Component-free strategy of firms under pressure from the NGOs*

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Abstract

There is a growing pressure of NGOs on firms to have them eliminate a component (as palm oil) harmful for the environment (as rainforests) from their products or to replace such a component with a sustainable substitute component the NGO certifies. Under which conditions NGO's pressure leads a firm to eliminate basic component in its product or, alternatively, to substitute a damaging component with the certified sustainable component? What are the ensuing effects on market structure? This paper addresses these issues using a model of two-dimensional vertical product differentiation.

Keywords: NGO; Eco-label; Environmental quality; Product differentiation

JEL classification: D11; D62; D83; L15; Q58

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1 Introduction

"If a company is doing the right thing, we are proud to stand up with them to advocate for solutions. If they are doing the wrong thing, we can campaign against them all around the globe to bring enough pressure to bear that they are forced to do the right thing." This statement of Daniel Kessler, a spokesperson of Non-Governmental organization (NGO) Greenpeace, illustrates the growing pressure of environmental NGOs on firms' strategies.[1] NGOs' campaigns may take various forms and aim different environmental goals. They often disclose information about the properties of the goods purchased by consumers, the sustainability of the production processes and their environmental impacts. A famous example is the campaign Greenpeace carried out in 2010 to *"Ask Nestlé to give rainforests a break"*.[2] Largely relayed by social network, it forced Nestlé to end its partnership with Sinar Mas, the largest palm oil producer in Indonesia and to commit to remove deforestation from its supply chains. In 2015, Greenpeace continues pressuring on global consumer goods manufacturers by publishing a report revealing how companies were keeping promises to stop deforestation in Indonesia for palm oil. Number other environmental NGOs' campaigns aim similar goals, as the French Greenpeace's "zero pesticide" run amongst the six largest retailers (Auchan, Carrefour, Casino, Intermarché, Monoprix, Magasins U).

These kind of campaigns resort to the field of what Baron (2009) calls as private politics, which include a vast range of tactics, from simple information disclosure (Baron (2011), Petrakis, Sartzetakis, and Xepapadeas (2005) or Heyes, Lyon, and Martin (2016)) to boycotts campaigns (studied by Innes (2006), Baron, Neale, and Rao (2016), Baron (2016), Delacote (2009), and Egorov and Harstad (2017)). They result in an increasing number of 'component-free products', such as palm oil, pesticide, antibiotic, GM, nitrate and also paraben-free products, in agri-food product and cosmetic markets. In the specific case of palm oil issue, the Roundtable on Sustainable Palm Oil (RSPO), including the environmental NGOs such as WWF, promotes the growth and use of certified sustainable palm oil (CSPO) as an alternative of elimination of damaging palm oil for firms, even though the effectiveness of such eco-labels in preventing deforestation have been contested (van der Ven, Rothacker, and Cashore (2018)). Firms may prefer this option because it avoids altering the texture of the product, contrary to the palm oil elimination. Under which conditions NGO's pressure leads a firm to eliminate basic component in its product or, alternatively, to substitute a damaging component with a certified sustainable component? What are the optimal strategies for the NGOs? What are the ensuing effects on market structure and on the quality of the environment? This paper addresses these issues using

[1] https://www.greenbiz.com/blog/2010/04/22/how-ngo-partnerships-changed-over-20-earth-days (accessed 2017/03/01).

[2] http://www.greenpeace.org/international/en/campaigns/climate-change/kitkat/ (accessed 2017/03/01).

a model of two-dimensional vertical product differentiation.

There is a rich theoretical literature on the competition between green and brown products, which studies efficiency of environmental policies (as minimum quality standards, voluntary labels, norms, taxation) depending on cost structure and abatement method of firms and on environmental consciousness, information and altruism of consumers. To the best of our knowledge, only some papers consider the role of NGOs as certifying organizations which aim at improving the quality of the environment (Bottega and De Freitas (2009), Fischer and Lyon (2014), Bonroy and Constantatos (2015), Poret (2016), Brécard (2014), Brécard (2017)) or the competition issues related with environmental awareness and labels (Conrad (2005), Ben Elhadj and Tarola (2015), Ben Elhadj, Gabszewicz, and Tarola (2015), Heyes and Martin (2015)). Altough we study the conditions of NGO's eco-labelling efficiency, we depart from these papers by more deeply analyzing the influence of NGO on consumer preferences and, through this, on firm choice of environmental quality.

Furthermore, we adapt the original model of bidimensional vertical differentiation of Garella and Lambertini (2014). Indeed, the use of the denounced component by the firm is due to technical reason: such a component (as palm oil) is crucial to assure the good product texture (as Nutella), that we refer to as organoleptic quality. Removing such a substance causes a significant deterioration in the taste characteristic. In other words, a high organoleptic quality is associated with a low environmental quality, and reversely. The component-free product is therefore viewed as a product with a high environmental quality but a low organoleptic quality. Such an assumption is close to the hypothesis made by Mantovani, Tarola, and Vergari (2016). Indeed, they assume that high intrinsic quality of a product generates high polluting emissions. However, we depart from their assumption in that the 'good' and the 'bad' attributes have no presupposed inversely proportional relation. Moreover, the harmful component can not only be eliminated, to the detriment of the product texture, but also replaced by a 'sustainable' component (as sustainable palm oil) certified by an NGO, which does not alter the organoleptic quality of the product. Moreover, in Mantovani et al. (2016) model, consumers have homogeneous preferences for the environmental quality and heterogeneous preferences for the intrinsic quality, whereas in our model, consumers have heterogeneous preferences for the environmental quality and homogeneous preferences for the organoleptic quality. In other words, the environmental attribute is the non-hedonic characteristic in their model, but the hedonic one in ours.

Using this original framework, we show how consumers' relative willingness-to-pay (WTP) for environmental quality and for organoleptic quality play a crucial role in efficiency of NGO campaign. The cost structures of elimination of the harmful component and of its replacement by a substitutable component also condition the effectiveness of the NGO campaign.

Moreover we extend our analysis of the strategies used by the NGO to fulfill its objective by considering the possibility for the NGO to directly influence the consumers environmental awareness through an information campaign on top of their disclosure campaign about the harmfulness of the component, and also to certify another component, less harmful for the environment. Our model shares therefore common features with Bottega, Delacote, Ibanez, et al. (2009), García-Gallego and Georgantzís (2009), and García-Gallego, Georgantzís, et al. (2010). Beyond the theoretical novelties of our approach, our main contribution is to show that, the NGO may waive the objective of achieving a market where only the least environmentally harmful product is offered, when the cost of developing such a product is very high, and may prefer to restrict the market share of this product by favouring the entry of a new competitor with a product using the certified component. However, we also show that, in other cases and for an initial budget sufficiently high, the NGO may prefer to hamper cost-effectiveness of the certified component, in order to increase the market share of the component-free product, or even to encourage the creation of a monopoly.

The remainder of the paper is structured as follows. Section 2 presents the basic model. Section 3 analyzes the effects of information disclosure and increasing-awareness campaign of the NGO on consumer and firm choices. Section 4 studies the conditions under which the certified sustainable component is adopted. Section 5 offers conclusions.

2 The model

2.1 Consumers

In the line with Garella and Lambertini (2014), we assume that consumers decide to buy one unit or zero of the good, which is characterized by two attributes: a non-hedonic (homogeneous) organoleptic characteristic, such as taste or texture, denoted t_i, and an hedonic (heterogeneous) environmental characteristic, denoted e_i (with $i = 0, L, M, H$). The latter is related to the component denounced by the NGO. Before information disclosure, consumers are not aware of such a harmful component in the product. The environmental attribute can be qualified as 'neutral'. After information disclosure, consumers have a full understanding of the damaging impact of the component on the environment (and/or the health). Therefore, the environmental characteristic is no longer a 'neutral attribute' but a 'bad attribute.'

Consumers' WTP for environmental quality is assumed uniformly distributed over $\left[\underline{\theta}, \overline{\theta}\right]$ before the NGO's campaign. The NGO's campaign increases the WTP, which is then defined by the increasing function $\theta(x)$, with x the raising-awareness effort of the NGO. The campaign is therefore a form of persuasive advertising (Bagwell, 2007; van der Made and Schoonbeek, 2009). For

the sake of simplicity, we assume that $\theta(x) = \theta + x$. Consumers' WTP for organoleptic quality is constant, denoted $\rho > 0$, for all consumers. Therefore, consumer preferences are represented by the following utility function

$$u_i(\theta, x) = \rho\ t_i + \theta(x)e_i\ \ - p_i \text{ for } \ i = 0, h, m, l \tag{1}$$

with p_i the price of the product i. The consumer indifferent between consuming the product i and refraining from buying at price p_i is characterized by marginal willingness to pay the environmental quality $\widetilde{\theta_i} = \frac{p_i - \rho t_i}{e_i} - x$.

2.2 Firm

We assume that, before the NGO's campaign, the market is fully covered by a monopoly producing a good with organoleptic quality t_0 and with an environmental quality perceived as being equal to e_0 by the uninformed consumers. The monopoly incurs a unit production cost c_0, which is supposed null, without loss of generality. The price that maximizes the profit of the monopoly is the maximal price that all consumers are ready to pay for the product: $p_0 = \rho\ t_0 + \underline{\theta} e_0$. The profit is then defined by $\pi_0^* = \rho\ t_0 + \underline{\theta} e_0$. Because consumers do not pay attention to the environmental quality of the product, we assume that $e_0 = 0$.[3]

After the NGO's campaign, according to the type of good the monopoly decides to supply, it earns a profit $\pi_i(p_i) = (p_i - c_i)d_i(p_i) - F_i$, with $i = H, M, L$. We assume that, when the firm continues to produce the product with the harmful component, denoted with a subscript L, it bears exactly the same cost than before the campaign, that is $c_L = 0$ and $F_L = 0$. To turn to a component-free product (denoted H), the monopoly has to engage in R&D. As usual in differentiation models, we assume that R&D only generates a fixed cost, such as $F_H \geq 0$ and $c_H = 0$. To turn to a certified product (denoted M), the firm has to buy a sustainable component to replace the denounced component. Therefore, we assume that it only bears a higher variable production cost than before, equal to $c_M \geq 0$, and that there is no fixed cost incurred when adopting the intermediate component ($F_M = 0$). Moreover, the firm has to pay a label fee, φ, to the NGO per unit of product M sold.[4]

The NGO's campaign may also foster entry of new firms in the market. By disclosing the damaging impacts of the denounced attribute, it creates possibility of product differentiation and profit opportunities for new entrants. According to these profit expectations, the market may move towards a duopoly or triopoly market structure.

[3] An alternative assumption could be that consumers only pay attention to the change in environmental quality due to information disclosure and campaign of the NGO.

[4] Allowing the variable production cost to increase with the environmental quality level e_M would only have an impact if this quality level was endogenous. However, we assume it to be exogenous (section 2.3).

2.3 NGO

Knowing a harmful component in the good, the NGO wants to disclose information and to promote consumer awareness of the damaging effect of this component on the environment. Disclosing information is costless but the awareness-raising campaign requires a cost strictly increasing and convex in effort x, with the quadratic form x^2 ($x \geq 0$). The objective of the NGO is to enhance the quality of the environment under its budget constraint. In the general case of three products coexisting on the market, the global quality of the environment is defined as the sum of the quality of the environment due to each product, defined as $E_i = e_i d_i$ for $i = L, M, H$. We assume that the NGO has an initial budget B that finances its awareness-raising campaign effort x^2. In case it decides to certify a substitutable component less harmful for the environment, it charges a unit fee φ that accrues to its initial budget, potentially allowing to finance a greater campaign effort. We assume here that the quality of the substitutable component is exogenously determined (depending on the bargaining power of the NGO and the local producers of this component). As a result, the NGO's program is

$$\begin{cases} \max\limits_{x,\varphi} \sum\limits_{L,M,H} E_i = \sum\limits_{L,M,H} e_i d_i \\ \text{st } x^2 \leq B + \varphi d_M \end{cases}$$

2.4 Timing of the game and market structure

The game involves a series of stages:

1. Before the NGO's campaign, the monopoly produces a good with an environmental quality index e_0 depending on the use of a given component (palm oil for Nutella, coal for electricity)

2. The NGO learns the harmfulness of the component used by the monopoly and decides to campaign (we assume that its objective function will make it profitable to campaign in any case) by disclosing this information, that is $e_L < e_0 = 0$. Disclosure is costless but influencing the environmental awareness of the consumers is costly.

3. The NGO decides to invest x^2 in order to increase the consumers' willingness to pay for environmental friendliness and to certify an intermediate component of quality e_M with $e_0 < e_M < e_H$.

4. The monopoly reacts to the information campaign of the NGO. It can choose between 3 options:

   (a) producing the low-quality good with the same harmful component, and losing profit;

(b) investing in R&D in order to produce a free-component good, of quality $e_H > e_0$;

(c) substituting the harmful component with the certified intermediate component, of quality $e_M \in]e_0, e_H[$.

5. Depending on the choice of the monopoly, other firms can enter the market and offer the other varieties of the good. The resulting market structure can thus potentially be a duopoly or a triopoly, as shown in Figure 10.

6. The consumers decide to buy one unit of the proposed products or none.

We solve the game backwards.

It is worth noting that similar market structures may originate from different causes. For example, the duopoly (L, H) corresponds to the case where the initial monopoly decides to maintain product L denounced by the NGO and a competitor enters the market with product H, whereas the duopoly (H, L) corresponds to the case where the initial monopoly decides to go for product H leaving enough space to a competitor to enter the market with product L, even though it is shamed by the NGO. In the first case, the monopoly maintains its initial product because going for product H would be too costly (high R&D costs) and induce a lower profit than keeping L, and the competitor enters if the duopoly profit obtained with H is greater than zero, despite the high R&D costs. In the second case, the monopoly decides to move for product H (low R&D costs) and the competitor enters as soon as its duopoly profit with product L is still positive. The sequence of the game will be more deeply analyzed in Section 3.4.

3 Information disclosure and awareness campaign

3.1 Monopoly equilibrium with the harmful component-containing product

After the NGO's campaign, when the monopoly continues to produce the same good, consumers consider the denounced component of the product as a "bad attribute", such as $e_L < e_0$, while the organoleptic attribute remains unchanged ($t_L = t_0$). Assuming $e_0 = 0$, the bad attribute is characterized by a negative quality index, $e_L < 0$. For the sake of simplicity, as e_L is the worst possible environmental quality, we define $e_L \equiv -\overline{e}$.

As a result of information disclosure about the detrimental nature of product L on the environment, consumers with high WTP for environmental quality turn away from the harmful component containing product. We therefore assume that the market gets uncovered.[5]

[5]Only consumers with $\theta \leq \widetilde{\theta}_L = \frac{\rho t_0 - p_L}{\overline{e}} - x$ buy the product.The demand is then defined by $d_L = \frac{\widetilde{\theta}_L - \underline{\theta}}{\overline{\theta} - \underline{\theta}}$.

Definition 1 *The minimal WTP for product L is defined as* $\underline{\omega}_L(x) \equiv \rho t_0 - (\overline{\theta} + x)\overline{e}$. *The maximal WTP is* $\overline{\omega}_L(x) \equiv \rho t_0 - (\underline{\theta} + x)\overline{e}$.

The equilibrium price is derived from the first order condition of maximization of $\pi_L(p_L) = p_L d_L(p_L)$. It is characterized by:

$$p_L^m(x) = \frac{1}{2}\overline{\omega}_L(x) \tag{2}$$

The monopoly faces a demand equal to:

$$d_L^m(x) = \frac{\overline{\omega}_L(x)}{2(\overline{\theta} - \underline{\theta})\overline{e}} \tag{3}$$

The profit is then defined by: $\pi_L^m(x) = (\overline{\theta} - \underline{\theta})\,\overline{e}\,d_L^m(x)^2$.

Assumption 1 $\rho t_0 > \underline{\theta}\overline{e}$.

Assumption 1 ensures that product L remains profitable for the monopoly after information disclosure about the harmful component as long as the NGO does not campaign to increase the environmental awareness. When the NGO increases its awareness-raising effort, this translates the space of marginal willingness to pay for environmental quality from $\left[\underline{\theta}, \overline{\theta}\right]$ to $\left[\underline{\theta} + x, \overline{\theta} + x\right]$. Intensification of the campaign urges the monopoly to reduce its price, meanwhile the demand is reduced anyway. Its profit is then decreasing with x. Therefore, all other things being equal, product L remains cost-effective as long as the awareness campaign is not too impactful and it yields lower profit than before information disclosure ($\pi_L^m(x) < \pi_0^*(x)$ for all x).[6]

3.2 Monopoly equilibrium with the component-free product

Under NGO pressure, the monopoly can decide to produce the component-free product. It bears R&D cost F_H. The environmental quality of the component-free product is a "good attribute" ($e_H > e_0 > e_L$), but its organoleptic attribute is of lower quality ($t_H < t_0$). Because the component-free product is of the best possible environmental quality, we assume that e_H and e_L are symmetrical with respect to e_0, that is $e_H = \overline{e}$. For the sake of simplicity and clarity, the Nash equilibria analysis focuses on the case of fully covered markets.

Definition 2 *The minimal WTP for product H is defined as* $\underline{\omega}_H(x) \equiv (\underline{\theta} + x)\overline{e} + \rho t_H$. *The maximal WTP is* $\overline{\omega}_H(x) \equiv (\overline{\theta} + x)\overline{e} + \rho t_H$.

Monopoly H has an interest in setting a price equal to $\underline{\omega}_H(x)$ and it earns profit $\underline{\omega}_H(x) - F_H$. Assumption 2 ensures that the market is covered.

[6] Conditions of existence and of market coverage are detailed in Appendix 6.1

Assumption 2 $\rho t_H \geq (\overline{\theta} - 2\underline{\theta})\,\overline{e}$.

Cost-effectiveness of product H requires that the NGO make a sufficiently impactful effort campaign. Starting from this threshold, when the NGO intensifies its campaign, the monopoly benefits from higher WTP for the component-free product. It increases its price and earns an improved profit. Therefore, as shown in Figure 1, there exists a campaign effort above which the monopoly has an interest in switching to the component free product, insofar as its profit is then higher than before ($\pi_H^m(x) \geq \pi_L^m(x)$).

3.3 Duopoly Equilibrium

Depending on the profitability of the market, the introduction of the component-free product can result in a duopoly or a monopoly equilibrium. Assume that a firm decides to enter the market and to supply a differentiated variety.

Assumption 3 $\rho(t_0 + t_H) \geq 2(\overline{\theta} - \underline{\theta})\,\overline{e}$.

Assumption 3 ensures that the duopolistic market is covered. It requires that the organoleptic attribute dominates the environmental attribute in such a way that the global WTP for organoleptic qualities is at least twice the global WTP for environmental qualities. All consumers are then ready to pay for their preferred product (at given prices) and firms act as usual differentiated duopoly. Demand functions are then defined as $d_H = \frac{\overline{\theta} - \widetilde{\theta}_{LH}}{\overline{\theta} - \underline{\theta}}$ and $d_L = \frac{\widetilde{\theta}_{LH} - \underline{\theta}}{\overline{\theta} - \underline{\theta}}$, with $\widetilde{\theta}_{LH} = \frac{p_H - p_L + \rho t_0 - \rho t_H}{2\overline{e}}$.

Maximization of profits with respect to price leads to the following Nash equilibrium:

$$\begin{aligned} p_L^{dLH} &= \frac{2(\overline{\theta} - 2\underline{\theta} - x)\overline{e} + \rho t_0 - \rho t_H}{3} \\ p_H^{dLH} &= \frac{2(2\overline{\theta} - \underline{\theta} + x)\overline{e} - \rho t_0 + \rho t_H}{3} \end{aligned} \tag{4}$$

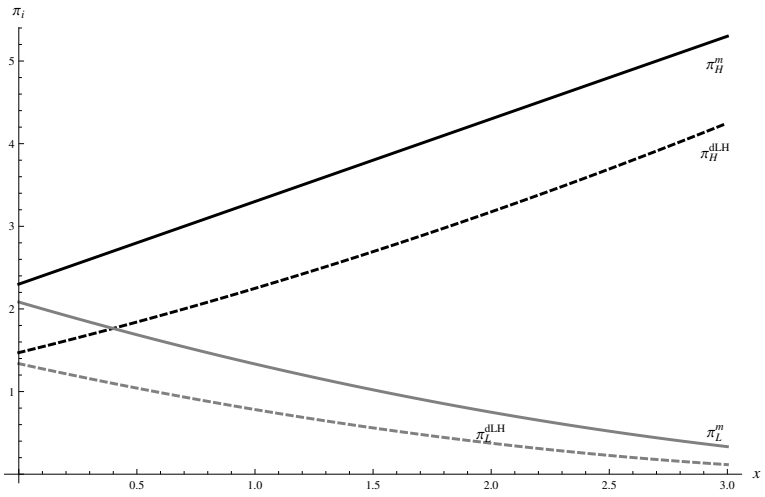
The resulting market shares are then characterized by:

$$d_H^{dLH} = \frac{2(2\overline{\theta} - \underline{\theta} + x)\overline{e} - \rho t_0 + \rho t_H}{6(\overline{\theta} - \underline{\theta})\,\overline{e}} \tag{5}$$

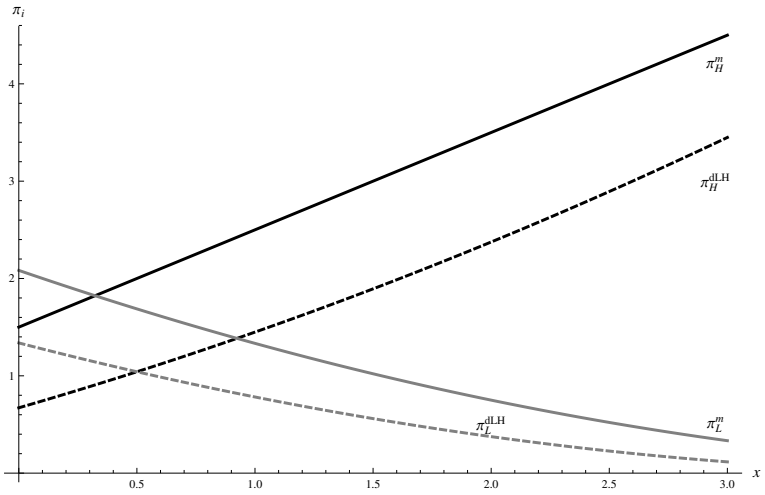
and $d_L^{dLH} = 1 - d_H^{dLH}$. The profits are equal to $\pi_L^{dLH}(x) = 2(\overline{\theta} - \underline{\theta})\,\overline{e}\,{d_L^{dLH}}^2$ and $\pi_H^{dLH}(x) = 2(\overline{\theta} - \underline{\theta})\,\overline{e}\,{d_H^{dLH}}^2 - F_H$.

Cost-effectiveness of both products requires that the NGO's campaign effort is neither too low nor too high. Moreover, as illustrated in Figure 1, Product H is more cost-effective than Product L when the campaign effort is higher than a given threshold. Such a threshold crucially depends on the fixed cost of elimination of the harmful component, F_H.[7]

[7] See details in Appendix 6.1.



(a) Low R&D cost F_H



(b) High R&D cost F_H

Figure 1: Effects of NGO's pressure on profit from product L and product H

3.4 Sequence of the game with the component-free product

The subgame perfect equilibrium (SPE) of the game depends on the relative profits of the monopolies and the duopoly, displayed in Figure 1. Backward induction implies that the new entrant decides to provide a differentiated product if the duopoly's profits are positive, that is fulfilled for 'medium' campaign effort (defined in Appendix 6.1). The incumbent has then an interest in still producing L when the containing harmul component product is more cost-effective than the component free product or in switching to H otherwise. Therefore, SPE (L, H), such as the incumbent still produces Product L and the new entrant supplies Product H, arises when the NGO makes a relatively low campaign effort, whereas SPE (H, L) occurs when x is higher (in the interval of x allowing duopoly cost-effectiveness). When the campaign effort is relatively large or when the R&D cost is high, the firm decides not to enter and the incumbent opts for the

most cost-effective product for a monopoly. Product H is likely to be chosen when the campaign effort is intensive or the R&D cost of harmful component eliminantion is low.

We can distinguish three cases to further analyze the best strategies of firms:

- When all consumers are sufficiently concerned with harmful effects of the denounced component to have a higher WTP for product H, despite its lower organoleptic attribute, than for product L (*i.e.* $\rho(t_0 - t_H) \leq 2\,\underline{\theta}$):[8] If the R&D cost is relatively low, as in Figure 1(a), the NGO has only to disclose information about the damaging component to make the component-free product cost-effective and to spur the incumbent to eliminate the denounced component. If the R&D cost is relatively high, as in Figure 1(b), the NGO must conduct a sufficiently forceful campaign to make the Product H more profitable than Product L for the incumbent.

- When the organoleptic attribute is so damaged by the elimination of the harmful component and/or consumers are so concerned with the product taste, that, at the same price, some consumers prefer product L to product H ($\rho(t_0 - t_H) \in [2\,\underline{\theta}\,\overline{e}, 2\,\overline{\theta}\,\overline{e}]$)[9], as depicted in Figure 1(b), only a sufficiently impactful campaign can encourage the incumbent to produce Product H (and the potential new entrant to provide Product L).

- When all consumers are insufficiently concerned with environmental issues to be ready to buy a component-free product, even if it costs the same as product L ($\rho(t_0 - t_H) \geq 2\,\overline{\theta}\,\overline{e}$),[10] the NGO has no way of promoting consumption and production of the free-component product.

Accordingly, when the initial WTP for the environmental quality is high enough for an effective campaign, the R&D cost of eliminating the denounced component is a critical success factor of the NGO's campaign.

Before any awareness campaign by the NGO (or with a null initial budget B), the mere disclosure of the environmental quality of the product of the initial monopoly may already lead to different market structures, depending on the value of the R&D cost, F_H.[11]

Lemma 1 *For a null initial budget, B, and no awareness campaign, there exists a threshold for R&D cost, denoted $\underline{F}_H$, below which the market is a duopoly and above which it remains a monopoly.*

[8] In this first case, $\underline{\omega}_H(0) \geq \overline{\omega}_L(0)$.

[9] In this second case, $\underline{\omega}_H(0) < \overline{\omega}_L(0)$ and $\overline{\omega}_H(0) > \underline{\omega}_L(0)$.

[10] In this third $\underline{\omega}_H(0) \leq \overline{\omega}_L(0)$.

[11] See proof in Appendix 6.2.

When $F_H \leq \underline{F}_H$, there exists a threshold $\hat{F}_H^d \leq \underline{F}_H$ such that the incumbent switches to Product H in case of R&D cost lower than $\hat{F}_H^d$ and still produces Product L if $F_H \in [\hat{F}_H^d, \underline{F}_H]$, meanwhile a competitor enters the market with the other product.

When $F_H > \underline{F}_H$, there exists a threshold $\hat{F}_H^m$ which can be lower or higher than $\underline{F}_H$, such that the monopoly switches to Product H if $\hat{F}_H^m > \underline{F}_H$ and $F_H \in [\underline{F}_H, \hat{F}_m]$ and still produces Product L if $\hat{F}_H^m \leq \underline{F}_H$ or $F_H > \hat{F}_H^m > \underline{F}_H$.

with $\underline{F}_H \equiv \dfrac{(2(2\overline{\theta} - \underline{\theta})\overline{e} - \rho t_0 + \rho t_H)^2}{18(\overline{\theta} - \underline{\theta})\,\overline{e}}$, $\hat{F}_H^d \equiv \dfrac{2}{3}\big((\overline{\theta} + \underline{\theta})\overline{e} - \rho t_0 + \rho t_H\big)$ *and* $\hat{F}_H^m \equiv \underline{\theta}\overline{e} + \rho t_H - \dfrac{(\underline{\theta}\overline{e} - \rho t_0)^2}{4(\overline{\theta} - \underline{\theta})\,\overline{e}}$

Lemma 1 states that market penetration of the component free product can be favored by a low R&D cost of elimination of the harmful component even before the NGO starts the awareness campaign. Moreover, a specific case arises when the organoleptic quality of Product H is close to that of Product L, in such a way that, before the campaign, the maximal R&D cost compatible with the duopoly cost-effectiveness ($\underline{F}_H$) is lower than the maximal R&D cost allowing higher cost-effectiveness of monopoly H than monopoly L ($\hat{F}_H^m$).[12] In that case, the monopoly has an interest in switching to Product H even without any campaign as long as its fixed cost is too high to trigger entrance of a new firm, but sufficiently low to make production of H the most profitable for the monopoly ($F_H \in [\underline{F}_H, \hat{F}_H^m]$). As a consequence, the utility and the intensity of the NGO's optimal campaign highly depends on the R&D cost.

3.5 Optimal campaign effort

In order to maximize the quality of the environment, the NGO has an interest in choosing an effort that encourages the monopoly to substitute Product H to Product L or, at least, an effort that restricts the market share of product L and makes the entry of a product H cost-effective. The environmental effectiveness of the NGO's campaign crucially depends on its effect on market structure, which, in turn, relies upon the level of R&D cost, F_H, and upon the extent of the reduction in organoleptic quality (relative to the increase in environmental quality) of the component-free product compared to the initial product. Clearly, when all market structures are possible, the 'greenest' situation is a monopoly providing the component-free product in a covered market and the second best situation is a duopoly.[13]

[12] We can show that $\hat{F}_H^m$ increases faster with t_H than $\underline{F}_H$, which means that $\hat{F}_H^m > \underline{F}_H$ when t_H is close to t_0.

[13] The global quality of the environment fulfills inequality $E^{mH}(x) = \overline{e} > E^{dLH}(x) > E^{mL}(x)$, where superscripts mL, mH and dLH respectively denote following market structures: monopoly of Product L, monopoly of Product H and duopoly (L, H) and (H, L).

Proposition 1 *For a given F_H, the quality of the environment increases with x until maximum $\overline{e}$ reached through Monopoly H in a covered market.*

Proofs of this proposition and the next ones in this subsection are provided in Appendix 6.2.

Proposition 1 combined with the NGO's budget constraint, $x^2 \leq B$, entails that the NGO exhausts its budget in order to make the maximal campaign effort, defined by $x^* = \sqrt{B}$, as long as the component-free product is not the only product in the market. Note that the campaign effort does not depend on environmental quality $\overline{e}$. In other words, the extent to which the component is damaging for the environment does not alter the NGO's behavior, since it must campaign in any case to increase consumer awareness of such damages.

Proposition 2 *For low R&D cost ($F_H \leq \underline{F}_H$), there exists a NGO's maximal useful budget, denoted $\overline{B}^d$, enabling the level of awareness campaign above which the duopoly cannot be profitable, with $\overline{B}^d \equiv \left(\frac{\rho(t_0 - t_H)}{2\overline{e}} + \overline{\theta} - 2\underline{\theta}\right)^2$.*

In case of low initial budget ($B \leq \overline{B}^d$), the NGO spends all its budget on the campaign to maximize the market share of Product H in the duopoly market.

In case of high initial budget ($B \geq \overline{B}^d$), the NGO only spends $\overline{B}^d$ in the campaign to ensure cost-effectiveness of Monopoly H.

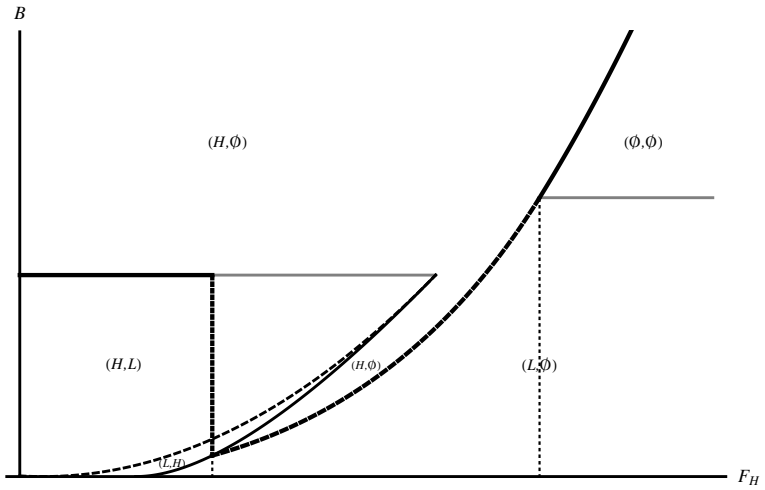


Figure 2: NGO's initial budget, R&D cost and market structures

Lemma 1 and Proposition 2 are illustrated by Figure 2,[14] which displays the equilibrium market structures resulting from the R&D cost and the NGO's budget. In Figure 2, the gray lines correspond to the maximal budgets compatibles with cost-effectiveness of Product L, that is $\overline{B}^d$ in case of duopoly (H, L) and $\overline{B}^m$ in case of monopoly L. The black curves illustrate the

[14]Figure 2 has been drawn using parameters $\underline{\theta} = 1$, $\overline{\theta} = 4$, $\overline{e} = 1$, $\varphi = 3$, $t_0 = 1$ and $t_H = 1/2$. In this case, $\hat{F}_H^m < \hat{F}_H^d$.

minimal budgets spent on the campaign allowing cost-effectiveness of Product H. The dashed curves define the minimal budgets ensuring that profit from Product H is higher that profit from Product L.

Proposition 2 and Figure 2 show that when the R&D cost and the budget are both relatively low ($F_H \leq \underline{F}_H$ and $B \leq \overline{B}^d$), the campaign is likely to favor a duopoly SPE (H, L), encouraging the incumbent to give up supplying the product containing the harmful component to produce the component-free product. The higher the R&D cost, the higher the initial budget required for duopoly (H, L). If the R&D cost tends to $\underline{F}_H$,[15] and the budget is close to zero, the incumbent decides to still produce Product L while a new entrant provides Product H, that is SPE (L, H). Higher budget and campaign effort result in greater profit from Product H, at the expense of Product L, leading to duopoly SPE (H, L). When the initial budget is sufficiently high to enable the NGO to campaign extensively ($B > \overline{B}^d$), the campaign allows for crowding out Product L and results in a Monopoly H (that is SPE $(H, \emptyset)$). The NGO has then no interest in spending more than $\overline{B}^d$ on the campaign, because the best environmental situation is reached with such a budget and spending more would not improve the quality of the environment further.

Proposition 3 *For intermediate R&D cost, such that $F_H \in [\underline{F}_H, \overline{F}_H]$, a rise in initial budget B results in the following impact on market structures:*

- *If $\hat{F}_H^m \leq \underline{F}_H$ and $F_H \in [\underline{F}_H, \tilde{F}_H]$, it reduces the market share of Monopoly L and favors entrance of product H in a duopoly market if $B > \underline{B}^d(F_H)$.*
- *If $\hat{F}_H^m \leq \underline{F}_H$ and $F_H \in [\tilde{F}_H, \overline{F}_H]$ or $F_H \geq \hat{F}_H^m > \underline{F}_H$, it reduces the market share of Monopoly L and encourages the monopoly to switch to Product H if $B \geq \hat{B}^m(F_H)$, the NGO spending no more than $\hat{B}^m(F_H)$ on the campaign.*
- *If $\hat{F}_H^m > \underline{F}_H$ and $F_H \in [\underline{F}_H, \hat{F}_H^m]$, the monopoly switches to Product H before the campaign, rending the campaign unnecessary.*

with $\tilde{F}_H$ such that $\pi_H^m(\tilde{F}_H, \tilde{B}) = \pi_L^m(\tilde{F}_H, \tilde{B})$ and $\pi_H^d(\tilde{F}_H, \tilde{B}) = 0$,

$$\overline{F}_H \equiv \rho(t_0 + t_H)$$

$$\underline{B}^d(F_H) \equiv \frac{\left(3\sqrt{2(\overline{\theta} - \underline{\theta})\overline{e}F_H} + \rho(t_0 - t_H) - 2(2\overline{\theta} - \underline{\theta})\overline{e}\right)^2}{4\overline{e}^2},$$

$$\text{and } \hat{B}^m(F_H) \equiv \left(2\overline{\theta} - 3\underline{\theta} + \frac{1}{\overline{e}}(\rho t_0 - 2\sqrt{(\overline{\theta} - \underline{\theta})(\rho(t_0 + t_H) + (\overline{\theta} - \underline{\theta})\overline{e} - F_H)\overline{e}}\right)^2.$$

Proposition 3 states that when the R&D cost is relatively high ($F_H > \underline{F}_H$) and the NGO's budget is relatively low ($B < \underline{B}^d(F_H)$), the potential entrant decides not to enter, neither with Product L nor with Product H because the R&D cost is too high and the campaign insufficiently

[15] More precisely, if $F_H \in [\frac{2}{3}((\overline{\theta} + \underline{\theta}\overline{e}) - \rho(t_0 - t_H), \underline{F}_H]$.

impactful to enable Product H to be cost-effective when product L is provided in the market. Therefore, the incumbent chooses to switch to the component free product if the campaign effort is high enough (through $B > \hat{B}^m(F_H)$) or to continue to produce product L otherwise. The higher the R&D cost, the higher the initial budget required to trigger switch to product H. Therefore, a sufficiently large budget allows the NGO to push the incumbent to produce Product H by only spending the part of its budget necessary to reach the frontier $\hat{B}^m(F_H)$ for a given F_H. Moreover, in the specific case where the organoleptic quality of Product H is close to that of Product L, in such a way that $\hat{F}_H^m > \underline{F}_H$, the NGO has an interest to launch the campaign only for relatively high R&D cost ($F_H \in [\hat{F}_H^m, \overline{F}_H]$).

Proposition 4 *For high values of the R&D cost ($F_H > \overline{F}_H$) and great campaign effort ($\overline{B}^m < B < \hat{B}^m(F_H)$), Products L and H are both non profitable anymore and the market disappears, with $\overline{F}_H \equiv \rho(t_0 + t_H)$ and $\overline{B}^m \equiv \left(\frac{\rho t_0 - \overline{\theta}\overline{e}}{\overline{e}}\right)^2$. However, Monopoly H becomes profitable again as soon as $B \geq \hat{B}^m(F_H)$*

Proposition 4 states that Product H is not profitable when elimination of the harmful component is too costly and the campaign is not impactful enough to enable the monopolist to produce the component free product.[16] Therefore, in case of high R&D cost, the only power of the NGO's campaign is to divert consumers from Product L supplied by Monopoly L by spending all its budget on the campaign. If it benefits from a budget higher than $\overline{B}^m$, the NGO can remove Product L from the market by only spending $\overline{B}^m$ on the campaign in such a way as there is no market anymore. Spending at least $\hat{B}^m(F_H)$ is needed to enable Monopoly H to appear.[17]

As a result of these mechanisms according the various market structures, the thick bold line in Figure 4 shows the level of the maximal useful budget B for the NGO. When the NGO's initial budget is under the line, there is a need for the NGO to implement another action in order to reach the highest environmental quality. But if its initial budget is higher, the NGO has no incentive to do so and will not exhaust its budget.

Figure 3 completes previous analysis by showing how the market structure is sensitive to WTP for organoleptic quality (for given positive cost F_H and WTP for environmental quality): all other things being equal, the higher WTP for the organoleptic quality, the greater the campaign effort (and the initial budget) must be to trigger entry of the component-free product.

[16] $\overline{F}_H$ corresponds to the abscissa of the intersection point of the gray and the black lines and $\overline{B}^m$ corresponds to intercept of the gray line in the North-East part of Figure 2.

[17] Monopoly H is preferred to no market at all by the NGO and the social planner in our framework because of our symmetry assumption about the respective environmental quality of Product H and L. Should we have assumed that $e_L < e_H < 0$, i.e. that damage due to Product H is only lower than damage caused by Product L, no market at all would be preferred to Monopoly H by the NGO.

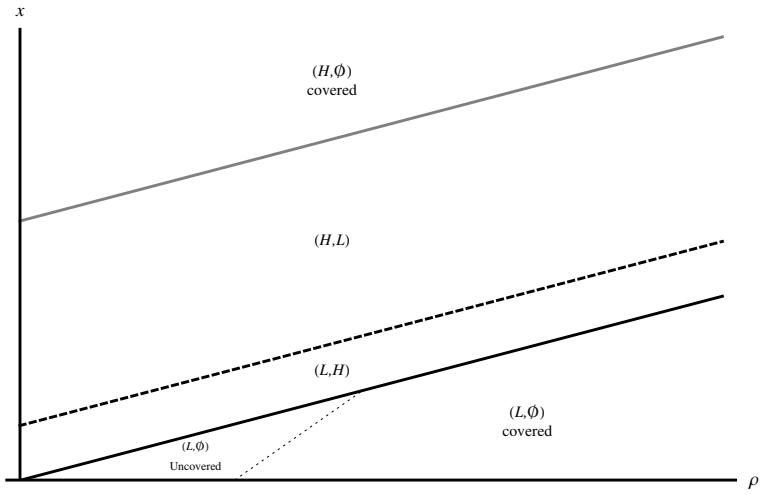


Figure 3: NGO's campaign, WTP for organoleptic quality and market structures

In any case, the awareness-raising campaign will not only disclose information on the harmful impact of a component of a product, undermining consumer perception of the product quality, but also increase consumer WTP for the environmentally friendly product, favoring cost-effectiveness of the component-free product against the component-containing product. However, the campaign may be wasteful when the component-free product requires a very high R&D cost and/or entails a too large degradation of the product taste (or texture), or when consumers place little importance to the environmental issue raised by the NGO in comparison to the product taste. Accordingly, there is a room for alternative solutions to reduce environmental impact of the product, while better preserving its organoleptic properties.

4 NGO's certification

Under NGO pressure, the incumbent or a new entrant has the possibility to use a sustainable component certified by the NGO. In this case, the firm adopts an NGO's label, which discloses the sustainable nature of the component to the consumers, and supplies Product M. The firm incurs a unit cost c_M and a fee φ paid to the NGO for using the label "sustainable component". The collected fees accrue to the NGO's budget, allowing potentially higher campaign expenditures x^2.[18] By assumption, substituting the sustainable component for the harmful one does not require a R&D investment, so that there is no fixed cost associated with such a product for the monopoly. The sustainable component is a perfect substitute to the harmful component in such a way that the organoleptic attribute of the good is not affected by the substitution ($t_M = t_0$). The environmental quality of the certified product is a "good attribute" of lower quality than

[18]Contrary to Bottega and de Freitas (2009), we do not assume that, because of the nonprofit nature of the NGO, the fee has to cover the awareness campaign of the NGO, x^2.

the component-free product ($e_0 < e_M < e_H \Leftrightarrow e_M \in [0, \overline{e}]$).

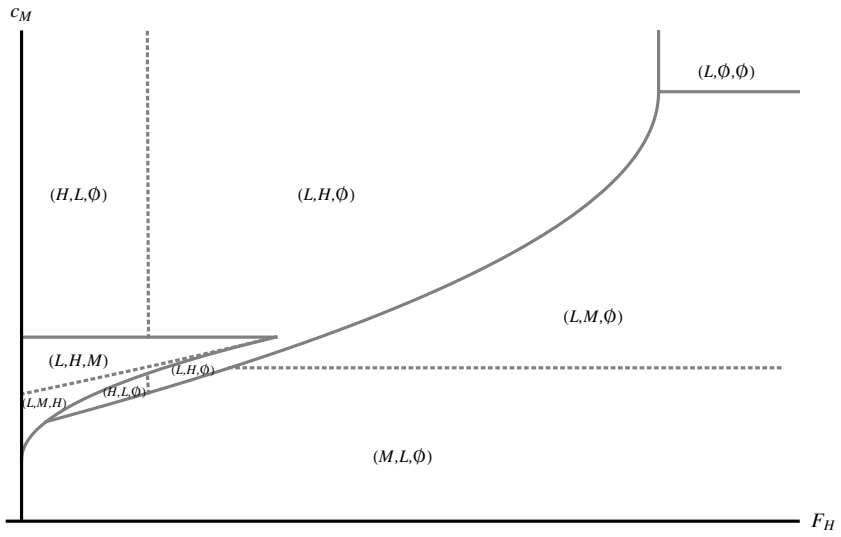


Figure 4: Market structures before the NGO's awareness campaign

The possibility of providing an eco-labeled product expands the range of potential market structures after information disclosure about the denounced component, but also after the launch of the awareness campaign. Figure 4 illustrates all the possible initial market structures before the campaign ($x = 0$) according to the production costs of Products M and H, when Product L is cost-effective (proofs available in Appendix 6.3). Indeed, co-existence of Product M and/or H with product L crucially depends on relative production costs, which determines the market-entry decisions of the third firm (*i.e.* triopoly or not) and of the second firm (*i.e* duopoly or not) and the most profitable choice between Products L, M and H of the incumbent (that perfectly anticipates the decision of the next potential entrants).[19] However, when the WTP for organoleptic quality is not sufficiently high to guaranty cost-effectiveness of product L, information disclosure is likely to lead to a monopoly supplying product M when $c_M + \varphi$ is sufficiently low and F_H is sufficiently high or a monopoly H when $c_M + \varphi$ is high and F_H is low. When $c_M + \varphi$ is low, Product H may be prevented to appear even for low F_H (as in Figure 4) if the WTP for organoleptic quality is sufficiently high, compared to the environmental quality $\overline{e}$ of Products H (see conditions of existence of duopoly (H, L) in Appendix 6.1).

Next sections investigate Nash equilibria when the certified product is cost-effective, other possible Nash equilibria being already characterized in section 3.

[19] The triopoly area arises from backward induction reasoning such that if a third firm has an interest in enter the market (with H or M), the other firms have also an interest in producing (see Figure 10). When $c_M + \varphi$ is slightly under the triopoly zone, for a given low F_H, then $\pi_H^t \leq 0$ and Firm F decides not to enter, then Firm E prefers to enter duopoly market (L, H), (M, L) or (H, L) and the incumbent then decides to switch to Product H because π_H^{dLH} is the highest possible profit in the three previously duopoly situations.

4.1 Monopoly equilibrium with the certified sustainable product

In the case of Monopoly M, only consumers with a willingness to pay the environmental quality higher than $\widetilde{\theta}_M = \frac{p_M - \rho t_0}{e_M} - x$ buy the product. Assuming a covered market ($\widetilde{\theta}_M < \underline{\theta}$), the monopoly maximizes $\pi_M(p_M) = (p_M - c_M - \varphi)d_M(p_M)$ by setting a price equal to the minimum WTP for Product M, that is to $p_M^m = \underline{\omega}_M(x) \equiv (\underline{\theta} + x)e_M + \rho t_0$. It then earns profit $\pi_M^m = (\underline{\theta} + x)e_M + \rho t_0 - c_M - \varphi$. The market is covered if $\rho t_0 \geq (\overline{\theta} - 2\underline{\theta})e_M + c_M + \varphi - xe_M$.[20]

When the NGO steps up its campaign, the monopoly benefits from higher WTP for the sustainable product. It increases its price, earning then a higher profit. However, the rise in profit is curbed if the NGO funds its raising campaign effort with an increasing fee.

Because the sustainable product has the same organoleptic attribute as the component-containing product, while being more environmentally friendly, all consumers have a higher WTP for this product than for the component-containing one (*i.e.* $\overline{\omega}_M(x) > \underline{\omega}_M(x) > \overline{\omega}_L(x)$). However, Product M production is more expensive than Product L production. Product M is then more cost-effective than Product L when the unit production cost and the NGO fee are not too high. In addition, Product M is more cost-effective than Product H when $c_M + \varphi$ is relatively low, F_H is relatively high and the campaign is soft.

For given R&D cost F_H and unit production cost of Product M, $c_M + \varphi$, if the awareness campaign effort x is low, Monopoly L remains the most profitable. By increasing x, the NGO can transform the market structure into a Monopoly M and then into a Monopoly H .

4.2 Duopoly equilibria

The existence of a certified sustainable component provides an additional opportunity for a firm to enter the market with a product differentiated from the monopoly's product. Product M can coexist with Product L or product H, depending on gaps in environmental and organoleptic attributes and in production costs, but also depending on NGO's behavior. For the sake of simplicity and clarity, the Nash equilibria analysis focuses on the cases of fully covered markets.[21]

4.2.1 Duopoly with Products L and M

The analysis of the duopoly supplying Products L and M is quite similar to the analysis carried on in Section 3.3. The consumer indifferent between Products L and M is characterized by $\widetilde{\theta}_{LM} =$

[20] When $\rho t_0 < (\overline{\theta} - 2\underline{\theta})e_M + c_M + \varphi - e_M x$, the market is uncovered. The monopoly sets a price equal to $p_M^m(x) = \frac{\rho t_0 + (\overline{\theta} + x)e_M + c_M + \varphi}{2}$, benefits form demand $d_M^m(x) = \frac{\rho t_0 + (\overline{\theta} + x)e_M - c_M - \varphi}{2(\overline{\theta} - \underline{\theta})e_M}$ and earns profit $\pi_M^m(x) = (\overline{\theta} - \underline{\theta})e_M {d_M^m}^2$.

[21] The results of the cases of uncovered market can be obtained on request from the authors.

$\frac{p_M - p_L}{\overline{e}+e_M} - x$.[22] Because providing the certified product requires positive unit costs (including the certification fee) although providing the component-free product requires fixed production cost, meanwhile products using the harmful and the sustainable components exhibit the same organoleptic quality, the conditions for existence of a duopoly supplying products L and M differ from the previous case with products L and H.

It is worth noting that the organoleptic quality does not play on prices and market shares insofar as both products benefit from the same quality. The strategies rather depend on relative environmental qualities and production costs. The NGO's campaign also leads some consumers to substitute the sustainable component-containing product for the harmful component-containing product.

Firms L and M share demand in a covered market only if the WTP for the organoleptic quality is sufficiently high, compared to environmental qualities and production costs of Product M, and if the NGO's campaign is sufficiently soft, according to:

$$\rho t_0 \geq \frac{(2\overline{\theta} - \underline{\theta})\overline{e} + (\overline{\theta} - 2\underline{\theta})e_M}{3} + \frac{2\overline{e} + e_M}{3(\overline{e} + e_M)}(c_M + \varphi) + \frac{\overline{e} - e_M}{3}x \tag{6}$$

As in the case of duopoly supplying products L and H, such a condition can be interpreted as a dominance of the organoleptic attribute over the environmental attribute in consumers' preferences.

4.2.2 Duopoly with Products M and H

Competition between the medium and the high environmental quality is more usual than competition between Product L and M or H. Consumers of both products are localized on the right side of the preference space, although consumers on the left side refrain from consuming the good or buy the medium quality. The specificity of the duopoly equilibrium arises from the nature of production costs. Production of the certified product only involves variable cost, including the cost of the certified component and the certification fee, whereas production of the component-free product only requires a fixed cost.

Firms M and H share demand in a covered market only if the WTP for the organoleptic quality is sufficiently high, compared to environmental qualities and production costs of Product M, if the R&D cost F_H is not too high and if the NGO's campaign is sufficiently soft, according

[22] It is worth noting that $\overline{e} + e_M$ measures the difference in environmental qualities of Product M (e_M) and Product L ($-\overline{e}$).

to the following set of conditions:

$$\rho t_H + 2\rho t_0 \geq (\overline{\theta} - 2\underline{\theta})(\overline{e} - e_M) + 2(c_M + \varphi) - (\overline{e} + 2e_M)x \tag{7}$$
$$\overline{F}_H < (\overline{\theta} - \underline{\theta})(\overline{e} - e_M)$$

As in the other cases of duopoly, market coverage requires that WTP for organoleptic quality are sufficiently high. Paradoxically, by enhancing WTP for environmental quality of all consumers, NGO's behavior penalizes the product containing the sustainable component, both through its campaign effort and through the certification fee, which reduce demand for Product M.

4.3 Triopoly equilibrium

A large heterogeneity of consumers' WTP for the environmental quality and low production costs may allow the three differentiated products to coexist in the market. Assume that a third firm enter the market and that the market is fully covered by the three mono-product firms.

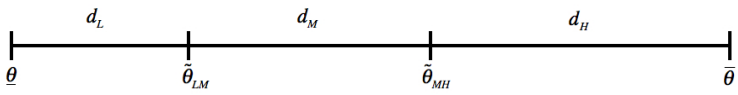


Figure 5: Market coverage with products L, M and H

Figure 5 depicts market sharing, with demand functions defined as $d_H = \frac{\overline{\theta} - \widetilde{\theta}_{MH}}{\overline{\theta} - \underline{\theta}}$, $d_M = \frac{\widetilde{\theta}_{MH} - \underline{\theta}}{\overline{\theta} - \underline{\theta}}$ and $d_L = \frac{\widetilde{\theta}_{LM} - \underline{\theta}}{\overline{\theta} - \underline{\theta}}$. Price competition leads Firm L to adjust its price upwards to the price of Product M, although the price of Product H only depends on the price of Product M, while the price of product M increases both with p_L and p_H.

An increase in x moves the two indifferent consumers towards the left in the preference space $[\underline{\theta}, \overline{\theta}]$, in such a way that the same number of consumers substitute Product M for L and H for M.[23] As a result, the awareness campaign only plays on market shares of the products L and H.

The triopoly can only emerge when differentiation in both organoleptic and environmental quality of the three products is sufficiently large, whilst the cost of the sustainable component and the cost of the harmful component removal are limited.

Accordingly, cost-effectiveness of the product containing the harmful component requires that the NGO's campaign is not too forceful. Moreover, the NGO must ensure that the certification fee does not discourage firms from using the sustainable component. There is a clear trade-off

[23] Indifferent consumers are such that $\frac{\partial \widetilde{\theta}_{ij}}{\partial x} = -\frac{1}{2}$, with $i, j = L, M, H$ and $i \neq j$.

for the NGO between eliminating the product containing the harmful component and fostering the sustainable component.

4.4 The sequence of the game

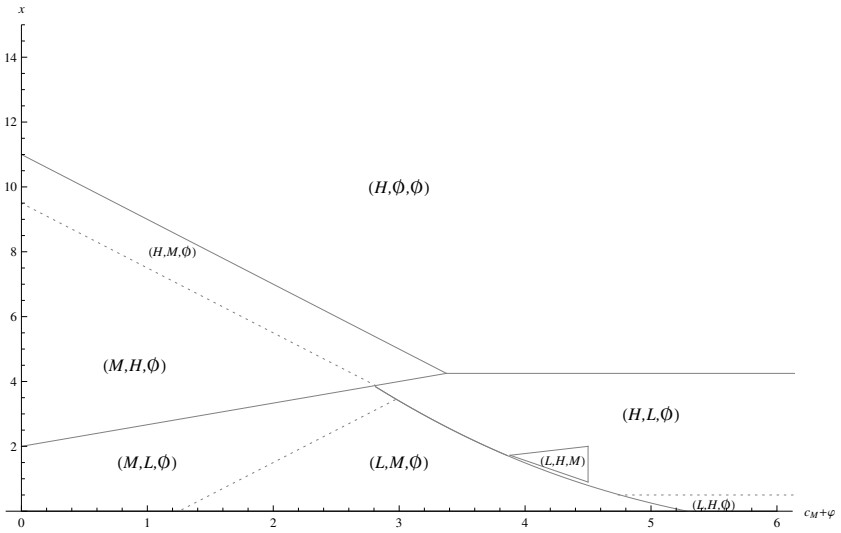


Figure 6: Market structures according to the NGO's strategies

In order to understand the sequence of the game, in line with the game tree (Figure 10), when the NGO campaigns again the denounced component, Figure 6 displays the resulting market structures according to x and $c_M + \varphi$, for intermediate values of F_H.

When the triopoly is cost effective before the campaign, the third firm, called 'F' in the game tree, always wants to enter the market. Backward induction highlights that the first entrant, E, chooses the most cost-effective strategy after the incumbent has itself opted for the most cost-effective strategy. Therefore, the SPE is (i, j, k) when $\pi_i^t > \pi_j^t > \pi_k^t \geq 0$, with $i, j, k = L, M, H$ and $i \neq j \neq k$. However, an increase in the campaign effort, x, and/or in the label fee, φ, would decrease the demand and the profits from Product M in such a way that production of M is no more cost-effective in a triopoly market.

When the triopoly is not cost effective before the campaign, the best incumbent's strategy is to produce the most cost-effective product knowing that Firm E will then decide to enter with the second best cost-effective product and Firm F will not enter the market. Therefore, according to the game tree in Figure 10 (Appendix 6), six duopoly SPE can be characterized depending on relative profits: SPE is (i, j) when $\pi_i^{dij} \geq \pi_j^{dij} \geq \pi_k^{dik}$, with $i, j, k = L, M, H$ and $i \neq j \neq k$.

The scenarios where Product L remains in the market are the most likely when the unit cost and the certification fee for the sustainable component and the R&D cost for the component-

free product are relatively high, meanwhile the NGO campaigns relatively softly. Because the awareness campaign decreases the profit of Firm L to the benefit of its competitor, there always exists a campaign effort which makes Products M and H more cost-effective than product L. The NGO can also foster the certified product by charging a low certification fee. Accordingly, in SPE (M, H), the incumbent switches to Product M and the entrant produces Product H when the NGO's effort and the certification fee are sufficiently low to favor Product M over Product H (such as $\pi_M^{dMH} \geq \pi_H^{dMH}$)[24], but sufficiently high to favor Product H over Product L (in such a way as $\pi_H^{dMH} \geq \pi_L^{dLM}$). SPE (H, M) arises when the campaign effort is sufficiently high to foster Product H over Product M (such as $\pi_H^{dMH} \geq \pi_M^{dMH}$) and the certification fee sufficiently low to foster Product M over product L (such as $\pi_M^{dMH} \geq \pi_L^{dLH}$).

The NGO can discourage entry in the market by making a very high campaign effort meanwhile forcing the incumbent to stop using of the denounced component. The incumbent retains its monopoly situation and chooses to switch to Product H if F_H is moderate (as in Figure 6) or to Product M if $c_M + \varphi$ is low and F_H is high.

Thereby, the NGO's budget decisions on the funds spent in the awareness-raising campaign and the funds raised by the certification fee is a crucial determinant of the market structure and on the more or less environmentally-friendly nature of the products supplied in the market.

4.5 Optimal NGO's strategy

By choosing the values of its instruments, the NGO is able to influence market structure $s \in S$, where S is the set of possible market structures represented in Figure 6, and the level of the environmental quality E^s. The NGO's program is characterized as follows:

$$\max_{s \in S} \left\{ \max_{x,\varphi} E^s(x, \varphi) \qquad \text{st } BC^s \equiv x^2 - B - \varphi d_M^s \leq 0 \right\}$$

In order to find the optimal NGO's strategy, depending on its initial budget, B, the first step consists in computing the values of x and φ that maximize the environmental quality E^s in each market structure. The second step consists in analyzing whether these values are compatible with the existence conditions of the considered market structure or lead to another market structure. This will provide the optimal NGO's strategy resulting in the 'greenest market structure'.

4.5.1 Duopoly (L,M)

Assume that the NGO faces a duopoly before the campaign (*i.e.* low to medium F_H and low $c_M + \varphi$ in Figure 6). As in previous section, the incumbent produces the most cost-effective product knowing that Firm E produces the second best cost-effective product and Firm F does

[24] $\pi_M^{dMH} \geq \pi_H^{dMH}$ involves $x \leq \frac{2(\rho t_0 - \rho t_H) - (\overline{\theta} + \underline{\theta})(\overline{e} - e_M) + 3F_H - 2(c_M + \varphi)}{2(\overline{e} - e_M)}$

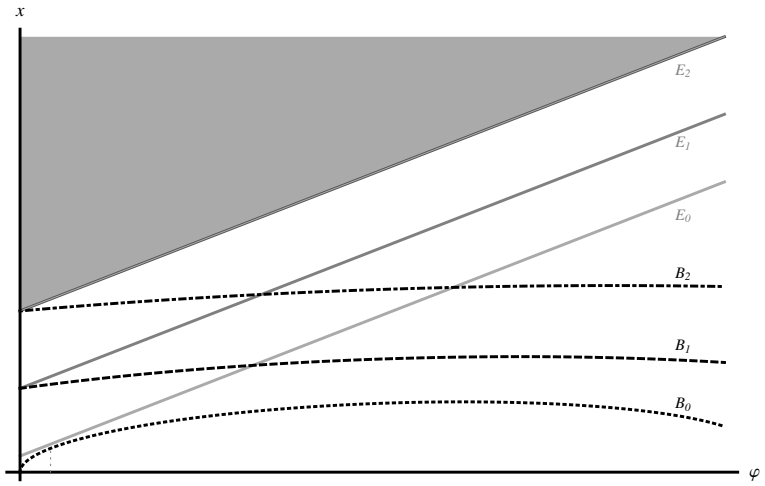


Figure 7: NGO's Optimal strategies in the Duopoly (L,M) case

not enter the market. The resulting six possible duopoly SPE entail different levels of global quality of the environment.

Before the campaign, the market struture is likely to be a duopoly (L, M) or (M, L), for low level of unit cost c_M and medium R&D cost F_H (see Figure 4 and Appendix 6.3). In this case, demand equations (18) result in the following global quality of the environment:

$$E^{dLM} = -\overline{e}d_L^{dLM} + e_M d_M^{dLM} = \frac{(2\overline{\theta} - \underline{\theta})e_M - (\overline{\theta} - 2\underline{\theta})\overline{e} - c_M - \varphi + (\overline{e} + e_M)x}{3(\overline{\theta} - \underline{\theta})} \tag{8}$$

Intensifying the campaign effort x increases the quality of the environment by crowding out Product L to the benefit of Product M, but increasing φ to finance the increasing effort plays in the opposite direction.

Figure 7 depicts the best strategies of the NGO.[25] The bell-shaped curves are the iso-budget curves, with $B_0 < B_1 < B_2$ three levels of initial budget and the increasing lines are the global environmental quality, with $E_0 < E_1 < E_2$ the three levels of global environmental quality that can be reached with each budget. The shadow area is the set of (φ, x) incompatible with the duopoly market structure, for given c_M. The slope of the iso-environment curve is positive and independent of the NGO's strategy although the slope of the iso-budget curve at the origin (when $\varphi = 0$) decreases with the budget constraint.

A low initial budget (such as $B_0 \equiv 0$) leads to the interior solution, in which the NGO chooses to combine a fee and a campaign whereas a higher budget (as B_1) leads to the corner solution, in which the NGO prefers not to claim a certification fee to Firm M, favoring demand for the sustainable product, and to use its entire initial budget in the awareness-raising campaign. In

[25] Figures 7 to 9 have all been drawn using the same set of parameters as in Figure 6, allowing the existence of all market structures, depending on x and φ.

the first case, the increase in campaign effort thanks to the additional budget provided by fees has a more powerful effect in increasing the market share of Product L than the increase in fees reduces that of M. But, in the second case, any level of fees would decrease the market share of Product M without any other impact on the market structure.

An even higher budget (as B_2) leads the NGO to campaign and to charge a certification fee such that Product L is removed from the market (at the intersection of curves B_2 and E_2). According to Figure 6, the resulting market structure anticipated by the NGO and the firms should be duopoly (M, H) and the NGO has to adapt its strategy to this case.[26]

Proposition 5 *For low unit cost c_M and intermediate R&D cost F_H leading to a duopoly (L, M) or (M, L),*

- when $B < \overline{B}^{dLM}$, the NGO chooses to bill a fee for the certified component in order to increase its campaign effort and to reduce the market share of Product L.

- when $\overline{B}^{dLM} \leq B \leq \overline{\overline{B}}^{dLM}$, the NGO maximizes the market share of the certified component by billing a zero fee and spending its entire initial budget in campaign effort.

- when $B \geq \overline{\overline{B}}^{dLM}$, the NGO chooses the level of fee that allows to finance a campaign effort sufficient to crowd out Product L.

with $\overline{B}^{dLM} \equiv \left(\frac{(2\overline{\theta}-\underline{\theta})(\overline{e}+e_M)+c_M}{6(\overline{\theta}-\underline{\theta})-\overline{e}-e_M}\right)^2$ *and* $\overline{\overline{B}}^{dLM} \equiv \left(\overline{\theta} - 2\underline{\theta} + \frac{c_M}{\overline{e}+e_M}\right)^2$

4.5.2 Duopoly (M,H)

When NGO's decision of relatively high campaign effort leads to cost-effective duopoly (M,H), demands are then defined by Equations (24) and the global quality of the environment is characterized by:

$$E^{dMH} = e_M d_M^{dMH} + \overline{e} d_H^{dMH} = \frac{(2\overline{\theta} - \underline{\theta})\overline{e} + (\overline{\theta} - 2\underline{\theta})e_M - \rho(t_0 - t_H) + c_M + \varphi + (\overline{e} - e_M)x}{3(\overline{\theta} - \underline{\theta})} \quad (9)$$

Unlike the case of duopoly (L, M), intensifying the campaign effort x and increasing φ exert positive effects on the overall environmental quality because both effects relatively crowd out Product M to the benefit of Product H, until firm M is ejected from the market.

An interior solution is unlikely to be chosen here because, facing both greenest products, it is in the interest of the NGO to favor Product H at the expense of Product M (when R&D cost F_H is sufficiently low). Because campaign effort and label fee are perfect substitutes for the NGO, Figure 8 shows that the iso-environment curve decreases with φ and crosses the iso-budget curves in the area where duopoly (M,H) is cost-effective. Therefore, for a positive initial budget, the

[26] It is worth noting that the game is static and that the SPE results from anticipations of the firms on the NGO strategies and the resulting market structures.

NGO should implement a strategy $(\varphi^{dMH*}, x^{dMH*})$ removing Product M (*i.e.* the intersections of curves B_i and E_2 such that $E^{dMH} = E^{mH} = \overline{e}$).

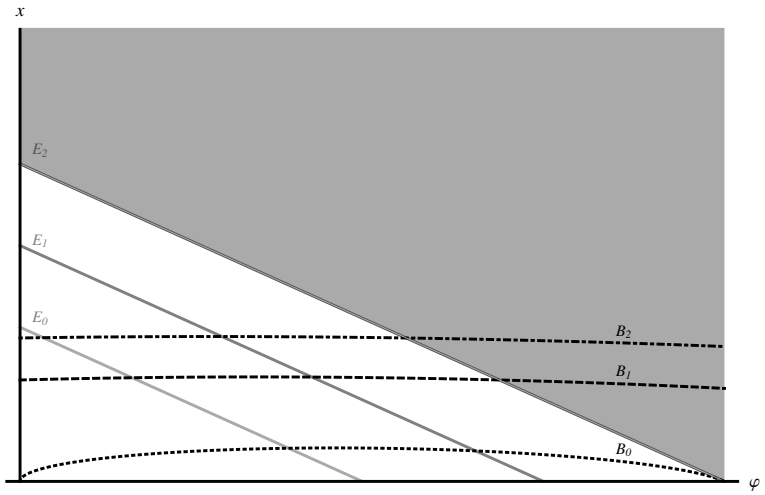


Figure 8: NGO's Optimal strategies in the Duopoly (M,H) case

Proposition 6 *The duopoly cases (M,H) or (H,M) never emerge as the NGO always favors the greenest product, H, whatever its positive initial budget.*

The label is therefore useless when R&D cost F_H is sufficiently low to allow cost-effectiveness of the component-free product. The resulting market structure is then Monopoly H. The NGO has to adapt its strategy to this case either by spending its total budget in the campaign $(x^* = \sqrt{B})$ if the market is uncovered, or by setting the fee and the campaign effort at levels such that Product M is not cost-effective in duopoly (H, M) when the market of monopoly H is covered. In the latter case, the quality of the environment, equal to $\overline{e}$, is the highest possible one. Such a result is paradoxical since the label fee is only used by the NGO to deter firms from using the eco-labeled component.

On the other hand, high R&D cost could make Monopoly M an interesting alternative for the incumbent and the NGO.[27] In this case, the quality of the environment is e_M and the NGO cannot improve it. The optimal fee and campaign are therefore such that Product M is cost-effective in the case of monopoly but not in the case of duopoly (H, M).

4.5.3 Triopoly

The triopoly can be cost effective either before the campaign or following the NGO's decision provided that F_H is relatively low and c_M is moderate. Using demand equations (32), global

[27] When F_H is higher than that assumed for drawing Figure 6, there exists an Area $(M, \emptyset, \emptyset)$ between Area $(M, H, \emptyset)$ and Area $(H, \emptyset, \emptyset)$.

environmental quality can be expressed as:

$$E^t = -\overline{e}d_L^t + e_M d_M^t + \overline{e}d_H^t = \frac{\overline{e}(\overline{\theta} - \underline{\theta} + 2x) + e_M(\overline{\theta} - \underline{\theta}) - \rho(t_0 - t_H)}{2(\overline{\theta} - \underline{\theta})} \tag{10}$$

It only depends on x because any increase in φ lowers the demand for Product M but increases equally the sum of the market shares of Product L and Product H. Symmetrically, intensifying the campaign effort contributes to crowding out L for the benefit of M and to increase the demand for H at the expense of M, the final effect being neutral for the demand of M. Depending on its initial budget B, the NGO can increase its campaign effort x and φ as long as the fee does not become excessive for the profitability of the certified product M.

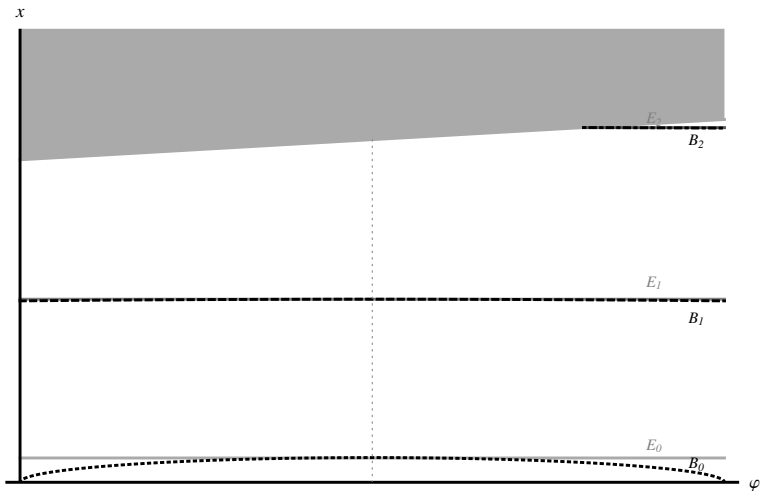


Figure 9: NGO's Optimal strategies in the triopoly case

Figure 9 shows that when the NGO has a relatively low initial budget (B_0 or B_1), its best strategy is to set a fee φ^{t*} that is all the higher as c_M is low and environmental quality e_M is high (see proof in Appendix 6.4). Because a high budget allows the NGO to undertake a more impactful campaign without additional fees receipt, a high budget (as $B_2 \geq \underline{B}^d(F_H)$ as defined in Proposition 3) prompts the NGO to prevent cost-effectiveness of Product L by choosing $(\hat{\varphi}^{t*}, x^*)$ at the limit of the shadow area (*i.e.* the intersection of curves B_2 and E_2). In the latter case, the market structure turns to be duopoly (H, L) and the NGO exhausts its initial budget in the campaign ($x^* = \sqrt{B}$). The higher the initial budget, the lower the market share of Product L will be to the benefit of Product H that could monopolize the market.

Proposition 7 *In the triopoly case,*

- when $B < \underline{B}^d(F_H)$, the NGO sets a fee φ^{t*}, in order to increase its campaign effort, which reduces the market share of Product L to the benefit of Product H;

- when $B \geq \underline{B}^d(F_H)$, the NGO sets a fee $\hat{\varphi}^{t*}$ that crowds out Product L as the third firm in

the triopoly, and the market structure is then the duopoly (L, H)*, in which the NGO exhausts its initial budget to favor Product* H*.*

A countertintuitive result appears in this case: when the initial budget is high enough, the NGO's optimal strategy is to eliminate Product L from the triopoly, but by doing so, it eliminates the triopoly case and *de facto* Product M because the most profitable market structure is thus the duopoly (L, H)

4.6 Overview of the optimal strategies for the NGO

When the NGO cannot propose any certified sustainable component, its only strategy is to spend its initial budget, partly or entirely, to finance an awareness campaign effort in order to maximize the market share of the greenest product and eventually eliminate the denounced component. The conditions for success of this strategy are a low R&D cost for the component-free product F_H, low differentiation in organoleptic quality, high differentiation in environmental quality and high initial budget B and campaign effort x. However, the denounced component is still produced in a duopoly when the R&D cost F_H is low, differentiation in organoleptic quality is high, but differentiation in environmental quality is low and when the budget is insufficient to finance the needed campaign effort. In that case, the certification fees of a sustainable component could provide additional budget to the NGO and enable it to further campaign. A third case can also occur, in which neither the brown product nor the green product is produced, because the R&D cost, the budget and the campaign effort are too high, but not high enough to render the green monopoly cost-effective. In that case also, increasing the NGO's budget could appear as a solution.

As we showed it, the NGO supply of a sustainable component triggers new market opportunities for the incumbent and new entrants even before the NGO's campaign. Labeling is an interesting alternative for the NGO for high R&D cost (F_H) of elimination of the denounced component and low unit cost of sustainable component (c_M), for high differentiation in organoleptic quality, for low-medium budget and campaign effort. The optimal fee is positive when the NGO benefits from a low initial budget, or faces a duopoly (M, H) because Product M is the lowest environmental quality, or faces a triopoly. However, the NGO will often use strategically the certification fee in order to maximize market share of Product H at the expense of Product M and only spend its initial budget B.

5 Conclusion

This paper has adopted a two-dimensional vertical product differentiation to determine the conditions under which the NGO's pressure is more likely to lead a monopoly to eliminate basic component in its product or, alternatively, to substitute a damaging component with a certified sustainable component.

In absence of a certified sustainable component, the NGO prefers elimination of the harmful component, which leads to the best quality of the environment. But it will not always exhaust its initial budget, which could turn out to be counterproductive for reaching the greenest situation (i.e. the green monopoly H).

The NGO may trade-off between investing in an awareness campaign to increase the consumers' willingness to pay for component-free products, despite their taste degradation, or to propose a certified component less harmful for the environment than the former one. One of the main results of the paper is that the NGO may prefer to favor the entry of a competitor using the certified component and to restrict the market share of the least environmentally harmful product, when establishing it in a monopoly situation is unreachable, because of high R&D costs or in case of a too low NGO's initial budget. The fees collected allow the NGO to intensify its awareness campaign and a duopoly or a triopoly may occur. But the NGO will often use strategically the certification fee in order to maximize market share of Product H at the expense of Product M.

Welfare comparison between the different market structures remain to be conducted in order to determine the optimal social solution.

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6 Appendix

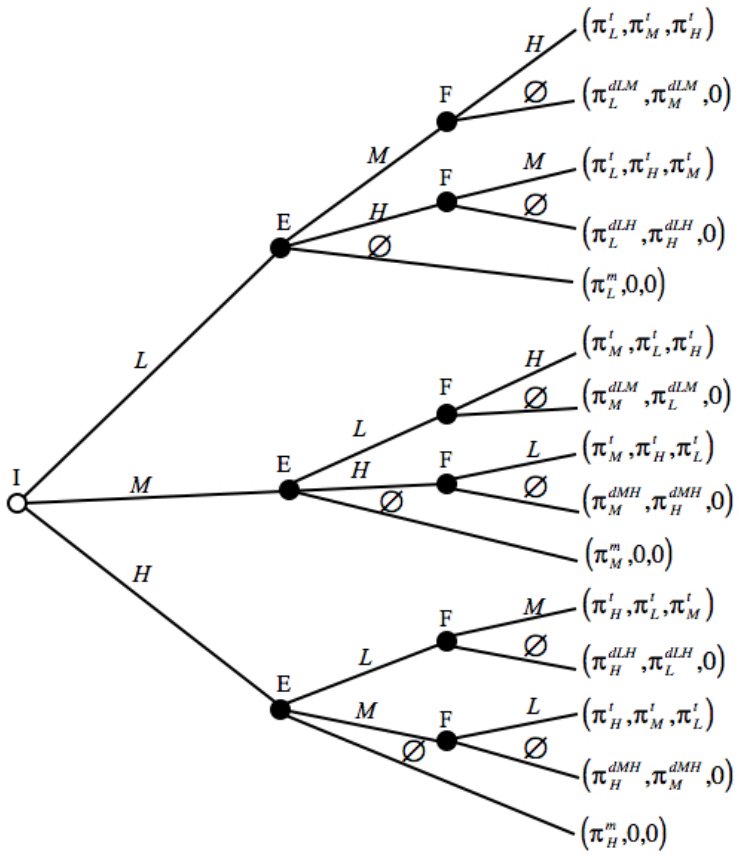


Figure 10: The game tree

6.1 Conditions of existence and of market coverage after information disclosure

Conditions of existence and of market coverage of Monopoly L

The maximal campaign effort allowing cost-effectiveness of product L is defined as follows:

$$x_{L0}^{m} \equiv \frac{\overline{\omega}_L(0)}{\overline{e}} \tag{11}$$

Moreover, the market is uncovered if $\overline{\omega}_L(x) < 2(\overline{\theta} - \underline{\theta})\overline{e}$.

When $\overline{\omega}_L(x) > 2(\overline{\theta}-\underline{\theta})\overline{e}$, that is $\rho t_0 > (2\overline{\theta}-\underline{\theta}+x)\overline{e}$, the market is covered and the monopoly has an interest in setting a price equal to the lowest WTP for product L, that is $\underline{\omega}_L(x)$. In this case, the profit, defined by $\underline{\omega}_L(x)$, is positive and lower than the initial profit $\rho t_0 + \underline{\theta} e_0$.

It can be shown that $\pi_L^m(x) < \pi_0^*(x)$ for all x.

Conditions of existence and of market coverage of Monopoly H

In the case of monopoly H, only consumers with a willingness to pay for the environmental quality higher than $\widetilde{\theta}_H = \frac{p_H - \rho t_H}{\overline{e}} - x$ buy the product.

Using the equilibrium price in an uncovered market, that is equal to $\overline{\omega}_H(x)/2$, the condition for covered market is: $\widetilde{\theta}_H = \dfrac{(\overline{\theta}+x)\overline{e} - \rho t_H}{2\overline{e}} < \underline{\theta}$. The market is thus covered for $x = 0$ when Assumption 2 is fulfilled.

The minimal campaign effort allowing cost-effectiveness of product H is then defined as follows:

$$x_{H0}^{m} \equiv \frac{F_H - \rho t_H}{\overline{e}} - \underline{\theta} \tag{12}$$

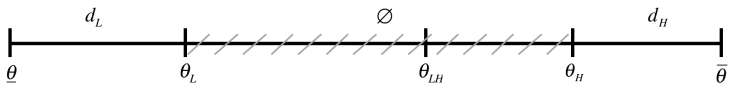
Because $\pi_H^m(x)$ is increasing in x whereas $\pi_L^m(x)$ is decreasing in x , there exists a minimal effort $\hat{x}^m$, such that $\pi_H^m(x) \geq \pi_L^m(x)$ when $x \geq \hat{x}^m$. This minimal effort is defined as follows:

$$\hat{x}^m \equiv 2\overline{\theta} - 3\underline{\theta} + \frac{\rho t_0 - 2\sqrt{(\overline{\theta}-\underline{\theta})(\rho(t_0+t_H) + (\overline{\theta}-\underline{\theta})\overline{e} - F_H)\overline{e}}}{\overline{e}} \tag{13}$$

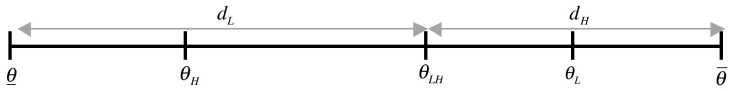
Conditions of existence and of market coverage of Duopoly LH

There is a consumer, with type $\widetilde{\theta}_{LH}$, who is indifferent between both products. However, depending on their prices and attributes, this consumer may be unwilling to buy one or the other product because $\widetilde{\theta}_L < \widetilde{\theta}_{LH} < \widetilde{\theta}_H$. In this case, the market remains uncovered. Conversely, all consumers buy one unit of the good when $\widetilde{\theta}_H < \widetilde{\theta}_{LH} < \widetilde{\theta}_L$.

When the market is uncovered, as in Figure 11a, those consumers who refrain from consuming the good have medium WTP such as $\theta \in [\widetilde{\theta}_L, \widetilde{\theta}_H]$. There is no strategic interaction between firms, which therefore act as monopolies. Using monopoly prices in uncovered markets, such that $p_i^m(x) = \overline{\omega}_i(x)/2$, the condition $\widetilde{\theta}_L < \widetilde{\theta}_H$ boils down to $\rho(t_0 + t_H) \leq (\overline{\theta} - \underline{\theta})\,\overline{e}$.



(a) Uncovered market



(b) Covered market

Figure 11: Market coverage with products L and H

Existence of both firms requires that the NGO's campaign effort remains in interval $[x^d_{H0}, x^d_{L0}]$, where both thresholds are defined as follows:

$$x^d_{H0} \equiv \frac{3\sqrt{2(\overline{\theta}-\underline{\theta})\overline{e}F_H} + \rho(t_0 - t_H)}{2\overline{e}} - 2\overline{\theta} + \underline{\theta} \tag{14}$$

$$x^d_{L0} \equiv \frac{\rho(t_0 - t_H)}{2\overline{e}} + \overline{\theta} - 2\underline{\theta} \tag{15}$$

Cost-effectiveness of duopoly (L, H) also necessitates that F_H is lower than $(\overline{\theta} - \underline{\theta})/(2\overline{e})$. Moreover, Product H is more cost-effective than Product L when the campaign effort is higher than the following threshold:

$$\hat{x}^d \equiv \frac{\rho(t_0 - t_H) - (\overline{\theta} + \underline{\theta})\overline{e}}{2\overline{e}} + \frac{3F_H}{4\overline{e}} \tag{16}$$

6.2 Proofs related to the information disclosure and campaign game

Proof of Lemma 1

In a duopoly, in absence of any NGO campaign increasing the WTP for the component-free Product H, this product can only be more cost-effective than Product L if and only if

$$\begin{aligned}
\pi^{dLH}_H(0) &\geq \pi^{dLH}_L(0) \\
2(\overline{\theta}-\underline{\theta})\,\overline{e}\left(d^{dLH}_H(0)^2 - d^{dLH}_L(0)^2\right) &\geq F_H \\
2(\overline{\theta}-\underline{\theta})\,\overline{e}\left(2d^{dLH}_H(0) - 1\right) &\geq F_H \\
\hat{F}^d_H \equiv \frac{2}{3}\left((\overline{\theta}+\underline{\theta})\overline{e} - \rho t_0 + \rho t_H\right) &\geq F_H
\end{aligned}$$

The market becomes a duopoly if and only if it is profitable for a new entrant to supply Product H:

$$\begin{aligned}
\pi^{dLH}_H(0) &\geq 0 \\
\underline{F}_H \equiv \frac{\left(2(2\overline{\theta}-\underline{\theta})\overline{e} - \rho t_0 + \rho t_H\right)^2}{18(\overline{\theta}-\underline{\theta})\,\overline{e}} &\geq F_H
\end{aligned}$$

It is easy to show that $\hat{F}_H^d < \underline{F}_H$.

When the market is a monopoly, the frontier between Monopoly H and Monopoly L is given by

$$\begin{aligned}
\pi_H^m(0) &\geq \pi_L^m(0) \\
\pi_H^m(0) &\geq (\overline{\theta} - \underline{\theta})\,\overline{e}\,d_L^m(0)^2 \\
\underline{\omega}_H(0) - F_H &\geq (\overline{\theta} - \underline{\theta})\,\overline{e}\,\Big(\frac{\overline{\omega}_L(0)}{2(\overline{\theta} - \underline{\theta})\overline{e}}\Big)^2 \\
\underline{\theta}\overline{e} + \rho t_H - F_H &\geq (\overline{\theta} - \underline{\theta})\,\overline{e}\,\Big(\frac{\rho t_0 - \underline{\theta}\overline{e}}{2(\overline{\theta} - \underline{\theta})\overline{e}}\Big)^2 \\
\hat{F}_H^m \equiv \underline{\theta}\overline{e} + \rho t_H - \frac{(\underline{\theta}\overline{e} - \rho t_0)^2}{4(\overline{\theta} - \underline{\theta})\,\overline{e}} &\geq F_H
\end{aligned}$$

Proof of Proposition 1

Since the R&D cost F_H is a fixed cost, the market share of Product H only depends on the WTP for both qualities. The NGO's awareness campaign x always decreases the market share of Monopoly L (eq. 3), and always increases the market share of Product H in a duopoly (eq. 5). Thanks to Assumption 3, the duopoly market is covered and any decrease in demand for L is covered by an increase in demand for H. The environmental quality is maximized when the market is covered by a Monopoly H, under Assumption 2. The global quality of the environment fulfills inequality $E^{mH}(x) = \overline{e} > E^{dLH}(x) > E^{mL}(x)$, where superscripts mL, mH and dLH respectively denote following market structures: monopoly of Product L, monopoly of Product H and duopoly (L, H) and (H, L).

Proof of Proposition 2

It has been shown in Appendix 6.1 that existence of both firms requires that the NGO's campaign effort remains in interval $[x_{H0}^d, x_{L0}^d]$. As soon as $F_H < (\overline{\theta} - \underline{\theta})/2\overline{e}$, $x_{H0}^d < x_{L0}^d$.

For low F_H, x_{L0}^d is therefore the maximal useful campaign effort to reach Monopoly H. $\overline{B}^d = \Big(x_{L0}^d\Big)^2 = \Big(\frac{\rho(t_0 - t_H)}{2\overline{e}} + \overline{\theta} - 2\underline{\theta}\Big)^2$.

Proof of Proposition 3

When $\hat{F}_H^m \leq \underline{F}_H$, Lemma 1 states that for $x = 0$, $\forall F_H \in [\underline{F}_H, \tilde{F}_H]$, Monopoly L remains on the market after information disclosure. However, any increase of the initial budget allows the NGO to campaign and to reduce its market share because $d_L^m(x) = \frac{\rho t_0 - (\underline{\theta}+x)\overline{e}}{2(\overline{\theta} - \underline{\theta})\overline{e}}$ (eq. 3). But, as this share decreases, it increases the minimal willingness to pay for Product H: $(\overline{\theta}+x)\overline{e}+\rho t_H$. Product H may thus become profitable, either for a new entrant in a duopoly, or for the incumbent who will switch to Monopoly H.

Let us define $\tilde{F}_H$ and $\tilde{B}$ such that $\pi_H^m(\tilde{F}_H, \tilde{B}) = \pi_L^m(\tilde{F}_H, \tilde{B})$ and $\pi_H^{dLH}(\tilde{F}_H, \tilde{B}) = 0$.
For $F_H < \tilde{F}_H$, when $B > \tilde{B}$, earning money with Product H becomes possible for a new entrant in a duopoly, but not for a monopoly H as soon as the campaign is sufficiently powerful, ie for $B > \underline{B}^d(F_H)$ such that $\pi_H^{dLH}(F_H, \underline{B}^d(F_H)) = 0$.

$$\pi_H^{dLH}(x) = 2(\overline{\theta} - \underline{\theta})\,\overline{e}\left(\frac{2(2\overline{\theta} - \underline{\theta} + x)\overline{e} - \rho t_0 + \rho t_H}{6(\overline{\theta} - \underline{\theta})\,\overline{e}}\right)^2 - F_H$$

$$x_{H0}^d(F_H) \equiv \frac{3\sqrt{2(\overline{\theta} - \underline{\theta})\overline{e}F_H} + \rho(t_0 - t_H) - 2(2\overline{\theta} - \underline{\theta})\overline{e}}{2\overline{e}} \text{ and } \underline{B}^d(F_H) = \left(x_{H0}^d(F_H)\right)^2$$

In the opposite case, when $F_H \geq \tilde{F}_H$, entry is deterred and the monopoly turns into Monopoly H as soon as the campaign is sufficiently powerful, ie for $B > \hat{B}^m(F_H)$ such that $\pi_H^m(F_H, \hat{B}^m(F_H)) \geq \pi_L^m(\hat{B}^m(F_H))$. It was already shown (Appendix 6.1) that the level of campaign effort equalizing both monopoly profits is $\hat{x}^m$. The necessary budget is thus $\hat{B}^m(F_H)$ defined as

$$\hat{B}^m(F_H) = \left(\hat{x}^m\right)^2 \equiv \left(2\overline{\theta} - 3\underline{\theta} + \frac{\rho t_0 - 2\sqrt{(\overline{\theta} - \underline{\theta})(\rho(t_0 + t_H) + (\overline{\theta} - \underline{\theta})\overline{e} - F_H)\overline{e}}}{\overline{e}}\right)^2$$

When $\underline{F}_H < \hat{F}_H^m$, according to Lemma 1, $\forall F_H \in [\underline{F}_H, \hat{F}_H^m]$, the Monopoly switches to Product H after information disclosure, even for $x = 0$. Increasing the campaign effort is useless.

Proof of Proposition 4

There exist limits $\overline{F}_H$ and $\overline{B}^m$ such that $\forall F_H \geq \overline{F_H}$ and $\forall B \geq \overline{B}^m$, Products L and H are both non profitable anymore and the market disappears, with $\overline{F}_H \equiv \rho t_0 + \rho t_H$ and $\overline{B} \equiv \left(\overline{\omega}_L(0)/\overline{e}\right)^2$. $\overline{B}^m$ is defined as the level of initial budget for which Monopoly L is no more cost-effective ($\pi_L^m(\hat{B}^m) = 0$ and $\overline{F}_H$ corresponds to the abscissa of the intersection point of the null profit line for Monopoly L and the null profit curve for Monopoly H ($\pi_H^m(\overline{F}_H, \hat{B}^m) = 0$).

6.3 Conditions of existence of different market structures including supply of a certified product

Conditions of existence of duopoly with Products L and M

When the market is fully covered by a duopoly $(L, M, \emptyset)$ or $(M, L, \emptyset)$, demand functions are defined as $d_M = \frac{\overline{\theta} - \theta_{LM}}{\overline{\theta} - \underline{\theta}}$ and $d_L = \frac{\theta_{LM} - \underline{\theta}}{\overline{\theta} - \underline{\theta}}$, with $\widetilde{\theta}_{LM} = \frac{p_M - p_L}{\overline{e} + e_M} - x$.[28] Maximization of profits with respect to prices leads to the following Nash equilibrium:

$$\begin{aligned} p_L^{dLM} &= \frac{(\overline{\theta} - 2\underline{\theta} - x)(\overline{e} + e_M) + c_M + \varphi}{3} \\ p_M^{dLM} &= \frac{(2\overline{\theta} - \underline{\theta} + x)(\overline{e} + e_M) + 2(c_M + \varphi)}{3} \end{aligned} \tag{17}$$

[28] Two monopolists co-exist in an uncovered market when $\widetilde{\theta}_L < \widetilde{\theta}_M$. Using monopoly prices, this condition is written as: $\rho t_0 < (\overline{\theta} - \underline{\theta})\frac{e_M}{\overline{e} + e_M} + (c_M + \varphi)\frac{\overline{e}}{\overline{e} + e_M}$. The WTP for the organoleptic quality has to be relatively low, but sufficiently high to allow cost-effectiveness of both monopolies (*i.e.* $\rho t_0 \geq (\underline{\theta} + x)\overline{e}$ and $\rho t_0 \geq c_M + \varphi - (\overline{\theta} + x)e_M$).

Demands are then written as:

$$\begin{aligned} d_L^{dLM} &= \frac{(\overline{\theta} - 2\underline{\theta} - x)(\overline{e} + e_M) + c_M + \varphi}{3(\overline{\theta} - \underline{\theta})(\overline{e} + e_M)} \\ d_M^{dLM} &= \frac{(2\overline{\theta} - \underline{\theta} + x)(\overline{e} + e_M) - c_M - \varphi}{3(\overline{\theta} - \underline{\theta})(\overline{e} + e_M)} \end{aligned} \tag{18}$$

The profits are then equal to $\pi_i^{dLM}(x) = (\overline{\theta} - \underline{\theta})(\overline{e} + e_M) d_i^{dLM\,2}$ with $i = L, M$.

Cost-effectiveness of Product M requires that its unit cost of production, $c_M + \varphi$, is sufficiently low to ensure that $d_M^{dLM} \geq 0$, that is:

$$c_M + \varphi \leq (2\overline{\theta} - \underline{\theta} + x)(\overline{e} + e_M) \tag{19}$$

Denoting $C_M \equiv c_M + \varphi$ and $\overline{C}_M^{dLM}$ the maximal unit cost allowing cost effectiveness of Product M before the campaign ($x = 0$), we deduce from the previous inequality that:

$$\overline{C}_M^{dLM} \equiv (2\overline{\theta} - \underline{\theta})(\overline{e} + e_M) \tag{20}$$

Existence of both firms requires that the NGO's campaign effort remains in interval $[x_{M0}^{dLM}, x_{L0}^{dLM}]$, where both thresholds are defined as follows:

$$\begin{aligned} x_{L0}^{dLM} &\equiv \overline{\theta} - 2\underline{\theta} + \frac{c_M + \varphi}{\overline{e} + e_M} \\ x_{M0}^{dLM} &\equiv -2\overline{\theta} + \underline{\theta} + \frac{c_M + \varphi}{\overline{e} + e_M} \end{aligned} \tag{21}$$

Moreover, the market is fully covered by the duopoly when consumers are ready to pay either for Product L (such that $\theta \leq \widetilde{\theta}_L = \frac{\rho t_0 - p_L}{\overline{e}} - x$) or for Product M (such that $\theta \geq \widetilde{\theta}_M = \frac{p_M - \rho t_0}{e_M} - x$), that requires that $\widetilde{\theta}_L \geq \widetilde{\theta}_M$, that is $\rho t_0(\overline{e} + e_M) \geq p_L^{dLM} e_M + p_M^{dLM} \overline{e}$. Using equations 17 in this inequality, the condition can be rewritten as follows:

$$\rho t_0 \geq \frac{(2\overline{\theta} - \underline{\theta})\overline{e} + (\overline{\theta} - 2\underline{\theta})e_M}{3} + \frac{2\overline{e} + e_M}{3(\overline{e} + e_M)}(c_M + \varphi) + \frac{\overline{e} - e_M}{3} x \tag{22}$$

Conditions of existence of duopoly with Products M and H

When the market is covered by a duopoly $(M, H, \emptyset)$ or $(H, M, \emptyset)$, demand functions are defined as $d_H = \frac{\overline{\theta} - \widetilde{\theta}_{MH}}{\overline{\theta} - \underline{\theta}}$ and $d_M = \frac{\widetilde{\theta}_{MH} - \underline{\theta}}{\overline{\theta} - \underline{\theta}}$, with $\widetilde{\theta}_{MH} = \frac{p_H - p_M + \rho t_0 - \rho t_H}{\overline{e} - e_M} - x$. Price competition results in the following Nash equilibrium:

$$\begin{aligned} p_M^{dMH} &= \frac{(\overline{\theta} - 2\underline{\theta} - x)(\overline{e} - e_M) + \rho t_0 - \rho t_H + 2c_M + 2\varphi}{3} \\ p_H^{dMH} &= \frac{(2\overline{\theta} - \underline{\theta} + x)(\overline{e} - e_M) - \rho t_0 + \rho t_H + c_M + \varphi}{3} \end{aligned} \tag{23}$$

Demands are then defined by:

$$\begin{aligned} d_M^{dMH} &= \frac{(\overline{\theta}-2\underline{\theta}-x)(\overline{e}-e_M)+\rho t_0-\rho t_H-c_M-\varphi}{3(\overline{\theta}-\underline{\theta})(\overline{e}-e_M)} \\ d_H^{dMH} &= \frac{(2\overline{\theta}-\underline{\theta}+x)(\overline{e}-e_M)-\rho t_0+\rho t_H+c_M+\varphi}{3(\overline{\theta}-\underline{\theta})(\overline{e}-e_M)} \end{aligned} \tag{24}$$

The profits are then equal to $\pi_M^{dMH}(x) = (\overline{\theta}-\underline{\theta})(\overline{e}-e_M)d_M^{dMH^2}$ and $\pi_H^{dMH}(x) = (\overline{\theta}-\underline{\theta})(\overline{e}-e_M)d_H^{dMH^2} - F_H$.

Cost-effectiveness of Product M requires that its unit cost of production, $c_M+\varphi$, is sufficiently low to ensure that $d_M^{dLM} \geq 0$, that is:

$$c_M + \varphi \leq (\overline{\theta}-2\underline{\theta}-x)(\overline{e}-e_M)+\rho t_0-\rho t_H \tag{25}$$

Denoting $\overline{C}_M^{dMH}(x)$ the maximal unit cost allowing cost effectiveness of Product M, we deduce from the previous inequality that:

$$\overline{C}_M^{dMH}(x) \equiv (\overline{\theta}-2\underline{\theta}-x)(\overline{e}-e_M)+\rho t_0-\rho t_H \tag{26}$$

Moreover, profitability of Product H requires that $F_H < (\overline{\theta}-\underline{\theta})(\overline{e}-e_M)d_H^{dMH^2}$. Such a condition leads, for a given F_H, to define the following minimal unit cost:

$$\underline{C}_H^{dMH}(x) \equiv 3\sqrt{(\overline{\theta}-\underline{\theta})(\overline{e}-e_M)F_H} - (\overline{e}-e_M)(2\overline{\theta}-\underline{\theta}+x)+\rho t_0-\rho t_H \tag{27}$$

Comparing Equation (26) and (27) shows that, without any effort campaign, the duopoly (M,H) appears as far as $F_H < \overline{F}_H^{dMH} \equiv (\overline{\theta}-\underline{\theta})(\overline{e}-e_M)$.

Moreover, $\overline{C}_M^{dMH}(x)$ decreases with x as $\underline{C}_H^{dMH}(x)$, that increases with F_H.

Existence of both firms requires that the NGO's campaign effort remains in interval $[x_{H0}^{dHM}, x_{M0}^{dMH}]$, where both thresholds are defined as follows:

$$\begin{aligned} x_{M0}^{dMH} &\equiv \overline{\theta}-2\underline{\theta}+\frac{\rho t_0-\rho t_H-c_M-\varphi}{\overline{e}-e_M} \\ x_{H0}^{dHM} &\equiv -2\overline{\theta}+\underline{\theta}+\frac{\rho t_0-\rho t_H-c_M-\varphi}{\overline{e}-e_M}+\frac{3\sqrt{(\overline{e}-e_M)(\overline{\theta}+\underline{\theta})F_H}}{\overline{e}-e_M} \end{aligned} \tag{28}$$

The market is fully covered by the duopoly when consumers are ready to pay either for Product M or for Product H. That implies that the consumer indifferent between buying M and refraining from consuming , denoted $\widetilde{\theta}_M \equiv \frac{p_M-\rho t_0}{e_M} - x$, is such that $\widetilde{\theta}_M \leq \underline{\theta}$, that is $\rho t_0 \leq p_M^{dLM} - (\underline{\theta}+x)e_M$. Using equation 23, the condition results in the following inequality:

$$\rho t_H + 2\rho t_0 \geq (\overline{\theta}-2\underline{\theta})(\overline{e}-e_M)+2(c_M+\varphi)-(\overline{e}+2e_M)x \tag{29}$$

Triopoly

With a triopoly market structure, demand functions are defined as $d_H = \frac{\overline{\theta}-\widetilde{\theta}_{MH}}{\overline{\theta}-\underline{\theta}}$, $d_M = \frac{\widetilde{\theta}_{MH}-\widetilde{\theta}_{LM}}{\overline{\theta}-\underline{\theta}}$ and $d_L = \frac{\widetilde{\theta}_{LM}-\underline{\theta}}{\overline{\theta}-\underline{\theta}}$. Maximization of the triopoly's profits with respect to prices leads to the following reaction functions:

$$\begin{aligned} p_L &= \frac{1}{2}(p_M - (\underline{\theta}+x)(\overline{e}+e_M)) \\ p_M &= \frac{1}{4\overline{e}}(p_H(\overline{e}+e_M) + p_L(\overline{e}-e_M) + (\rho t_0 - \rho t_H)(\overline{e}+e_M) + 2(c_M+\varphi)\overline{e}) \\ p_H &= \frac{1}{2}(p_M - (\overline{\theta}+x)(\overline{e}-e_M) - (\rho t_0 - \rho t_H)) \end{aligned} \tag{30}$$

Such reaction functions result in the following Nash equilibrium:

$$\begin{aligned} p_L^t &= \frac{(-6(\underline{\theta}+x)\overline{e} + (\overline{\theta}-\underline{\theta})(\overline{e}-e_M) + \rho t_0 - \rho t_H)(\overline{e}+e_M) + 4(c_M+\varphi)\overline{e}}{12\overline{e}} \\ p_M^t &= \frac{((\overline{\theta}-\underline{\theta})(\overline{e}-e_M) + \rho t_0 - \rho t_H)(\overline{e}+e_M) + 4(c_M+\varphi)\overline{e}}{6\overline{e}} \\ p_H^t &= \frac{(6(\overline{\theta}+x)\overline{e} + (\overline{\theta}-\underline{\theta})(\overline{e}-e_M))(\overline{e}-e_M) - (\rho t_0 - \rho t_H)(5\overline{e}-e_M) + 4(c_M+\varphi)\overline{e}}{12\overline{e}} \end{aligned} \tag{31}$$

Demands are then defined by:

$$\begin{aligned} d_L^t &= \frac{(-6(\underline{\theta}+x)\overline{e} + (\overline{\theta}-\underline{\theta})(\overline{e}-e_M) + \rho t_0 - \rho t_H)(\overline{e}+e_M) + 4(c_M+\varphi)\overline{e}}{12(\overline{\theta}-\underline{\theta})(\overline{e}+e_M)\overline{e}} \\ d_M^t &= \frac{((\overline{\theta}-\underline{\theta})(\overline{e}-e_M) + \rho t_0 - \rho t_H)(\overline{e}+e_M) - 2(c_M+\varphi)\overline{e}}{3(\overline{\theta}-\underline{\theta})(\overline{e}+e_M)(\overline{e}-e_M)\overline{e}} \\ d_H^t &= \frac{(6(\overline{\theta}+x)\overline{e} + (\overline{\theta}-\underline{\theta})(\overline{e}-e_M))(\overline{e}-e_M) - (\rho t_0 - \rho t_H)(5\overline{e}-e_M) + 4(c_M+\varphi)\overline{e}}{12(\overline{\theta}-\underline{\theta})(\overline{e}-e_M)\overline{e}} \end{aligned} \tag{32}$$

The profits are characterized by $\pi_L^t(x) = (\overline{\theta}-\underline{\theta})(\overline{e}+e_M){d_M^t}^2$, $\pi_M^t(x) = \frac{(\overline{\theta}-\underline{\theta})(\overline{e}+e_M)(\overline{e}-e_M)}{2\overline{e}}{d_M^t}^2$ and $\pi_H^t(x) = (\overline{\theta}-\underline{\theta})(\overline{e}-e_M){d_H^t}^2 - F_H$.

Cost-effectiveness of Product M in a triopoly before the campaign involves a maximal unit cost, deduced from condition $d_M^t \geq 0$, defined as follows:

$$\overline{C}_M^t \equiv \frac{\big((\overline{\theta}-\underline{\theta})(\overline{e}-e_M) + \rho t_0 - \rho t_H\big)(\overline{e}+e_M)}{2\overline{e}} \tag{33}$$

The condition for cost effectiveness of Product H before the campaign $\pi_H^t(0) \geq 0$ can be translated as a minimal unit cost, denoted $\underline{C}_M^t$, for a given R&D cost F_H, defined as:

$$\underline{C}_M^t \equiv 3\sqrt{(\overline{\theta}-\underline{\theta})(\overline{e}-e_M)F_H} + \frac{\overline{e}(\overline{e}-e_M)(\underline{\theta}(\overline{e}+e_M) - \overline{\theta}(7\overline{e}+e_M) + (5\overline{e}-e_M)\overline{e}(\rho t_0 - \rho t_H)}{4\overline{e}^2} \tag{34}$$

Moreover, conditions $C_M \leq \overline{C}_M^t$ and $C_M \geq \underline{C}_M^t$ imply a maximal R&D cost compatible with the triopoly, defined as follows:

$$\overline{F}_H^t \equiv \frac{(\overline{e}-e_M)\big(\underline{\theta}(\overline{e}+e_M) - \overline{\theta}(3\overline{e}+e_M) + \rho t_0 - \rho t_H\big)^2}{16(\overline{\theta}-\underline{\theta})\overline{e}^2} \tag{35}$$

Therefore, the triopoly market structure can only emerge before the campaign for $C_M \in [\underline{C}_M^t, \overline{C}_M^t]$ and $F_H \leq \overline{F}_H^t$. Product L is also cost effective when both other products are cost effective if we assume that $(\overline{\theta} - \underline{\theta})(\overline{e} - e_M) + \rho t_0 - \rho t_H > 2\underline{\theta}\overline{e}$ because d_L^t is an increasing function of C_M and $d_L^t > 0$ when $C_M = \underline{C}_M^t$ as long as the previous condition is fulfilled.

Existence of the three firms requires that the NGO's campaign effort remains in interval $[x_{H0}^t, x_{L0}^t]$, where both thresholds are defined as follows:

$$\begin{aligned} x_{L0}^t &\equiv -\frac{6\underline{\theta}\overline{e} + (\overline{\theta} - \underline{\theta})(\overline{e} - e_M) - (\rho t_0 - \rho t_H)}{6\overline{e}} + \frac{2(c_M + \varphi)}{3(\overline{e} + e_M)} \\ x_{H0}^t &\equiv -\frac{6\overline{\theta}\overline{e} + (\overline{e} + e_M)(\overline{\theta} - \underline{\theta}) - (\rho t_0 - \rho t_H)}{6\overline{e}} - \frac{4(c_M + \varphi)\overline{e} - (\rho t_0 - \rho t_H)}{6(\overline{e} - e_M)} \\ &\quad + \frac{2\sqrt{(\overline{e} - e_M)(\overline{\theta} - \underline{\theta})F_H}}{\overline{e} - e_M} \end{aligned} \tag{36}$$

The market is fully covered by the triopoly when consumers are ready to pay either for Product L ($\theta \leq \widetilde{\theta}_L = \frac{\rho t_0 - p_L}{\overline{e}} - x$) or for Product M ($\theta \geq \widetilde{\theta}_M = \frac{p_M - \rho t_0}{e_M} - x$) or for Product H ($\theta \geq \widetilde{\theta}_H = \frac{p_H - \rho t_0}{e_H} - x$), that requires that $\widetilde{\theta}_L \geq \widetilde{\theta}_M$, that is $\rho t_0(\overline{e} + e_M) \geq p_L^t e_M + p_M^t \overline{e}$. Using equations 17 in this inequality, the condition can be rewritten as follows:

$$\begin{aligned} 12(\overline{e} + e_M)\overline{e}\rho t_0 \quad \geq \quad & (\overline{e} + e_M)\big((\overline{\theta} - \underline{\theta})(2\overline{e}^2 - e_M^2) - (\overline{\theta} + 5\underline{\theta})e_M\overline{e}\big) \\ & + (2\overline{e} + e_M)\big(\rho t_0 - \rho t_H + 4(c_M + \varphi)\overline{e}\big) - 6(\overline{e} + e_M)e_M\overline{e}x \end{aligned} \tag{37}$$

Conditions on production costs for market structures before the campaign (Figure 4)

According to backward induction reasoning, the triopoly is a Nash equilibrium when a third firm has an interest in enter the market (with H or M) and the other firms have also an interest in producing (see Figure 10), that is when $\pi_i^t > 0$ for all $i = L, M, H$. In Figure 4[29], the triopoly area corresponds to the kind of triangle on the west of the graph, with $\underline{C}_M^t$ the growing curve that reaches threshold $\overline{C}_M^t$ for F_H equal to $\overline{F}_H^t$. When $c_M + \varphi$ is outside this range, the third firm decides not to enter either because C_M is too low to allow cost-effectiveness of Product H (*i.e.* $C_M < \underline{C}_M^t$ and $\pi_H^t \leq 0$) or C_M is too high to allow cost-effectiveness of Product M (*i.e.* $C_M > \overline{C}_M^t$ and $\pi_M^t \leq 0$). The market structure can therefore be a duopoly.

In the case of covered market by the duopoly, the best incumbent's strategy is to produce the most cost-effective product knowing that the firm will then decide to enter with the second best cost-effective product.

[29]Figure 4 has been drawn using parameters $\underline{\theta} = 1$, $\overline{\theta} = 4$, $\overline{e} = 1$, $e_M = 1/2$, $\rho = 3$, $t_0 = 2$ and $t_H = 1/2$.

Duopoly with products L and M is a Nash equilibrium before the campaign if $C_M \leq \overline{C}_M^{dLM}$. In Figure 4, this threshold corresponds to the horizontal line in the northeast of the graph Moreover, duopoly $(M, L, \emptyset)$ is the SPE of the game if $\pi_M^{dLM}(x) > \pi_L^{dLM}(x)$, that implies $c_M + \varphi \leq (\overline{\theta} + \underline{\theta} + 2x)(\overline{e} + e_M)$. Therefore, the maximal unit cost triggering the incumbent to switch to M before the campaign is defined as $\hat{C}_M^{dLM} \equiv (\overline{\theta} + \underline{\theta})(\overline{e} + e_M)$. A higher cost leads the incumbent to still produce L meanwhile the new entrant supplies M. In Figure 4, threshold $\hat{C}_M^{dLM}$ corresponds to the horizontal dotted line.

Existence of SPE $(L, M, \emptyset)$ requires non deviation condition $\pi_M^{dLM}(0) > \pi_H^{dLH}(0)$, that can be written:

$$\frac{\big((2\overline{\theta} - \underline{\theta} + x)(\overline{e} + e_M) - c_M - \varphi)\big)^2}{9(\overline{\theta} - \underline{\theta})(\overline{e} + e_M)} > \frac{\big(2(2\overline{\theta} - \underline{\theta} + x)\overline{e} - \rho t_0 + \rho t_H\big)^2}{18(\overline{\theta} - \underline{\theta})\,\overline{e}} - F_H \tag{38}$$

Denoting $\hat{C}_M^d$ the maximal unit cost leading the new entrant to produce M rather than H to compete with Product L before the campaign ($x = 0$), we deduce from the previous inequality that:

$$\hat{C}_M^d \equiv \frac{2\overline{e}(2\overline{\theta} - \underline{\theta})(\overline{e} + e_M) - \sqrt{2\overline{e}(\overline{e} + e_M)\big(- 18\overline{e}(\overline{\theta} - \underline{\theta})F_H + (2\overline{e}(2\overline{\theta} - \underline{\theta}) - \rho(t_0 - t_H))^2\big)}}{2\overline{e}} \tag{39}$$

Note that when $F_H = \underline{F}_H$ (such that $\pi_H^{dLH} = 0$), the term under the square root is equal to zero and $\hat{C}_M^d$ is equal to $\overline{C}_M^{dLM}$. In Figure 4, $\hat{C}_M^d$ corresponds to the growing curve, between areas of duopoly $(L, H, \emptyset)$ and duopoly $(L, M, \emptyset)$, ending with a vertical line for $F_H = \underline{F}_H$ and $\hat{C}_M^d = \overline{C}_M^{dLM}$.

Existence of SPE $(M, L, \emptyset)$ requires non deviation condition $\pi_L^{dLM}(0) > \pi_H^{dMH}(0)$, that implies:

$$\frac{\big((\overline{\theta} - 2\underline{\theta} - x)(\overline{e} + e_M) - c_M - \varphi\big)^2}{9(\overline{\theta} - \underline{\theta})(\overline{e} + e_M)} > \frac{\big((2\overline{\theta} - \underline{\theta} + x)(\overline{e} - e_M) - \rho t_0 + \rho t_H + c_M + \varphi\big)^2}{9(\overline{\theta} - \underline{\theta})\,(\overline{e} - e_M)} - F_H \tag{40}$$

Denoting $\tilde{C}_M^d$ the maximal unit cost leading the new entrant to produce L rather than H to compete with Product M before the campaign ($x = 0$), we deduce from the previous inequality that:

$$\begin{aligned} \tilde{C}_M^d \;\equiv\; & \frac{(\overline{e} + e_M)\big(- (\overline{e} - e_M)(2\overline{\theta} + \underline{\theta}) + \rho t_0 - \rho t_H\big)}{2e_M} \\ + \; & \frac{\sqrt{(\overline{e} - e_M)(\overline{e} + e_M)\big(18e_M(\overline{\theta} - \underline{\theta})F_H + (-3e_M(\overline{\theta} - \underline{\theta}) + \overline{e}(\overline{\theta} + \underline{\theta}) - \rho t_0 - \rho t_H))^2\big)}}{2e_M} \end{aligned} \tag{41}$$

In Figure 4, threshold $\tilde{C}_M^d$ does not appear because, with our parameters, $\tilde{C}_M^d > \hat{C}_M^d$ and the non deviation conditions are both fulfilled when $c_M + \varphi \leq \hat{C}_M^d$.

Duopoly with products L and H is a Nash equilibrium before the campaign if non deviation condition $\pi_H^{dLH}(0) \geq \pi_M^{dLM}(0)$ is fulfilled, that implies $C_M \geq \hat{C}_M^d$, and if Product H is cost effective, that requires $F_H \leq \underline{F}_H$. Second non deviation condition $\pi_L^{dLH}(x) \geq \pi_M^{dMH}(x)$ is characterized as follows:

$$\frac{\left(2(\overline{\theta}-2\underline{\theta}-x)\overline{e}+\rho t_0-\rho t_H\right)^2}{18(\overline{\theta}-\underline{\theta})\,\overline{e}} \geq \frac{\left((\overline{\theta}-2\underline{\theta}-x)(\overline{e}-e_M)+\rho t_0-\rho t_H-c_M-\varphi\right)^2}{9(\overline{\theta}-\underline{\theta})(\overline{e}-e_M)} \tag{42}$$

Denoting $\check{C}_M^d$ the minimal unit cost leading the new entrant to produce L rather than M to compete with Product H before the campaign ($x=0$), we deduce from the previous inequality that $\check{C}_M^d$ is defined as follows :

$$\check{C}_M^d \equiv (\overline{\theta}-2\underline{\theta})(\overline{e}-e_M)+\rho t_0-\rho t_H-\frac{\sqrt{2(\overline{e}-e_M)\overline{e}\left(2(\overline{\theta}-2\underline{\theta})\overline{e}+\rho t_0-\rho t_H\right))^2)}}{2\overline{e}} \tag{43}$$

In Figure 4, threshold $\check{C}_M^d$ does not appear because, with our parameters, $\check{C}_M^d < \hat{C}_M^d$ and the non deviation conditions are both fulfilled when $c_M+\varphi \geq \hat{C}_M^d$. Moreover, the SPE is $(L,H,\emptyset)$ when $F_H \in [\hat{F}_H, \underline{F}_H]$ and $(H,L,\emptyset)$ if $F_H < \hat{F}_H$. Threshold $\hat{F}_H$ corresponds to the vertical dotted line in Figure 4.

Duopoly with products M and H is a Nash equilibrium before the campaign if $C_M \in [\underline{C}_M^{dMH}, \overline{C}_M^{dMH}]$ and $F_H < \overline{F}_H^{dMH}$. Non deviation condition for SPE $(M,H,\emptyset)$ is $\pi_H^{dMH}(0) \geq \pi_L^{dLM}(0)$, that requires $C_M > \tilde{C}_M^d$. Non deviation condition for SPE $(H,M,\emptyset)$ is $\pi_M^{dMH}(0) \geq \pi_L^{dLH}(0)$, that involves $C_M < \check{C}_M^d$. In Figure 4, these SPE do not emerge because, with our parameters, $\check{C}_M^d \leq \underline{C}_M^{dMH} \leq \overline{C}_M^{dMH} < \tilde{C}_M^d$ and the second firm has an interest in deviating from H to L if the incumbent supplies M and in deviating from M to L if the incumbent supplies H.

6.4 Proofs related to the certification and campaign game

Proof of Proposition 5

The first order conditions (FOC) for an interior solutions of the NGO's program implicitly define the best NGO's strategies, denoted x^{dLM*} and φ^{dLM*}:[30]

$$\begin{cases} x^{dLM*} = \dfrac{(2\overline{\theta}-\underline{\theta})(\overline{e}+e_M)-c_M-\varphi^{dLM*}}{6(\overline{\theta}-\underline{\theta})-(\overline{e}+e_M)} \\ x^{dLM*2} = B+\varphi^{dLM*}\dfrac{(2\overline{\theta}-\underline{\theta}-x^{dLM*})(\overline{e}+e_M)+c_M+\varphi^{dLM*}}{3(\overline{\theta}-\underline{\theta})(\overline{e}+e_M)} \end{cases}$$

The interior solution only applies when the initial budget is lower than a given threshold, denoted $\overline{B}^{dLM}$. Above this initial budget, the marginal rate of substitution of x to φ which keeps the environmental quality constant is lower than the implicit relative price exhibited by the budget

[30] The expression of x^{dLM*} and φ^{dLM*}, which are relatively indigestible, can be obtained on request upon the authors.

constraint (i.e. $\frac{\partial E^{dLM}}{\partial \varphi} / \frac{\partial E^{dLM}}{\partial x} < \frac{\partial BC^{dLM}}{\partial \varphi} / \frac{\partial BC^{dLM}}{\partial x}$).[31] The first FOC is not fulfilled and the best strategy of the NGO is the corner solution such that the NGO provides the label for free and makes a campaign effort $x^{dLM*} = \sqrt{B}$. (i.e. $\frac{\partial E^{dLM}}{\partial \varphi} / \frac{\partial E^{dLM}}{\partial x} < \frac{\partial BC^{dLM}}{\partial \varphi} / \frac{\partial BC^{dLM}}{\partial x}$). Using the budget constraint, $\varphi = 0$ and $x^{dLM} = \sqrt{B}$, the budget threshold can be defined as follows:

$$\overline{B}^{dLM} = \Big(\frac{(2\overline{\theta} - \underline{\theta})(\overline{e} + e_M) + c_M}{6(\overline{\theta} - \underline{\theta}) - \overline{e} - e_M} \Big)^2 \tag{44}$$

Product L is no more cost-effective as soon as $x \geq x_{L0}^{dLM} \equiv \overline{\theta} - 2\underline{\theta} + \frac{c_M + \varphi}{\overline{e} + e_M}$. For $\varphi = 0$, it defines the upper budget threshold above which any further increase in the campaign efoort x by the NGO would transform the duopoly (L, M) into a duopoly (M, H):

$$\overline{\overline{B}}^{dLM} = \Big(\overline{\theta} - 2\underline{\theta} + \frac{c_M}{\overline{e} + e_M} \Big)^2 \tag{45}$$

Proof of Proposition 6

Because campaign effort and label fee are perfect substitutes for the NGO (Equation 9, Figure 8), for a positive initial budget, there is no interior solution and the NGO should implement a strategy $(\varphi^{dMH*}, x^{dMH*})$ removing Product M, such that $d_M^{dMH} = 0$ and$E^{dMH} = E^{mH} = \overline{e}$, as follows:

$$\begin{cases} x^{dMH*} = \sqrt{B} \\ \varphi^{dMH*} = 3(\overline{\theta} - \underline{\theta})(\overline{\theta} - 2\underline{\theta})\overline{e} + \rho\,(t_0 - t_H) - (\overline{e} - e_M)\sqrt{B} - c_M \end{cases} \tag{46}$$

Proof of Proposition 7

When the NGO has a relatively low initial budget ($B < \underline{B}^d(F_H)$), its best strategy is to set (φ^{t*}, x^{t*}) allowing to fulfill the FOC:

$$\begin{aligned} \varphi^{t*} &= -\frac{1}{2}c_M + \frac{(\overline{e} + e_M)[(\overline{\theta} - \underline{\theta})(\overline{e} - e_M) + \rho(t_0 - t_H)]}{4\overline{e}} \\ x^{t*} &= \sqrt{B + \frac{(\overline{\theta} - \underline{\theta})(\overline{e} - e_M)(\overline{e} + e_M) + \rho(t_0 - t_H) - 2c_M\overline{e}}{24(\overline{\theta} - \underline{\theta})(\overline{e} - e_M)(\overline{e} + e_M)\overline{e}}} \end{aligned} \tag{47}$$

This interior solution is characterized by fee φ^{t*} that is all the higher as c_M is low and environmental quality e_M is high.

Because a high budget allows the NGO to undertake a more impact full campaign, when $B \geq \underline{B}^d(F_H)$), meanwhile E^t does not depend on φ and increases with x, the NGO tries to prevent cost-effectiveness of Product L by choosing $(\hat{\varphi}^{t*}, \hat{x}^{t*})$ at the limit of the shadow area in Figure 9, where $d_L^t = 0$, and the market structure turns to be a duopoly.

[31] The first FOC is $\frac{\frac{\partial E_M^m}{\partial \varphi}}{\frac{\partial E_M^m}{\partial x}} = -\frac{1}{\overline{e} + e_M} = \frac{\frac{\partial BC_M}{\partial \varphi}}{\frac{\partial BC_M}{\partial x}} = \frac{c_M + 2\varphi^{dLM*} - (2\overline{\theta} - \underline{\theta} + x^{dLM*})(\overline{e} + e_M)}{(6(\overline{\theta} - \underline{\theta})x^{dLM*} + \varphi_M^{m*})(\overline{e} + e_M)}$