponding price for the high quality good:

$$p_h^{CL*}(s_l) = \frac{1}{16b} - \frac{1}{2}s_l, \tag{11}$$

Replacing s_h by its optimal value given in equation (17), we can write the maximum profit of the producers' organization when it chooses to produce under a common private label:

$$\pi_h^{CL*}(s_l, b) = \tfrac{1}{64b} - \tfrac{1}{4}s_l .$$

The optimal price of the product under the common private label is decreasing with the fixed cost linked to *CL* quality *b*, and with the level of the low quality product. Also note that the quantity produced does not depend on the parameters *b* and s_l. As a result, profits under the common private label are decreasing with both *b* and s_l.

The private common label is profitable for the producers' organization if $b \leq \frac{1}{16 s_l}$. This means that the profitability of the common label is linked to the trade-off between the level of quality differentiation and the marginal cost for quality *b*. Notice here that the strategic choice of the private common label does not depend on the quantity produced, but rather on the level of differentiation in quality, which affects prices.

3. Private incentives of the producers' organization

We now solve for the first stage of the quality promotion game, where the producers' organization chooses PDO certification, private common labeling, or no quality promotion.

The optimal choice for the producers' organization depends on the equilibrium market outcomes presented above. The solution to the choice problem is summarized in the following proposition. It emphasizes the tradeoff between certification costs and the cost for quality required in the production of PDO or common labeling. The results integrate the variable cost difference linked to PDO certification in the theoretical model, which turns out to influence the private incentives connected with this particular certification. It is worth noting here that Chambolle and Giraud-Héraud (2003) focuses instead on fixed costs and the underlying investment in quality, without integrating variable cost differences related to publicly certified vs. privately promoted quality. The difference in their setting between private and public certification is that in addition to the possible difference in investment, the PDO product is subject to a production constraint.[14] Our results highlight the fact that the variable costs under PDO certification play a central role in determining the private incentives for choosing PDO method.

[14] Note that the level of the constraint in their setting has to be lower than the optimal production whit a private brand. In their setting, equilibrium quantity does not depend on the level of quality, which is given by the market size. Moreover, the PDO certification allows him to get minimum quality level at no cost.

Proposition 1

i) The producers' organization produces a low quality product if $a \geq \frac{1}{4s_l}$ *and* $b \geq \frac{1}{16s_l}$. *The cost of quality (either under PDO or under private labeling) is too high to engage in quality promotion.*

ii) The organization opts for the private common label if $a \geq \frac{1}{4s_l}$ *and* $b < \frac{1}{16s_l}$. *The organization achieves positive profits under this situation while it achieves negative profits under PDO.*

iii) The organization decides to engage in PDO certification if $a < \frac{1}{4s_l}$ *and* $b \geq \frac{1}{16s_l}$. *The organization makes positive profits under PDO if*

(C1) $C \leq f(s_l, a) = \frac{1}{54a} - \frac{s_l}{27}(3 + 12as_l - 32a^2 s_l^2) + \frac{1}{54a}[1 - 4as_l + (4as_l)^2]^{\frac{3}{2}}$;

and negative profits under private common labeling.

iv) PDO certification is also chosen by the organization if $a < \frac{1}{4s_l}$ *and* $b < \frac{1}{16s_l}$, *and if*

$C \leq \frac{1}{16b} + \frac{5}{36}s_l + \frac{1}{54a}\left(1 - 24a^2 s_l^2 + 64a^3 s_l^3 + \left(1 + 16a^2 s_l^2 - 4as_l\right)^{\frac{3}{2}}\right)$ *, that is for*

(C2) $b \geq \frac{27a}{16\left[2 - 108aC + 15as_l - 48a^2 s_l^2 + 128a^3 s_l^3 + 2\left(1 + 16a^2 s_l^2 - 4as_l\right)^{\frac{3}{2}}\right]}$.

Otherwise, the organization opts for private common labeling.

The group of producers' decision clearly depends on the cost parameters *a* and *b*. These could be interpreted as the effort in terms of cost to make the quality perceived by consumers (and also by the certification agency in the PDO case). A low value of "a" means that the technology requirements in terms of input provision and processing do not have to be too restrictive (relative to the standard product) to enhance the perceived quality of the product. A high value of "*a*" will reflect large technology requirement efforts for the quality to be perceived. Then the effort *a* can become too high for the group of producers to make positive profits with a PDO strategy, this is so for $a \geq \frac{1}{4s_l}$.

Similarly, the cost parameter "*b*" measures the effort in terms of innovation and advertising investment in order to make the quality of the product perceived by consumers. Increasing values of "*b*" mean that this effort has to be higher, and if it is too high then the Common Label (CL) strategy becomes no more profitable $b \geq \frac{1}{16 s_l}$. So, when both efforts *a* and *b* are not too high ($a < \frac{1}{4 s_l}$ *and* $b < \frac{1}{16 s_l}$), both options can be profitable and a tradeoff occurs given the desirability of the two options. For a given value of s_l, the group of producers will choose the PDO certification system if the technological effort does not need to be too high.

Certification also plays a role. If condition (C1) does not hold and the certification cost is too high then PDO becomes a non profitable strategy. This condition is similar in spirit to the one of Marette et al. (1999). It is a non linear condition with respect to the cost effort *a*. The trade-off (C2) we found between certification and investment in private common labelling extends this result by introducing the outside option of private investment in a collective private label. The profitability of PDO relative to CL occurs for a smaller range of effort cost couple {a,b}.

Graphical illustration of the proposition

Figure 2 illustrates the results of Proposition 1 for a given value of s_l. The first case (i) occurs when the costs of quality are too high (upper right quadrant). In this case, the market for quality collapses. When the technical requirements linked to PDO certification are too restrictive, this generates a very high cost of PDO quality. The organization then never opts for PDO certification. This is illustrated in case (ii) in Figure 2. Case (iii) illustrates the opposite effect, where the costs incurred for developing the private common label are too prohibitive for it to be profitable. Case (iv) illustrates the private tradeoff for the producers' organization between PDO and private common labeling, linked to the interplay between the cost parameters for each quality label.

As also illustrated in Figure 2, higher fixed certification costs for PDO decrease the area where opting for this label is efficient for the producers' organization.

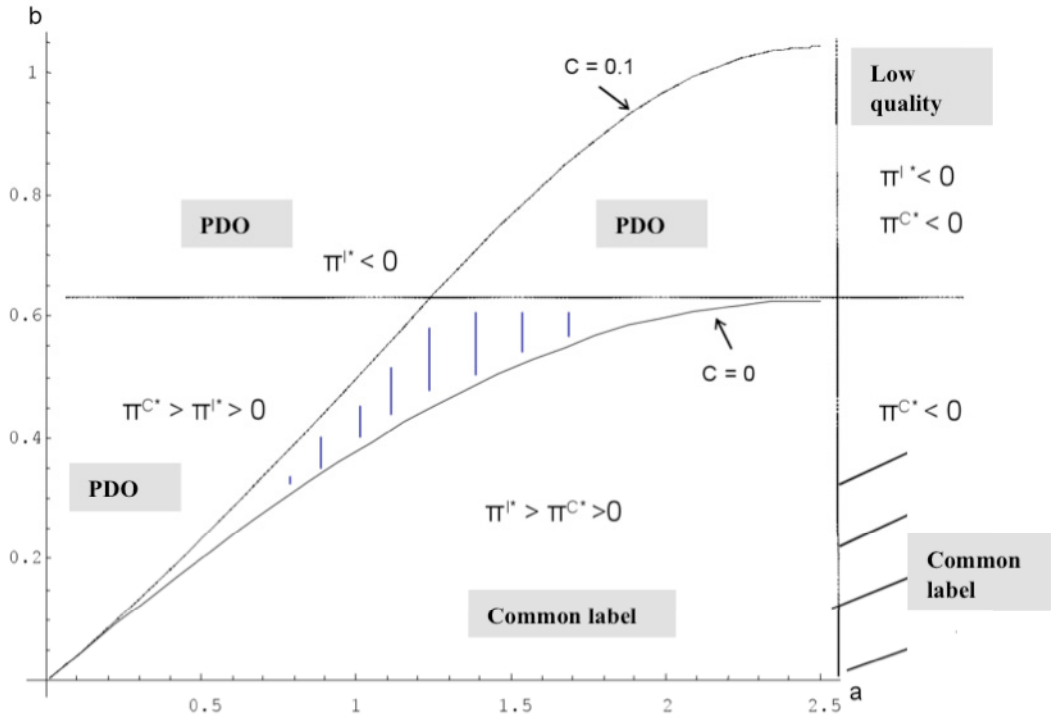


Figure 2: Private incentives for the cartel[15]

Impact of s_l on the choice of labeling

The strategic decision of the group of producers also depends on the level of standard quality s_l already existing on the market. If this quality were too high, the group of producers would obviously not have an incentive to produce a higher quality product. The cost it would have to bear (either as an investment or to adapt the technology) in order to differentiate its product to the one already offered on the market would then be too high. As illustrated in Figure 3, the area of *{a,b}* values for which producing the high quality is profitable is decreasing with s_l. However, what is interesting is that the "limit" level of s_l for the existence of a higher quality on the market differs among the strategies. When the trade-off between the two options is possible given the level of efforts *a* and *b*, s_l may make a difference and changes the tradeoff presented in Figure 2. As shown in Figure 3, when s_l increases, the frontier defining the profitability of PDO relative to CL is shifted downward meaning that PDO becomes profitable for more *{a,b}* values.

Such a result comes from the fact that when s_l increases, the quality of CL products cannot be adapted (equation 10) because it only depends on the level of

[15]We assume here that $s_l = 0.1$.

the cost effort *b*. Then the group of producers when opting for CL enjoys from less price differentiation than with lower s_l. With a PDO strategy on the other hand, it can adapt the level of quality and price of its product and still benefit from quality differentiation. Then, it will get a higher price/quality than under CL for a larger range of *{a,b}* values (cf. Figure 4) with increasing value of s_l, which leads to higher profits.

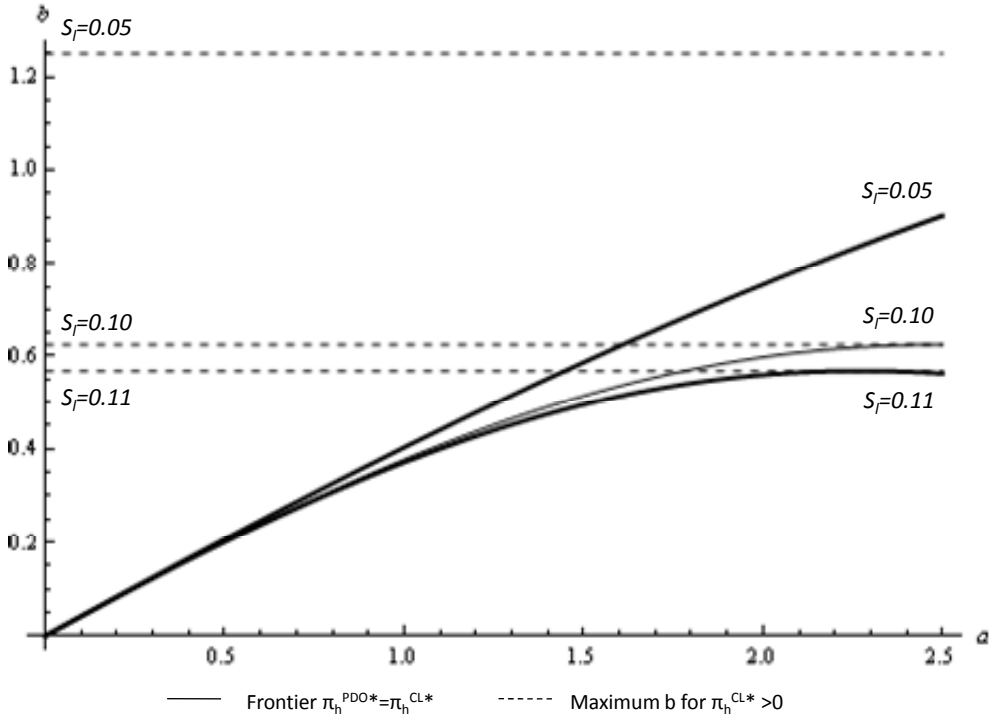


Figure 3: Impact of the low quality good on the private incentives for the cartel

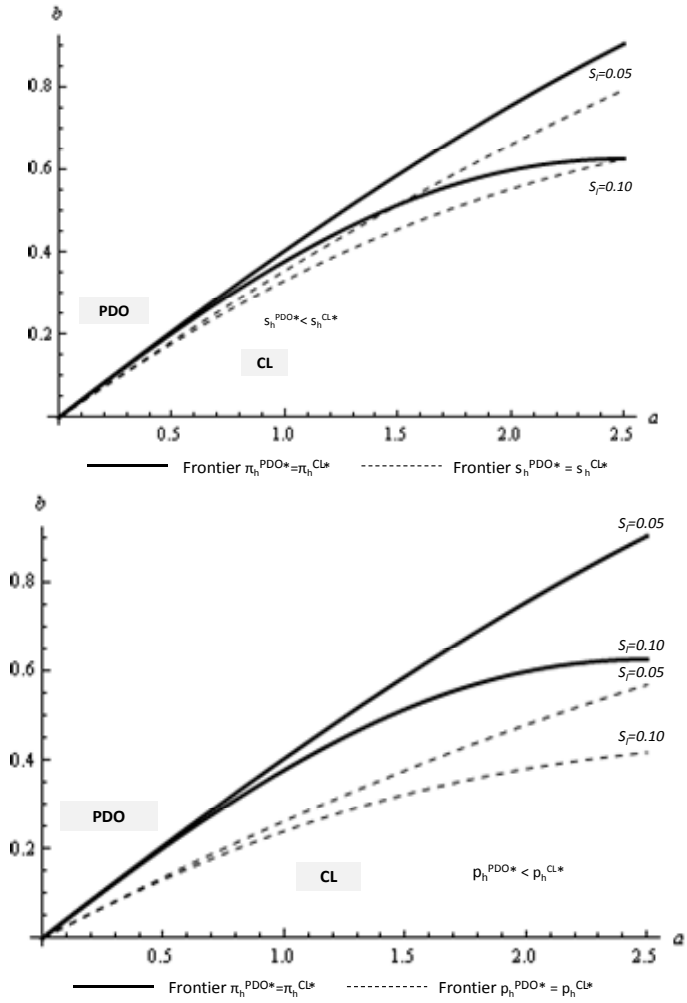


Figure 4: Impact of the low quality good on prices and high quality

Impact of the labeling choice on optimal quality

The strategic choice of the group of producers will have an impact on the quality supplied. When PDO certification is chosen given *a* and *b*, the quality of the PDO products is higher than the one that it would have provided under CL (cf. Figure 4). However, the reverse is not always true. When CL is preferred, the quality provided could be lower than under PDO certification for some *{a,b}* values. This is because a higher quality differentiation with PDO has to compensate the lower quantity produced in order to be more profitable than the CL. Also, for the two strategies to generate equal profits, the quality and price under PDO must be higher.

4. Efficiency of public PDO versus private collective advertising

In this section, we analyze the impact of the strategic choice of the group of producers opting for PDO or Common Label (CL) on consumers and social welfare. The role of certification costs and restrictive capacity constraints are emphasized in the social welfare tradeoff.

4.1. Impact on consumer surplus

Consumers' surplus when only the low variety is produced is given by $CS_l = \int_{\theta_0}^{1} (\theta s_l - p_l) d\theta$ where $\theta_0 : \{\theta | \theta s_l - p_l\}$ by definition. When the high quality is produced the consumers' surplus becomes: $CS_h = \int_{\tilde{\theta}}^{1} (\theta s_h^* - p_h^*) d\theta$, $CS_l = \int_{\theta_0}^{\tilde{\theta}} (\theta s_l - p_l) d\theta$ where $\tilde{\theta} : \{\theta | \theta s_l - p_l = \theta s_h^* - p_h^*\}$. It can be shown that consumers are better off when the producers' organization decides to engage in PDO certification or in private common labeling; compared to a situation where there is only the low quality product. We focus therefore in the following analysis on comparing consumer surplus under PDO certification option or private collective labeling. The tradeoffs in consumers' surplus are summarized in the following proposition.

Proposition 2

i) Consumers of the low quality product are better off under PDO certification than under common labeling. The higher the low quality level, the higher the difference in surplus between PDO certification and private common labeling. This difference also increases with the marginal cost of quality.

ii) Consumers of the high quality product can be better or worse-off under PDO certification than under common labeling, depending on the quality cost interplay.

iii) The difference between total consumers' surplus under certification and private labeling can thus be positive or negative.

Proof: See Appendix.

Consumer surplus for the low quality segment is higher under PDO because the quantity produced in the low quality market is higher when the producers' organization chooses PDO certification for its high quality product.

(cf. previous sections). When the cost of PDO increases (parameter *a* above), the quantity produced of the PDO product decreases. This implies higher quantity on the low quality market, which leads to higher consumer surplus in this market.

The surplus of the high quality product consumers depends on the price and quantity differences between the public and private labeling schemes. The quantity of the high quality product is always higher under the private common label than under PDO, because the private label is less technologically constrained. The lower the cost associated with the PDO quality (parameter *a* above), the lower the difference between quantities under the two alternatives. The price for the private common label can be lower or higher than under PDO, depending on the interplay between the costs of the two labels.

4.2. Impact on total welfare

The total welfare effects of the choice between PDO certification and common private labeling are determined by the sum of producers and consumers' surpluses. We focus on the case where both quality promotion techniques may be profitable, as welfare is improved whenever one of the two techniques is chosen. Welfare comparison results are summarized in the following proposition.

Proposition 3

i) PDO certification dominates common private labeling if, for $a < \frac{1}{4as_l}$ *and* $b < \frac{1}{16s_l}$, condition under which the markets for PDO and private common labeling do not collapse,

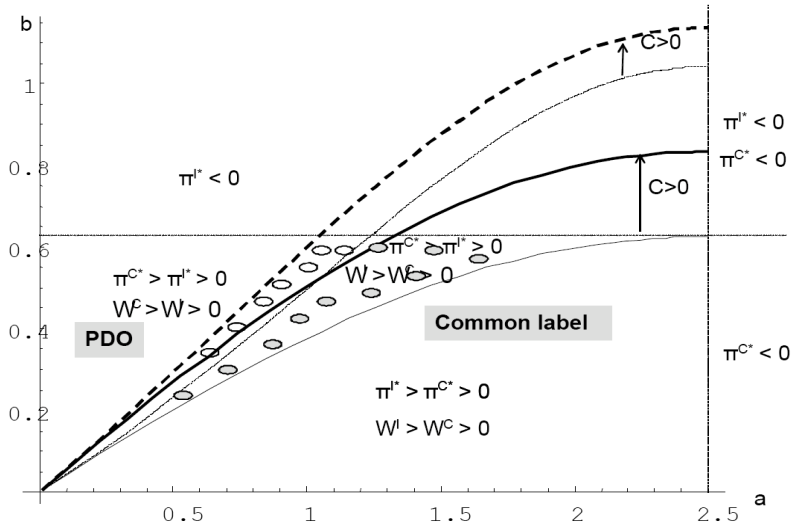
$$b \geq \frac{9a}{4\left[2 - 72aC + 15as_l - 48a^2 s_l^2 + 128a^3 s_l^3 + 2\left(1 + 16a^2 s_l^2 - 4as_l\right)^{\frac{3}{2}}\right]}.$$

ii) Even if, under some conditions, common private labeling dominates PDO certification from a global welfare perspective, the producers' organization may still find it more profitable to adopt the PDO label.

Proof: Computing directly the difference between the sum of profits and consumer surplus under both quality certification schemes leads to i). Result ii) is based on computations in the previous section and relative differences in welfare under each quality promotion method.

The proposition's results are illustrated in Figure 5. We first consider the case where the group of producers does not pay for a certification cost. If the technical requirements linked to PDO quality are too restrictive (i.e. for high values of *a* relative to *b*), then it is straightforward to see that the PDO label becomes unattractive, both for the organization and total welfare. Alternatively, if the fixed costs linked to the private common label are excessive relative to the variable costs of the PDO label, then PDO certification dominates the private common label from both the producers' organization and total welfare's perspectives.

Our main theoretical finding is obtained for intermediate values of the cost parameters. There is a range for quality cost parameters where the optimal outcomes differ with respect to private incentives (the organization's profit) and social welfare. In this range (see Figure 5), the organization's profit is higher under PDO certification but does not compensate for the loss in consumer surplus. In this range, consumers are globally better off under the private common label. Consumers of the low quality are better off while consumers of the high quality are worse off. When *a* increases, the cost for PDO quality increases which reduces the quality chosen. The quantity of PDO produced is reduced, which increases the difference in production between PDO and CL. In this range, quality is still higher than the common label one but its small positive impact on consumer surplus is more than offset by the quantity effect.



The solid lines represent the case with no certification cost, and the dotted line represents the case of positive certification cost. The bold line represents the welfare frontier while the other one represents the profit frontier.

Figure 5: Welfare comparison: PDO certification vs. common private label

There is no impact of the certification cost on welfare ranking for low values of *a* relative to *b* as well as for very high values of *a* relative to *b*. For intermediate values, the certification cost will have an ambiguous effect on the ranking of quality promotion schemes because private and public tradeoffs are different from the previous situation. When the certification cost for PDO increases, PDO certification may become suboptimal from a welfare perspective compared to the previous situation. Policymakers may want to consider this interaction when setting public quality certification costs. Certification costs do not affect consumer surplus but alter the producers' organization profits, meaning that the area where PDO is efficient from a private perspective is reduced. Similarly, the area where PDO is socially efficient is reduced, which reduces the area where private incentives diverge from public ones.

5. Conclusion and policy recommendations

This paper has presented theoretical argument that questions the economic efficiency of the PDO public label in the food-processing sector when compared to other private common labeling schemes. Existing case studies from various agro-food sectors have called into question the usual theoretical modeling framework for analyzing common public quality labels. Most of the literature dealing with this issue has conceptualized the efficiency of the public label as an interaction between three main factors: the gains in better quality signaling, the losses linked to the fixed costs of public certification, and the losses due to the potential grouping of producers under professional organizations to certify the quality of their products. In our paper, we integrate the specific features of the PDO common label, namely higher variable costs and production capacity constraint, in a theoretical model of endogenous quality choice. In this model, a group of producers can choose a 'niche strategy' and adopt the PDO label, which implies a high quality product with constrained production, fixed certification costs and high production variable costs. Alternatively, the group can collectively adopt a private labeling scheme that entails fixed costs (in the form of advertising and R&D), lower variable costs and a higher production level. Our results show that the efficiency of the PDO label as compared to the private collective label ultimately depends on the interplay between the variable production costs under PDO and the fixed costs of the private label.

The model also demonstrates that even if PDOs are efficient from a producer perspective, society might be better-off with other less stringent techniques of product certification, which rely more on R&D and collective certification. Many food producers' groups, in the EU and around the world, are

increasingly examining whether to engage in a collective public labeling scheme similar to the PDO one. The typical approach in assessing the profitability of a potential food quality label is to evaluate whether consumers' willingness to pay is higher for this label, and whether a higher price obtained for the labeled product is enough to cover the certification costs incurred under the labeling process. Our paper has shown that this approach is incomplete; taking into account the specific cost and production features of the PDO label is essential for full assessment of the costs and benefits of the PDO certification. Production capacity constraints and higher variable costs linked to the specific PDO technical requirements should play a central role in the analysis of the welfare impacts of this type of food label.

Our analysis also provides insights on the voluntary choice of quality promotion schemes for a producers' organization. However, it has some limitations. Our framework may be more appropriate for agricultural and food market organizations than others. This suggests that a fruitful extension of our theoretical work would be to consider possible coexistence in the market of several differentiated products, like national brands for instance. On the empirical front, there is need for analyses of market competition structures between competing food labels. Results from such empirical studies will provide a better understanding of firms' competitive behavior with respect to certification.

6. Appendix

Proof of proposition 2

i) We compare the difference in consumer surplus for low quality consumers under certification and advertising:

$$CS_l^{PDO} - CS_l^{CL} = \int_{\theta_0}^{\tilde{\theta}^C} (\theta s_l) d\theta - \int_{\theta_0}^{\tilde{\theta}^I} (\theta s_l) d\theta$$
$$= \frac{1}{72} s_l \left[4(1 + 4as_l + \sqrt{1 + 16a2s_l^2 - 4as_l})^2 - 9 \right]$$

This difference is positive for

$$4\left(1 + 4as_l + \sqrt{1 + 16a^2 s_l^2 - 4as_l}\right)^2 - 9 =$$
$$\left(2\left(1 + 4as_l + \sqrt{1 + 16a^2 s_l^2 - 4as_l}\right) + 3\right)\left(2\left(1 + 4as_l + \sqrt{1 + 16a^2 s_l^2 - 4as_l}\right) - 3\right) \geq 0,$$

which is verified only if $2\left(1+4as_l+\sqrt{1+16a^2s_l^2-4as_l}\right)-3\geq 0$. Define x such that $x=4as_l>0$. This condition can also be written $f(x)=2x+2\sqrt{1+x^2-x}-1\geq 0$ where $1+x^2-x>0$ for all $x>0$. We can check that $f'(x)=2+\frac{2x-1}{\sqrt{1+x^2-x}}>0$ with $f(0)=1$ and $f'(0)=1$ and $f''(x)=\frac{3}{2(1+x^2-x)^{3/2}}>0$. We thus have $f(x)>0$

We can calculate the derivative of the difference $CS_l^{PDO}-CS_l^{CL}$ with respect to s_l:

$$\frac{\partial\left(CS_l^{PDO}-CS_l^{CL}\right)}{\partial s_l}=$$

$$\frac{\sqrt{1+16a^2s_l^2-4as_l}\left[32as_l(1+12as_l)-1\right]+8\left[1+2as_l(1+4asl(24as_l-1))\right]}{72\sqrt{1+16a^2s_l^2-4as_l}}.$$

The denominator is positive. This equality can be written $\frac{\partial\left(CS_l^{PDO}-CS_l^{CL}\right)}{\partial s_l}=\frac{\sqrt{1+x^2-x}g(x)+f(x)}{72\sqrt{1+16a^2s_l^2-4as_l}}$. From $g(x)=\sqrt{1+x^2-x}(24x^2+8x-1)$, we get $g'(x)=\frac{17+2x(72x^2-44x+35)}{2\sqrt{1+x^2-x}}>0$ for $x \textcircled{>} 0$, $g''(x)=\frac{157+8x\left(72x^3-112x^2+141x-57\right)}{4\left(1+x^2-x\right)^{\frac{3}{2}}}>0$, $\lim_{x\to 0}g(x)=-1$ and $\lim_{x\to 1}g(x)=31$. From $h(x)=24x^3-4x^2+4x+8$, we get $h'(x)=72x^2-8x$, $h'(\frac{1}{9})=0$, $h'(x)\leq 0$ for $x\leq\frac{1}{9}$, $h'(x)\geq 0$ for $x\geq\frac{1}{9}$ and $h''(x)=144x>0$ for $x>0$. Moreover, the minimum of the function $h(x)$ is obtained for $h(\frac{1}{9})=\frac{2048}{243}\approx 8.42$, which is greater than the minimum of the function $g(x)=\lim_{x\to 0}g(x)=-1$. Then, $\frac{\partial\left(CS_l^C-CS_l^I\right)}{\partial s_l}>0$.

The derivative of the difference $CS_l^C-CS_l^I$ with respect to a is:

$$\frac{\partial\left(CS_l^{PDO}-CS_l^{CL}\right)}{\partial a}=\frac{2}{9}s_l^2\left(2+\frac{8as_l-1}{\sqrt{1+16a^2s_l^2-4as_l}}\right)\left(1+4as_l+\sqrt{1+16a^2s_l^2-4as_l}\right)$$

As $\frac{2}{9}s_l^2\left(1+4as_l+\sqrt{1+16a^2s_l^2-4as_l}\right)$ is always positive, then $\frac{\partial\left(CS_l^C-CS_l^I\right)}{\partial a}>0$ if and

only if $k(x)=\frac{2x-1}{\sqrt{1+x^2-x}}>-2$. We have $k'(x)=\frac{3}{2\left(1+x^2-x\right)^{\frac{3}{2}}}>0$ with $\lim_{x\to 0} g(x)=-1$ and $\lim_{x\to 1} g(x)=1$. Then $k(x)$ is always greater than -2.

ii) We compare the difference in consumer surplus for high quality consumers under certification and advertising:

$$CS_h^{PDO}-CS_h^{CL}=\int_{\tilde{\theta}^C}^{1}(\theta s_h^{PDO*}-p_h^{PDO*})d\theta-\int_{\theta_0}^{\tilde{\theta}^C}(\theta s_h^{CL*}-p_h^{CL*})d\theta$$

$$=\frac{1}{108a}\left[1+36as_l-48a^2{s_l}^2-128a^3{s_l}^3+(1-16as_l-32a^2{s_l}^2)\sqrt{1+16a^2{s_l}^2-4as_l}\right]-\frac{1+16bs_l}{64b}$$

We can calculate b such that $CS_h^{PDO}-CS_h^{CL}=0$. There is a unique solution for b that depends on the level of the low quality good s_l and on the marginal cost for quality a:

$$b^0=-\frac{27a}{16\left[-1-9as_l+48a^2s_l^2+128a^3s_l^3+(16asl+32a^2s_l^2-1)\sqrt{1+16a^2s_l^2-4as_l}\right]}$$

For values of $b>b^0$, the consumer surplus is higher when the cartel certify, for $b=b^0$, consumers are indifferent between certification and advertising and for $b<b^0$ and $b\le\frac{1}{16s_l}$, consumers benefit more from advertising. However if $b\ge\frac{1}{16s_l}$, the cartel has no incentive to produce the high quality but consumers still benefits from high quality trough the certified good.

iii) We compare the difference in total consumer surplus under certification and advertising:

$$CS_h^{PDO}-CS_h^{CL}=$$

$$\frac{1}{1728ab}\left[16b+16b\left(1+16a^2s_l^2-4as_l\right)^{\frac{3}{2}}+a\left(8bs_l(15-48as_l+128a^2s_l^2)-27\right)\right].$$

We can calculate b such that $CS_h^{PDO}-CS_h^{CL}=0$. There is a unique solution for b that depends on the level of the low quality good s_l and on the marginal cost for quality a:

$$b^{00} = \frac{27a}{8\left[2+15as_l-48a^2s_l^2+128a^3s_l^3+2\left(1+16a^2s_l^2-4as_l\right)^{\frac{3}{2}}\right]}$$

For values of $b > b^{00}$, the total consumer surplus is higher when the cartel certify, for $b = b^{00}$, consumers are indifferent between certification and advertising and for $b < b^{00}$ and $b \leq \frac{1}{16s_l}$, consumers benefit more from advertising. However if $b \geq \frac{1}{16s_l}$, the cartel has no incentive to produce the high quality but consumers still benefits from high quality trough the certified good.

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