Labeling by a private certifier and public regulation*

Ibrahima BARRY[†1], Olivier BONROY[‡2,1], and Paolo G. GARELLA[§3]

[1]Université Grenoble Alpes, UMR 1215 GAEL, F-38000 Grenoble, France.
[2]INRA, UMR 1215 GAEL, F-38000 Grenoble, France.
[3]Department of Economics, Management, and Quantitative Methods, University of Milano, Italy.

January 8, 2015

Abstract

This paper considers the effects of labels in a vertically differentiated duopoly. A label certifies the level of a product's measurable characteristic. It is shown that the certification level chosen by a private (for profit) certifier is lower than both the socially optimal and the firm's preferred one. Public policies that lead to an increase in the label can improve welfare - while also potentially benefiting firms. We find that: (i) if public and private certification are offered, an indirect regulatory outcome is achieved (a second best) where the private certifier raises the standard of his label - even though no firm adopts the public label; (ii) two common tools like a per unit tax on the unlabeled product or a subsidy in favor of the labeled one lead to a lower private certification standard with ambiguous effects on welfare; (iii) an ad valorem tax on the unlabeled product, by contrast, increases welfare.

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

JEL classification: L13, L15, L5.

*The authors are grateful to participants at the 41st Annual Conference of the European Association for Research in Industrial Economics and at 2013 Annual Meeting of the Association of Southern European Economic Theorists for their useful comments and suggestions. Responsibility for any errors and omissions is entirely ours.

[†]✉Ibrahima.Barry@upmf-grenoble.fr
[‡]Corresponding author. ✉olivier.bonroy@grenoble.inra.fr
[§]✉paolo.garella@unimi.it

1 Introduction

The significant and always increasing presence of labeled products, in the agri-food as well as in a number of industrial sectors, has aroused great interest on the implications for firms and consumers, and on the impact on the quality of products that are marketed. The ongoing debate concerns both, the theory and the empirical evidence (see e.g. Fulton and Giannakas, 2004; Hamilton and Zilberman, 2006; Roe and Sheldon, 2007; Baron, 2011; Bonroy and Lemarié, 2012; Kiesel and Villas-Boas, 2013; Fischer and Lyon, 2014). Several empirical studies show the existence of increased willingness to pay by consumers for labelled products embodying a larger amount of a desirable characteristic (see e.g. Marette *et al.*, 2012). Labels then are interesting for firms who want to certify that they produce according to some specified technical standard, or respect some social and ethical norms that are valued by buyers. Since consumers cannot gain the necessary information by inspecting the good, or by any other means, the labels are aimed at making it known that a desirable standard has been applied.[1] In some cases this also amounts to complying with rules protecting the environment; as examples, think of "Dolphin Friendly" fishing (see Teisl *et al.*, 2002), or of *eco*-labels showing the percentage of recycled material used in textiles, jewelry and other products; or of "energy saving production" labels. In the agri-food sector, labels are seen by Governments and by producers' groups as part of policies concerned with the survival of crop varieties, of animal breed varieties[2], of typical and regional products requiring special ingredients or special production methods.

A label must usually follow a prescribed standard and the product which is labelled is somehow certified to conform to it. Certification to obtain a label is delegated to certifying bodies, that we shall term "certifiers" in what follows. These allow the use of a label by a firm only after analysis of the adopted production processes and of final products, and proceed over time to monitoring of producers. Certification, therefore, is a costly activity. Some for-profit private certification bodies develop their own certification standards and deliver the corresponding labels.[3] Unlike Government-owned certification bodies, a for-profit certifier will try to extract part of the firms' profit through a certification fee. Since the certification standard allows a firm to increase profits, the choice of the level of the standard will affect the fee that can be asked. By contrast, a publicly-owned certifier will in principle aim at maximizing social welfare, and in any case will not pursue profit maximization. Therefore we expect that different standards will be selected by the two types of certifiers. This is, so to speak, the first result and level of analysis in the present paper. Second, we ask whether

is it desirable and possible to ameliorate the standard selected by the private certifier. We refer to different policy tools that can be chosen. The first tool is the institution of a public certifier that competes with the private certifier. The second tool is represented by the choice of a tax or a subsidy as is typical of public policies. The latter category of tools is very popular and long-dated, if one thinks of the use of taxes to discourage production of some goods and subsidies to promote that of others. These are especially important in contexts where protection of production process or of product varieties are considered important - like in the agri-food sector. By comparison, instead, the analysis of the interaction of a private and a public certifier is a recent issue and rather specific to the institution of labels.

Unlike the present paper, the existing literature on the interaction between non-public certifier and public regulation largely focuses on non-governmental organizations (NGO) maximizing average quality and private certifier maximizing the industry's profit.[4] Heyes and Maxwell (2004) consider a sequential game where the regulator chooses the level of MQS at the first stage, the NGO chooses the level of a voluntary label at the second, and firms select their quality level at the third. They consider firms that differ with respect to their marginal cost of quality-improvements and find that a properly designed MQS, coupled with an NGO label, is welfare increasing. Bottega and DeFreitas (2009) examine similar questions by assuming a multiproduct monopolist. In their setting, the two instruments, label and MQS, are set simultaneously. The presence of the label, then, reduces the role of the MQS to function only as a control for excessive product differentiation. This implies that the presence of a label pushes the optimal level of MQS downwards. They find that, surprisingly, the NGO would prefer a lower level for the MQS than is realized at equilibrium. Indeed, the introduction of the MQS leads some consumers to switch from the high to the low quality product, thereby worsening the weighted average quality consumed in the market.

Only few papers deal with labels set by for-profit certifiers (see e.g. Bottega and DeFreitas, 2009 or Manasakis *et al.*, 2013) and at our knowledge no work has yet, i) considered environments where firms compete for the services of the private certifier, and ii) analyzed the interaction with public instruments other than a MQS.[5] In our model there are two firms competing in prices; if there is no label their products are homogeneous since both produce the Minimum Quality Standard in the industry. A higher standard than the minimum cannot be communicated directly by a firm to the customers, for obvious moral hazard reasons, and therefore a firm cannot independently provide a label and differentiate its product. With homogeneous products, whatever is their common quality, the Bertrand zero-profit equilibrium in prices will follow (like in Gabszewicz and Thisse, 1979, and Shaked and Sutton, 1982),

hence if a firm obtains the label, the rival's best reply is *not* to adopt the label itself, or it would fall in the zero-profit equilibrium. Crucial to our results is that the objective function of the private certifier shall not coincide with profit maximization of the labeled firm - because the certifier cannot extract all of the firm's rent. The reason is that the labeled firm cannot be forced to pay more than the amount that the rival would be willing to pay for acquiring the label to himself.

The result is that the private certifier sets a lower standard than that which maximizes the labeled firm's profit.

This also gains significance when we consider a private certifier and public regulation. Indeed, from the social point of view increasing the standard above the level chosen by the private certifier is desirable. As to the policy tools available, we show that (i) nothing but the 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. The non-adopted public label can be interpreted as a label offered by public institutions in the market where the duopolists compete as well as in other markets (for instance an eco-label of some sort that applies to several categories of goods). As to the second set of policy tools, taxes and subsidies, we find that (ii.a) 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, (ii.b) an ad valorem tax on the unlabeled product leads to a higher private label level. These results imply that, in a situation with a label delivered by a for-profit private certifier, some regulatory tools may obtain unintended outcomes; in particular, an "inactive" public label may be welfare improving, while a per unit tax and a subsidy may have negative welfare effects and may lower average quality. Our analysis suggests that an ad-valorem tax on the unlabeled product is the best among the traditional tools.

Finally, we also report results for when a tax is applied in equal rates to both products. In that case we observe that this tool leads to a lower welfare.

The paper is organized as follows. Section 2 presents our basic model and section 3 characterizes the price equilibrium. Section 4 presents the optimal certification level for different certifiers (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). Finally, Section 6 concludes.

2 The model

We assume that two symmetric 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 that there are no variable production costs. To simplify we also assume that a "base" quality product defined by a minimum quality standard $\underline{s}$ can be developed by firms at no cost. Quality of the product can be increased by firms if they pay a development cost, $C(s)$, incurred prior to physical production, and defined as follows:[6]

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

The cost function $C(s)$ has two components. The first is the term in square brackets and relates to an increase of quality above the minimum level $\underline{s}$; we assume that this component is common knowledge. The cost T is an additional fixed cost which is the same for both firms and is only observed by firms; it results as the realization of a random variable with distribution $G(T)$ over the interval $[0, \bar{T}]$. For instance, one may think of T as the cost of actions like: retraining the workforce, retooling for technology reasons like the compatibility of processes and materials, reorganizing the supply chain, enhancing quality controls at different production units, or a mix of all these.

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 of type θ 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 $[\underline{\theta}, \overline{\theta}]$. Furthermore we assume that: i) the consumers' distribution is 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—since equilibrium prices are always strictly positive. When a product is certified by a label, consumers know for sure that the quality level is s, as displayed. In other words, labeling can only mean here that the consumer regains full information about s. Our model fits in the class of vertically differentiated duopolies (Gabszewicz and Thisse, 1979, Shaked and Sutton, 1982, Motta, 1993, Wauthy, 1996).

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 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 payments 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 without loss of generality that $s_2 \geq s_1$, hence firm 1 shall always be the low quality firm. 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 equilibrium demands such that $D_1(p_1, p_2) + D_2(p_1, p_2) < 1$, with $D_i(p_i, p_j) > 0$. For the purpose of the analysis the following description of demand functions is sufficient, without detailing on the zero-demand cases that may arise out of equilibrium[7]:

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

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

It is possible to focus on the certification of the high quality product if in equilibrium the low-quality firm has no advantage in supplying a quality superior to the minimum quality standard (MQS): $s_1 = \underline{s}$. This condition is guaranteed only if the MQS level $\underline{s}$, is higher than firm 1's best reply in quality to s_2. We shall assume that this condition is satisfied throughout. To shorten the notation, we define here $\pi_1(s_2) = \pi_1(\underline{s}, s_2)$ as the profit to firm 1 when it produces the MQS level against s_2; similarly, we let $\pi_2(s_2) = \pi_2(\underline{s}, s_2)$.

Self-certification.

If full information was assumed, firm 2 could self-certify its product and then choose the s_2 level of certification to maximize its profits $\pi_2(s_2) - M(s_2)$. The first order condition (FOC) of this problem can be written as:

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

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.[8] .

Public certification

We 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 moni-

toring costs $M(s_2)$. The following condition determines the level of the public label:

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

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 strict concavity of the $W(s_2)$ is ensured, and the FOC given by the equation (10) has a unique solution denoted s_g.[9] We shall assume, to simplify, that $\pi_2(s_g) - M(s_g) \geq 0$, for all T.

Unconstrained Private certification

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

A private certifier here sets a standard, call it s_2, and firms decide whether to adopt it or not, where if a firm adopts the standard it has to pay a fee for the services of the certifier. Both firms gain from escaping the Bertrand-like equilibrium in which they are trapped by imperfect information on qualities. If one firm can obtain certification 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 trap. Hence, at an equilibrium, one firm only adopts the label. The labeling firm should then pay a certification fee $F(s_2)$ which must at least cover the costs $M(s_2)$, namely $M(s_2) \leq F(s_2)$.

Since the fixed cost T is private information of the firms, the certifier is not able to determine the profit of the firm taking the label. This implies that some negotiation must take place. For instance the certifier asks a fee; if the fee is accepted by one firm it means that this firm is making a non-negative profit, hence that the fee may not be the one which maximizes the certifier profit. However, a higher fee may be refused by firms because the cost T is so high that the fee is not sustainable. The certifier then needs reduce his request. Obviously, firms will not accept high fees if they expect that their refusals will lead to a lower request by the certifier. However, we can easily determine the equilibrium fee in a negotiation process of this kind. In fact it is the same equilibrium that is reached if firms propose the payment level in a kind of Bertrand competition. The maximum fee that a firm can accept is defined by the equivalence $\pi_2(s_2) - F_2(s_2) = \pi_1(s_2)$. The reason is that the "winning firm" must make

a payment that cannot be "beaten" by a higher offer made by the rival. Now, consider an equilibrium where firm 2 takes the label at a fee F^* and the rival makes profit $\pi_1(s_2)$. Then, the latter would *not* try to upset the equilibrium by offering a fee $F' > F^*$ to obtain the label only if it prefers to remain unlabeled against the rival, namely if $\pi_2(s_2) - F' < \pi_1(s_2)$ for all $F' > F^*$. Furthermore, all fees, F, such that $\pi_2(s_2) - F < \pi_1(s_2)$ are unnecessarily high from the viewpoint of firm 2 as firm 1 is not tempted to upset the equilibrium, given such a high fee: hence the equilibrium fee is defined by the equality $\pi_2(s_2) - F^* = \pi_1(s_2)$.[10]

The profit for the certifier is then $F(s_2) - M(s_2)$ and the maximization problem is:

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

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:

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

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 strictly concave, and the condition given by the equation (13) has an unique solution.[11]

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. *For all $s_2 > \underline{s}$, the inequalities $MR_g(s_2) > MR_2(s_2) > MR_p(s_2)$ are verified.*

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

Proposition 1. *The order of the certification standards is the following: the government sets the highest certification standard, followed in sequence by the self-certification and by the private certification level, formally $s_g^* > s_f^* > s_p^*$.*

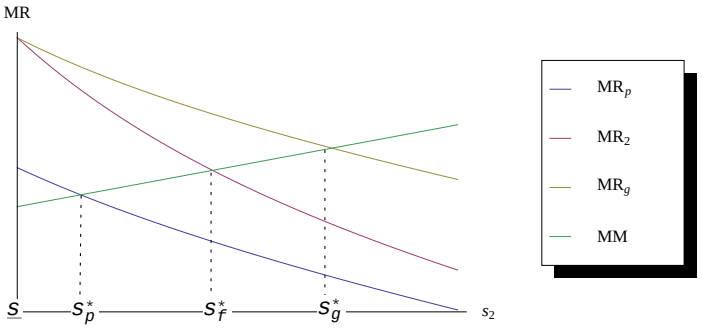

Figure 1: Graphical representation of the FOCs for $MM(s_2) = s_2$

Our result, that a for-profit monopoly private certifier sets a certification level inferior to the one maximizing the profit of the high-quality firm contrasts with Bottega and DeFreitas (2009), where the certifier extracts all the rent from the firm and chooses the level of the standard which maximizes the firm's profit. In our approach, 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.

5.1 Private and public certification

Assume now that a public label is implemented at a level s_g, before the private certifier sets its policy. In this way, at stage 1, given s_g, the certifier chooses a certification level denoted s_p.[12]

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:

$$\max_{s_p} \{\pi_2(s_p) - (\pi_2(s_g) - M(s_g)) - M(s_p)\}. \tag{15}$$

We obtain the following FOC:

$$MR_p(s_p) = MM(s_p). \tag{16}$$

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:

$$F_p = \pi_2(s_f^*) - (\pi_2(s_g) - M(s_g)). \tag{17}$$

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 the unlabeled producer, 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, which is increasing for s_2 ranging from zero to s_g^*.

As in Fischer and Lyon (2014) we show that offering a non private label alongside a private one may benefit producers in the industry. Fischer and Lyon (2014) explain such a result by the presence of various firms with divergent preferences (in their setting there is a continuum of firms and hence they act non-strategically) and choosing different standards. In this way, a non-private label offers an additional option to firms. In our work, the mechanism that drives the result is the effect of a public label on the reserve profit that the private certifier must leave to the labeled firm.

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.

Consider a tax targeted *only* on the unlabeled product. 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:

$$\pi_1 = p_1(1-t)D_1 - C(s_1). \tag{18}$$

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 without tax, the best replies are not affected by an ad valorem tax (a property that will not hold for the unit tax below) and the equilibrium prices as functions of s_2 are given by equation 5. The demand functions, the profit

function to firm 2, and the welfare function are also unchanged. In the certification stage, the effect of the tax on the private certification standard, s_p, only depends on the reservation profit $\pi_1(s_p)$, which is affected by the tax and which enters the certifier's objective function defined by (12). In this way, it can be shown that, compared to s_p^* (given in Section 4), the private certification standard is increased. Such a result is driven by the upward shift of the marginal revenue function in equation (13) above, modified after the introduction of an ad valorem tax. Finally, as welfare does not depend on the tax level in this case, the certification standard s_g^*, is not changed by the tax rate. Therefore, essentially because it moves s_p closer to s_g^*, an ad valorem tax policy is welfare improving.

Proposition 3. *Compared to the equilibrium under an unconstrained private certifier, an ad valorem tax policy on the unlabeled product only, the private certification standard is higher and welfare is improved.*

Proof. In the certification game the FOC is given by $MR_p(s_2) = MM(s_p)$ with

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

where A is a term independent of t and is given by the right hand side in equation (8) above. Then it is clear that $\dfrac{\partial MR_p(s_p)}{\partial t} > 0$ obtains.

As for welfare, the first derivative $\frac{dW}{dt} = \frac{\partial W}{\partial s_p}\frac{\partial s_p}{\partial t} + \frac{\partial W}{\partial t}$ where (i) $\frac{\partial W}{\partial t} = 0$, (ii)$\frac{\partial W}{\partial s_p} > 0$ in the relevant range, and (iii) $sign\frac{\partial s_p}{\partial t} = sign\frac{\partial MR_p(s_p)}{\partial t}$. Therefore, $\frac{dW}{dt}$ is positive as far as s_p is lower than s_g^*.

□

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 can be shown then that the equilibrium demand for both types of product decreases under an ad valorem tax, while the relative market shares remain unchanged. In fact, as a policy remark, it seems striking that if the tax aims at encouraging the consumption of the labeled good, it indeed obtains the opposite result, even though a welfare improvement is achieved.

It is worth noting that if the same tax is levied upon *both*, the labeled and the unlabeled good, then one can show that the certifier's marginal revenue function from an increase in the standard, shifts downwards, leading to the opposite result: a *lower* standard and a lower welfare level.[13] This aligns our finding to the result of Cremer and Thisse (1994) for the ad

valorem tax when the same rate applies to both goods and where the firms themselves choose their own qualities to maximize their profits (in their model there is no certifier and no MQS).

Per unit tax.

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

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

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:

$$p_1(s_1, s_2, \tau) = \frac{s_1\,(s_2 - s_1) + 2s_2\tau}{4s_2 - s_1}, \qquad p_2(s_1, s_2, \tau) = \frac{s_2\,(2(s_2 - s_1) + \tau)}{4s_2 - s_1}. \tag{20}$$

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, $\forall\tau \in]0, \underline{s}[$, and compared to s_p^*, the private certification standard is lowered by the tax, leading to tougher price competition and to higher 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^*, leading to ambiguous 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) $sign\frac{\partial s_p}{\partial t} = sign\frac{\partial MR_p(s_p)}{\partial t}$, 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 change the market equilibrium, or maybe to favor the consumption of the labelled good. A not too high per unit tax on the unlabeled good will drive the label level down with a negative impact total welfare. There are, further, two opposite effects on the demand to the unlabeled good: the decrease in s_2 increases it, on the other hand the tax leads to a decrease in the price difference $p_2 - p_1$. This second effect dominates and the demand for the unlabeled good decreases. The final effect on the demand for the labeled good, however, cannot be signed unambiguously.

If the unit tax is levied at the same rate on *both* goods, then it can be shown that the effect on total welfare is unambiguously negative, as one may have expected. As to the effects on prices and quantities, however, the effect is ambiguous. A unit tax, for given qualities, leads to an upward shift in both price reaction functions so that prices would increase if qualities were unchanged. However, since the private certifier reduces the level of the label, the quality difference between the two products is reduced and there is an increase in the intensity of (Bertrand) competition in prices, which pushes equilibrium prices downward. One cannot tell which effect dominates in general, so that the final effect on equilibrium prices and quantities is ambiguous. Even this is rather surprising, however, since one would expect that total demand unambiguously fall.

Subsidy.

A subsidy on labeled products can be used (or advocated). An example is provided by the subsidies allocated on a per-hectare basis to the organic farmers in several OECD countries (OECD, 2003).[14] We represent here a subsidy as a per unit subsidy λ. The profit function for firm 2 is changed to

$$\pi_2 = (p_2 + \lambda)D_2 - C(s_2). \tag{21}$$

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:

$$p_1(s_1, s_2, \lambda) = \frac{s_1\,(s_2 - s_1 - \lambda)}{4s_2 - s_1}, \qquad p_2(s_1, s_2, \lambda) = \frac{2s_2\,(s_2 - s_1 - \lambda)}{4s_2 - s_1}. \tag{22}$$

In the certification stage, the changes induced by a subsidy are, predictably, an increase in profit 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 direction of change in the result of the maximization of $\pi_2(s_p) - \pi_1(s_p)$ is not a priori clear. Compared to s_p^*, it can be shown that the private certification standard is lowered by a subsidy on the labeled product. 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.

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 subsidy on welfare is then ambiguous.*

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

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

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

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 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) $sign\frac{\partial s_p}{\partial \lambda} = sign\frac{\partial MR_p(s_p)}{\partial \lambda}$, the sign of $\frac{dW}{d\lambda}$ is ambiguous.

□

The result is always to be interpreted for small subsidies. The equilibrium prices of both goods can be shown to be lowered by the introduction of a subsidy, as it is quite intuitive considering that the quality difference is reduced and the price reaction function of the high quality shifts downward. The effect on the equilibrium demand for the labeled product can also be shown to be positive, while that on the demand for the unlabeled product is ambiguous. As a consequence it cannot be said if the average (weighted by the market shares) quality is increased or decreased, though given the decrease in the level of the label a decrease in

the unweighted average is obviously obtained. This is a surprising result and most likely an unintended one for a policy maker.

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 analyze the effects of 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. Surprisingly a per unit tax, which negatively affects the level of the private standard prevailing may not be desirable. We further show that subsidies to producing the labelled product have unintended effects since they push the private certifier to choose a lower certification level. The ad valorem tax targeted only to the unlabeled product emerges as the best policy option in terms of welfare, among those here considered, though with a caveat: the equilibrium consumption of both goods, labeled and unlabeled, will decrease.

We also show that when both, the public and the private certifier are in 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

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 Constantatos, C. (2015). "On the economics of labels: How their introduction affects the functioning of markets and the welfare of all participants". *American Journal of Agricultural Economics*, **97**(1):239–259.

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

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

Caswell, J. A. and Mojduszka, E. M. (1996). "Using informational labeling to influence the market for quality in food products". *American Journal of Agricultural Economics*, **78**(5):1248–1253.

Cremer, H. and Thisse, J.-F. (1994). "Commodity Taxation in a Differentiated Oligopoly". *International Economic Review*, **35**(3):613–33.

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

Fischer, C. and Lyon, T. P. (2014). "Competing environmental labels". *Journal of Economics & Management Strategy*, **23**(3):692–716.

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.

Gabszewicz, J. J. and Thisse, J.-F. (1979). "Price competition, quality and income disparities". *Journal of Economic Theory*, **20**(3):340–359.

Garella, P. and Petrakis, E. (2008). "Minimum quality standards and consumers information". *Economic Theory*, **36**(2):283–302.

Hamilton, S. F. and Zilberman, D. (2006). "Green markets, eco-certification, and equilibrium fraud". *Journal of Environmental Economics and Management*, **52**(3):627–644.

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.

Kiesel, K. and Villas-Boas, S. B. (2013). "Can information costs affect consumer choice? Nutritional labels in a supermarket experiment". *International Journal of Industrial Organization*, **31**(2):153–163.

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.

Marette, S., Messéan, A., and Millet, G. (2012). "Consumers willingness to pay for eco-friendly apples under different labels: Evidences from a lab experiment". *Food Policy*, **37**(2):151 – 161.

Motta, M. (1993). "Endogenous quality choice: Price vs. quantity competition". *The Journal of Industrial Economics*, **41**(2):pp. 113–131.

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

OECD (2003). *Organic Agriculture: sustainability, markets and policies*. OECD Publishing.

OECD (2008). *Promoting sustainable consumption: good practices in OECD countries*. OECD Publishing.

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.

Scherf, B. D. (2000). *World Watch List for Domestic Animal Diversity*. Rome, Italy: FAO.

Shaked, A. and Sutton, J. (1982). "Relaxing price competition through product differentiation". *The Review of Economic Studies*, **49**(1):3–13.

Taberlet, P., Valantini, A., Rezaei, H. R., Naderi, S., Pompanon, F., Negrini, R., and Ajmone-Marsan, P. (2008). "Are cattle, sheep, and goats endangered species?" *Molecular Ecology*, **17**(1):275–284.

Teisl, M. F., Roe, B., and Hicks, R. L. (2002). "Can eco-labels tune a market? evidence from dolphin-safe labeling". *Journal of Environmental Economics and Management*, **43**(3):339 – 359.

Wauthy, X. (1996). "Quality choice in models of vertical differentiation". *The Journal of Industrial Economics*, **44**(3):345–353.

Notes

[1]All attributes related to the production process of a good cannot be known by consumers either before or after consumption, such attributes are defined by the literature as credence attributes (Darby and Karni, 1973). When it comes to credence attributes, mechanisms (founded on bootstrap reputation and bayesian belief update) that deal satisfactorily with the asymmetric information problem become almost powerless, leaving certification by a reputable agent as the only possible mechanism for signaling quality (see Caswell and Mojduszka, 1996). In this way, even if price signalling cannot be totally excluded, yet is contingent on very restrictive assumptions (see e.g. Bonroy and Constantatos, 2008, and Garella and Petrakis, 2008). Hence, for credence goods markets, labels represent the main, if not the only source of reliable information, being in many cases a strict requirement for such markets to even exist.

[2]Scherf (2000) documents that 17% of cattle breeds and 14% of sheep breeds have already been lost and 1350 of farm breeds are threatened with exticntion. See also Taberlet *et al.* (2008).

[3]Ecocert, Scientific Certification System, Asbl Biogarantie, or OEKO-TEX are examples of for-profit private certifiers. Ecocert delivers labels to producers whose products fulfil standards developed by Ecocert and related to the human and environmental protection - organic cosmetics, environmentally friendly detergents, fair trade, ecological green spaces, are some examples. 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. OEKO-TEX delivers international labels certifying that a textile has been successfully tested in accordance with OEKO-TEX Standards, guaranteeing a textile to be harmless for human health, environmentally friendly, and socially responsible.

[4]See Bonroy and Constantatos (2015) for a detailled analysis of this literature.

[5]Bottega and DeFreitas (2009) and Manasakis *et al.* (2013) consider environments (multiproduct monopoly and symmetric firms) where a for-profit certifier sets a certification standard maximizing the high-quality firm's profit.

[6]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 appearance of a label, or because the production of its quality is trivial (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 $C(\underline{s}) = \frac{1}{2}\underline{s}^2$.

[7]It is important to remind here that the high quality producer cannot adopt profitable limit pricing strategies, that lead to zero demand for good 1, since $\underline{\theta}$ and variable costs are both zero.

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

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

[10]In a different set-up, a similar condition is required at equilibrium in Manasakis *et al.* (2013).

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

[12]As we noted previously, we consider that in equilibrium the low-quality firm has no advantage in supplying a quality superior to the MQS. In this way, $\underline{s}$ is higher than firm 1's best reply to both labels, private and public, so that in equilibrium only firm 2 adopts a label.

[13]By computation when both goods are taxed at the rate t one gets $\frac{\partial MP_p(s_p)}{\partial t} = -\frac{1}{4}\left(1 + \frac{3s_1^2}{(4s_p-s_1)^2}\right) < 0.$

This entails a lower total welfare.

[14]Governments may also use a subsidy to encourage consumption of high-quality products as sustainable products (OECD, 2008), in this case the subsidy is granted directly to consumers. Our results do not change whatever the agent receiving the subsidy: the high-quality firm or the consumers of the high-quality product. The only difference is the monetary transfer between these agents.