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Green Leader or Green Liar? Differentiation and the role of NGOs

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Abstract

This paper addresses how corporate environmentalism can be a means of differentiation and of green-washing. Since consumers can seldom directly observe a firm's environmental quality (a problem not easily solved through eco-labeling), published environmental reports and advertising can mislead them. As a result, the role of the NGO becomes both crucial and ambiguous. On the one hand, by helping to increase consumer awareness, NGOs enlarge the market share of green differentiated firms. On the other hand, the risk that consumers will punish a firm perceived to be supplying inaccurate environmental information may bring about the paradoxical result of discouraging differentiation efforts.

JEL classification: L12 - L15 - L31 - M37 - Q50

Key words: Differentiation - Environmental concern - Imperfect competition - Quality - Advertising - NGO.

1 Introduction

Firms increasingly publish environmental reports (beyond legal constraints) or advertise their commitment to manage according to sustainable development criterions. What are their motivations? The most obvious argument might be that it would allow firms to differentiate their product from the others, in the same way as eco-labeling. Some papers

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have stressed that the environmental concern of consumers may increase profit opportunities for firms which would address the environmental problem seriously (Eriksson [16]). It is also well known that differentiation lowers competition and increases profits: imperfect competition would enhance the incentives to use a less polluting production technology. And as a seemingly paradoxal result, the market forces tend then to alleviate the environmental burden. But, even when consumers are concerned about environment, if only a few firms choose more environmental friendly production processes while the other ones maintain a low level of care about the environment, imperfect competition may not suffice as a substitute for environmental regulation.

In fact, the environmental global quality of a firm is seldom directly observable by consumers and this generates an asymmetric information situation between firms and consumers. In this case, there is no eco-labeling possibility. Publishing environmental reports or advertising on the firm's approach of sustainable development may be understood like a signal for consumers, i.e. an attempt to reduce uncertainty about its real environmental quality. But even this signal can be noisy and it might increase, instead of reduce, the uncertainty for consumers. This paper addresses then an original issue, not yet analyzed in the existing literature. When firms are perfectly aware of one of their peculiar characteristics which consumers value but have no mean to know exactly nor to learn through repeat purchases, are there incentives for firms to choose to provide a higher quality or even the highest possible one? If not, are there incentives for them to substitute a high level of advertising about this characteristic instead of actually providing it? By this way, they might replace a true differentiation with only a perceived one.

Our paper builds then on three distinct streams of the economic literature: endogenous quality choice in differentiated oligopolistic markets, imperfect information and advertising.

The standard results about vertical differentiation in duopolistic markets have been demonstrated by Shaked and Sutton [33], Tirole [36], Crampes and Hollander [12] or Lehmann-Grube [22]: the high-quality firm will earn higher profits than the low-quality firm, even when the costs of quality improvement are substantial and increasing. In a sequential-quality game, the firm that has the first choice of quality will choose the higher quality and will earn higher profits than the follower, and like in spatial models, firms are incited to differentiate their products according to a "maximal differentiation principle" (quoting d'Aspremont et al. [13]). The first papers focusing on green differentiation were

Eriksson [16] or Amacher, Koskela and Ollikainen [1] who address specifically the issue of endogenous choice of environmental quality by focusing on eco-labeling which is a way of asserting quality without any uncertainty about environmental friendliness of product. Conrad [11] shows that the level of green differentiation chosen by a duopoly is not socially optimal.

Many studies show indeed that imperfect information (among producers) may distort product differentiation. In the case of spatial competition, it depends on the assumption about transportation costs: such a distorsion appears when these costs are linear (Boyer et al. [7]) whereas it is not the case under quadratic costs assumption (Boyer et al. [8]). In case of vertical differentiation, Bester [6] argues that imperfect information about the quality of goods reduces the producers' incentives for product differentiation: "the centrifugal force of the maximum differentiation principle (of d'Aspremont et al. [13]) is eliminated when consumers are uncertain about quality and use observed prices to ascertain the quality of goods".

Fishman and Simhon [18] argue that, when producers are privately informed about quality, signalling models can successfully explain an equilibrium correlation between prices and exogenous quality but do not account for incentives to invest in quality improvement. They show that, when buyers are uninformed about quality, there are no incentives at all for a monopolist to invest in quality. But such incentives do exist and are all the greater when the consumers can get information at a lower cost: the ability to get information limits, but does not eliminate, the low quality producer's incentive to mimic the high quality price. One could think that the consumers would be better off if they could benefit from any public information about the quality of the goods (for example through notation agencies). Schlee [31] establishes that, when there is quality uncertainty on both sides of the market, (sellers and buyers being uncertain about the quality of the goods they exchange), there are two circomstances in which, contrary to intuition, consumers may dislike public quality information: in case of increasing returns to scale and of "sufficiently" convex marginal costs. But when costs and demand functions are linear, information is always valuable to consumers. The specific case of uncertainty bearing on the environmental characteristics has been studied by Mahenc [25] who analyzes the use of high prices to signal greener products.

In order to study the incentives to provide high quality when the consumers are not

perfectly aware of the product's quality, Schmalensee [32] or Smallwood and Conlisk [35] incorporate learning into consumer choice by assuming that quality is positively related to the probability of repeat purchase. Their works rely on the distinction introduced by Nelson [29] between "search goods" and "experience goods". The characteristics of the former are evident on inspection while the quality of the latter is impossible to verify, except through use of the product. Nelson's crucial insight was that the mere fact that a particular brand of an experience good was advertised could be a signal to customers that the brand was of high quality (Nelson [30]). He argues that, in case of experience goods, there may be incentives to lie since firms claims are not easily verifiable and lies might induce trial purchases.

Generally, this kind of issue is addressed with repeat sales mechanisms (like Schmalensee [32] or Smallwood and Conlisk [35]). Schmalensee shows that, when the unit-cost advantage enjoyed by low-quality is great and when there are economies of scale for advertising, there exist equilibria in which the lowest-quality brands advertise most, have the largest market shares and are the most profitable: in this case, a high level of advertising does not signal high quality. In Bester [6] also, consumers are a priori uninformed but learn actual quality after consuming a unit of the good. But Shapiro [34] notices that this approach was not based on rational consumer decisionmaking and prefers to address the issue of endogenous quality choice for a monopoly by underlining the role of reputation. At any date, each consumer has some expectations regarding product quality: these expectations constitute the firm's reputation, which determines the position of its demand curve. Consumer learning involves adjusting expected quality toward true quality.

Models dealing with experience goods, such as Milgrom and Roberts [27], generally assume that there is no credible direct way by which the firm can provide the information about quality before customers make their initial purchase decision. The firm's decision variables are the price and the advertising expenditure. Customers, after observing price and adverstising expenditures, make their initial purchase decisions and, through direct use of the product or communication with other users, then gain information about quality. Smallwood and Conlisk [35] consider a market, in which the product lasts one period, each consumer buys one unit of the product each period, there are a given number of brands and there is a positive breakdown probability (which differs among brands) which may not be discovered by inspection. When the purchased product breakdowns, the customer considers a change of brand. The breakdown probability can be interpreted in a

broader sense: this is the dissatisfaction probability. Shapiro [34] considers that reputation increases as sales increases, and converges to the actual quality. His specification is in some extent consistent with the explanation through repeat sales but also with optimization.

If we consider the environmental friendliness or the level of sustainability commitments, it can be seen as a quality associated to the good but this quality is hardly known by the consumers. Such a good cannot be considered a "search good" because this characteristic of the firm is not evident on simple inspection, nor as an "experience good" because this characteristic is impossible to verify even through use of the products. In this case repeat purchases do not provide any further information about the true level of environmental friendliness of the firm. The environmental friendliness of the firm has to be considered more as a "credence quality", as defined by Darby and Karni [14]: "credence qualities are those which, although worthwile, cannot be evaluated in normal use". In such cases, regulation becomes more necessary but it is specially difficult and the informational issue may be dealt with if there is a possibility of a punishment when the consumers become aware of a fraud about quality.

In our case, apparently exogenous events may provide such information and reveal the actual quality of a product or of its producer: an oil slick, for example, should reveal that the oil company cheated about prevention measures. Consumer learning depends on the fulfilment of such events which undermine then the reputation of the firm. But this requires strong punishments, which individual consumers cannot enact, except by collective actions. There are also independent notation agencies or NGOs which provide evaluations of the degree of reliability of environmental reports or advertising campaigns, but such agencies are unable to exactly verify the announced quality either of a product or of a firm. So, even if public information might be valued by consumers, there is no way to provide them with accurate information. Any environmental disaster caused by the firm or any disclosure by an NGO of its true friendliness will increase the dissatisfaction probability of the consumers. This will reduce the incentive to cheat for the firm.

Our paper therefore proposes a three-stage model of an asymmetric differentiated market with asymmetric information between consumers and firms. One of the competitive firms can choose to adopt a cleaner technology or to announce a greater environmental friendliness, and then become a monopolist facing a competitive fringe. At the first stage, the monopolist chooses the actual quality of their product by investing in a given produc-

tion technology, more or less environmental friendly. At the second stage, it invests in advertising expenditure to claim the environmental quality of its behavior: it decides for example to publish environmental reports or to publicly sign a charter on sustainable development. Contrary to Dixit and Norman [15] who assume that advertising can change consumers tastes, we assume that consumers preference for quality remains unchanged but that advertising modifies their expected quality for the advertised firm. Until any verifiable information appears about the true quality of this product, advertising on the environmental friendliness of the firm may induce consumers to overvalue the good (if the firm is cheating). To publish environmental reports or to claim that the firm is managed according to sustainable development principles is a way for the firm to improve its reputation. Using a similar idea of Kotowitz and Mathewson [21], we assume that the expected quality of a product for a consumer characterized by his tastes increases with advertising expenditures, and is never less than the actual quality, if firms are rational. But, at the same time, NGOs may audit firms and detect them as cheaters. In the third stage, the monopoly determines its price and the producers compete in the goods market. We show that the most environmentally efficient firm is generally induced to advertise, depending on the availability of public information about the quality, the characteristics of the demand side of the market, and on the cost differential between firms. The role of NGOs may have ambiguous effects on the choice of differentiation, because it can increase the demand faced by the monopolist by increasing the size of the global market but it might also increase the consumers' skepticism and then reduce their demand to the differentiated monopolist.

Section 2 develops our model of differentiation choice by a monopolist facing a competitive fringe under perfect competition. Section 3 compares the choices of the monopolist to the optimal output of the social planner's program. Section 4 presents the main results about the impact of imperfect information and claims about sustainable differentiation. In section 5 we analyze the influence of NGOs on the market and on the global impact on environment. Section 6 concludes.

2 The choice of differentiation under perfect information

We assume the market originally competitive but one firm is able to develop or to buy a new technology which allows it to produce the same good while differentiating from the other producers by their environmental friendliness (less waste, lower emissions). Since

consumers are sensitive to the environmental reputation of producers, this firm becomes a monopolist while the others constitute a competitive fringe. The level of environmental friendliness of the fringe is perfectly known and assumed to be zero ; it corresponds to a constant global impact coefficient β. This impact on the environment can be a combination of negative ones (pollution) and positive ones (amenities). For simplicity, we will assume that the global environmental impact of a firm is proportional to its output. Our framework is very close to Mahenc [24] who studies the wine market provided by a competitive fringe of producers of ordinary wine and by a monopolist producing a wine of higher quality, nevertheless affected by uncertainty due to weather conditions and other uncontrollable factors. However, we depart from this framework because the market is not assumed to be intrinsically differentiated by other characteristics than environmental friedliness. Like Conrad [11] in the duopoly case, we will focus on the choice of the environmental quality.

In Lehmann-Grube [22], the costs of quality are independent of output and convex in the chosen quality: there are here no variable costs of quality. At the contrary, in Crampes and Hollander [12], the unit cost of output depends on quality. In our case, we have to consider that quality is related to pollutant emissions: there are both fixed costs (to obtain or to buy a cleaner technology) and variable costs (abatement costs). The effect of fixed costs have already been analysed by Amacher et al. [1]. We assume for simplicity reason that they are only variable costs for the environmental friendliness θ, and the production cost writes $c(\theta)q$ with $c'(\theta) > 0$ and $c''(\theta) \geq 0$. As the quality of the product is defined by the environmental friendliness of the producer, we can assume that the emission coefficient of the monopoly is equal to $\beta - \theta$ and its emissions are $e = (\beta - \theta)\, q$. The production cost of the competitive firms is normalized to zero and thus the price of their product is also zero.

As a first step, we will study the case of perfect information, where there is no possibility for the firm to delude the consumers. In this case, the game reduces to two stages: the choice of differentiation and the stage of determination of the demand and the price for a given differentiation level.

The general framewok of consumer behavior is inspired by Tirole [36], Choi and Shin [10], Lehmann-Grube [22] or Amacher et al. [1] but if each firm knows the actual, realized quality of its product, the potential customers do not. Instead of considering vertical

differentiation, we take into account the fact that consumers are not unanimous about the value of the environmental friendliness of the producer from whom they buy the product. Therefore, we use a spatial differentiated model and the choice of quality by the firms becomes a location choice. Consumers receive the same utility U when consuming a unit of the good but they differ in their taste parameter θ (marginal willingness to pay for environmental performance) uniformly distributed on the interval $\left[0, \overline{\theta}\right]$. A rationale for this assumption may be the one given by Tirole [36], and used by Arora and Gangopadhyay [2], who relate the heterogeneity of the marginal willingness to pay to the heterogeneity of marginal utility of income. The number of consumers is standardized to unity. In this benchmark case, we assume that information is absolutely perfect and symmetric about the environmental friendliness of the firm, denoted by $\widetilde{\theta}$.

At the last stage each consumer buys at most one unit from either the monopoly or from the other competitive firms and gets a net utility from buying an expected quality $\widetilde{\theta} \leq \overline{\theta}$, at price p. A consumer with environmental awareness θ will buy from the firm that offers the best quality-price combination for her (if her utility is positive). She will suffer a marginal disutility measured by t when buying a good that does not correspond to his ideal, and the "costs of transportation" are assumed to be quadratic (unlike in Conrad [11] who deals with linear costs). The expected utility of the agent purchasing the homogeneous good is then given by $U - t\theta^2$ while her expected utility if she bought the differentiated good would be $U - p - t(\theta - \widetilde{\theta})^2$. The market is split, and the marginal consumer who is indifferent between purchasing the homogeneous good or the differentiated one is defined by θ_i such that:

$$U - t\theta_i^2 = U - p - t(\theta_i - \widetilde{\theta})^2$$

which gives

$$\theta_i = \frac{\widetilde{\theta}}{2} + \frac{p}{2t\widetilde{\theta}}$$

The demand for the good produced by the monopoly is then

$$D(p, \widetilde{\theta}) = \overline{\theta} - \theta_i = \overline{\theta} - \frac{\widetilde{\theta}}{2} - \frac{p}{2t\widetilde{\theta}} \tag{1}$$

The profit function of the monopoly writes as

$$\pi(p, \widetilde{\theta}) = \left(p - c(\widetilde{\theta})\right) D(p, \widetilde{\theta})$$

It maximizes this profit by choosing its price p, for given environmental friendliness $\widetilde{\theta}$:

$$p^* = \frac{c(\widetilde{\theta})}{2} + t\widetilde{\theta}\left(\overline{\theta} - \frac{\widetilde{\theta}}{2}\right) \tag{2}$$

This price will be above the marginal production cost if and only if the differentiation is sufficient, that is:

$$(\overline{\theta} - \widetilde{\theta})^2 < \overline{\theta}^2 - \frac{c(\widetilde{\theta})}{t} \tag{3}$$

For low levels of production cost , it is easiest for the monopoly to obtain a price greater than the marginal cost without seeking a too large differentiation.

Assumption 1: $c(\overline{\theta}) \leq t\overline{\theta}^2$

Under this assumption, which ensures that both the margin of the monopolist and its demand are non négative for $\widetilde{\theta} = \overline{\theta}$ and more generally for any $\widetilde{\theta} \in \left[0; \overline{\theta}\right]$, the range of environmental awareness is large enough, relatively to the ratio of the production cost depending on quality to the transportation cost, for allowing the level of differentiation to cover the entire interval.

At the second stage, the differentiated firm chooses its level of environmental friendliness, by maximizing its expected profit, which leads to the following necessary conditions:

$$\left.\frac{\partial \pi(p, \widetilde{\theta})}{\partial \widetilde{\theta}}\right|_{p(\widetilde{\theta})} = \left[p(\widetilde{\theta}) - c(\widetilde{\theta})\right]\frac{\partial D}{\partial \widetilde{\theta}} + D\left[\frac{\partial p}{\partial \widetilde{\theta}} - c'(\widetilde{\theta})\right] = 0 \tag{4}$$

$$\left.\frac{\partial^2 \pi(p, \widetilde{\theta})}{\partial \widetilde{\theta}^2}\right|_{p(\widetilde{\theta})} \leq 0 \quad \text{for any} \quad \widetilde{\theta} \in \left[0; \overline{\theta}\right] \tag{5}$$

Proposition 1 *When the willingnesses to pay for environmental friendliness of the consumers are uniformly distributed on the interval* $\left[0, \overline{\theta}\right]$*, the optimal level of differentiation for the monopolist under perfect information is* $\theta^* < \overline{\theta}$ *such that* $\left(\overline{\theta} - \theta^*\right) \geq \dfrac{c'(\theta^*)}{2t}$.

Proof. The optimal price, for any given environmental quality, writes $p(\widetilde{\theta}) = \frac{c(\widetilde{\theta})}{2} + t\widetilde{\theta}\left(\overline{\theta} - \frac{\widetilde{\theta}}{2}\right)$ while the demand is $D(\widetilde{\theta}) = \frac{1}{2}\left(\overline{\theta} - \frac{\widetilde{\theta}}{2}\right) - \frac{c(\widetilde{\theta})}{4t\widetilde{\theta}}$. This allows to obtain the following derivatives:

$$\begin{cases} \dfrac{\partial p}{\partial \widetilde{\theta}} - c'(\widetilde{\theta}) = -\dfrac{c'(\widetilde{\theta})}{2} + t\left(\overline{\theta} - \widetilde{\theta}\right) \\ \dfrac{\partial D}{\partial \widetilde{\theta}} = -\dfrac{1}{4} - \dfrac{\widetilde{\theta}c'(\widetilde{\theta}) - c(\widetilde{\theta})}{4t\widetilde{\theta}^2} \end{cases} \tag{6}$$

$$\left.\frac{\partial \pi(p,\widetilde{\theta})}{\partial \widetilde{\theta}}\right|_{p(\widetilde{\theta})} = \left[p(\widetilde{\theta}) - c(\widetilde{\theta})\right] \underbrace{\frac{\partial D}{\partial \widetilde{\theta}}}_{-} + D \underbrace{\left[\frac{\partial p}{\partial \widetilde{\theta}} - c'(\widetilde{\theta})\right]}_{+/-} = 0 \tag{7}$$

Under Assumption 1, a necessary condition for this FOC to admit a solution θ^* is that the price effect is positive, but since $c'(\widetilde{\theta}) \geq 0$ and $\left(\overline{\theta} - \widetilde{\theta}\right)$ is decreasing, this will be verified if and only if $\theta \leq \check{\theta}$ with $\check{\theta}$ such that $t\left(\overline{\theta} - \check{\theta}\right) \geq \frac{c'(\check{\theta})}{2}$. If the cost conditions are such that the first order condition is verified, it can only be for $\widetilde{\theta} \leq \check{\theta}$. If this FOC does not admit any solution in $\left[0; \check{\theta}\right]$, since the marginal profit equals zero for $\widetilde{\theta} = 0$ and decreases when $\widetilde{\theta}$ increases, the profit is maximized for $\widetilde{\theta} = \check{\theta}$. QED ■

3 The choice of the social planner

Does the level of environmental friendliness chosen by the firm coincide with the optimal one? Intuitively, it cannot be optimal, for the simple and usual reason that the social planner would wish to reduce the competitive distorsion and to take account for the environmental damage that the firm ignores.

Since we have assumed that the emissions coefficient of the producers is linked to their environmental friendliness : β for the competitive fringe and $\beta - \widetilde{\theta}$, let us define the damage due to emissions: $d(e)$ with $d'(e) > 0$ and $d''(e) \geq 0$.

The objective of the social planner is then to maximize the aggregate social welfare, considering that each unit produced by the competitive fringe is the source of a damage $d(\beta)$ and each unit purchased from the monopolist cause a damage $d(\beta - \widetilde{\theta})$:

$$\max_{\widetilde{\theta}} W = \int_0^{\Theta_i} \left[U - t\theta^2 - d(\beta)\right] d\theta + \int_{\Theta_i}^{\overline{\theta}} \left[U - c(\widetilde{\theta}) - t(\theta - \widetilde{\theta})^2 - d(\beta - \widetilde{\theta})\right] d\theta \tag{8}$$

From the social point of view, the indifferent consumer between buying the homogeneous good or the differentiated one is defined by Θ_i such that:

$$U - t\Theta_i^2 = U - c(\widetilde{\theta}) - t(\Theta_i - \widetilde{\theta})^2$$

which leads

$$\Theta_i = \frac{c(\widetilde{\theta})}{2t\widetilde{\theta}} + \frac{\widetilde{\theta}}{2}$$

As expected, for a given quality, the optimal market share of the environmental friendly firm is greater than the monopolist's market share.

We compute first the expression of the social welfare, for a given quality of the monopolist, and then we derive the FOC of this maximization program.

$$\begin{aligned}
\frac{dW}{d\widetilde{\theta}} &= -\left(\overline{\theta}-\Theta_i\right)\left[c'(\widetilde{\theta})-d'(\beta-\widetilde{\theta})-t\left(\overline{\theta}+\Theta_i-2\widetilde{\theta}\right)\right] \\
&\quad +\frac{d\Theta_i}{d\widetilde{\theta}}\left[c(\widetilde{\theta})-d(\beta)+d(\beta-\widetilde{\theta})+t\widetilde{\theta}^2-2t\Theta_i\widetilde{\theta}\right] \\
\text{s.t. } \Theta_i &= \frac{c(\widetilde{\theta})}{2t\widetilde{\theta}}+\frac{\widetilde{\theta}}{2} \\
\frac{d\Theta_i}{d\widetilde{\theta}} &= \frac{1}{2}+\frac{1}{2t}\frac{c'(\widetilde{\theta})\widetilde{\theta}-c(\widetilde{\theta})}{\widetilde{\theta}^2}=\frac{1}{2}+\frac{c'(\widetilde{\theta})}{2t\widetilde{\theta}}-\frac{c(\widetilde{\theta})}{2t\widetilde{\theta}^2}
\end{aligned}$$

The optimal level of environmental friendliness Θ^* of the differentiated firm is then defined by a standard, even complicated, equalization between marginal costs and benefits, weighted by the respective market shares of the two kinds of producers. Regarding the purchasers of the differentiated good $\left(\overline{\theta}-\Theta_i\right)$, any increase in the environmental friendliness of the firm will be judged as regards to the difference between the marginal cost of this increase in quality $c'(\widetilde{\theta})$, the avoided marginal damage $d'(\beta-\widetilde{\theta})$ and the difference implied for the transportation costs $t\left(\overline{\theta}+\Theta_i-2\widetilde{\theta}\right)$. In addition, this increase in the quality generates a switch in the demand from the generic good toward the differentiated good $\frac{d\Theta_i}{d\widetilde{\theta}}$ which has to be valued by the difference between the production cost $c(\widetilde{\theta})$ and the fixed damage $d(\beta)$, and the change in the transportation costs.

The following intuitive proposition can be proved by comparison of the explicit expressions of the first-order conditions between this program and the previous one.

Proposition 2 *When the willingnesses to pay for environmental friendliness of the consumers are uniformly distributed on the interval* $\left[0,\overline{\theta}\right]$ *the level of differentiation chosen by the monopolist under perfect information* θ^* *is less than the optimal one* Θ^*.

4 The choice of differentiation with uninformed consumers

Our second step addresses the optimal choice of differentiation of the firm in case it is possible to lie to the consumers and hence to exaggerate its level of environmental friendliness.

The decision process of the monopoly is now described by a three-stage game. At the first stage of the game, the monopoly chooses its true environmental friendliness $\widetilde{\theta}$ (like in

Lehmann- Grube [22] for a duopoly case) but in the second stage of the game, instead of disclosing this true quality to the consumers, it chooses a level of advertising expenditures and thus to display a greater environmental friendliness (or equivalently a smaller emission coefficient) $\theta_a > \widetilde{\theta}$. At the third stage, the firm determines the price by maximizing profit and supplies the demand. As usual, the model is solved using backward induction.

The core of the model is the assumption that the monopolist chooses a given level of environmental friendliness but may have some incentives to let consumers think that this quality is even higher than the true one. Such a result can be obtained through environmental partial disclosures (like in Lyon and Maxwell [23]) or through advertisement. Assume that the firm can buy a technology which will enable it to produce with quality $\widetilde{\theta}$ that is unknown by the consumers, and that the producer invests in advertising in order to mislead the consumers by displaying a greater environmental friendliness θ_a. But any such attempt of cheating is costly. And, more crucially, in a context characterized by imperfect information, consumers are more or less aware of the firm's incentive to cheat. Here come the environmental NGOs on. We will later discuss their role more thoroughly, but in this part, let us formulate one of the most natural assumption about it: in general, NGOs can scrutinize the environmental disclosure of the firms, and they can eventually detect cheating attempts and disclose the true level of environmental friendliness. A typical model of Perfect Bayesian Equilibrium would introduce the action of NGOs and then formalize the expected quality of the firm as the result of the consumer's beliefs formation according to the information given by the NGOs or by the firm, and to the level of confidence of consumers respectively in firms and NGOs. By denoting by μ the probability for consumers that the firm tells the truth and $(1-\mu)$ that the NGOs are right, this could be modelled as:

$$\widehat{\theta} = \mu\theta_a + (1-\mu)\,\widetilde{\theta}$$

Unless assuming that μ is itself endogenous, we can simplify the reasoning and adopt a reduced form for this process. We suppose that the firm advertises a greater level of quality than true but that the information given by the NGOs weakens the efficiency of the advertising campaigns, or equivalently, increases its costs for cheating. This combined process results in an expected quality for consumers $\widehat{\theta} > \widetilde{\theta}$. Let us denote $\epsilon = \widehat{\theta} - \widetilde{\theta}$ the size of the obtained cheating. The cost of obtaining this level of quality over-statement is due both to the cost of the advertising campaign and to the fact that the NGOs reduced the efficiency of the campaign. To summarize, we can set that the cost of the perceived

over-statement of quality is $A(\epsilon)$ with $A'(\epsilon) > 0$ and $A''(\epsilon) \geq 0$.

Compared to the previous model under perfect information, the first stage is similar in the spirit, except that the producer maximises its profit given its true production cost depending on $\widetilde{\theta}$ while the demand depends on $\widehat{\theta}$.

$$\begin{cases} D(p,\widehat{\theta}) = \overline{\theta} - \theta_i = \overline{\theta} - \dfrac{\widehat{\theta}}{2} - \dfrac{p}{2t\widehat{\theta}} \\ p(\widetilde{\theta},\widehat{\theta}) = \dfrac{c(\widetilde{\theta})}{2} + t\widehat{\theta}\left(\overline{\theta} - \dfrac{\widehat{\theta}}{2}\right) \end{cases} \tag{9}$$

or equivalently

$$\begin{cases} D(\widetilde{\theta},\epsilon) = \dfrac{1}{2}\left(\overline{\theta} - \dfrac{\widetilde{\theta}+\epsilon}{2}\right) - \dfrac{c(\widetilde{\theta})}{4t\left(\widetilde{\theta}+\epsilon\right)} \\ p(\widetilde{\theta},\epsilon) = \dfrac{c(\widetilde{\theta})}{2} + t\left(\widetilde{\theta}+\epsilon\right)\left(\overline{\theta} - \dfrac{\widetilde{\theta}+\epsilon}{2}\right) \end{cases} \tag{10}$$

We intercalate here a second stage between the first one where the firm chooses its true level of differentiation and the last one where the demand and price are determined. At this stage, the already differentiated firm chooses the level of advertising, for a given true environmental friendliness. It is worth noting here that if the firm has incentive to cheat because any increase in its environmental friendliness is costly, it has also incentive to really differentiate because advertising under the pressure of NGOs is costly as well.

The profit can be rewritten as

$$\pi(\widetilde{\theta},\epsilon) = \left[p(\widetilde{\theta},\epsilon) - c(\widetilde{\theta})\right] D(\widetilde{\theta},\epsilon) - A(\epsilon) \tag{11}$$

Proposition 3 *When the willingnesses to pay for environmental friendliness of the uninformed consumers are uniformly distributed on the interval* $\left[0,\overline{\theta}\right]$*, there are incentives for the differentiated monopolist to cheat by exaggerating its environmental friendliness:* $\epsilon \geq 0$.

Proof. By using the envelope theorem, we find

$$\left.\frac{\partial \pi(p,\widetilde{\theta},\epsilon)}{\partial \epsilon}\right|_{p(\widetilde{\theta},\epsilon)} = \underbrace{\left[p(\widetilde{\theta},\epsilon) - c(\widetilde{\theta})\right]\frac{\partial D}{\partial \epsilon}}_{+/-} + \underbrace{D\frac{\partial p}{\partial \epsilon}}_{+} - \underbrace{A'(\epsilon)}_{+} = 0 \tag{12}$$

because

$$\begin{cases} \dfrac{\partial p}{\partial \epsilon} = t\left(\overline{\theta} - \dfrac{\widetilde{\theta}+\epsilon}{2}\right) - \frac{1}{2}t\left(\widetilde{\theta}+\epsilon\right) = t\left(\overline{\theta} - \left(\widetilde{\theta}+\epsilon\right)\right) = t\left(\overline{\theta} - \widehat{\theta}\right) \\ \dfrac{\partial D}{\partial \epsilon} = -\dfrac{1}{4} + \dfrac{c(\widetilde{\theta})}{4t\left(\widetilde{\theta}+\epsilon\right)^2} \end{cases}$$

The effect on price is strictly positive since the seeming differentiation is not maximal. No increase in price could be obtained by overpassing the upper limit of the consumers' environmental concerns. One can show that there is an upper limit to the cheating of the firm above which any additional cheating will lead to a decrease in the demand:

$$\epsilon \leq \sqrt{\frac{c(\widetilde{\theta})}{2t}} - \widetilde{\theta} \tag{13}$$

If $\sqrt{\frac{c(\widetilde{\theta})}{2t}} - \widetilde{\theta} \geq 0$, the demand increases for any lower level of cheating but decreases above it. If this condition happens not to be met (after the choice of the real level of diffentiation), the demand would decrease when the cheating increases.

Conditionally that the demand effect (if negative) is less than the price effect, there is an incentive for the firm to increase its seeming level of environmental friendliness, until the marginal benefit of doing so equalizes the marginal cost of advertising. QED ■

Proposition 4 *When the willingnesses to pay for environmental friendliness of the uninformed consumers are uniformly distributed on the interval* $\left[0, \overline{\theta}\right]$*, the announced environmental friendliness by the differentiated monopolist* $(\widehat{\theta})$ *is equal to the level chosen under perfect information* θ^* *if and only if* $A'(\theta^*) = D(\theta^*)c'(\theta^*)$*. In all other cases, the annonced level of environmental friendliness is different than under perfect information: if the marginal cost of environmental friendliness is greater than the marginal cost of advertising, the firm will choose to announce* $\widehat{\theta} > \theta^*$*.*

Proof. Let us rewrite in $\widehat{\theta}$ the FOC of this probleme (eq. 12) and compare it with the FOC of the previous model under perfect information (eq. 4).

$$\left.\frac{\partial \pi(p, \widetilde{\theta}, \widehat{\theta})}{\partial \widehat{\theta}}\right|_{p(\widetilde{\theta},\widehat{\theta})} = \underbrace{\left[p(\widetilde{\theta}, \widehat{\theta}) - c(\widetilde{\theta})\right] \frac{\partial D(\widehat{\theta})}{\partial \widehat{\theta}}}_{+/-} + \underbrace{D(\widehat{\theta}) \frac{\partial p(\widetilde{\theta}, \widehat{\theta})}{\partial \widehat{\theta}}}_{+} - \underbrace{A'(\widehat{\theta})}_{+} = 0 \tag{14}$$

$$\left.\frac{\partial \pi(p,\widetilde{\theta})}{\partial \widetilde{\theta}}\right|_{p(\widetilde{\theta})} = \left[p(\widetilde{\theta}) - c(\widetilde{\theta})\right] \underbrace{\frac{\partial D(\widetilde{\theta})}{\partial \widetilde{\theta}}}_{-} + D(\widetilde{\theta}) \underbrace{\left[\frac{\partial p}{\partial \widetilde{\theta}} - c'(\widetilde{\theta})\right]}_{+/-} = 0 \tag{15}$$

Assume that $\widehat{\theta} = \theta^*$. It would lead to $A'(\theta^*) = D(\theta^*)c'(\theta^*)$. If this condition is not met, the solutions of these two equations are then different: $\widehat{\theta} \neq \theta^*$. QED ■

Lastly, at the first stage, the firm chooses its true level of environmental friendliness, knowing that it will be led to announce a greater environmental concern and expecting the price and demand.

Proposition 5 *When the willingnesses to pay for environmental friendliness of the uninformed consumers are uniformly distributed on the interval* $\left[0, \overline{\theta}\right]$*, the true environmental friendliness of the differentiated monopolist is also different from the optimal one under perfect information.*

Proof. By using again the envelope theorem, one obtains

$$\left.\frac{\partial \pi(p,\widetilde{\theta},\epsilon)}{\partial \widetilde{\theta}}\right|_{p(\widetilde{\theta},\epsilon)} = \left[p(\widetilde{\theta},\epsilon) - c(\widetilde{\theta})\right] \underbrace{\frac{\partial D(\widetilde{\theta},\varepsilon)}{\partial \widetilde{\theta}}}_{+/-} + D(\widetilde{\theta},\varepsilon) \underbrace{\left[\frac{\partial p(\widetilde{\theta},\epsilon)}{\partial \widetilde{\theta}} - c'(\widetilde{\theta})\right]}_{+/-} = 0 \tag{16}$$

which is only seemingly similar to eq. 4 because of the impact of the cheating ϵ.

$$\begin{cases} \dfrac{\partial D(\widetilde{\theta},\varepsilon)}{\partial \widetilde{\theta}} = -\dfrac{1}{4} - \dfrac{\left(\widetilde{\theta}+\epsilon\right)c'(\widetilde{\theta}) - c(\widetilde{\theta})}{4t\left(\widetilde{\theta}+\epsilon\right)^2} \lesseqgtr 0 \\ \dfrac{\partial p(\widetilde{\theta}+\varepsilon)}{\partial \widetilde{\theta}} - c'(\widetilde{\theta}) = -\dfrac{c'(\widetilde{\theta})}{2} + t\left(\overline{\theta} - \left(\widetilde{\theta}+\epsilon\right)\right) \lesseqgtr 0 \end{cases}$$

■

The intuition allows to think that it should be less that the level θ^* chosen by the firm under perfect information. But it remains to be showed. What is also intuitive is that there are absolutely no reason to hope that the monopolist's choice could converge towards the optimal level of environmental friendliness, Θ^*.

5 The role of NGOs

One can observe that NGOs have in general two lines of action. Some of them decide to directly cooperate with firms in order to influence their behavior, but most of them remain

external to the firms. They question and audit their practices but the greatest part of their efficiency comes from the influence they exert on consumers. What is the nature of this influence? One can think that NGOs have two crucial roles on consumers: on the one hand, they increase their information about environmental issues and hence can increase their environmental awareness; on the other hand, they increase their ability to analyze the environmental claims of firms and can increase the consumers' skepticism about them.

During the second period, environmental NGOs can audit the monopoly and detect the cheating, or not. If it does not occur, firms maintain the same prices as during the first period because consumers have no reason to modify their demand. But if such an event occurs, it reveals that the responsible firm was less environmental friendly than initially perceived by the consumers due to advertising expenses. Some consumers who were misled about quality can decide to buy the other product.

5.1 Increase of the green awareness of consumers

We can elaborate three assumptions concerning the increase of green awareness allowed by the actions of NGOs. One can first consider that all consumers are not affected in the same way by the NGOs, the more sentitive to green arguments becoming the more affected by the NGOs campaigns and the less concerned being quite indifferent to them. This hypothesis can have two different meanings: the range of the green concern can be enlarged, or the distribution of the green concerns will be modified. One could also imagine that all consumers are equally affected by advertising, whatever their environmental concern, the range of the consumers tastes for the environment being translated from $\left[0, \overline{\theta}\right]$ toward $\left[\underline{\theta}, \overline{\overline{\theta}}\right]$ with $\underline{\theta} > 0$ and $\overline{\overline{\theta}} - \underline{\theta} = \overline{\theta}$. In the real world, the impact of the action of NGOs certainly results in a combination of these three motions.

In this paper, we will focus on the first case. Assuming that the range of green awareness enlarges, without affecting the less sensitive consumer, means that $\overline{\theta}$ increases. One can then examine the consequences of this increase in $\overline{\theta}$. Because the number of consumers does not change, the increase of $\overline{\theta}$ means a decrease in the density function characterizing their distribution. This case is represented by Figure 2, where the colored area symbolizes the density of the distribution of consumers over the interval of green awareness.

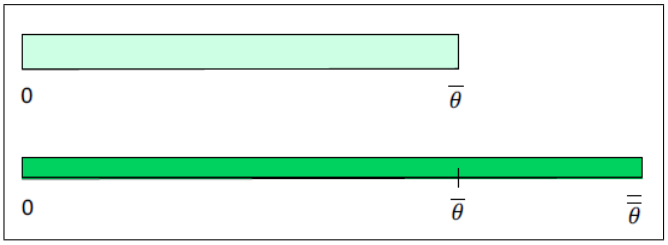

Figure 2

Under perfect information, like under imperfect information of consumers about its environmental friendliness, one can expect that the choices of the monopolist are just translated towards greater environmental friendliness, its market share being nevertheless modified because the demand to the monopolist is not simply proportional to $\overline{\theta}$. Let us precise the impacts of a change in $\overline{\theta}$, in the case of perfect information, on $\pi(\widetilde{\theta})$:

$$\begin{aligned} \frac{\partial \left[p(\widetilde{\theta}) - c(\widetilde{\theta})\right]}{\partial \overline{\theta}} &= t\widetilde{\theta} \\ \frac{\partial D}{\partial \overline{\theta}} &= \frac{1}{2} \end{aligned}$$

As the demand and the margin of any monopolist $\widetilde{\theta}$ increase with $\overline{\theta}$, its profit increases. But the effect of the rise in $\overline{\theta}$ on the choice of its environmental friendliness by the monopolist is more ambiguous, as it is established by Proposition 6.

Proposition 6 *When the maximal willingness to pay for environmental friendliness $\overline{\theta}$ of the uninformed consumers is increased to $\overline{\overline{\theta}}$, the consumers becoming uniformly distributed on the interval $\left[0, \overline{\overline{\theta}}\right]$, the level of quality chosen by the monopolist increases if and only if $\left|t\theta^* D(\theta^*)\eta_{\widetilde{\theta}}(\theta^*)\right| < tD(\theta^*) - \frac{1}{2}\left[p(\theta^*) - c(\theta^*)\right]\eta_{\widetilde{\theta}}(\theta^*)$, where $\eta_{\widetilde{\theta}}(\theta^*) < 0$ is the elasticity of the demand addressed to the monopolist relatively to its choice of environmental friendliness.*

Proof. Let us compute the effects of a change in $\overline{\theta}$, in the case of perfect information, on $\pi'(\theta^*)$:

$$\frac{\partial \pi'(\theta^*)}{\partial \overline{\theta}} = t\theta^* D(\theta^*) \underbrace{\eta_{\widetilde{\theta}}(\theta^*)}_{-} + tD(\theta^*) - \frac{1}{2}\left[p(\theta^*) - c(\theta^*)\right] \underbrace{\eta_{\widetilde{\theta}}(\theta^*)}_{-}$$

where $\eta_{\widetilde{\theta}}(\theta^*) < 0$ is the elasticity of the demand addressed to the monopolist relatively to its choice of environmental friendliness. It is easy to see in the above equation that $\overline{\theta}$ has a negative impact on $\pi'(\theta^*)$ because of the demand effect of any change in the

quality but has also a positive impact through the price effect. Both effects depend on the demand elasticity $\eta_{\widetilde{\theta}}(\theta^*)$. The monopolist will choose a greater level of quality if and only if $\partial\pi'(\theta^*)/\partial\overline{\theta}$ or equivalently if and only the change in $\overline{\theta}$ increases the marginal profit obtained in θ^*: as $\pi'(\theta^*)$ becomes positive and because of the concavity of the profit function, the profit will be maximized for a higher level of quality. ■

Even in this simple case, the role of the NGOs is ambiguous, since it does not always allow to reach a greater level of environmental concern of the monopolist, and then a lower level of polluting emissions.

5.2 Increase of the consumers' information/skepticism

Once again, consumers confidence in the monopoly's claims might be equally affected by the action of the NGOs or it might be influenced at different extent, depending on their green awareness and on the action of NGOs. One of the most natural assumption about this effect is to assume that the information given by th NGOs weaken the efficiency of the advertising campaigns of the monopolist, or equivalently, increase its costs for cheating. Under this assumption, the incentives to cheat weaken, the chosen level of fraud decreases and the level of the announced and of the true environmental friendliness get closer to the optimal level chosen under perfect competition.

But this is a quite optimistic wiew of the impact of the NGOs attacks on cheating firms. It relies on perfect valuations by the NGO of the environmental friendliness of the firm and on the perfect confidence of consumers in the NGOs audit. But the attacks of NGOs on some firms may increase the global skepticism of the consumers about the claims of all firms.

On can then describe this set of assumptions by assuming that the consumers do not accept any more the level of the announced environmental friendliness as a fact but form their own expectations of this quality by weighting the announced one with a lower limit for the true one, this limit being arbitrarily dropped as the consumers skepticism get worse.

$$\widehat{\widehat{\theta}} = \underbrace{\mu}_{NGO\searrow}\,\widehat{\theta} + (1-\mu)\,\underbrace{\theta_0}_{NGO\searrow}$$

As a result, if the expected level of environmental concern of the monopolist happens

to be lower than the true one would be under perfect information, the demand expressed by consumers is lower and the firm may be compelled to choose a level of environmental quality below the level of perfect information.

6 Conclusion

In this paper, we have shown that, when the consumers cannot acquire accurately information about the environmental friendliness of the firms, the most environmentally efficient firm is generally induced to advertise and to cheat about its true level of environmental concern, the characteristics of the demand side of the market, and on the cost differential between the monopolist and the other firms. The role of NGOs may have ambiguous effects on the choice of differentiation, because it can increase the demand faced by the monopolist by increasing the size of the global market but it might also increase the consumers' skepticism and then reduce their demand to the differentiated monopolist.

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