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Labelling by a for-profit certifier*

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Abstract

We analyze a for-profit certifier's eco-labelling policies in industries where firms have some *"countervailing power"*. We show that the certification standard for an environmental quality is lowered when firms bargain over the certification fee. This result is explained by the firms obtaining a positive profit when they do not adopt the label (an outside option). Without *"countervailing power"* the certifier would be able to extract the whole surplus from the labeling firm and would set a higher standard for the environmental quality. Taxes and subsidies aimed to increase the latter also affect the fee and the standard; the final effect of these policies may be shown to be reversed by the *"countervailing power"*.

Keywords: For-profit certifier, environmental quality, buyer power, tax, subsidy.

JEL classification: L13, L15, L5.

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1 Introduction

An environmental label must usually follow a set standard to which a labeled producer must comply. Certification to obtain labels is delegated to certifying bodies, that in this paper we term "certifiers", who grant permission to use a label only to firms that agree to the certifier analyzing and monitoring their production processes and their final products. Certification, therefore, is a costly activity. It has a market value, and there are now several for-profit private certification agencies that develop their own standards, monitoring requirements, and technologies, and deliver the corresponding labels. A report of the Corporate Sustainability Initiative (CSI) at Duke University reviews a survey of 150 ecolabeling organizations. This report indicates that for-profit certifiers represent the second highest proportion of the organizational structure of ecolabels (15%), preceded by non-profit certifiers (49%), and at the same level of public/private partnerships (15%) (see Golden, 2010). For-profit certifiers, providers of ecolabels, are generally present in manufacturing such as in textile and cosmetic industries (see e.g. Ecocert, Scientific Certification System, or OEKO-TEX).[1]

A for-profit certifier will use the certification fee to extract part of the firms' profits, which in turn depend upon the level of the standard. However, in industry markets, the certifier may be confronted to firms whose size confers of them a *countervailing power* (see Galbraith, 1952). In this case, this firms' ability to bargain on the fee ("firm power") modifies the standard as compared to when the certifier has full bargaining power ("certifier power"). This is, so to speak, the first result and level of analysis in the present paper. Few works consider for-profit certifiers as providers of labels. Bottega and DeFreitas (2009) compares the certification policies of a non-profit certifier and a profit certifier when the products are supplied by a monopoly. They show that the non-profit certifier always labels a higher quality than the for-profit certifier. Manasakis *et al.* (2013) provide an exten-

[1] Ecocert delivers labels to producers who meet the standards developed by Ecocert and related to human and environmental protection. Organic cosmetics, environment-friendly detergents, and 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. 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, environment friendly, and socially responsible.

sion of the previous result to the case where a monopoly certifies the quality of n firms competing à la Cournot. In addition to that, they show that the outcomes of the certification crucially depend on whether certification takes place before or after firms decide on their quality efforts. Recently Das (2015), analyses the optimal certification policy of a for-profit certifier in a Bertrand duopoly framework where two firms supply different variants of an environmental friendly product. He shows that when the variants are not sufficiently horizontally differentiated, then only one firm opts for the certification whereas the other supplies the lowest quality. Unlike our paper, the literature always assumes firms without any countervailing power in the business relationship with the supplier of certification. If this assumption seems fit several markets where producers are many and small (as e.g. for agricultural markets), it does not fit reality for many industrial markets where the large firms have generally an advantage in haggling for price concessions from suppliers, certifier included.

We consider two firms engaged in price competition in a vertical differentiation model (as in Gabszewicz and Thisse, 1979, and Shaked and Sutton, 1982). The differentiation dimension is the environmental quality, representable by a measurable index ranging from a base quality (or a Minimum Quality Standard set for the industry) to a maximum obtainable level. A higher average quality in the market also provides a higher positive externality for the environment, hence the level of the standard also affects the level of the externality. Due to moral hazard a higher standard than the base quality cannot be communicated directly by a firm to its customers (as in Roe and Sheldon, 2007).[2] The firm is therefore left with the options to produce the base quality or to adopt the label, certified by a for-profit certifier. In this set up, since firms gain from differentiating their products, they have no incentive to share the label. Firms then are also competitors in that they *compete for labeling*.[3]

[2]Environmental characteristics are defined by the literature as credence attributes (Darby and Karni, 1973). Revelation mechanisms hinging on bootstrap reputation and bayesian belief update become almost powerless with credence attributes, leaving certification by a reputable agent as the only possible mechanism for signaling quality (see Caswell and Mojduszka, 1996).

[3]Note that there exist labels shared by many producers and then there is no competition for labeling. This is typical of agricultural labelling, where producers adopt a collective label in order to benefit from a collective reputation (see e.g. Hamilton and Zilberman, 2006). Certifiers then also serve as monitors to prevent free-riding by labeled firms (see Baksi and Bose, 2007). By contrast, in our work, firms compete

We show that firm power, within the relationships between firms and private certifier, leads to a lower certification standard as compared with the one chosen under certifier power. In the latter case the standard would in fact coincide with the one which maximizes the labeled firm's profit, gross of the certification fee. By contrast, under firm power the certifier's profit as a function of the standard no longer coincides with the (gross of the fee) profit of the labeled firm. This difference is due to the existence of an "outside option" for the firm that pays the certification fee, providing a floor for this firm's equilibrium payoff.

Assuming firm power gains significance when we consider a private certifier and policies like taxes or subsidies. Since a market failure occurs in any case, reducing the distance between the socially optimal level for the standard and the level chosen by the private certifier is always socially desirable, whether firm power prevails or not. However, we show that the effects of a green tax or subsidy on the certification level are not as obvious as one may expect. Furthermore, the effects of the policies depend upon whether there is firm power or not. This is because these policies affect the market outcome and the externality not just through the pricing mechanism but also and maybe primarily through the standard chosen for the label. The environmental standard actually depends upon the fee extraction incentives for the certifier, which in turn are affected by anything, like taxes or subsidies, altering the firms equilibrium profits in the price game. Through this channel, for instance, a subsidy for the labeled (environment friendly or "clean") product worsens the environmental performance of the market outcome while under certifier power it improves it. In particular, compared to the equilibrium where the certifier sets the certification fee, in the presence of firm power (i) an ad valorem tax on the unlabeled good increases the eco-label standard instead of being neutral, and welfare is improved instead of unaffected; (ii) a per-unit subsidy on the labeled good decreases the private certification standard, instead of increasing it, and social welfare is reduced instead of increased—with a complete reversal of the effects. As a per unit tax on the unlabeled product decreases the private certification

for the label because a firm has no incentive to share it with rivals. This situation is typical of oligopoly competition, particularly when the main source of products differentiation in inter-firm competition is the attribute certified by the label (see e.g. Roe and Sheldon, 2007, and Das, 2015).

standard in any case, it should not be recommended based upon the results of our analysis.

The present paper is related to the literature on labeling (see Crespi and Marette, 2005, Roe *et al.*, 2014 and Bonroy and Constantatos, 2015 for surveys on the economics of labeling) and to the literature on green taxes, although the latter is mainly concerned with producers choosing their environmental qualities so as to maximize their own profits (see e.g. Cremer and Thisse, 1999, Constantatos and Sartzetakis, 1999, Moraga-González and Padrón-Fumero, 2002, and Brécard, 2011). Yet in the presence of a certifier, when a firm adopts an eco-label, provided by a for-profit certifier, it must follow a prescribed standard for environmental quality, otherwise the label is refused or withdrawn. The environmental quality may be thus determined by the private certifier—and owner of the label—and not by the firm. This is why the presence of a certifier is likely to modify the effects of taxes and subsidies as policy tools.

The paper is organized as follows. Section 2 presents the model's assumptions. Sections 3 and 4 analyze the certification standard when the certification fees are respectively set by the certifier and by the firms. Section 5 considers the interactions between private certifier and environmental taxes or subsidies. Finally, Section 6 concludes.

2 The model

We consider a market with two producers selling vertically differentiable products to a population of consumers. Each product is characterized by an environmentally relevant and measurable attribute, s, also called its "environmental quality". The higher its level, the better the environmental performance of the good. Consumers care for this attribute. Firm i produces a good with environmental quality at level s_i, a real number, and sells it at price p_i, with $i = 1, 2$.

To simplify we assume that there are no variable costs in production but that, in order to achieve the desired environmental quality, firms must incur development costs that are increasing in quality.

We assume, in particular, that a "base" quality product defined by a minimum quality standard $\underline{s}$ can be developed by firms at no cost. However, the quality of the product can be increased by firms only if they pay a development cost, $C(s)$, incurred prior to physical production, and defined as follows:[4]

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

We consider consumers' preferences as described in Mussa and Rosen (1978). Each consumer has a type θ which is uniformly distributed over the interval $[0, 1]$ (the density is equal to 1 and hence the population mass is also equal to 1). Each consumer buys at most one unit of the indivisible good; similarly to Cremer and Thisse (1999) the utility function of a consumer of type θ is defined as:

$$U_\theta(s, p) = \theta s + \gamma\theta s_a - p \tag{2}$$

when she consumes a unit of product of quality s sold at price p. The term $\gamma\theta s_a$ is a positive externality associated with the average environmental quality consumed, s_a, where the intensity of the externality effect is measured by the positive parameter γ, which is constant over the population of consumers[5]. This positive externality is the way in which the consumer is affected by the environmental market outcome. If γ is zero, which is also possible, then the utility of the consumer is only affected by the environmental quality that she consumes individually (for instance a consumer only cares about her contribution to the environment). On the other hand a positive γ implies that the choice of the rest of

[4]We consider that providing the base quality does not require any developing costs either because the corresponding investment ($C(\underline{s}) = \frac{1}{2}\underline{s}^2$) has been sunk, or because the production of the base 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 $C(s) = \frac{1}{2}(s^2 - \underline{s}^2)$. Note that the model would be unaffected had we introduced a first stage where firms decide whether or not to enter the market, entry being contingent upon an investment in the base quality $C(\underline{s}) = \frac{1}{2}\underline{s}^2$.

[5]Without loss of generality, instead of a positive one, we may consider a negative externality given by $\gamma(\overline{s} - s_a)$, with $\overline{s}$ the unabated emission intensity of the product and s_a the average abatement effort of firms (see Lombardini-Riipinen, 2005)

the population determines the well-being of a consumer, even for consumers who do not consume any unit of the good. Because an individual cannot affect the average quality, the externality term will be a constant in the optimization problem of each consumer. The externality term therefore has no relevance in the decision about buying from firm 1 or 2, or whether to buy or not, and ultimately it has no effect on the duopoly equilibrium (see Cremer and Thisse, 1999). Finally, it is worth reminding that the term relating to the externality, since it enters the individual utilities, cannot be considered constant in the evaluation of the welfare in the industry; and in particular, in the evaluation of public policies (Proposition 1 and Section 5).

Furthermore, we assume that when a product is certified by a label, consumers know for sure that the quality meets that standard. Note that differently from Lizzeri (1999) the certifier of a label has a single disclosure policy: he chooses the certification standard and only certifies if a product meets or not this one. Without any label, consumers cannot ascertain the quality of a good neither before nor after purchase (quality is here a credence attribute), so that they expect to buy the *base quality*. This base quality can also be seen as being determined by an exogenous minimum quality standard (MQS), denoted as $\underline{s}$. The presence of a label or its absence thus defines a consumer perception of the environmental quality of a product.

Given that firms can improve their product's quality only by increasing their costs, it is natural to assume here that a consumer expects the base quality 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 private or public supervisory body, entrusted with the task of controlling the firms' behavior with regard to 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, e.g because uncertified labeling is equally costly for any type of product, e.g. truly eco-dyed fabrics or not.

We assume, furthermore, that self-certification is not technically feasible (or it could be manipulated) and that a certifier is needed. A "monitoring" cost, borne by the certifier, is then incurred in order to ascertain that the good's quality respects the standard defined by the label. 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 $\partial MM(s)/\partial s \geq 0$. As in Bottega and DeFreitas, 2009 and Manasakis *et al.*, 2013, we consider that the certifier sets a fixed fee F that firms must pay in order to obtain the labeling. Here this fee represents the payments that a producer must pay to certify its production with a label delivered by for-profit private certifiers. For instance OEKO-TEX's certification fee include the licensing fee. We proceed in line with the existing literature and assume that the certifier is independent and honest.

In general, the incentives of the certifier and firms are not aligned. The question of which side has the initiative when the certification fee is set, is therefore important as it bears consequences not only on the profits of both the certifier and the firms, but also on the certification level of the label. As we show below, the effects of public policies also crucially depend upon how the fee is negotiated.

To capture the possible differences in the incentives of certifier and firms, we shall compare two polar cases: (i) certifier power: the certifier makes take-it-or-leave-it offers to the firms, and (ii) firm power: the two firms make offers to the manufacturer in a non-cooperative fashion. In both cases, frequently used policies (tax, subsidy) are considered.

3 Certifier power

When the certifier offers contracts to firms we consider the following three-stage game:

1. At the first stage the certifier sets the certification standard s_2 and the respective fee F.

2. At the second stage each firm decides whether to adopt the label or not. A firm that does not adopt any label supplies the base quality $\underline{s}$; a firm that adopts the label pays the fee to the certifier, and incurs the supplementary development cost $C(s_2)$ that enables it to provide quality which conforms to the certification standard.

3. At the third stage firms simultaneously choose prices and competition is resolved.

3.1 Price Competition

At the last stage, price competition, the environmental quality levels are given and we assume without loss of generality that $s_2 \geq s_1$, so that firm 1 shall always be the low quality firm. We shall denote a good by its s_i 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

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

All consumers with $\theta > \widetilde{\theta}\,(p_1, p_2)$ strictly prefer product s_2 to s_1. Some consumers may refrain from purchasing at all. 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). This results in 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[6]:

$$\begin{cases} D_1(p_1, p_2) = \widetilde{\theta}\,(p_1, p_2) - \theta_1\,(p_1) \\ D_2(p_1, p_2) = 1 - \widetilde{\theta}\,(p_1, p_2)\,. \end{cases} \tag{4}$$

Firms choose prices to maximize their profits $\pi_i(p_i, p_j) = p_i D_i(p_i, p_j) - C(.)$, with $i = 1, 2$, $i \neq j$. Note that as the certification fee is independent of the level of production, we consider here firm 2's profit gross of the fee, to simplify the exposition.

The resulting best reply function of each firm is upward sloping and linear in the rival's price: the best reply for firm 1 is $p_1 = \frac{p_2 s_1}{2 s_2}$, that for firm 2 is $p_2 = \frac{p_1 + s_2 - s_1}{2}$ (see Choi and Shin, 1992).

The Nash equilibrium prices are given by

[6] 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.

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

The equilibrium firms' profits (as it is assumed $0 < s_1 < s_2$) are given by:

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

It can easily be verified that, for a given level of s_1, the profit $\pi_1(s_1, s_2)$ of firm 1 increases as the rival's quality s_2 increases; by contrast, for a given level of s_2, the profit $\pi_2(s_1, s_2)$ decreases as the rival's quality s_1 increases. Finally, if $s_1 = s_2$ profits gross of development costs are zero.

3.2 Choice of certification level and associated fee

At the third stage, if both products are perceived to be of identical environmental quality, the ensuing Bertrand equilibrium entails prices equal to marginal costs (here zero for simplicity). If development costs are positive, firms make then negative profits, or zero profits if both firms produce the MQS. Both firms therefore have an incentive to differentiate their products. Accordingly, if firm i adopts the label, the best reply by firm j is not to adopt it. As a result only one firm adopts the label in equilibrium; technically, there are two possible asymmetric equilibriums, one with firm 1 and one with firm 2 being the labeled firm.[7]

In line with our notation in what follows we assume that firm 1 is the one not choosing the label. This firm supplies the minimum quality standard, $s_1 = \underline{s}$. In any case, any different choice by the unlabeled firm could not be communicated to consumers, who would anyway perceive the unlabeled quality as $\underline{s}$. To shorten the notation, we define $\pi_1(s_2) = \pi_1(\underline{s}, s_2)$ as firm 1's profit when it produces the MQS level against s_2; similarly, we let $\pi_2(s_2) = \pi_2(\underline{s}, s_2)$.

[7] In our work, at equilibrium, the label is not adopted by all firms. This ouctome is driven by the duopoly framework; however it may also hold in an oligopoly framework where horizontal variants of a product can be made more or less environmentally clean as in Das (2015). In such an environment, both firms i and j that provide horizontal variants sufficiently differentiated may then share the label, while an other firm k that provides a variant too close to one of i or j does not adopt it.

A private certifier sets the certification standard s_2, and firms decide whether to adopt it or not. If a firm adopts the standard it has to pay a fee $F(s_2)$ to the certifier. Both firms gain from escaping the Bertrand-like trap due to imperfect information on qualities. The profit of the environmental labeled firm then becomes $\pi_2(s_2)$ and that of the other $\pi_1(s_2)$. The labeled firm should then pay a certification fee $F(s_2)$ which must at least cover the costs $M(s_2)$, with $M(s_2) \leq F(s_2)$. Obviously, the maximum fee that a firm can agree to is defined by the equivalence $\pi_2(s_2) - F_2(s_2) = 0$.

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

$$\max_{s_2} \{\pi_2(s_2) - M(s_2)\}. \tag{7}$$

To avoid trivial cases we assume that the set of environmental quality levels s_2 such that $\pi_2(s_2) - M(s_2) > 0$ is not empty. The first order condition (FOC) of (7) under certifier power can be written as:

$$MR_{cp}(s_2) = MM(s_2), \tag{8}$$

where $MR_{cp}(s_2)$, the marginal revenue function, is given by

$$\frac{\partial \pi_2}{\partial s_2} = \frac{1}{4} - s_2 + \frac{\underline{s}^2 (20 s_2 + \underline{s})}{4 (4 s_2 - \underline{s})^3}, \tag{9}$$

and with $MM(s_2) \equiv \frac{\partial M(s_2)}{\partial s_2}$, the marginal monitoring cost. Since $MR_{cp}(s_2)$ is continuous and decreasing and $MM(s_2)$ continuous and increasing in s_2, the certifier's profit function given by $\pi_2(s_2) - M(s_2)$ is concave, and the FOC has a unique solution denoted s^*_{cp}.[8] As in line with Manasakis *et al.*, 2013 and Bottega and DeFreitas, 2009, the for-profit certifier with all bargaining power sets the certification standard at a level that maximizes the firm's gross profits from certification.

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

4 Firm power

In this section we assume that firms have the ability to bargain over the fee for obtaining the label. Accordingly, we consider a game where firms act as duopsony and make simultaneously offers to the certifier.[9] The certifier sets a certification level and firms can "buy" the certification by submitting a fee.

For the purpose of this specification of the game a offer is intended as a payment proposal made of two entries: (f_i, f_i^S) where f_i refers to a non-shared certification, while f_i^S applies to a certification shared by both firms. In other words each offert is contingent on the number of accepted offers (see e.g. Miklós-Thal *et al.*, 2011). Such a menu of offers allows to consider the number of certified firms in the negotiation.

To avoid any misinterpretation, it is very important at this point to anticipate that in what follows the certifier in equilibrium will accept at most one offer. As it shall become apparent this result depends upon firms falling into a Bertrand trap with zero profits if they both certify. Clearly, if firms have capacity constraints then profits under double certification (gross of the fee) may be positive, such as positive offers f_i^S would be possible in equilibrium, and double certification could be obtain.[10] This however is not essential to our arguments since what matters in the present game is that the payoff under the *non-certification* option depends on the standard—as it shall become apparent in the sequel. This outside option—to stay without label against a labeled rival firm—must in any case remain "unbeaten" for a firm accepting certification.

The game then unfolds as follows:

1. At the first stage the certifier sets the certification level s_2.

2. At the second stage each firm i offers a pair of options $\left(f_i, f_i^S\right)$.

3. At the third stage the certifier accepts or rejects offers. A firm whose offer is accepted

[9]Such a game enables to solve the (extreme) case where firms set the certification fee, or in other words where the certifier has no bargaining power.

[10]In a standard duopoly model of vertical product differentiation where firms compete in prices, Boccard and Wauthy (2010) show that in the presence of capacity constraints, there exists symmetric equilibrium where both firms select the highest quality and share the monopoly profits.

pays the fee to the certifier, and incurs the supplementary development cost required to attain the quality that conforms to the certification standard. An uncertified firm supplies the minimum quality $\underline{s}$.

4. At the final stage both firms simultaneously choose prices and competition is resolved.

4.1 The negotiation game

Prior to solving the game in detail we state a useful result that greatly simplifies the analysis.

Lemma 1. *The strategies for firm i involving $f_i^S > 0$ are weakly dominated by strategies with $f_i^S = 0$.*

Proof. See Appendix 1 □

Lemma 1 implies that for stages 3 and 4 if we impose backward rationality (or trembling hand subgame perfection) we can analyze only the subgames starting after offers $f_i^S = 0$ and therefore restrict attention to non-shared certification.

To find the solution to the game we proceed by imposing sequential rationality and using backward induction. The solution to stage 4, which is the last, is already provided in subsection 3.1. To analyze stage 3 we must describe the certifier's best reply function to the received offers f_i, and we can ignore the offers f_i^s since they are null in this subgame. Given a offer pair (f_A, f_B), if the certifier accepts f_i he obtains $f_i - M(s)$; if he refuses both offers his payoff is zero. Let $f' \equiv \max\{f_A, f_B\}$, then the best reply for the certifier is:

$$\begin{cases} (i) \text{ if } f' < M(s_2) \text{ reject both offers} \\ (ii) \text{ if } f' > M(s_2) \text{ and } f_A \neq f_B, \text{ accept } f' \\ (iii) \text{ if } f' > M(s_2) \text{ and } f_A = f_B, \text{ randomize.} \end{cases} \tag{10}$$

If $f' < M(s_2)$ the certifier would make a loss by accepting any offer. Case *(ii)* is self-evident. Case *(iii)* is the way to solve a tie.

We now proceed with stage 2. As above, 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 $\pi_2(s_2) = \pi_2(\underline{s}, s_2)$. Thus, if an offer is accepted, the firm with the accepted offer (if any) gets $\pi_2(s_2) - f_i$ in the ensuing price game in stage 4; the firm with rejected offer gets $\pi_1(s_2)$. If no offer is accepted the firms produce $\underline{s}$ and obtain a null profit at stage 4.

Given s_2, assume first that $\pi_2(s_2) - M(s_2) > 0$ *(A.A.)* and analyze all possible pairs of offers and possible *unilateral* deviations in order to check for all possible pair of mutual best replies in the subgame starting after s_2. Denote firms as A and B.

1. (f_A, f_B) with $f' = \max\{f_A, f_B\} \leq M(s_2)$ cannot be a pair of mutual best replies because the certifier would reject both offers and $\pi_A = \pi_B = 0$, while given Assumption *(A.A.)* there exists ε (small enough) such that for $f_i = \varepsilon + M(s_2)$ the certifier accepts f_i at stage 3 and firm i obtains $\pi_2(s_2) - M(s_2) - \varepsilon > 0$.

2. (f_A, f_B) with $f_i > f_j$ and $f_i = f' > M(s_p)$ cannot be mutual best replies because the winning firm i can choose ε small enough, offer $f_i = f' - \varepsilon > f_j$, and still win.

3. If $f_A = f_B = f$ then the certifier will randomize its choice by assigning probability γ to firm i and $1-\gamma$ to firm j, with $0 < \gamma < 1$. At any $(f_A, f_B) = (f, f)$ the expected payoff to firm i (respectively to firm j) is $\gamma\,[\pi_2(s_2) - f] + (1-\gamma)\,[\pi_1(s_2)] = E_i$ (respectively $(1-\gamma)\,[\pi_2(s_2) - f] + \gamma\,[\pi_1(s_2)] = E_j$). Now, for any γ, firm i could deviate to $f - \varepsilon < f$, lose the offer and get payoff $\pi_1(s_2)$ for sure instead of E_i. Such a deviation is profitable if for some $\varepsilon > 0$ (using a shortened notation) $\pi_1 > \gamma\,(\pi_2 - f) + (1-\gamma)\pi_1$ or $(\pi_1 - \pi_2 - f) > \varepsilon$. In order to exclude such a deviation for all $\varepsilon > 0$ it is therefore necessary to have $\pi_1 \leq \pi_2 - f$ (c.1). Similarly, the same firm i could deviate to $f + \varepsilon > f$ and win for sure to obtain $\pi_2 - f - \varepsilon$ instead of E_i. In order to exclude such a deviation it must be true that $\pi_2 - f - \varepsilon < \gamma\,(\pi_2 - f) + (1-\gamma)\pi_1$ or $(1-\gamma)(\pi_2 - f - \pi_1) > \varepsilon$; in order to exclude this possibility for any $\varepsilon > 0$ it must be $\pi_2 - f \leq \pi_1$ (c.2). Putting together (c.1) and (c.2) implies $\pi_2 - f = \pi_1$. This reasoning, being independent of γ, applies to firm j as well as to firm i; therefore for both firms to use (f, f) it must be

true that $\pi_2(s) - f = \pi_1(s)$.

The only possible pair of offers that can be part of a subgame perfect Nash equilibrium therefore is $(f_i, f_j) = (f_s, f_s)$ where f_s is such that

$$f_s = \pi_2(s_2) - \pi_1(s_2). \tag{11}$$

To complete the reasoning, assume now that *(A.A.)* is violated and $\pi_2(s_2) - M(s_2) < 0$. Any acceptable offer would then lead to negative profits for the firm. In this case any pair of offers lower than or equal to $\pi_2(s_2)$ is an equilibrium pair, but the certifier refuses the offers and firms produce the base quality. All agents, including the certifier, make zero profits.

Lemma 2. *Under firm power, if s_2 is set such that $\pi_2(s_2) - M(s_2)$ is nonnegative, then the certification fee is given by $F = \pi_2(s_2) - \pi_1(s_2)$. Furthermore, after paying the fee, the labeled firm has the same equilibrium profit as the unlabeled one.*

The equilibrium fee offered by the winning firm is such that firms make the same equilibrium profit, $\pi_1(s_2)$. If a firm unilaterally deviates to offer less than f_s it will obtain $\pi_1(s_2)$, with no gain. An offer above f_s will lead the firm to obtain $\pi_2(s_2) - f_s - \varepsilon = E - \varepsilon$ instead of E, leading to a lower profit than by sticking at f_s.

We may note that under firm power the upper bound for the fee is limited by what is the profit that a firm would obtain by staying itself without a label and leaving the label to the rival; this profit acts like as an outside option for firms.[11]

The choice of the standard s_2 made at stage 1 by the private certifier is considered in the following subsection.

4.2 Choice of certification level

Stage 1. At stage 1 any choice s_2 that violates *(A.A.)* implies zero profits for the certifier and is strictly dominated by the choice of s_2 such that *(A.A)* holds true, since this leads

[11] In an market with more than two firms, this "outside option" is also positive when firms' products are differentiated according to at least two attributes, incluing the certified one. An example is when firms supply horizontal variants of a product that can be made more or less environmentally clean.

to acceptable offers equal to $f_s = \pi_2(s_2) - \pi_1(s_2)$. Hence, the certifier chooses s_2 so as to maximize $f_s - M(s_2)$, namely to solve:

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

Whence the following FOC obtains:

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

with $MR_{fp}(s_2)$, 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 $MR_{fp}(s_2)$ 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 a unique solution, denoted s^*_{fp}.[12]

By comparison with the certification level when the certifier offers a take-it-or-leave-it contract to firms, we find that $s^*_{cp} > s^*_{fp}$. Furthermore, irrespective of the agent offering the contract (certifier or firms) the certification level is always lower than the socially optimal certification level s^*_g (see Appendix 2 for the derivation of the socially optimal certification). The following proposition summarizes these results.

Proposition 1. *i) The private certification standard is always lower than the socially optimal certification standard; its level is lower under firm power than under certifier power, namely $s^*_g > s^*_{cp} > s^*_{fp}$. ii) The distance $s^*_g - s^*_{cp}$ increases with the externality intensity γ.*

Proof. i) For all $s_2 > \underline{s}$, the inequalities $MR_g(s_2) > MR_{cp}(s_2) > MR_{fp}(s_2)$ are verified, with $MR_g(s_2)$ the marginal revenue function of the government given by the equation (24). Therefore for $MM(s) > 0$ and $\partial MM(s)/\partial s \geq 0$ we have $s^*_g > s^*_{cp} > s^*_{fp}$. See Figure 1 for a graphical illustration. ii) See Lemma 3 in Appendix 2.

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

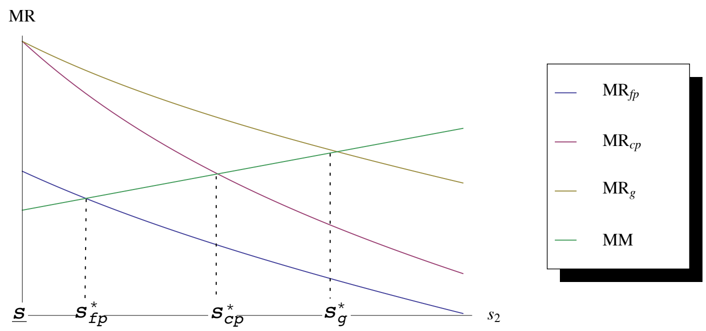

Figure 1: Graphical representation of the FOCs for $MM(s_2) = s_2$ and for $\gamma = 0$.

□

Our result, that a for-profit monopoly private certifier may set 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 that maximizes the firm's profit. In our approach, crucial to the result is the existence of an (endogenous) reserve profit, given by the "firm power" and 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 intervention

Given the result in Proposition 1 it is natural to ask whether traditional policy tools like taxes or subsidies may increase the private standard towards the socially optimal level, and whether this increases welfare. It is worth stressing that this possible basis for taxes and subsidies differs from the usual arguments resting on discouraging the consumption of goods with poor environmental standards, while encouraging that of "cleaner" or environment friendly ones. In our framework, demand effects of taxes and subsidies are brought forth by changes in the certification standard, which in turn also affects consumer welfare directly (also through the externality term).

Possible policies include encouragement of the production of the labeled product by means of a unit subsidy that eventually determines a lower final price in the market, or a tax on the unlabeled product so as to discourage its consumption and favor that of the labeled good. We distinguish in particular between an *ad valorem* and a *per-unit* tax. In the following we consider the "firm power" case, and we compare the results with those obtained with "certifier power".

A tax on the unlabeled product may or may not shift the best reply function of firm 1 in the price game, according to whether it is a per-unit or an ad valorem tax. It also affects the firms' profits and the solution in the negotiation game. In fact we shall see that this effect plays an important role in the analysis. We start with the analysis of a unit subsidy on production and then proceed with the analysis of taxes.

Subsidy

Consider a subsidy for the production of the labeled product consisting in the transfer from the government to the producer of a fixed amount of money for each unit sold. We call this a *subsidy policy.*[13] We represent a subsidy here as a per-unit subsidy λ. The profit function in the price game for firm 2 is changed to

$$\pi_2(p_1, p_2, \lambda) = (p_2 + \lambda)D_2(p_1, p_2) - C(s_2). \tag{15}$$

In the price game, it is clear that if one depicts the best reply functions in the space of ordinate pairs (p_1, p_2), then the best reply function of firm 2 is shifted downward, and the equilibrium prices *for given* s_1 *and* s_2 are both lowered by the presence of a subsidy. One does not know however if the change in s_2 caused by the subsidy will increase or lower prices. The Nash equilibrium prices as functions of qualities, denoted by $p_i(s_1, s_2, \lambda)$, are

[13]Note that governments may use a subsidy to encourage consumption of high-quality products such as sustainable products (OECD, 2008). In this case the subsidy is granted directly to consumers. Our results remain valid, irrespective of 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.

indeed equal to:

$$p_1(s_1, s_2, \lambda) = p_1(s_1, s_2) - \frac{s_1\lambda}{4s_2 - s_1}, \qquad p_2(s_1, s_2, \lambda) = p_2(s_1, s_2) - \frac{2s_2\lambda}{4s_2 - s_1} \tag{16}$$

where $s_1 = \underline{s}$ and $p_1(s_1, s_2)$ and $p_2(s_1, s_2)$ are the equilibrium prices in (5).

Under firm power, in the certification game the certifier will manipulate s_2 considering the effects of the subsidy on the equilibrium offer, $f_s = \pi_2(s_2, \lambda) - \pi_1(s_2, \lambda)$. Therefore, on the one hand the certifier's marginal revenue from an increase in s_2 is enhanced by the positive effect of a subsidy on the marginal effect of s_2 on $\pi_2(s_2, \lambda)$, on the other hand the subsidy leads to a change in the function $\pi_1(s_2, \lambda)$ — implying a higher marginal effect of s_2 on $\pi_1(s_2, \lambda)$. The direction of change in the result of the maximization of $\pi_2(s_2, \lambda) - \pi_1(s_2, \lambda) - M(s_2)$ is therefore not clear a priori. However we show that, compared to s^*_{fp}, 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. By contrast, under certifier power, it is apparent from equation (8) that only the positive effect on $\pi_2(s_2, \lambda)$ remains, and as a consequence the subsidy increases the certification level and is welfare improving.

Proposition 2. *i) Under firm power, a not-too-high subsidy policy decreases the private certification standard, with a negative impact on welfare. The total effect of a subsidy on welfare is then ambiguous. ii) By contrast, under certifier power, the private certification standard is increased and welfare is unambiguously improved.*

Proof. See Appendix 3. □

The result is to be interpreted for small subsidies. Under firm power the equilibrium prices after the change in s_2 are both lowered by the introduction of a subsidy, which is quite intuitive considering that: (i) the quality difference is reduced and (ii) the price reaction function of the high quality shifts downward, as discussed above. The effect on the equilibrium demand for the labeled product can also be shown to be positive, as this firm attracts consumers who would buy from the rival if the subsidy was zero. This increase in demand is entirely due to the lower equilibrium price difference since firm 2's labeled quality is lowered by the subsidy. The change in the demand for the unlabeled product cannot be signed (see Appendix 4). This seller, given that $s_1 = \underline{s}$ and that its equilibrium price is lowered by the standard, also sells to consumers that did not purchase before the introduction of the subsidy, thereby countervailing the loss of consumers that buy from firm 2.

Under firm power, the desirable increase in consumption of the labeled product is obtained at the cost of a lower standard. As a consequence it cannot be said if the average quality (weighted by the market shares) is increased or decreased. This is a surprising result and most likely an unintended one for a policy maker.

Under certifier power the effect on prices and on the demand for the labeled product is ambiguous. Nonetheless the overall welfare effect is positive, as it is driven by the increase in the standard.

Summarizing, a subsidy has opposite effects on the level of the standard in the two cases: negative under firm power and positive under certifier power. The welfare effect cannot be signed under firm power while it is positive under certifier power; however, we can say that firm power always reduces the welfare improvement induced by a subsidy due to the negative effect on the standard.

Per unit tax

Normally a (unit) subsidy generates opposite effects to a unit tax. Therefore one could expect that if a subsidy reduces the private standard, as under firm power, a tax may succeed in increasing it. This intuition is however misleading, because the channel through which the tax or the subsidy affects the standard is the objective function of the certifier. The tax reverses the result only in the case of certifier power, where the subsidy improves the standard while the tax lowers it. Consider a tax targeted *only* on the unlabeled product, and that we call a *per unit tax policy.* Obviously one can only consider tax rates that allow firm 1 to have a positive equilibrium profit. A per unit tax, τ, on the unlabeled product changes firm 1's profit in the price stage to

$$\pi_1(p_1, p_2, \tau) = (p_1 - \tau)D_1(p_1, p_2) - C(s_1). \tag{17}$$

In the price game, it is clear that firm 1 responds with a higher price to any price by the rival (its best reply shifts to the left). Since prices are strategic complements, the equilibrium prices for given s_1 and s_2 are both higher than without a tax (firm 2's best reply remains unchanged). The Nash equilibrium in the price game is then given by:

$$p_1(s_1, s_2, \tau) = p_1(s_1, s_2) + \frac{2s_2\tau}{4s_2 - s_1}, \qquad p_2(s_1, s_2, \tau) = p_2(s_1, s_2) + \frac{s_2\tau}{4s_2 - s_1}. \tag{18}$$

Under firm power, in the certification game the effect of the tax on the private certification standard s_p depends upon its effect on both the high-quality firm's profit, π_2, and the reserve profit π_1. For this reason, $\forall \tau \in]0, \underline{s}[$, and compared to s^*_{fp}, the private certification standard is lowered by the tax. This outcome, again, is driven by the downward shift of the marginal revenue function in equation (13) above, modified by the introduction of a unit tax. The downward shift moves s_2 away from s^*_g, leading to ambiguous effects of a per unit tax policy on the welfare. It is furthermore easy to show that the signs of the effects are the same in the case with certifier power, where the certifier maximizes $\pi_2(s_2, \tau) - M(s_2)$.

Proposition 3. *Under both certifier power and firm power, a not-too-high per unit tax policy lowers the private certification standard. This has a negative effect on welfare, so that the tax total effect on welfare is ambiguous.*

Proof. See Appendix 5 □

Under firm power, the effect on the level of equilibrium prices is ambiguous. Since qualities are brought closer together by the tax, price competition is exacerbated. However the tax also pushes prices upward via the displacement in firm 1's reaction function. There are, also, two forces, countering each other, that affect the *demand* for the labeled good:

the decrease in s_2 and the decrease in the equilibrium price difference $p_2 - p_1$ (and in the relative price p_2/p_1). The final effect on the demand for the labeled good can be shown to be positive, it is entirely due to the lower relative price (see the Appendix 6).

To summarize, under both regimes, a trade-off arises in terms of quality and consumption: a unit tax *increases* consumption of the labeled good (possibly as intended by the policymaker) but *lowers* the certification standard, thus reducing the desired "environmental quality" of the labeled good.

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 in the price game is then defined as:

$$\pi_1(p_1, p_2, t) = p_1(1-t)D_1(p_1, p_2) - C(s_1). \tag{19}$$

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 does not hold for the unit tax or for the subsidy) 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. Under firm power, in the certification game, the effect of the tax on the private certification standard, s_2, only depends on the reservation profit $\pi_1(s_2, t)$, which is affected by the tax. It can then be shown that, compared to s^*_{fp} (given in Section 4.2), 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. It is also easy to show that if we consider "certifier power" an ad valorem tax has no effect whatsoever on the certification level (s^*_{cp}).

Proposition 4. *i) Under firm power, a not-too-high ad valorem tax policy on the unlabeled product increases the private certification standard; total welfare is improved. ii) By contrast, under certifier power the tax has no effect on the private certification standard or on* *welfare.*

Proof. See Appendix 7 □

It is interesting to consider that under firm power the increase in s_2 leads to a higher degree of differentiation, which relaxes price competition and entails a higher price level for both products (see Appendix 8). It can be shown then that the equilibrium demand for both types of product decreases under an ad valorem tax. As a policy remark, it seems striking that while the tax aims at encouraging the consumption of the labeled good, it actually obtains the opposite result, even though a welfare improvement is achieved.

It is worth noting that if the same tax is levied on *both* the labeled and the unlabeled good, then the certifier's marginal revenue function can be shown to shift downwards, leading to the opposite result: a *lower* standard and a lower welfare level.[14] 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).

Certifier's profit and firms' profit

Consider now how the certifier and the firms are affected by tax and subsidy policies.[15] We show that the certifier always benefits from taxes and subsidies.[16] Under certifier power, by setting the certification fee the certifier may capture the entire benefit provided by the policy to the subsidized producer or (indirectly) to the non-taxed one. Therefore a tax or a subsidy has no effect on the profit of the labeled firm. Under firm power, the competition between firms on the label drives a transfer of the benefit of the subsidy or the tax from the labeled firm to the certifier. Therefore the effect of a per-unit tax or a subsidy on the labeled firm's profit is given by the effect on the non-labeled firm's profit, which is always

[14]By computation when both goods are taxed at the rate t one gets $\frac{\partial MR_{fp}(s_2)}{\partial t} = -\frac{1}{4}\left(1 + \frac{3\underline{s}^2}{(4s_2 - \underline{s})^2}\right) < 0$. This entails a lower total welfare.

[15]The proof is given in Appendix 9

[16]The only case where the certifier does not benefit from the policy instrument is under certifier power when the government implements an ad valorem tax on the unlabelled firm. The tax then has no effect on the certifier's profit.

negative as expected.

6 Conclusions

The present work makes a contribution to the literature on eco-labeling of credence goods. We show that a for-profit private certifier chooses a certification level that depends upon whether the fee is set in a take-it-or-leave-it offer by the certifier (*certifier power*) or in a negotiation where firms act as a duopsony (*firm power*). In the first case the equilibrium standard is the same that would be chosen to maximize the labeled firm profit, while in the second case the certification standard falls below that level. This result, which cannot be found in the literature so far, is due to the certifier inability to extract the whole surplus from the labeling firm when the latter, to have the certification, must offer no more than is necessary to "outbid" the non-labeled rival. This implies, also, that once the fee is paid out the labeled and the unlabeled firm end up with an identical equilibrium profit.

Furthermore, the private certification standard remains below the welfare maximizing level that a Government may want to obtain. We therefore analyze the effects of commonly used policy tool options that aim to improve environmental quality and in general to increase welfare. We show that the presence of a certifier may modify the effects of taxes and subsidies as policy tools when firms may bargain on the certification fee.

We show that subsidies for production of the labeled product have different effects in the two possible scenarios: under certifier power a subsidy increases the level of the standard chosen by the certifier and improves total welfare in the industry. Under firm power, however, the environmental standard is lowered by the subsidy, which reduces welfare. This result contradicts the very purpose of a subsidy favoring a specific environmental quality. A per unit tax on the unlabeled product leads the certifier to choose a lower environmental standard in both scenarios, which reduces welfare and increases the environmental externality, showing that quality effects are important in shaping the total impact of a tax.

The ad valorem tax targeted only at the unlabeled product is the only policy option among the three considered here that never leads to a lower standard: it increases both the standard and total welfare under firm power, although its effects are nullified if no firm power exists. Among the two tools that raise revenue for the Government from the industry, therefore, our analysis is in favor of an ad valorem tax and rejects a per unit tax.

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Appendix

1 Proof of Lemma 1

The proof is in three parts.

Part (i). In any subgame starting after a offer profile such that $(f \geq 0, f^S = 0)$ for both, A and B, where $f' \equiv \max\{f_A, f_B\}$ and $f_A \neq f_B$, the unique equilibrium strategy for the intermediary is to accept f' if $f' > M(s_2)$ and reject both offers otherwise; $f_A = f_B > M(s_2)$ the certifier randomizes his choice. This is obvious since offers can be rejected whenever they lead to negative profits for the certifier.

Part (ii). In any subgame starting after $\big((f_A, f_A^S), (f_B, f_B^S)\big)$ where $f^S > 0$ for A and B, the certifier's equilibrium strategies involve accepting both non exclusive offers if and only if $f_A^S + f_B^S > f'$.

Part (iii). Analyze firm A's strategy, with no loss of generality. (iii.a) First, it is possible to restrict attention to offers f_A^S and f_A such that $\pi_2(s_2) - f \geq 0$, since all other offers are weakly dominated. (iii.b) Suppose $f_A > 0$; then using an offer with $f_A^S > 0$, a positive shared certification offer by A, leads to $\big((f_A, f_A^S), (f_B, f_B^S)\big)$ as in Part (ii) above and entails strictly negative profits for A if it is accepted, while if it is refused leads to the same profits as $(f_A, 0)$; however, this last offer leads to $\pi_2(s_2) - f \geq 0$ whenever it is accepted and hence it weakly dominates all offers with $f_A^S > 0$.

2 Analysis of the socially optimal certification

We consider next that firms cannot certify their products by a private label and that a public certifier implements a voluntary label. Compared to the game developed in section 3 only the first stage is modified such as the certification standard s_2 and the respective fee F are now set by the public certifier.

The public certifier sets the certification level s_2 so as to maximize total welfare W:[17]

$$W(s_2) = \pi_1(s_2) + \pi_2(s_2) + SC(s_2) - M(s_2), \tag{20}$$

with the consumer surplus:

$$SC(s_2) \equiv \int_{\widetilde{\theta}(p_1,p_2)}^{1} (\theta s_2 + \theta\gamma s_a - p_2)d\theta + \int_{\theta_1(p_1)}^{\widetilde{\theta}(p_1,p_2)} (\theta \underline{s} + \theta\gamma s_a - p_1)d\theta, \tag{21}$$

and the average weighted environmental quality (see Cremer and Thisse, 1999) is:

$$s_a \equiv \frac{\int_{\widetilde{\theta}(p_1,p_2)}^{1} s_2 d\theta + \int_{\theta_1(p_1)}^{\widetilde{\theta}(p_1,p_2)} \underline{s} d\theta}{1-\theta_1(p_1)} = \frac{2s_2 + \underline{s}}{3} \tag{22}$$

p_1 and p_2 are given by the equation (5).

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:

$$MR_g(s_2) = MM(s_2), \tag{23}$$

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

$$\frac{\partial\left(\pi_1(s_2) + \pi_2(s_2) + SC(s_2)\right)}{\partial s_2} = \frac{1}{8}\left(3 - 8s_2 + \frac{\underline{s}^2\left(4s_2 + 11\underline{s}\right)}{\left(4s_2 - \underline{s}\right)^3}\right) + \frac{(20s_2^3 - 15s_2^2\underline{s} + 3s_2\underline{s}^2 + \underline{s}^3)\gamma}{(4s_2 - \underline{s})^3}. \tag{24}$$

Since for not too high value of γ, $MR_g(s_2)$ is continuous and decreasing in s_2, the strict concavity of the $W(s_2)$ is ensured, and the FOC given by the equation (23) has a unique solution denoted s_g^*. As expected s_g^* is increasing in γ.

Lemma 3. *The socially optimal certification standard s_g^* is increasing with the intensity γ of the externality positive for the consumers.*

Proof. As $\frac{\partial MR_g(s_2)}{\partial\gamma} = \frac{(20s_2^3 - 15s_2^2\underline{s} + 3s_2\underline{s}^2 + \underline{s}^3)\gamma}{(4s_2 - \underline{s})^3} > 0$ and $\frac{\partial MM(s_2)}{\partial\gamma} = 0$, then s_g^* is also increasing

[17] The solution to stage three is given by the subsection 3.1.

in γ.

3 Proof of Proposition 2

In the following we analyze the effect of a subsidy policy on the certification level and on welfare.

i) Using the FOC in the certification game, one can define how a subsidy λ affects the private certification standard. By fully differentiating the FOC with respect to λ one obtains:

$$\frac{\partial s_2}{\partial \lambda} = \frac{\frac{\partial MR_{fp}(s_2,\lambda)}{\partial \lambda}}{\frac{\partial MM(s_2)}{\partial s_2} - \frac{\partial MR_{fp}(s_2,\lambda)}{\partial s_2}},$$

as we have $\frac{\partial MM(s_2)}{\partial s_2} - \frac{\partial MR_{fp}(s_2,\lambda)}{\partial s_2} > 0$ (due to the second order condition), then $sign\frac{\partial s_2}{\partial \lambda} = sign\frac{\partial MR_{fp}(s_2,\lambda)}{\partial \lambda}$.

Under firm power, in the certification game the FOC is given by $MR_{fp}(s_2, \lambda) = MM(s_2)$ with

$$MR_{fp}(s_2,\lambda) \equiv \frac{\partial\left(\pi_2(s_2,\lambda) - \pi_1(s_2,\lambda)\right)}{\partial s_2} = A - \frac{2\lambda \underline{s} + 4\lambda^2}{(4s_2 - \underline{s})^2} \tag{25}$$

where A is a term independent of λ and is given by the right hand side in equation (14). It is obvious that $\frac{\partial MR_{fp}(s_2,\lambda)}{\partial \lambda} = -\frac{2(\underline{s}+4\lambda)}{(4s_2-\underline{s})^2} < 0$. Therefore the private certification standard is decreasing in the subsidy level ($\frac{\partial s_2}{\partial \lambda} < 0$).

Now, we evaluate the full derivative of the welfare with respect to λ: $\frac{dW}{d\lambda} = \frac{\partial W}{\partial s_2}\frac{\partial s_2}{\partial \lambda} + \frac{\partial W}{\partial \lambda}$. The welfare is given by:

$$W = \int_{\widetilde{\theta}(p_1,p_2)}^{1} (\theta s_2 + \gamma\theta s_a)d\theta + \int_{\theta_1(p_1,p_2)}^{\widetilde{\theta}(p_1,p_2)} (\theta \underline{s} + \gamma\theta s_a)d\theta - C(s_2) - M(s_2) \tag{26}$$

with p_1 and p_2 given by equation (16) and $s_a = \frac{(2s_2+\underline{s}+2\lambda)s_2}{3s_2+\lambda}$. As a) $\frac{\partial W}{\partial \lambda} = \frac{(4s_2-3\underline{s})s_2(s_2-\underline{s}-\lambda)}{(4s_2-\underline{s})^2(s_2-\underline{s}))} + \frac{(8s_2^2-5s_2\underline{s}-4s_2\lambda)\gamma}{2(4s_2-\underline{s})^2} > 0 \;\forall\lambda < (s_2-\underline{s})$, b), $\frac{\partial W}{\partial s_2} > 0 \;\forall s_2 \in]\underline{s}, s_g^*(\lambda)[$ with $s_g^*(\lambda)$ the socially optimal certification standard for a per subsidy λ given, and c) $\frac{\partial s_2}{\partial \lambda} < 0$, then the sign of $\frac{dW}{d\lambda}$ is ambiguous.

ii) Under certifier power, in the certification game the FOC is given by $MR_{cp}(s_2, \lambda) = MM(s_2)$ with

$$MR_{cp}(s_2, \lambda) \equiv \frac{\partial \pi_2(s_2, \lambda)}{\partial s_2} = B + \frac{(4\underline{s}^2(s_2 - \underline{s})^2 - \lambda(2s_2 - \underline{s})(8s_2^2 - 10\underline{s}s_2 + 5\underline{s}^2))\lambda}{(4s_2 - \underline{s})^3(s_2 - \underline{s})^2} \quad (27)$$

where B is a term independent of λ and is given by the right hand side in equation (9).

We find that for sufficiently low values of the subsidy, $MR_{cp}(s_2, \lambda)$ is increasing with λ ($\frac{\partial MR_{cp}(s_2,\lambda)}{\partial \lambda} = \frac{4\underline{s}^2(s_2-\underline{s})^2-2\lambda(2s_2-\underline{s})(8s_2^2-10\underline{s}s_2+5\underline{s}^2)}{(4s_2-\underline{s})^3(s_2-\underline{s})^2}$), therefore both the private certification standard and the welfare are increasing in the subsidy ($\frac{\partial s_2}{\partial \lambda} > 0$, and $\frac{dW}{d\lambda} > 0$).

4 The Effects of a subsidy policy on prices and quantities

First we consider the effect of a subsidy policy prices and quantities under firm power. The following results are to be interpreted for small values of λ.

The effect of the subsidy on the equilibrium price p_1 is given by $\frac{dp_1}{d\lambda} = \frac{\partial p_1}{\partial s_2}\frac{\partial s_2}{\partial \lambda} + \frac{\partial p_1}{\partial \lambda}$. As i) $\frac{\partial p_1}{\partial \lambda} = -\frac{\underline{s}}{4s_2-\underline{s}} < 0$, ii) $\frac{\partial p_1}{\partial s_2} = \frac{\underline{s}(3\underline{s}+4\lambda)}{(4s_2-\underline{s})^2} > 0$ and iii) $\frac{\partial s_2}{\partial \lambda} < 0$, then $\frac{dp_1}{d\lambda} < 0$. The effect of the subsidy on price p_1 is negative.

The subsidy effect on the equilibrium price p_2 is given by $\frac{dp_2}{d\lambda} = \frac{\partial p_2}{\partial s_2}\frac{\partial s_2}{\partial \lambda} + \frac{\partial p_2}{\partial \lambda}$. As i) $\frac{\partial p_2}{\partial \lambda} = -\frac{2s_2}{4s_2-\underline{s}} < 0$, ii) $\frac{\partial p_2}{\partial s_2} = \frac{2(\underline{s}^2+4s_2^2+\underline{s}(-2s_2+\lambda))}{(4s_2-\underline{s})^2} > 0$ and iii) $\frac{\partial s_2}{\partial \lambda} < 0$, then $\frac{dp_2}{d\lambda} < 0$. The effect of the subsidy on price p_2 is negative.

The subsidy effect on the price difference $(p_2 - p_1)$ is given by $\frac{d(p_2-p_1)}{d\lambda} = \frac{\partial(p_2-p_1)}{\partial s_2}\frac{\partial s_2}{\partial \lambda} + \frac{\partial(p_2-p_1)}{\partial \lambda}$. As i) $\frac{\partial(p_2-p_1)}{\partial \lambda} = -\frac{2s_2-\underline{s}}{4s_2-\underline{s}} < 0$, ii) $\frac{\partial(p_2-p_1)}{\partial s_2} = \frac{8s_2^2-\underline{s}^2-2\underline{s}(2s_2+\lambda)}{(4s_2-\underline{s})^2} > 0$ for low value of λ and iii) $\frac{\partial s_2}{\partial \lambda} < 0$, then $\frac{dp_2}{d\lambda} < 0$. The effect of the subsidy on price difference $(p_2 - p_1)$ is negative.

The subsidy effect on equilibrium demand D_1 is given by $\frac{dD_1}{d\lambda} = \frac{\partial D_1}{\partial s_2}\frac{\partial s_2}{\partial \lambda} + \frac{\partial D_1}{\partial \lambda}$. As i) $\frac{\partial D_1}{\partial \lambda} = -\frac{s_2}{4s_2^2-5\underline{s}s_2+\underline{s}^2} < 0$, ii) $\frac{\partial D_1}{\partial s_2} = -\frac{\underline{s}(s_2-\underline{s})^2-(4s_2^2-\underline{s}^2)\lambda}{(4s_2^2-5\underline{s}s_2+\underline{s}^2)^2} < 0$, and iii) $\frac{\partial s_2}{\partial \lambda} < 0$, then the sign of $\frac{dD_1}{d\lambda}$ is undefined. The subsidy effect on unlabeled product quantity is ambiguous.

The subsidy effect on equilibrium demand D_2 is given by $\frac{dD_2}{d\lambda} = \frac{\partial D_2}{\partial s_2}\frac{\partial s_2}{\partial \lambda} + \frac{\partial D_2}{\partial \lambda}$. As i) $\frac{\partial D_2}{\partial \lambda} = \frac{2s_2-\underline{s}}{4s_2^2-5\underline{s}s_2+\underline{s}^2} > 0$, ii) $\frac{\partial D_2}{\partial s_2} = -\frac{2\underline{s}(s_2-\underline{s})^2+(8s_2^2-8s_2\underline{s}+3\underline{s}^2)\lambda}{(4s_2^2-5\underline{s}s_2+\underline{s}^2)^2} < 0$, and iii) $\frac{\partial s_2}{\partial \lambda} < 0$, then

$\frac{dD_2}{d\lambda} > 0$, the subsidy final effect on labeled product quantity is positive.

The subsidy effect on total demand $(D_1 + D_2)$ is given by $\frac{d(D_1+D_2)}{d\lambda} = \frac{\partial(D_1+D_2)}{\partial s_2}\frac{\partial s_2}{\partial \lambda} + \frac{\partial(D_1+D_2)}{\partial \lambda}$. As i) $\frac{\partial(D_1+D_2)}{\partial \lambda} = \frac{1}{4s_2-\underline{s}} > 0$, ii) $\frac{\partial(D_1+D_2)}{\partial s_2} = \frac{-3\underline{s}-4\lambda}{(4s_2-\underline{s})^2} < 0$, and iii) $\frac{\partial s_2}{\partial \lambda} < 0$, then $\frac{dD_2}{d\lambda} > 0$, the subsidy effect on total demand is positive.

Now we consider the subsidy effects under certifier power. Comparing to the environment under firm power, the only difference is on the sign of $\frac{\partial s_2}{\partial \lambda}$ that is now positive. Therefore i) the effect on both equilibrium prices p_1 and p_2 is ambiguous, ii) the effect on equilibrium demand is negative for the unlabeled product and ambiguous for the labeled product, and iii) the effect on total demand is ambiguous.

The following table summarizes the effects of a small subsidy on prices and demand:

	Firm power	Certifier power
s_2	$-$	$+$
p_1	$-$	undefined
p_2	$-$	undefined
$p_2 - p_1$	$-$	undefined
D_1	undefined	$-$
D_2	$+$	undefined
$D_1 + D_2$	$+$	undefined

Table 1. Effects of a subsidy

5 Proof of Proposition 3

In the following we analyze the effect of a per unit tax policy on the certification level and on the welfare.

i) Under firm power, in the certification game the FOC is given by $MR_{fp}(s_2, \tau) = MM(s_2)$ with

$$MR_{fp}(s_2,\tau) \equiv \frac{\partial\left(\pi_2(s_2,\tau) - \pi_1(s_2,\tau)\right)}{\partial s_2} = A - \frac{2\tau\underline{s} - \tau^2}{(4s_2 - \underline{s})^2} \tag{28}$$

where A is a term independent of τ and is given by the right hand side in equation (14). It is obvious that $\forall \tau \in [0, \underline{s}[$ then $\frac{\partial MR_{fp}(s_2,\tau)}{\partial \tau} = -\frac{2(\underline{s}-\tau)}{(4s_2-\underline{s})^2} < 0$, therefore the private certification standard is decreasing in the tax rate for small values of τ ($\frac{\partial s_2}{\partial \tau} < 0$).

Now, we evaluate the full derivative of the welfare with respect to τ: $\frac{dW}{d\tau} = \frac{\partial W}{\partial s_2}\frac{\partial s_2}{\partial \tau} + \frac{\partial W}{\partial \tau}$. The welfare is given by the equation (26) with p_1 and p_2 given by equation (18) and $s_a = \frac{(2s_2+\underline{s}-\tau)\underline{s}}{3\underline{s}-2\tau}$. As a) $\frac{\partial W}{\partial \tau} > 0$ $\forall \tau < \frac{\underline{s}^2 s_2 - \underline{s}^3}{4s_2^2 - 3\underline{s}s_2}$, b), $\frac{\partial W}{\partial s_2} > 0$ $\forall s_2 \in]\underline{s}, s_g^*(\tau)[$, with $s_g^*(\tau)$ the socially optimal certification standard for a per unit tax τ given, and c) $\frac{\partial s_2}{\partial \tau} < 0$, then the sign of $\frac{dW}{d\tau}$ is ambiguous.

ii) Under certifier power, in the certification game the FOC is given by $MR_{cp}(s_2, \tau) = MM(s_2)$, with

$$MR_{cp}(s_2,\tau) \equiv \frac{\partial \pi_2(s_2,\tau)}{\partial s_2} = B - \frac{s_2\tau(8\underline{s}(s_2-\underline{s})^2 + \tau(4s_2^2 + \underline{s}s_2 - 2\underline{s}^2))}{(4s_2-\underline{s})^3(s_2-\underline{s})^2} \tag{29}$$

where B is a term independent of τ and is given by the right hand side in equation (9).

We find that $MR_{cp}(s_2,\tau)$ is decreasing in τ ($\frac{\partial MR_{cp}(s_2,\tau)}{\partial \tau} = -\frac{s_2(8\underline{s}(s_2-\underline{s})^2 + 2\tau(4s_2^2+\underline{s}s_2-2\underline{s}^2))}{(4s_2-\underline{s})^3(s_2-\underline{s})^2} < 0$), therefore, as under firm power, the private certification standard is decreasing in the tax rate ($\frac{\partial s_2}{\partial \tau} < 0$), and the sign of $\frac{dW}{d\tau}$ is ambiguous.

6 The Effects of a per unit tax policy on prices and quantities

In the same way as in Appendix 4 we determine the effect of a per unit tax policy on prices and quantities under both firm power and certifier power. Note that as the sign of $\frac{\partial s_2}{\partial \tau}$ is the same under firm power and under certifier power, the sign of the effects of the tax is also the same under these environments. The results are summarized in the following table. They are to be interpreted for small values of τ.

	Firm power	Certifier power
s_2	$-$	$-$
p_1	undefined	undefined
p_2	undefined	undefined
$p_2 - p_1$	$-$	$-$
D_1	undefined	undefined
D_2	$+$	$+$
$D_1 + D_2$	$+$	$+$

Table 2. Effects of a per unit tax

7 Proof of Proposition 4

In the following we analyze the effect of an ad valorem tax policy on the certification level and on the welfare.

i) Under firm power, in the certification game the FOC is given by $MR_{fp}(s_2, t) = MM(s_2)$ with

$$MR_{fp}(s_p, t) \equiv \frac{\partial(\pi_2(s_2) - \pi_1(s_2, t))}{\partial s_2} = A + \frac{\underline{s}^2(2s_2 + \underline{s})t}{(4s_2 - \underline{s})^3}, \tag{30}$$

where A is a term independent of t and is given by the right hand side in equation (14). Then it is clear that $\dfrac{\partial MR_{fp}(s_2, t)}{\partial t} > 0$. Therefore the private certification standard is increasing in the tax level ($\frac{\partial s_2}{\partial t} > 0$).

The welfare is given by the equation (26) with p_1 and p_2 given by equation (5) and s_a given by equation (22). As for welfare, the first derivative $\frac{dW}{dt} = \frac{\partial W}{\partial s_2}\frac{\partial s_2}{\partial t} + \frac{\partial W}{\partial t}$ where a) $\frac{\partial W}{\partial t} = 0$, b) $\frac{\partial W}{\partial s_2} > 0$ in the relevant range, and c) $\frac{\partial s_2}{\partial t} > 0$. Therefore, $\frac{dW}{dt}$ is positive as far as s_2 is lower than s_g^*.

ii) Under certifier power, in the certification game the FOC is $MR_{cp}(s_2) = MM(s_2)$, with $MR_{cp}(s_2) \equiv \frac{\partial \pi_2(s_2)}{\partial s_2}$ given by the right hand side in equation (9) and independent of

t. Then it is clear that an ad valorem tax policy has no effect on the certification level and the welfare ($\frac{\partial s_2}{\partial t} = 0$, and $\frac{dW}{dt} = 0$).

8 The Effects of an ad valorem tax policy on prices and quantities

In the same way as in Appendix 4 we determine the effect of an ad valorem tax policy on prices and quantities under both firm power and certifier power. Note that under certifier power the tax has no effect on prices and quantities. The results are summarized in the following table. They are to be interpreted for small values of t.

	Firm power	Certifier power
s_2	$+$	no effect
p_1	$+$	no effect
p_2	$+$	no effect
$p_2 - p_1$	$+$	no effect
D_1	$-$	no effect
D_2	$-$	no effect
$D_1 + D_2$	$-$	no effect

Table 3. Effects of an ad valorem tax

9 The Effects of taxes and subsidy on the certifier's profit and the firms' profit

First we analyze the effect of a subsidy policy. They are to be interpreted for small values of λ.

Under firm power the certifier's profit is given by: $\pi_2(s_2, \lambda) - \pi_1(s_2, \lambda) - M(s_2)$. Due to the envelope theorem we have $\frac{d(\pi_2(s_2,\lambda)-\pi_1(s_2,\lambda)-M(s_2))}{d\lambda} = \frac{\partial(\pi_2(s_2,\lambda)-\pi_1(s_2,\lambda)-M(s_2))}{\partial\lambda} = \frac{2(s_2+\lambda)}{4s_2-\underline{s}} > 0$; the subsidy increases the certifier's profit. Under certifier power the certifier's profit is given by: $\pi_2(s_2, \lambda) - M(s_2)$ and is increasing in the subsidy ($\frac{\partial(\pi_2(s_2,\lambda)-M(s_2))}{\partial\lambda} =$

$\frac{2(2s_2-\underline{s})(2s_2(s_2+\lambda)-\underline{s}(2s_2+\lambda))}{(4s_2-\underline{s})^2(s_2-\underline{s}))} > 0)$.

Under firm power the two firms get identical profits given by: $\pi_1(s_2, \lambda)$. The effect of the subsidy on $\pi_1(s_2, \lambda)$ is given by $\frac{d\pi_1(s_2,\lambda)}{d\lambda} = \frac{\partial \pi_1(s_2,\lambda)}{\partial s_2}\frac{\partial s_2}{\partial \lambda} + \frac{\partial \pi_1(s_2,\lambda)}{\partial \lambda}$. As i) $\frac{\partial \pi_1(s_2,\lambda)}{\partial \lambda} = -\frac{2s_2\underline{s}(s_2-\underline{s}-\lambda)}{(4s_2-\underline{s})^2(s_2-\underline{s})} < 0$, ii) $\frac{\partial \pi_1(s_2,\lambda)}{\partial s_2} = \frac{\underline{s}(s_2-\underline{s}-\lambda)(8s_2^2t+2s_2\underline{s}(s_2-2t)-\underline{s}^3-\underline{s}^2(s_2+\lambda))}{(4s_2-\underline{s})^3(s_2-\underline{s})^2} > 0$ and iii) $\frac{\partial s_2}{\partial \lambda} < 0$, then $\frac{d\pi_1(s_2,\lambda)}{d\lambda} < 0$. The effect of the subsidy on firms' profit is negative. Under certifier power, the firm 2's profit is null; the subsidy has no effect over it. The effect of the subsidy on the firm 1's profit ($\pi_1(s_2, \lambda)$) is given by $\frac{d\pi_1(s_2,\lambda)}{d\lambda} = \frac{\partial \pi_1(s_2,\lambda)}{\partial s_2}\frac{\partial s_2}{\partial \lambda} + \frac{\partial \pi_1(s_2,\lambda)}{\partial \lambda}$. Comparing to the environment under firm power, the only difference is on the sign of $\frac{\partial s_2}{\partial \lambda}$ that is now positive. Therefore the subsidy effect on firm 1's profit cannot be signed.

In the same way, we determine the effects of ad valorem and per unit taxes on the certifier's profit and the firms' profit. All results are summarized in the following table.

	Subsidy		Per unit tax		Ad valorem tax	
	FP	*CP*	*FP*	*CP*	*FP*	*CP*
Certifier's profit	+	+	+	+	+	no effect
Firm 2's profit	−	no effect	−	no effect	undefined	no effect
Firm 1's profit	−	undefined	−	−	undefined	−

Table 4. Effects of policy instruments on certifier and firms payoffs