Labeling by a private certifier and public regulation

Ibrahima BARRY[*], Olivier BONROY[†*], and Paolo GARELLA[‡]

December 4, 2013

Abstract

This paper considers the effects of labels that can certify desirable characteristics of products in a duopolistic market. Under a private certifier only one firm uses the label. Competition among firms cannot eliminate a reservation profit for the labeling firm and the label falls short of profit maximization for the labeling firm. Then, Government policies aimed to improve on the private certifier outcome are analyzed. If public certification is offered, in competition to private, although no firm will choose it in equilibrium, the private certifier will increase the certification standard of his label and welfare will be improved. Surprisingly, a per unit tax on the unlabeled product and a subsidy on the labeled one lead to unintended results, while an ad valorem tax and a MQS policy can increase welfare.

Keywords: Labels, private certification, public certification, tax, subsidy, MQS.

JEL classification: L13, L15, L5.

[*]Université Grenoble Alpes, UMR 1215 GAEL, F-38000 Grenoble, France
[†]INRA, UMR 1215 GAEL, F-38000 Grenoble, France
[‡]Dipartimento di Economia, Università degli Studi di Milano, Italy

1 Introduction

The significant and always increasing presence of labelled products, especially in the agro-food sector, has attracted great interest on the implications and impact of labels from both, the theoretical, and the policy perspective (see e.g. Fulton and Giannakas, 2004; Bonroy and Constantatos, 2008; Roe and Sheldon, 2007; Baron, 2011, or Bonroy and Lemarié, 2012). A label must usually follow a prescribed standard and the product which is labelled is somehow certified to conform to it. Some for-profit private certification bodies develop their own certification standards and delivers the corresponding labels.[1] Unlike Government owned certification bodies, a for-profit certifier has the objective to extract the firms' profit through a certification fee, possibly deviating from the socially optimal certification standard. In this respect, the presence of private certifiers raises a legitimate question on their interaction with public regulation.

Unlike the present paper, the existing literature on the interaction between non-public certifier and public regulation largely focuses on non-governmental organization (NGO) maximizing average quality and private certifier maximizing the industry's profit. Heyes and Maxwell (2004) consider a sequential game where the regulator chooses the level of MQS at the first stage, the NGO the level of a voluntary label at the second, and firms decide their quality level at the third. The authors consider firms that differ with respect to their marginal cost of quality-improvements. They find that a properly designed MQS, when coupled with an NGO label, produces higher welfare. Bottega and Freitas (2009) examine similar questions by assuming a multiproduct monopolist. The two instruments are set simultaneously. The presence of the label reduces the role of the MQS to control for excessive differentiation. This implies that the presence of a label pushes the optimal level of MQS downwards. Surprisingly, the NGO would prefer a lower level for the MQS.

[1] Ecocert, Scientific Certifcation System, Asbl Biogarantie, or OEKO-TEX are exemples of for-profit private certifiers. Ecocert delivers labels to producers whose products fulfil standards developped by Ecocert and related to the human and environmental protection (organic cosmetics, environmentally friendly detergents, fair trade, ecological green spaces, ...). The Scientific Certification Systems develops internationally recognized standards in pursuit of high levels of environmental performance and social accountability. In belgium, asbl Biogarantie delivers a label certifying organic products. At last, OEKO-TEX delivers intenational labels certiying that a textile has been successfully tested in accordance with OEKO-TEX Standards, standards guaranting a textile harmless to human health, environmentally friendly and socially reponsable.

Indeed, the introduction of the MQS leads some consumers to switch from high to low quality. Hence, the MQS may deteriorate the average quality due to its negative effect on the market share of the low quality.

Few papers deal with labels set by for-profit certifiers (see e.g. Bottega and Freitas, 2009 or Manasakis *et al.*, 2013), and at our knowledge no work has yet i) considered environments where the firms compete for the sevices of the private certifier so that the latter shall not automatically selct the certification standard maximizing the certifying firms' profits (i.e. the self-certification level), and ii) analyzed the interaction with public instruments other than a MQS.[2] By contrast, we look at an environment where the for-profit private certifier finds it profitable to set a label at a lower level than the self-certification. This result gains significance when we consider the interaction between private certifier and public regulation. Indeed, we show that the mere presence of a public label (even if not adopted by firms in equilibrium) leads the private certifier to set the self-certification level that enables a second best solution to be achieved. Moreover, we find that a per-unit tax on the unlabeled product or a subsidy on the labeled product are conducive to a lower private certification standard. By contrast, an ad valorem tax on the unlabeled product and a MQS obtain a higher private label level. This implies that, in an environment with a label delivered by a for-profit private certifier, some regulatory tools may obtain unintented results; in particular, an inactive public label may be welfare improving, while a per unit tax and a subsidy may have negative welfare effects. Our results are driven by the property that, due to the competition between firms, the private certifier must leave, to the labeled firm, a non null reserve profit equal to the profit of an unlabeled firm.

The paper is organized as follows. Section 2 presents our basic model and section 3 characterizes its price equilibrium. Section 4 presents the optimal certification level according to the certifier (self-certification, certification by a public body and by a for-profit private certifier). Section 5 analyses the interactions between private certifier and public regulation. Several tools are considered (public label, tax, subsidy and MQS).

[2] Bottega and Freitas (2009) and Manasakis *et al.* (2013) consider environments (muliproduct monopoly and symmetric firms) such as a for-profit certifier sets a certification standard maximizing the high-quality firm's profit.

Finally, Section 6 concludes.

2 The model

We assume that two firms are selling products of different qualities to a population of consumers. Firm i produces a good with a quality level s_i and sells it at price p_i, $i = 1, 2$. We assume a base quality defined by a minimum quality standard $\underline{s}$ is available at no cost. Quality can be increased by firms if they pay a development cost, prior to physical production, defined as follows:[3]

$$C(s) = \begin{cases} \frac{1}{2}s^2 - \frac{1}{2}\underline{s}^2 & \text{if } s > \underline{s} \\ 0 & \text{otherwise.} \end{cases} \tag{1}$$

We assume that there are no unit production costs.

We consider consumers' preferences as described in Mussa and Rosen (1978). Each consumer buys at most one unit of the indivisible good; the utility function of a consumer is

$$U(\theta) = \theta s - p \tag{2}$$

when consuming a unit of product of quality s sold at price p. The taste parameter θ varies across individuals so that the consumer population is described by the distribution of θ over the interval $[\underline{\theta}, \overline{\theta}]$. Unless otherwise i) the consumers' distribution is assumed to be uniform with unit density, and ii) the distribution's endpoints are normalized to $\overline{\theta} = 1$ and $\underline{\theta} = 0$, implying that the market is never totally covered at equilibrium. When a product is certified by a label, consumers know that the quality level is s, as displayed.

Consumers cannot ascertain the quality of a good neither before nor after purchase. In Darby and Karni (1973) terminology we are dealing with credence goods. Consumers

[3] We consider that providing the base quality does not require any developing costs either because the corresponding investment ($C(\underline{s}) = \frac{1}{2}\underline{s}^2$) have been sunk before the appareance of a label, or because the production of its quality is trivialized (due for instance to spillovers). In this way, providing a quality s superior to the base quality requires a quality development cost $C(s) = \frac{1}{2}s^2 - \frac{1}{2}\underline{s}^2$. Note that the model will be qualitatively the same if we consider a first stage where firms decides whether or not to enter the market, entry being conditioned to an investment in the base quality $C(\underline{s}) = \frac{1}{2}\underline{s}^2$.

perceive qualities based on the presence of a label or not. Without any label they expect to buy the base quality given by an exogenous minimum quality standard (MQS) denoted as $\underline{s}$.

In the presence of an MQS and given that firms can improve their product's quality only by increasing their costs, it is natural to assume that a consumer expects the MQS level for an unlabeled product. On the other hand, the condition that firms cannot cheat when labeling can only be guaranteed by the existence of an external supervisory body, private or public, entrusted with the task of controlling the firms' behavior in labeling. A signaling equilibrium where a false label is not convenient because it is more costly to label a lemon than a good product is assumed not to exist: we assume that labeling is equally costly for any type of product, e.g. truly OGM-free or falsely so.

For demonstration purposes, however, and in order to get a benchmark, we start by considering the case of self-certification, where an external certifier is not necessary. In all other cases, we abandon this assumption and assume instead that self-certification is not technically feasible and a certifier is needed. In any case a monitoring cost is incurred in order to ascertain the good's quality. This cost, denoted by $M(s)$, and its respective marginal cost, $MM(s)$, are assumed to be increasing functions of s, that is, $MM(s) > 0$ and $\partial MM(s)/\partial s > 0$. The certifier sets a fixed fee F that firms must pay in order to obtain the labeling. Such fee is in accordance with the royalties that a producer must pay to certify its production with a label delivered by for-profit private certifiers as e.g. asbl Biogarantie or OEKO-TEX. We proceed in line with the existing literature and assume that the certifier is independent and honest.

We consider a three-stage game. At the first stage the certifier sets the certification level of the label and the respective fee. At the second stage each firm decides whether to adopt the label or not. A firm that does not adopt any label supplies the minimum quality standard $\underline{s}$; a firm that adopts the label pays the fee to the certifier, faces the supplementary development cost that enables the provision of a quality which conforms to the certification standard, and supplies the product. Hence a label choice is equivalent to a quality choice. At the third stage firms simultaneously choose prices.

3 Price Competition

At the last stage, price competition, the quality levels are given and we assume $s_2 \geq s_1$. We shall denote a good by its quality level. The preference index of the consumer who is indifferent about the purchase of s_1 and s_2 is $\widetilde{\theta}(p_1, p_2) = \dfrac{p_2 - p_1}{s_2 - s_1}$. This satisfies

$$\widetilde{\theta}(p_1, p_2)\, s_1 - p_1 = \widetilde{\theta}(p_1, p_2)\, s_2 - p_2. \tag{3}$$

All consumers with $\theta > \widetilde{\theta}(p_1, p_2)$ strictly prefer product s_2 to s_1. Some consumers may refrain from purchasing a good. In particular, all consumers with $\theta < \theta_1(p_1) = p_1/s_1$ do not buy product 1 at price p_1. Since $\underline{\theta} = 0$, at equilibrium there will always be consumers who do not buy at all (uncovered market configuration), namely we shall have $D_1(p_1, p_2) + D_2(p_1, p_2) < 1$, with $D_i(p_i, p_j) > 0$, and

$$\begin{cases} D_1(p_1, p_2) = \widetilde{\theta}(p_1, p_2) - \theta_1(p_1) \\ D_2(p_1, p_2) = \overline{\theta} - \widetilde{\theta}(p_1, p_2). \end{cases} \tag{4}$$

Firms choose prices to maximize their gross profits $\pi_i = p_i D_i(p_i, p_j) - C(.)$, with $i = 1, 2$, $i \neq j$.

The Nash equilibrium is given by

$$p_1(s_1, s_2) = \frac{s_1(s_2 - s_1)}{4s_2 - s_1}, \qquad p_2(s_1, s_2) = \frac{2s_2(s_2 - s_1)}{4s_2 - s_1}. \tag{5}$$

The equilibrium firms' profits are given by:

$$\begin{cases} \pi_1(s_1, s_2) = \dfrac{s_1 s_2 (s_2 - s_1)}{(4s_2 - s_1)^2} - C(s_1), \\ \pi_2(s_1, s_2) = \dfrac{4s_2^2 (s_2 - s_1)}{(4s_2 - s_1)^2} - C(s_2). \end{cases} \tag{6}$$

4 Choice of certification level

In order to focus on the certification of the high quality product we consider in the following that at equilibrium the low-quality firm has no advantage in supplying a quality superior

to the minimum quality standard (MQS): $s_1 = \underline{s}$. We define $\pi_1(s_2) = \pi_1(\underline{s}, s_2)$ and $\pi_2(s_2) = \pi_2(\underline{s}, s_2)$.

Self-certification.

If there was no information asymmetry on firms' actions, firm 2 could self-certify its product and then choose the s_2 level certification to maximize its profits $\pi_2(s_2) - M(s_2)$. The first order condition (FOC) of this problem is:

$$MR_2(s_2) = MM(s_2), \tag{7}$$

with $MR_2(s_2)$, the marginal revenue function, given by

$$\frac{\partial \pi_2}{\partial s_2} = \frac{1}{4}\left(1 - 4s_2 + \frac{\underline{s}^2\,(20s_2 + \underline{s})}{(4s_2 - \underline{s})^3}\right), \tag{8}$$

and with $MM(s_2) \equiv \frac{\partial M(s_2)}{\partial s_2}$ as the marginal monitoring cost. Since $MR_2(s_2)$ is continuous and decreasing and $MM(s_2)$ continuous and increasing in s_2, the Firm 2's profit function given by $\pi_2(s_2) - M(s_2)$ is concave, and the FOC has an unique solution.[4] .

Public certifier

We next consider next that firms cannot self-certify their products and that a public certifier implements a voluntary label. The public certifier sets the certification level s_2 so as to maximize total welfare W:

$$W(s_2) = \pi_1(s_2) + \pi_2(s_2) + SC(s_2) - M(s_2), \tag{9}$$

with $SC(s_2) \equiv \left(\int_{\widetilde{\theta}(p_1,p_2)}^{1} (\theta s_2 - p_2)\, d\theta + \int_{\theta_1(p_1)}^{\widetilde{\theta}(p_1,p_2)} (\theta \underline{s} - p_1)\, d\theta\right)$. We assume that the public certifier is constrained to zero profits and therefore charges the firm a fee equal to the monitoring costs $M(s_2)$. The following condition determines the level of the public label:

$$MR_g(s_2) = MM(s_2), \tag{10}$$

[4] $\forall s_2, \underline{s} > 0 : \frac{\partial MR_2}{\partial s_2} = -1 - \frac{8\underline{s}^2(5s_2+\underline{s})}{(4s_2-\underline{s})^4} < 0.$

where $MR_g(s_2)$, the marginal revenue function, is given by

$$\frac{\partial\left(\pi_1(s_2)+\pi_2(s_2)+SC(s_2)\right)}{\partial s_2}=\frac{1}{8}\left(3-8s_2+\frac{\underline{s}^2\left(4s_2+11\underline{s}\right)}{\left(4s_2-\underline{s}\right)^3}\right). \tag{11}$$

Since $MR_g(s_2)$ is continuous and decreasing in s_2, the concavity of the $W(s_2)$ is respected, and the FOC given by the equation (10) has an unique solution.[5]

Unconstrained Private certification

The third case we consider is that of a label supplied by a monopolistic *private certifier*.

Private certification can arise here because both firms gain from escaping the Bertrand-like equilibrium in which they are trapped by imprfect information. If one firm can obtain certification of the label then it will adopt the label and produce a quality, s_2 say, which is higher than the rival's. The profit of the former become $\pi_2(s_2)$ and those of the latter $\pi_1(s_2)$. If both firms certify they fall back into the zero-profit equilibrium. Hence they will always prefer that one firm only adopts the label. Side transfers between firms are assumed to be forbidden (e.g. the Antitrust authorities would consider them as an indication of coordination efforts). The labeling firm should then pay the cost of certification via fees such that $M(s_2)\leq F_2(s_2)$, assuming that firm 2 is the labeling firm. The equivalence $\pi_2(s_2)-F_2(s_2)\geq\pi_1(s_2)$ should then apply, since firm 2 would not agree to a fee and quality pair that penalizes it with respect to the rival firm (both firms would compete for being firm 1 instead of firm 2 and adoption of the label would be delayed or eliminated altogether). Whence the fee would be $F_2(s_2)\leq\pi_2(s_2)-\pi_1(s_2)$. The obvious assumption to make then is that the certifier chooses the level of s_2 to maximize $F(s_2)-M(s_2)$, respecting the constraint that $F_2(s_2)\leq\pi_2(s_2)-\pi_1(s_2)$ or it would not receive a mandate by firm 2 (without loss of generality) to act as a certifier. The problem for the certifier is then:

$$\max_{s_2}\left\{\pi_2(s_2)-\pi_1(s_2)-M(s_2)\right\}. \tag{12}$$

[5] $\forall s_2,\underline{s}>0:\frac{\partial MR_g}{\partial s_2}=-1-\frac{\underline{s}^2(4s_2+17\underline{s})}{(4s_2-\underline{s})^4}<0.$

Whence the following FOC obtains:

$$MR_p(s_2) = MM(s_2), \tag{13}$$

with $MR_p(s_2)$, the marginal revenue function, given by:

$$\frac{\partial\left(\pi_2(s_2) - \pi_1(s_2)\right)}{\partial s_2} = \frac{1}{4}\left(1 - 4s_2 + \frac{3\underline{s}^2}{\left(4s_2 - \underline{s}\right)^2}\right). \tag{14}$$

Since $MR_p(s_2)$ is continuous and decreasing in s_2, the private certifier's profit function, given by $\pi_2(s_2) - \pi_1(s_2) - M(s_2)$, is concave, and the condition given by the equation (13) has an unique solution.[6]

Given the equilibrium conditions for a maximum (for the high-quality firm, the public and the monopoly private certifier), it is now possible to compare the solutions.

Lemma 1. $\forall s_2 > \underline{s}$, $MR_g(s_2) > MR_2(s_2) > MR_p(s_2)$.

Based on the this Lemma, we have the following implication.

Proposition 1. *The government sets a certification standard superior to the private certification standard and to the self-certification level, while the private certification standard is inferior to the self-certification level.*

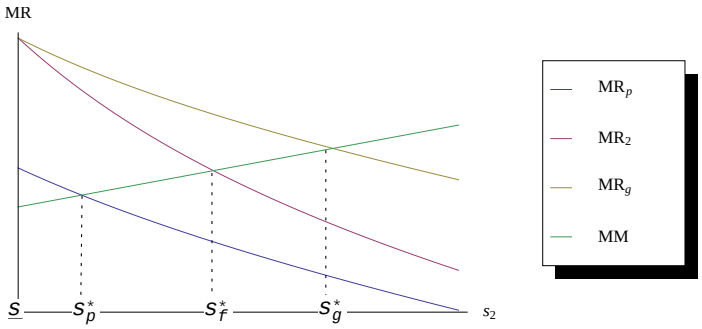

Figure 1:

[6] $\forall s_2, \underline{s} > 0 : \frac{\partial MR_p}{\partial s_2} = -1 - \frac{6\underline{s}^2}{(4s_2 - \underline{s})^3} < 0.$

In what follows we define as s_f^* the solution to equation (7), s_g^* the solution to equation (10) and s_p^* the solution to equation (13) (See Figure 1). Hence way, s_g^*, s_f^* and s_p^* represent the first best certification levels respectively for the government, the high-quality firm, and the private certifier, with $s_g^* > s_f^* > s_p^*$.

Contrary to Bottega and Freitas (2009) and Manasakis *et al.* (2013) our result is that a for-profit monopoly private certifier sets a certification level inferior to the one maximizing the profit of the high-quality firm. Crucial to the result is the existence of an (endogenous) reserve profit, equal to the profit of an unlabeled firm, that the private certifier must leave to the labeled firm. In order to avoid increasing this reserve profit, the private certifier must choose a lower level of certification than the self-certification level.

5 Private certification and public regulation

Consider now the case where the Government tries to ameliorate the market outcome where a private certifier is active. One possible policy is that of providing public certification, without however banning the private certification, leading to a coexistence of two certification options for firms. Another possible tool is represented by a tax on the unlabeled product so as to discourage its consumption and favor the consumption of the labelled good. We shall distinguish in particular between an ad valorem and a per unit tax. A third possibility is that of encouraging the consumption of the labelled product by means of a subsidy. Finally, the Government may alter the market outcome by varying the level of the MQS.

5.1 Private and public certification

To analyze the situation where a public agency sets its label level, while leaving the market for certification open to a private certifier, we modify the first stage of the game by considering that the private certifier and the public certifier implement their labeling policies in a sequence: stage 1a and 1b, with the Government choosing at 1a and the private certifier at 1b. The certification levels chosen are denoted s_g and s_p respectively. If two distinct labels are supplied on the market, we assume that $\underline{s}$ is higher than firm 1

best reply to the label level s_2 so that firm 1 at equilibrium prefers to play $\underline{s}$ rather than a higher quality, and hence it will not adopt any label. Only firm 2 adopts a label.

At stage 1a assume first that the Government sets s_g such that

$$\pi_2(s_g) - M(s_g) \geq \pi_1(s_f^*). \tag{15}$$

We shall show next that this assumption will be respected at equilibrium.

At stage 1b, given s_g which respects the constraint given by (15) , firm 2 adopts the label s_p if and only if its profit under private certification, $\pi_2(s_p) - F$, is at least as high as its profit under public certification, $\pi_2(s_g) - M(s_g)$. Hence the private certifier aims to maximize $F - M(s_p)$ under the constraint $F \leq \pi_2(s_p) - [\pi_2(s_g) - M(s_g)]$. For any given s_g, the private certifier sets a label so as to maximize:

$$\max_{s_p} \{\pi_2(s_p) - (\pi_2(s_g) - M(s_g)) - M(s_p)\}. \tag{16}$$

We obtain the following FOC:

$$MR_p(s_p) = MM(s_p). \tag{17}$$

Contrary to the case where the private certifier is alone in the certification market (see Section 4) $MR_p(.)$ is equal to the marginal revenue function of firm 2 given by the equation 8. Then the private certifier sets a certification level equal to the self-certification level, s_f^*, and charges a certification fee F_p given by:

$$F_p = \pi_2(s_f^*) - (\pi_2(s_g) - M(s_g)). \tag{18}$$

We shall show now that it is not in the interest of the Government to violate (15). Consider a choice of s_g by the Government at stage 1a such that (15) is violated. Then the private certifier at stage 1.b would choose a level $s_p < s_f^*$, leading to a lower total welfare. The reasoning is as follows. If (15) is violated public certification is less attractive than offering the low quality and obtaining $\pi_1(s_f^*)$. Therefore, the private certifier can play firm 1 and 2 one against each other and he can obtain $\pi_2(s_p) - \pi_1(s_p)$. Furthermore we know

that $s_p^* < s_f^*$ and $\pi_1(s_2)$ is increasing in s_2. Hence for some s_p such that both $s_p < s_f^*$ and in the range determined by the inequalities $\pi_1(s_f^*) > \pi_1(s_p) > \pi_2(s_g) - M(s_g)$ the private certifier is better off than he is at s_f^* (recall that $\pi_2(s_p) - \pi_1(s_p)$ is a concave function). But a lower s_p than s_f^* affords a lower total welfare and the Government will prefer the solution provided when the condition (15) is satisfied.

Accordingly, at equilibrium firm 2 adopts the private label and firm 1 supplies the minimum quality standard. The public label is not adopted but its presence has an impact on the private certification level. As we saw in the previous section, without public labeling the private certifier sets a label with a certification level given by s_p^*. When both private and public certifying institutions are active, the private certifier is pushed up to the higher certification level s_f^*. Note that mere presence of a public label is sufficient to drive the private certifier to set the self-certification level. The public label's certification level label has no direct impact on the private certification level and, consequently, on welfare. It only impacts the certification fee F_p.

The following proposition summarizes the previous results.

Proposition 2. *When two certifying institutions (private and public) are active, only the private certification is adopted by one firm in equilibrium. Compared to the equilibrium when a private certifier is alone in the market, the presence of the public certification leads the private certifier to increase the certification standard to the self-certification level. Therefore, the implementation of a public label allows a second best solution to be achieved.*

It is noteworthy that Firm 1 prefers pure public labeling to all other solutions, because its equilibrium profit is increasing in s_2; its second best is the coexistence of public and private certifier. By contrast, firm 2 prefers the solution where a public and a private certifier coexist, because it recovers its first best profit. Such a solution so obtained is a second best in terms of total welfare since total welfare is a concave function of s_2.

Finally, if we consider a competitive private certification market, then only one label is adopted. This one is set at the self-certification level s_f^*. Competition drives the certification fee to match the monitoring cost. Note that this result contrasts with Manasakis *et al.* (2013) where the monopoly private certifier sets the same certification level as the private certifying companies do in a competitive market.

5.2 Taxes and subsides

In markets where private certifiers provide their solution to the labeling problem, a government may still want to ameliorate the market outcome through the use of other instruments than public labels. To this effect, unlabeled products are often subject to taxes aimed to reduce their consumption. It is natural therefore in our context to ask what are the effects of this type of taxes on the behavior of firms and of the certifier. A tax on the unlabeled product may shift the best reply function of firm 1 in the price game, and it decreases its profit. In fact we shall see that this second effect plays an important role in the analysis.

Ad valorem tax.

An ad valorem tax modifies the revenue from the sale of one unit of the unlabeled product, decreasing it from p_1 to $p_1(1-t)$, where $0 < t < 1$ is the tax rate. The profit to firm 1 is then defined as:

$$\pi_1 = p_1(1-t)D_1 - C(s_1). \tag{19}$$

Obviously one can only consider tax rates that leave a positive equilibrium profit to firm 1. In the price game, and compared to the equilibrium whitout tax, the best reply in the price game is not affected by such a tax and the equilibrium prices are given by the equation 5. The demands, the profit to firm 2 and the wefare are also unchanged. In the certification game, the effect of the tax on the private certification standard s_p depends only of its effect on the reserve profit π_1. In this way, it can be shown that, compared to s_p^* (given in Section 4), the private certification standard is higher. Such a result is driven by the upward shift of the marginal revenue function in equation (13) above, modified after the introduction of a unit tax. Finally, as welfare does not depend on the tax level, the certification standard maximizing the welfare is not impacted by the tax rate. By bringing s_p closer to s_g^*, an ad valorem tax policy is welfare improving.

Proposition 3. *Compared to the equilibrium under an unconstrained a private certifier, and as a result of the ad valorem tax policy, the private certification standard is higher and welfare is improved.*

Proof. In the certification game the FOC is given by $MR_p(s_p) = MM(s_p)$ with

$$MR_p(s_p) \equiv \frac{\partial\left(\pi_2(s_p) - \pi_1(s_p)\right)}{\partial s_p} = \frac{1}{4}\left(1 - 4s_p + \frac{\underline{s}^2(20s_p + \underline{s})}{(4s_p - \underline{s})^3}\right) - \frac{\underline{s}^2(2s_p + \underline{s})(1-t)}{(4s_p - \underline{s})^3}$$

It is obvious then the private certification standard is increasing in the tax rate ($\frac{\partial MR_p(s_p)}{\partial t} = \frac{\underline{s}^2(2s_p+\underline{s})}{(4s_p-\underline{s})^3} > 0$).

Now, we evaluate the full derivative of the welfare $W = \int_{\widetilde{\theta}}^{1}(\theta s_p)d\theta + \int_{\theta_1}^{\widetilde{\theta}}(\theta\underline{s})d\theta - C(s_p) - M(s_p)$ with respect to t, and show that it is positive. $\frac{dW}{dt} = \frac{\partial W}{\partial s_p}\frac{\partial s_p}{\partial t} + \frac{\partial W}{\partial t}$, as i) $\frac{\partial W}{\partial t} = 0$, ii), $\frac{\partial W}{\partial s_p} > 0\ \forall s_p \in]\underline{s}, s_g^*[$ (see Section 4), and iii) $\text{sign}\frac{\partial s_p}{\partial t} = \text{sign}\frac{\partial MR_p(s_p)}{\partial t}$, then $\frac{dW}{dt} > 0$ whenever $s_p < s_g^*$.

Note that for high level of t, s_p may be superior to s_g^* such as the evolution of welfare is ambiguous. □

It is interesting to consider that the increase in s_p leads to a higher degree of differentiation, which relaxes price competition and entails a higher price level for both products. It follows that the equilibrium demand for both types of product decreases under an ad valorem tax, while the relative market shares remain unchanged.

Per unit tax.

A per unit tax, τ, on the unlabeled product changes the profit to firm 1 to

$$\pi_1 = (p_1 - \tau)D_1 - C(s_1). \tag{20}$$

In the price game, it is clear that the best reply function of firm 1 is shifted to the left, and the equilibrium prices for given s_1 and s_2 are both higher than without a tax. The Nash equilibrium is given by:

$$p_1(s_1, s_2, t) = \frac{s_1\left(s_2 - s_1\right) + 2s_2 t}{4s_2 - s_1}, \qquad p_2(s_1, s_2, t) = \frac{2s_2\left(s_2 - s_1 + \frac{t}{2}\right)}{4s_2 - s_1}. \tag{21}$$

In the certification game, the effect of the tax on the private certification standard s_p depends of its effect on both the high-quality firm's profit π_2 and the reserve profit π_1. In

this way, $\forall t \in]0, \underline{s}[$, and compared to s_p^*, the private certification standard is lower, with an increase in price competition and in equilibrium quantities sold for both types of goods. This result is driven by the downward shift of the marginal revenue function in equation (13) above as modified after the introduction of a unit tax. Such an effect moves away s_p from s_g^*, driving to ambigous effects of a per unit tax policy on the welfare.

Proposition 4. *Compared to the equilibrium under an unconstrained private certifier, and as a result of a not too high per unit tax policy, the private certification standard is lower. The effect of such a tax on welfare is then ambiguous.*

Proof. In the certification game the FOC is given by $MR_p(s_p) = MM(s_p)$ with

$$MR_p(s_p) \equiv \frac{\partial\left(\pi_2(s_p) - \pi_1(s_p)\right)}{\partial s_p} = \frac{\underline{s}^2 - 2\underline{s}s_p - \underline{s}^2 s_p + 4s_p^2 + 8\underline{s}s_p^2 - 16s_p^3 - 2t\underline{s} + t^2}{(4s_p - \underline{s})^2}$$

It is obvious then $\forall t \in [0, \underline{s}[$ the private certification standard is decreasing in the tax rate $\left(\frac{\partial MR_p(s_p)}{\partial t} = -\frac{2(\underline{s}-t)}{(4s_p-\underline{s})^2}\right)$.

Now, we evaluate the full derivative of the welfare $W = \int_{\widetilde{\theta}}^{1}(\theta s_p)d\theta + \int_{\theta_1}^{\widetilde{\theta}}(\theta \underline{s})d\theta - C(s_p) - M(s_p)$ with respect to t. $\frac{dW}{dt} = \frac{\partial W}{\partial s_p}\frac{\partial s_p}{\partial t} + \frac{\partial W}{\partial t}$, as i) $\frac{\partial W}{\partial t} > 0\ \forall t < \frac{\underline{s}^2 s_p - \underline{s}^3}{4s_p^2 - 3\underline{s}s_p}$, ii), $\frac{\partial W}{\partial s_p} > 0\ \forall s_p \in]\underline{s}, s_g^*(t)[$, with $s_g^*(t)$ the socially optimal certification standard for a per unit tax t given, and iii) $\text{sign}\frac{\partial s_p}{\partial t} = \text{sign}\frac{\partial MR_p(s_p)}{\partial t}$, the sign of $\frac{dW}{dt}$ is ambiguous.

□

The results on the two types of taxes are noteworthy in that they inform on the kind of mistakes that could be done in devising a tax aimed to favor the consumption of the labelled good. A not too high per unit tax will drive the label level down with a negative impact total welfare. Furthermore it will not discourage the consumption of the unlabeled good, although it also favors that of the labelled one. An ad valorem tax lowers consumption of both goods but increases the level of the label and ameliorates welfare.

Subsidy. A subsidy on labeled products can be used (or advocated). An example is provided by the subsidies allocated to the organic farming in Austria. We represent here

a subsidy as a per unit subsidy λ. The profit function for firm 2 is changed to

$$\pi_2 = (p_2 + \lambda)D_2 - C(s_2). \tag{22}$$

In the price game, it is clear that the best reply function of firm 2 is shifted to the right, and the equilibrium prices for given s_1 and s_2 are both lower than without a subsidy. The Nash equilibrium is given by:

$$p_1(s_1, s_2, \lambda) = \frac{s_1\,(s_2 - s_1 - \lambda)}{4s_2 - s_1}, \qquad p_2(s_1, s_2, \lambda) = \frac{2s_2\,(s_2 - s_1 - \lambda)}{4s_2 - s_1}. \tag{23}$$

In the certification stage, the changes induced by a transfer are, predictably, an increase in the marginal revenue from s_2 for firm 2. At the same time, however, the subsidy leads to a change in the function $\pi_1(s_2)$ implying also a higher derivative of $\pi_1(s_2)$ with respect to s_2. Therefore the maximization of $\pi_2(s_p) - \pi_1(s_p)$ is not a priori clear. In this way, and compared to s_p^*, it can be shown that the private certification standard is lower. This result is driven by the downward shift of the marginal revenue function in equation (13) above as modified after the introduction of a subsidy. Such an effect moves away s_p from s_g^*, driving to ambigous effects of a subsidy policy on the welfare.

Proposition 5. *Compared to the equilibrium under an unconstrained private certifier, and as a result of a subsidy policy, the private certification standard is lower. The effect of a not too strong subsidy policy on welfare is then ambiguous.*

Proof. In the certification game the FOC is given by $MR_p(s_p) = MM(s_p)$ with

$$MR_p(s_p) \equiv \frac{\partial\left(\pi_2(s_p) - \pi_1(s_p)\right)}{\partial s_p} = \frac{\underline{s}^2 - 2\underline{s}s_p - \underline{s}^2 s_p + 4s_p^2 + 8\underline{s}s_p^2 - 16s_p^3 - 2\lambda\underline{s} - 4\lambda^2)}{(4s_p - \underline{s})^2}$$

It is obvious then the private certification standard is decreasing in the subsidy level $\left(\frac{\partial MR_p(s_p)}{\partial \lambda} = -\frac{2(\underline{s}+4\lambda)}{(4s_p - \underline{s})^2} < 0\right)$.

Now, we evaluate the full derivative of the welfare $W = \int_{\widetilde{\theta}}^{1}(\theta s_p)d\theta + \int_{\theta_1}^{\widetilde{\theta}}(\theta\underline{s})d\theta - C(s_p) - M(s_p)$ with respect to λ. $\frac{dW}{d\lambda} = \frac{\partial W}{\partial s_p}\frac{\partial s_p}{\partial \lambda} + \frac{\partial W}{\partial \lambda}$, as i) $\frac{\partial W}{\partial \lambda} > 0\ \forall\lambda < (s_p - \underline{s})$, ii), $\frac{\partial W}{\partial s_p} > 0$ $\forall s_p \in]\underline{s}, s_g^*(\lambda)[$, with $s_g^*(\lambda)$ the socially optimal certification standard for a subsidy λ given , and iii) $\text{sign}\frac{\partial s_p}{\partial \lambda} = \text{sign}\frac{\partial MR_p(s_p)}{\partial \lambda}$, the sign of $\frac{dW}{d\lambda}$ is ambiguous.

□

5.3 Minimum Quality Standard

The last instrument that we analyze is an increase in the MQS. As expected, a marginal increase of the MQS level, given by $\underline{s}$, induces for firm 2 a higher marginal revenue from s_2 (see Ronnen, 1991). At the same time, however, the increase of $\underline{s}$ leads also to a higher derivative of $\pi_1(s_2)$ with respect to s_2. Therefore the maximization of $\pi_2(s_p) - \pi_1(s_p)$ is not a priori clear. It can be shown however that, unambiguously, s_p increases with the level of the MQS.

Proposition 6. *Compared to the equilibrium under an unconstrained private certifier, and as a result of a MQS policy, the private certification standard is higher. Provided the MQS is not too high, it improves welfare.*

Proof. In the certification game the FOC is given by the equation (13) above. It is obvious then the private certification standard is increasing in the MQS level ($\frac{\partial MR_p(s_p)}{\partial \underline{s}} = \frac{6s_p\underline{s}}{(4s_p-\underline{s})^3} > 0$).

Now, we evaluate the full derivative of the welfare $W = \int_{\widetilde{\theta}}^{1}(\theta s_p)d\theta + \int_{\theta_1}^{\widetilde{\theta}}(\theta \underline{s})d\theta - C(s_p) - M(s_p)$ with respect to $\underline{s}$. $\frac{dW}{d\underline{s}} = \frac{\partial W}{\partial s_p}\frac{\partial s_p}{\partial \underline{s}} + \frac{\partial W}{\partial \underline{s}}$, as i) $\frac{\partial W}{\partial \underline{s}} > 0$, ii), $\frac{\partial W}{\partial s_p} > 0\ \forall s_p \in]\underline{s}, s_g^*[$, and iii) $\text{sign}\frac{\partial s_p}{\partial \underline{s}} = \text{sign}\frac{\partial MR_p(s_p)}{\partial \underline{s}}$, then $\frac{dW}{d\underline{s}} > 0$ whenever $s_p < s_g^*$. □

Note that, the optimal policy for the government is to implement a sufficient high level of MQS such that any private label may be on the market. As in Baltzer (2012) the government finds optimal to prevent firms from exploiting their market power rather than to restore full information.

6 Conclusion

The present work is a contribution to the literature on public labeling of credence goods. Contradicting the results obtained so far in the literature, we show that a for-profit private certifier chooses a certification level inferior to the one maximizing the profit of the high-quality firm (i.e. the self-certification level). This result is driven by a non null reserve

profit, equal to the profit of an unlabeled firm, that the private certifier must leave to the labeled firm. In order to avoid increasing this reserve profit, the private certifier must choose a lower level of certification than the self-certification level.

The private certification standard remains below the welfare maximizing level that a purely public certifier may want to obtain.

We then have analyzed various policy options for the Government seeking to improve over the solution obtained by a private certifier. We show that the effect on the private certifier choice of the reservation profit that we have highlighted may indeed interfere with the efficiency of some public policies in favor of the labeled products. For instance, due to this effect, an ad-valorem tax on unlabeled products leads the private certifier to increase the certification level of the label, and ameliorates welfare, while surprisingly it leads to the opposite for a per unit tax, which negaltively affects the welfare. We also show that subsidies on the labelled product have unintended effects since they push the private certifier to choose lower his certification level.

Interestingly, we show that when both, the public and the private certifier are on the market, only the private label is adopted. Nevertheless, even if the public label is not adopted by firms, its presence modifies the reservation profit of the labeled firm, inducing the private certifier to increase his certification level up to the self-certification level. Accordingly, the implementation of an "ineffective" public label allows a second best solution to be achieved.

References

Baltzer, K. (2012). "Standards vs. labels with imperfect competition and asymmetric information". *Economics Letters*, **114**(1):61–63.

Baron, D. P. (2011). "Credence attributes, voluntary organizations, and social pressure". *Journal of Public Economics*, **95**(1112):1331–1338.

Bonroy, O. and Constantatos, C. (2008). "On the use of labels in credence goods markets". *Journal of Regulatory Economics*, **33**:237–252.

Bonroy, O. and Lemarié, S. (2012). "Downstream labeling and upstream price competition". *European Economic Review*, **56**(3):347–360.

Bottega, L. and Freitas, J. D. (2009). "Public, private and nonprofit regulation for environmental quality". *Journal of Economics & Management Strategy*, **18**(1):105–123.

Darby, M. R. and Karni, E. (1973). "Free competition and the optimal amount of fraud". *Journal of Law and Economics*, **16**(1):67–88.

Fulton, M. and Giannakas, K. (2004). "Inserting gm products into the food chain: The market and welfare effects of different labeling and regulatory regimes". *American Journal of Agricultural Economics*, **86**(1):42–60.

Heyes, A. G. and Maxwell, J. W. (2004). "Private vs. public regulation: political economy of the international environment". *Journal of Environmental Economics and Management*, **48**(2):978–996.

Manasakis, C., Mitrokostas, E., and Petrakis, E. (2013). "Certification of corporate social responsibility activities in oligopolistic markets". *Canadian Journal of Economics*, **46**(1):282–309.

Mussa, M. and Rosen, S. (1978). "Monopoly and product quality". *Journal of Economic Theory*, **18**(2):301–317.

Roe, B. and Sheldon, I. (2007). "Credence good labeling: The efficiency and distributional implications of several policy approaches". *American Journal of Agricultural Economics*, **89**(4):1020–1033.

Ronnen, U. (1991). "Minimum quality standards, fixed costs, and competition". *The RAND Journal of Economics*, **22**(4):490–504.