Informative advertising by an environmental group

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Abstract

Consuming a product does not (necessarily) reveal the environmental damage of the good. In terms of environmental damage, most goods are credence goods. Therefore, through advertising and pricing the firm will not be able to transmit this information to the consumers. I examine the scope for an environmental group to signal this information to consumers via advertising and campaigning. Both the short-run (where environmental damage is given but unknown to the consumers) and the long-run (where environmental damage is chosen by the firm, but not observed by the consumers) are considered. In the short-run, Pareto-improving advertising is impossible and social welfare improving advertising is only possible if the difference between a clean product and a dirty product is sufficiently large. However, in the long-run, the presence of an EG seems to have a positive effect on social welfare. This is achieved solely by the threat of the EG to advertise if environmental damage is too high.

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1 Introduction

Consuming a product does not (necessarily) reveal the environmental quality of the good. If consumers care about the environmental quality of the good (and there is evidence that they do, see Kuhn (2005, pp.12–19) and the references therein), then how does this information get transmitted to consumers? Of course the government can force the firm to disclose information, but this requires costly monitoring by the government. In vogue with recent practices, one then can turn the attention to private initiatives (see, e.g. Baron, 2003). In this context, the actions of the firm itself offer little hope. For a firm it will be extremely difficult to convey information about environmental quality to the consumers. To see why, imagine that consumers expect a low price if environmental quality is low and a high price if environmental quality is high. Additionally assume that demand does not go down if price is high (i.e. the positive effect of higher environmental quality outweighs the negative effect of

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a higher price). As long as the marginal cost of producing a low quality good are lower than the marginal cost of producing a high quality good, the low quality producer could exploit the expectations of the consumer by setting the high price and increasing its profit in the process.[1]

Hence, there is scope for a third party to act as a monitor of the firm and disseminate information among consumers. In the case of environmental quality, a candidate would be an environmental group (EG) such as Greenpeace. One channel through which an EG can disseminate information is advertising. In case of low environmental quality an EG would be willing to spend large amounts on advertising to convince consumers that environmental quality is low. The willingness to pay this amount will be less if quality is high. This feature allows the EG to credibly transmit information. Note that I use the term advertising loosely. It refers to any kind of information transmission by an EG whether it is advertising on television or seeking the attention of the media through campaigning (and getting on the news).

A quick look at the website of Greenpeace reveals that a large part of the activities of Greenpeace consists of informing consumers. For instance, recently they have been attaching stickers on Disney pajamas (in stores in the UK) warning the consumers that the product contains dangerous chemicals.[2] This falls under the broad definition of advertising that I employ. Another example is the 'Viswijzer', an informative brochure aimed at Dutch consumers. This brochure tells consumers which fish are on the brink of extinction and of which the consumption should be avoided. The brochure is advertised on television by the World Wildlife Fund.[3] Observe that the product itself does not display this kind of information and, hence, we have something that is distinct from (eco)labeling.

I model this in the following manner. A monopolistic firm and an EG know the damage per unit of production that is caused by the production of the good. Consumers, however, are unaware of this damage. The firm and the EG simultaneously decide on, respectively, the price of the good and the amount of money to be spent on an advertising campaign. Consumers can observe both the price and the amount of money and they form expectations about the damage of the good. Using these expectations, the consumers then decide to buy the good or not at the announced price.

Two variants are examined. In the first variant, the firm does not choose the damage per unit of production. Instead this is chosen at random (by Nature) prior to the game. I interpret this as the short run in which the firm has already chosen damage and did not anticipate the reaction of the EG or the consumers. I compare a benchmark equilibrium, in which the EG is prohibited to advertise (and no information about the product is transmitted to consumers), to an equilibrium, in which the EG does advertise and transmits information to the consumers.

I show that it is indeed possible for an EG to signal environmental quality through advertising. Furthermore, there are two features of the advertising campaign. First, the EG will always elicit dirty firms. In Diermeier and Baron (forthcoming)'s model of negotiation between an EG and a firm, a similar phenomenon occurs. In their model, however, by assumption the EG demands that the firm reduces pollution and will hurt the firm if it does not comply: note

[1] Environmental quality is therefore a credence good (the seminal reference is Darby and Karni, 1973, recent expositions are Emons, 2001 and Emons, 1997). Note that Mahenc (forthcoming) does find an equilibrium in which each type of firm signals it environmental quality precisely by adjusting the cost structure.

[2] See `www.greenpeace.org.uk`. The information can be found under Campaigns/Toxics.

[3] This information, only in Dutch unfortunately, can be found at `www.wnf.nl` under Natuurbescherming/Campagnes/Leven in de zee 2006/Viswijzer/

that the goal of the EG could equally well be attained by praising the firm if it complies. I do not impose that the EG must target dirty firms: it follows from the model. Second, the EG is hurt by their own campaign. This possibility is also noticed by Laffont and Tirole (1991) in their model of interest groups influencing the government. On the other hand, on average, in the model presented in this paper the firm and the consumer do benefit from the information transmission. The results for this first variant cast doubt on the short-run effectiveness of advertising by EGs.

In the second variant the firm does choose damage, which is interpreted as the long run. In this variant, I show that the EG can costlessly 'force' the firm to chose a clean product. Compared to the benchmark of no EG, this turns out to be a Pareto-improvement. The presence of the EG seems to be beneficial in the long run.

The informative advertising model presented here is related to the auditing model presented in Feddersen and Gilligan (2001), which studies a duopoly situation in which firms are price-takers. In their model, the EG can investigate a firm and discover how damaging the production process is. This information can then be transmitted to consumers. One difference is that Feddersen and Gilligan suppose that information needs to be gathered whereas I suppose that information needs to be disseminated. Both approaches emphasize the difficulty the EG faces when it tries to convince the public. Feddersen and Gilligan, in particular, study costless investigation. Consequently, their model relies on cheap talk to transmit information. The fact that cheap talk is possible, is an artifact of their model. Crawford and Sobel (1982) investigate the conditions under which an informative equilibrium arises in general cheap-talk games. Crawford and Sobel conclude that while such an equilibrium can exist, it is only possible if the disagreement between the receiver and the sender is not too large. Applied to this situation we see that while the EG and consumer may agree that a lower damage per unit of production is better than a higher damage, the consumers also want to keep price as low as possible. Feddersen and Gilligan eliminate this factor by making the firms compete in price.

Besides Feddersen and Gilligan (2001), there is other related literature. First, the model in Heijnen and Schoonbeek (forthcoming) is similar to the model presented here, but in that paper advertising is solely persuasive instead of informative; that paper argues that the threat of advertising is more effective than actually advertising. Besides different results, the model presented here has informative advertising. This fact implies that an analysis of social welfare is meaningful. Second, the model is also closely related to models of costly lobbying (cf. Grossman and Helpman, 2001). In these models, special interest groups spend money to convince a policy maker about the state of the world. In contrast to this literature, I study direct action by an EG aimed at the consumer. Finally, since the model describes a game of asymmetric information the analysis boils down to an investigation of signaling equilibria, where the EG and the firm try to signal the environmental quality of the good by selecting an appropriate level of, respectively, the cost of the campaign and the price of the good. For related studies in the standard advertising literature, see e.g. Hertzendorf and Overgaard (2001) and Milgrom and Roberts (1986).

This paper is organized as follows. Section 2 introduces the model. Section 3 presents the equilibria of the model. Section 4 contains the results: the effect of advertising on the EG, the firm and the consumers and it analyzes social welfare. The effect of a firm choosing its damage level is analyzed in Section 5. Section 6 concludes.

2 The model

Consider a market in which a single profit-maximizing firm sells one good. This good is characterized by the damage d it causes to the environment per product sold. *Ex ante*, with probability ρ damage is low, $d = d_L$, and with probability $1 - \rho$ damage is high, $d = d_H$. Assume that $0 < d_L < d_H$ and $0 < \rho < 1$. The firm and the EG know the true value of d while the consumers, who care about the damage the product causes, only know the distribution of d. The price of the good is p.

First the focus is on the short run; the production technology is fixed. Irrespective of d, it costs $c > 0$ to produce one unit of the good. Usually, marginal cost is assumed to be decreasing in damage level. By abstracting from this, I focus purely on the communication problem. Consumers are indexed by θ, where θ is uniformly distributed on the interval $[0, \bar{\theta}]$. Without loss of generality let $\bar{\theta} = 1$. Consumer θ has the following utility function:

$$U(\theta, p) = \begin{cases} V - \theta\mu - p & \text{if one unit of the good is bought,} \\ 0 & \text{if zero units are bought,} \end{cases} \tag{1}$$

where V is a positive constant, θ measures the disutility of environmental damage and μ is the expected damage level associated with the consumption of one unit of the good. This is the standard vertical differentiation model used for products that differ in environmental quality (see, e.g., Moraga-González and Padrón-Fumero, 2002 or Cremer and Thisse, 1999 for a similar specification). All consumers have the same information, which they process in the same manner. After they have observed the actions of the firm and the EG, the consumers have the *ex post* belief that damage is low with a probability ϕ. If they receive no new information, then $\phi = \rho$ and $\mu = \phi d_L + (1 - \phi) d_H$. Note that the relation between ϕ and μ is strictly decreasing and utility is linear in expected damage. Hence, there is no loss of generality to consider only μ.

Only consumers with a sufficiently low θ will buy the good. The indifferent consumer can be found by equating utility to zero:

$$\hat{\theta} = \frac{V - p}{\mu}. \tag{2}$$

The demand for the good $q(p, \mu)$ is $\hat{\theta}$. I will assume an interior solution: there are always some consumers that do not buy the good because they care much about the environment, but there are also some consumers that always buy the good. A consequence is that demand is between zero and one.

The profit of the firm is $\Pi(p, \mu) = q(p, \mu)(p - c)$. It can be easily verified that the optimal price is given by:

$$p^* = \frac{1}{2}V + \frac{1}{2}c. \tag{3}$$

Note that if consumers could observe the damage of the product, then the price chosen by the firm would be the optimal price, which does not depend on μ.[4] Finally, observe that:

$$q(p^*, \mu) = \frac{(V - c)}{2\mu}, \tag{4}$$

$$\Pi(p^*, \mu) = \frac{(V - c)^2}{4\mu}. \tag{5}$$

Notice that demand and profit are decreasing in μ. Furthermore, both functions are convex in μ.

There is an environmental group that knows the true per product damage and cares about the total environmental damage caused by the production of the good. The cost of environmental damage to the EG is $q(p, \mu)d$, which is increasing in demand and increasing in d. Simultaneously with the firm's price decision, the EG can launch an advertising campaign. This advertising consists of a message ("The firm is of type d") and has cost x. It is assumed that when advertising is observed by the consumers and the firm, then it is possible for these observers to infer the cost of the advertising campaign. For instance, if consumers see an ad on prime-time television, they will note that this would have cost the EG a great deal of money. The cost of the advertising campaign is common knowledge.

The EG tries to minimize the sum of total damage and advertising cost: $\gamma q(p, \mu)d+x$. Here γ converts total environmental damage to its monetary value. Note that q possibly depends indirectly on x through the beliefs of the consumers. For example, the consumers might think that a costly advertising campaign signals a dirty product and therefore the consumers update the expected damage level upwards. For convenience I will set γ equal to one. As we will see, this has no effect apart from scaling the cost of the EG in equilibrium by a factor γ.[5] In the social welfare analysis of Section 4.2, I will therefore reintroduce the γ-parameter.

The members of the EG are activists who never buy the product. Furthermore, they are willing to exert effort to figure out how damaging per unit of production the good really is. I assume that the EG has ample funds to launch an advertising campaign. But they want to spend money as efficient as possible for there might be other projects that need money. This idea is captured by making the EG minimize cost.

It is important to notice that the actual message is not important, but the cost of advertising is. It should be noted that it is *not* the objective of the EG to maximize consumers' surplus. The public's skeptical view of the EG stems from the non-alignment of the public interest and the EG's interest. To see that the content of the messages can never be trusted by the consumers if the EG does not spend money on advertising campaigns, take the following situation. The message of the advert is either "$d = d_L$" or "$d = d_H$". For the consumer to trust the message "$d = d_L$", we need that:

$$q(p, d_L)d_L \leq q(p, d_H)d_L. \tag{6}$$

In other words, if $d = d_L$, then the cost of the EG should be lower if they tell the truth instead of claiming that "$d = d_H$". However, since q is decreasing in μ and $d_L < d_H$, if $d = d_L$, then

[4] This lack of dependency is a result of the following two assumptions. First, the marginal cost of producing the good does not depend on d. Second, the lower boundary of the distribution of θ is zero. These two assumptions considerably ease the calculations while they do not affect the results qualitatively.

[5] In particular, all equilibrium values of x that are derived in Section 3, are multiplied by γ. It is straightforward to check that in all equilibrium conditions γ drops out and γx is indeed an equilibrium value. The cost of the EG in equilibrium is then $\gamma q(p, \mu)d + \gamma x$. Therefore, γ is just a scaling factor.

the EG will claim that the firm is of a type d_H. Hence, the consumer will not trust the EG. To simplify the analysis (and without loss of generality), I assume that the content of the advert is cheap talk, but by showing how much it is willing to spend the EG can try to convince the public that it is telling the truth.

The timing of the game is as follows:

Period 0: Nature draws damage level per unit of production d .

Period 1: The firm and the EG observe d. The EG chooses the intensity of the advertising x. The firm chooses its price p.

Period 2: Consumers observe x and p. They update their beliefs μ (following Bayes' rule whenever possible) and choose to buy the good or not. This results in a demand $q(p, \mu)$.

The equilibrium concept that will be used, is the perfect Bayesian equilibrium (Mas-Colell, Whinston, & Green, 1995, p.285). The two requirements of this equilibrium concept are that the firm and the EG choose optimal actions given the beliefs of the consumers, and the consumers' beliefs are consistent with these actions. Note that usually there is one sender of information (cf. Milgrom and Roberts, 1986), whereas here there are two senders (the firm and the EG).

The order in which the game is played, mainly the fact that the firm and the EG move simultaneously, is the result of the following consideration. If the firm is allowed to determine the price after the EG chooses an advertising campaign, then the firm's reaction on x happens before the consumers observe x and update their beliefs. Considering that the advertising campaign is aimed at the consumers this chain of events is highly unlikely. The correct way of modeling this would be to let the consumers update their beliefs twice: first after witnessing x, then after observing p. For sake of simplicity, the firm and the EG are assumed to choose x and p simultaneously.

3 Equilibria

The forces that shape the set of equilibria are the following. Intuitively speaking, the EG wants to convince the consumers that damage per unit of production is high while the firm wants to achieve the opposite. If in an equilibrium the consumers believe that damage is low, then the cost of convincing the consumers that damage is high should be high enough to discourage the EG to choose this action. One way of 'punishing' the EG is to assume that the damage expected by the consumers off the equilibrium path (after a deviation of the EG) is sufficiently low. If in an equilibrium the consumers believe that damage is high, then the gains of convincing the consumers that damage is low should be so low that the firm will not choose this action. By assuming that off the equilibrium path (after a deviation of the firm) the expected damage is sufficiently high, the consumers can punish this type of behavior from the firm. The beliefs that sustain an equilibrium therefore assign low expected damage levels to deviations from the EG and high expected damage levels to deviations from the firm.

Two types of equilibria can be distinguished: separating equilibria and pooling equilibria. A separating equilibrium is one in which the consumers can distinguish between each state of the world, i.e. $\mu = d_L$ if $d = d_L$ and $\mu = d_H$ if $d = d_H$. Since consumers must be able to differentiate the two situations, it must be that $(x_L, p_L) \neq (x_H, p_H)$, where $x_L = x(d_L)$,

$x_H = x(d_H)$, $p_L = p(d_L)$ and $p_H = p(d_H)$. This denotes advertising levels and prices for both states of the world.

In this game there are two senders, the EG and the firm. One of the consequences of this is that there are two-sided separating equilibria (TSE) and one-sided separating equilibria (OSE). The terminology originates in Bagwell and Ramey (1991) and is defined as follows. In a TSE both senders emit different signals in both states of the world: i.e. $x_L \neq x_H$ and $p_L \neq p_H$. In an OSE only one sender emits a different signal in both states of the world. There are two distinct OSE: one where the firm signals ($p_L \neq p_H$ and $x_L = x_H$) and one where the EG signals ($x_L \neq x_H$ and $p_L = p_H$). One of the peculiarities of a TSE is that it is impossible for either the firm or the EG alone to make the consumers believe that they are in another state of the world, e.g. pretend that $d = d_L$ when it is in fact d_H. Even if, for instance, the firm decides to choose p_L when the state of the world is d_H, the EG would still choose x_H. The consumers would not automatically infer that $d = d_L$. Since there are two senders in this game, this would require a coordinated deviation where the EG chooses x_L instead of x_H and the firm chooses p_L instead of p_H. Hence, it is clear that a deviation from the equilibrium strategy by one player will always result in an out-of-equilibrium action.

As is common in games of asymmetric information, there is a plethora of equilibria. Four types can be distinguished: TSE, OSE where the EG informs, OSE where the firm informs and pooling equilibria. Since I am interested in the effect of advertising by EGs, the OSE in which the EG informs the consumers is the obvious equilibrium to explore.[6] As a benchmark I will use the case in which it is impossible to advertise (i.e. $x_L = x_H = 0$). Formally, this benchmark equilibrium coincides with a pooling equilibrium. Heijnen (2007, pp. 41–53) derives all equilibria and argues in detail why these two equilibria should be compared.

Before I continue, with the derivation of first the benchmark equilibrium of no advertising and then the equilibrium with advertising, a short remark on notation: $\mu(x, p)$ denotes the belief about the expected value of d if the consumers observe an advertising level of x and a price of p.

3.1 The benchmark

The benchmark of no advertising is a pooling equilibrium. In a pooling equilibrium neither the firm nor the EG provides the consumer with information. Consequently, in each state of the world they choose the same action. In case of the EG I restrict their actions: they are not allowed to advertise. Hence $p_L = p_H = \hat{p}$ and $x_L = x_H = 0$. Then $\mu(0, \hat{p}) = \rho d_L + (1-\rho) d_H \equiv \bar{\mu}$. Let us first consider the incentives of the firm. Since profit does not depend on the true value of d directly, in a pooling equilibrium the constraint on out-of-equilibrium beliefs to rationalize the firm's action is:

$$\frac{(V-\hat{p})(\hat{p}-c)}{\bar{\mu}} \geq \frac{(V-p)(p-c)}{\mu(0,p)} \text{ for all } p \neq \hat{p}, \tag{7}$$

which can be rewritten as:

$$\mu(0,p) \geq \frac{(V-p)(p-c)}{(V-\hat{p})(\hat{p}-c)}\bar{\mu}. \tag{8}$$

[6] It may seem arbitrary to ignore the TSE in which the EG also advertises, but these equilibria can be easily dismissed with equilibrium refinements. For instance, Bagwell and Ramey (1991)'s unprejudiced equilibrium refinement rules out any TSE.

Note that if the RHS of (8) exceeds d_H, then $\hat{p}$ cannot be part of an equilibrium. If $\hat{p} = p^*$, then the RHS is always smaller than or equal to $\bar{\mu} < d_H$. So, there is a pooling equilibrium in which $\hat{p} = p^*$.

There are also other pooling equilibria. Suppose $\hat{p} \neq p^*$ and the deviation is p^*. For $\hat{p}$ to be part of an equilibrium we must have:

$$\frac{(V - p^*)(p^* - c)}{(V - \hat{p})(\hat{p} - c)} \bar{\mu} \leq d_H, \tag{9}$$

i.e. the RHS of (8) should not exceed d_H for the (most tempting) deviation p^*. Let I be the interval for $\hat{p}$ implied by (9). If $\hat{p} \in I \subset [c, V]$, then it can be part of a pooling equilibrium. Note that $p^* \in I$ and the equilibrium in which $p = p^*$ is the natural one to select. Since the firm moves first, the equilibrium in which the firm has the highest level of profit will probably be the equilibrium to be played. The benchmark will be an equilibrium in which the firm always sets its price equal to p^* and the EG never advertises.

3.2 The equilibrium with advertising

The discussion is continued by examining OSE in which the EG informs and the firm's strategy is to set the same price in each state of the world. Since this is an OSE where the EG informs, beliefs must be such that $\mu(x_L, p_L) = d_L$ and $\mu(x_H, p_H) = d_H$.

I start with the decision of the firm. We know that in this kind of equilibrium $p_L = p_H$. In fact, the price the firm will set must be p^* in both states of the world. Suppose on the contrary that $p_L = p_H = \hat{p} \neq p^*$. Take $d = d_H$. Then the deviation to p^* must not be profitable, and we must have:

$$\frac{(V - \hat{p})(\hat{p} - c)}{d_H} \geq \frac{(V - p^*)(p^* - c)}{\mu(x_H, p^*)}. \tag{10}$$

Since $\hat{p} \neq p^*$, we know that $(V - \hat{p})(\hat{p} - c) < (V - p^*)(p^* - c)$. But then it must be that $d_H < \mu(x_H, p^*)$ which is impossible. Hence $\hat{p} = p^*$. Take $\mu(x_H, p) = d_H$ for all $p \neq p^*$. These out-of-equilibrium beliefs ensure that it is never profitable for the firm to deviate from the equilibrium since $\frac{(V-p^*)(p^*-c)}{d_H}$ is the minimal profit the firm receives in equilibrium as well as the supremum of profit it could receive out-of-equilibrium. Similarly, $\mu(x_L, p) = d_H$ for all $p \neq p^*$ ensures that it is never profitable for the firm to deviate if $d = d_L$. Of course, these are extreme out-of-equilibrium beliefs and the equilibrium can be supported by more moderate ones.

In equilibrium the EG determines x_L from:

$$x_L = \arg\min_x \frac{V - p_L}{\mu(x, p_L)} d_L + x \tag{11}$$

if $d = d_L$, and x_H from

$$x_H = \arg\min_x \frac{V - p_H}{\mu(x, p_H)} d_H + x \tag{12}$$

if $d = d_H$. The aim is to find all x_L and x_H with $x_L \neq x_H$ that, for some $\mu(x, p_L)$ and $\mu(x, p_H)$, satisfy (11) and (12) with respectively $x \neq x_L$ and $x \neq x_H$.

Suppose $d = d_L$ and the EG deviates. What out-of-equilibrium beliefs are necessary to sustain the equilibrium amount of advertising x_L? We must have:

$$\frac{V - p_L}{\mu(x, p_L)} d_L + x \geq \frac{V - p_L}{d_L} d_L + x_L \text{ for all } x \neq x_L. \tag{13}$$

For $x > x_L$, this inequality always holds if $\mu(x, p_L) = d_L$ (i.e. $\mu(x, p_L)$ remains low). This restriction implies that extra money spent on advertising is useless since consumers do not increase their expected damage levels. For $x < x_L$, a necessary condition is $\mu(x, p_L) < d_L$, which is impossible. To make this deviation unattractive, the consumers must believe that the product is cleaner than they know is possible. Hence, there can be no $x < x_L$, and I conclude that $x_L = 0$. If the product is clean, then the EG does not advertise.

Next, suppose that $d = d_H$. Here the out-of-equilibrium beliefs must satisfy:

$$\frac{V - p^*}{\mu(x, p^*)} d_H + x \geq \frac{V - p^*}{d_H} d_H + x_H \text{ for all } x \neq x_H. \tag{14}$$

If $x > x_H$, then this inequality holds if $\mu(x, p^*) = d_H$. Again the interpretation is that if the extra cost does not increase the expected damage level, then for the EG such a deviation is not worthwhile. Let $x < x_H$ and rewrite (14) as:

$$\mu(x, p^*) \leq \frac{V - p^*}{(V - p^*) + (x_H - x)} d_H. \tag{15}$$

Note that the RHS is smaller than d_H. However, without further restrictions, it might also be smaller than d_L, which should be impossible. The RHS is minimal at $x = 0$. If we take $0 < x_H \leq (V - p^*) \frac{d_H - d_L}{d_L} \equiv R$, and set $\mu(x, p^*) = d_L$ for $x < x_H$ (the worst belief for the EG), then inequality (15) is true. Thus, out-of-equilibrium beliefs that support the equilibrium under consideration are the following: $\mu(x, p^*) = d_L$ if $x < x_H$ and $\mu(x, p^*) = d_H$ if $x > x_H$. So, the EG is punished severely if it advertises less than x_H, and the beliefs ensure that it is never optimal to advertise more than x_H.

So, in equilibrium we have $x_L = 0$ and $0 < x_H \leq R$, but there is an additional restriction. The reason is that in addition the EG must not be tempted to choose x_H if $d = d_L$ and x_L if $d = d_H$. For the EG these incentive constraints imply:

$$\frac{V - p^*}{d_L} d_L \leq \frac{V - p^*}{d_H} d_L + x_H \qquad \text{if } d = d_L \tag{16}$$

$$\frac{V - p^*}{d_H} d_H + x_H \leq \frac{V - p^*}{d_L} d_H \qquad \text{if } d = d_H, \tag{17}$$

which implies that:

$$x_H \in \left[\left(\frac{V - p^*}{d_L} - \frac{V - p^*}{d_H} \right) d_L, \left(\frac{V - p^*}{d_L} - \frac{V - p^*}{d_H} \right) d_H \right] \equiv [L, R]. \tag{18}$$

Observe that $R > L > 0$. Thus, in these OSE, the EG always advertises if $d = d_H$. The cost of advertising if the product is dirty must be sufficiently large; this ensures that if the product is clean, then the benefits of campaigning are too small.

Summarizing, in these OSE the firm no longer needs to inform consumers and chooses its optimal price p^*. The EG now has to advertise with at least an intensity of L if damage is high. So, there are OSE in which $x_L = 0$, $x_H \in [L, R]$ and $p_L = p_H = p^*$. These equilibria are supported by out-of-equilibrium beliefs in which, in case of deviations of the firm, perceived damage is high enough and, in case of deviations of the EG, perceived damage is low enough. Note that the OSE, in which $x_L = 0$, $x_H = L$ and $p_L = p_H = p^*$, Pareto-dominates any other equilibrium of this type. Therefore I will use this equilibrium, referred to as the equilibrium with advertising, to compare the benchmark with.

4 Results

4.1 The equilibrium with advertising versus the benchmark

In this section the OSE with advertising will be compared with the benchmark of no advertising. In particular, I will compare the *ex ante* cost of the EG and profit of the firm. Let me start with the equilibrium with advertising. If damage is low, then the total cost of the EG in the equilibrium is:

$$\Delta_L = \frac{V - p^*}{d_L} d_L, \tag{19}$$

and the profit of the firm is:

$$\Pi_L = \frac{(V - p^*)(p^* - c)}{d_L}. \tag{20}$$

Similarly, if damage is high, then the total cost of the EG in the equilibrium is:

$$\Delta_H = \frac{V - p^*}{d_H} d_H + L, \tag{21}$$

and the profit of the firm is:

$$\Pi_H = \frac{(V - p^*)(p^* - c)}{d_H}. \tag{22}$$

Thus, for the equilibrium with advertising, the *ex ante* expected total cost and profit are:

$$\Delta_{ads} = \rho \frac{V - p^*}{d_L} d_L + (1 - \rho) \frac{V - p^*}{d_H} d_H + (1 - \rho)L, \tag{23}$$

$$\Pi_{ads} = \rho \frac{(V - p^*)(p^* - c)}{d_L} + (1 - \rho) \frac{(V - p^*)(p^* - c)}{d_H}. \tag{24}$$

In the benchmark equilibrium, we have:

$$\Delta_{bench} = \frac{V - p^*}{\rho d_L + (1 - \rho)d_H} (\rho d_L + (1 - \rho)d_H) \tag{25}$$

and

$$\Pi_{bench} = \frac{(V - p^*)(p^* - c)}{\rho d_L + (1 - \rho)d_H}. \tag{26}$$

Remark that $\Delta_{ads} = (V - p^*) + (1 - \rho)L$ and $\Delta_{bench} = (V - p^*)$. Hence $\Delta_{bench} < \Delta_{ads}$, i.e. the cost of the EG increases when it is able to advertise.

The firm's *ex ante* profit is always higher in the equilibrium with advertising compared to the benchmark equilibrium. To see this, note that profit is convex in μ. Applying Jensen's inequality, we obtain:

$$\Pi_{bench} = \frac{(V - p^*)(p^* - c)}{\rho d_L + (1 - \rho)d_H} < \rho \frac{(V - p^*)(p^* - c)}{d_L} + (1 - \rho) \frac{(V - p^*)(p^* - c)}{d_H} = \Pi_{ads}. \tag{27}$$

Note that the low-damage firm prefers the advertising equilibrium over the benchmark equilibrium since in the former equilibrium the firm sells the good at the same price as in the latter but the consumer values the low-damage good higher. This results in more demand. For the high-damage firm the opposite occurs. However, the gain of the low-damage firm is higher than the loss of the high-damage firm, and on average the firm benefits from advertising.

Regarding consumers' surplus, note that in case of a linear demand and a monopolistic firm, the consumers' surplus is exactly half of monopoly profit. Hence, *ex ante* the consumers also prefer the advertising equilibrium.

Concluding, the EG can transmit information by advertising if damage is high, but it does not benefit the EG. The firm, however, does benefit from the information transmission by the EG. While the EG transmits information, it is its adversary, the firm, that profits from it. The reason for this is that the goal of the EG is not to inform the consumers *per se*. On average and net of advertising cost, the EG is indifferent between having informed or uninformed consumers since $q(p^*, d_L)d_L = q(p^*, d_H)d_H = q(p^*, \mu)\mu$ is constant in this model. Ideally the EG wants to delude the consumers: to make them believe that damage is higher than it actually is. This is precisely what happens in the benchmark case to uninformed consumers if damage is low. However, those same uninformed consumers believe the product is fairly clean when damage is high. And this is the point at which the EG starts to advertise if advertising is possible. Consequently, the EG is now paying to inform consumers, but it is, net of advertising cost, indifferent between having informed and uninformed consumers.

4.2 Social Welfare

In this section I will perform an analysis of social welfare. We have already seen in the previous section that both the firm and consumers *ex ante* prefer the advertising equilibrium over the benchmark equilibrium whereas the EG prefers the benchmark equilibrium. In order to determine which effect dominates, social welfare will be examined. I define social welfare as:

$$SW_i = \Pi_i + CS_i - \gamma\Delta_i, \tag{28}$$

where $i \in \{\text{ads}, \text{bench}\}$ and CS_i denotes consumers' surplus. Recall the role of the γ-parameter as discussed in Footnote 5: its role is to scale the cost of the EG and hence I will include it here. Since $CS_i = \frac{1}{2}\Pi_i$ we have:

$$SW_i = \frac{3}{2}\Pi_i - \gamma\Delta_i. \tag{29}$$

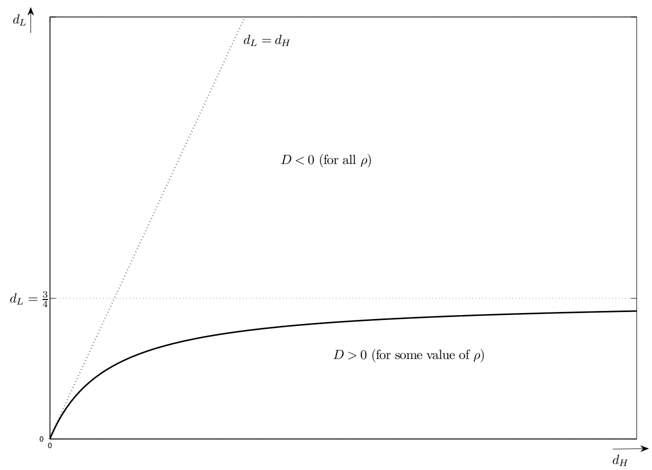
Since $\Pi_{bench} > \Pi_{ads}$ and $\Delta_{bench} > \Delta_{ads}$, it is immediately clear that by taking γ small enough the advertising equilibrium will be preferred and by taking γ large enough the benchmark equilibrium will be preferred. So, I will again set γ equal to 1 and determine the effect of the other parameters, i.e. ρ, d_L, d_H, V and c. Define $D = SW_{ads} - SW_{bench}$ as the difference in social welfare between the advertising equilibrium and the benchmark equilibrium. So if $D > 0$, then advertising raises social welfare. After some tedious, but straightforward algebra, we obtain:

$$D = \frac{V-c}{4} \times \left[\frac{3}{2}\left(\frac{\rho}{d_L} + \frac{1-\rho}{d_H}\right) - 2\left(1 - \frac{d_L}{d_H}\right) - \frac{3}{2(\rho d_L + (1-\rho)d_H)}\right]. \tag{30}$$

Note that V and c have no effect on the sign of D. Also, if ρ is either 0 or 1, then $D < 0$. This is expected since in these two cases there is no uncertainty about damage. Let $\hat{\rho}$ be such that $D = 0$. It can be shown that:

$$\hat{\rho} = \frac{1}{6}(3 + 4d_L) \pm \frac{1}{6}\sqrt{\frac{(d_H - d_L)(3 + 4d_L)^2 - 48 d_L d_H}{(d_H - d_L)^2}}. \tag{31}$$

Figure 1: The region in which advertising might increase social welfare



Observe that, given d_L and d_H, these two roots are either imaginary (and in that case $D < 0$ for all ρ) or both roots are in the interval $[0, 1]$. Since the roots should be real for there to be a situation in which there exist ρ such that $D > 0$, we need that:

$$(d_H - d_L)(3 + 4d_L)^2 - 48d_Ld_H > 0. \tag{32}$$

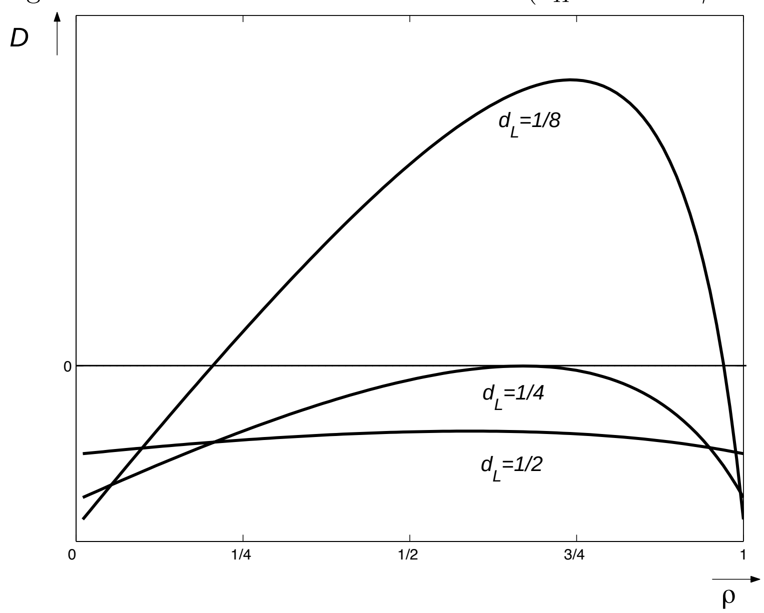
For instance, if $d_H = 1$, it can be shown that this inequality holds if $d_L < \frac{1}{4}$. Hence, the dirty good has to cause at least four times more damage per unit of production such that, for at least some value of ρ, the advertising equilibrium is better than the benchmark equilibrium in terms of social welfare. Figure 1 shows the combinations of d_L and d_H for which $D > 0$ (for some values of ρ) and the combinations for which $D < 0$ (for all values of ρ). It reveals that d_L has to be small compared to d_H for the advertising equilibrium to be socially optimal. In fact, if $d_L \geq \frac{3}{4}$, then advertising is never socially optimal.

Figure 2 plots D for different values of d_L (and $d_H = 1$). This figure shows two things. First, the maximal D is reached at $\rho > \frac{1}{2}$,[7] i.e. it should be more likely that the product is dirty than clean. Second, it shows that the interval of ρ's for which $D > 0$ can be quite large once the ratio d_L/d_H is small enough.

Concluding, if it is almost certain that the good is clean or dirty, then the benchmark equilibrium is socially optimal. Only if the clean good is very clean relative to the dirty good, can it be possible that advertising is socially optimal. And if the clean good is clean enough for this to happen, then there must also be a higher probability that the good is dirty. This (partial) numerical analysis also shows that the losses of the EG can be substantial and that advertising can decrease social welfare.

[7] This is also evident from (31) since the interval implied by this equation is symmetric around $\frac{1}{6}(3+4d_L) > \frac{1}{2}$.

Figure 2: The difference in social welfare ($d_H = 1$ and $\gamma = 1$)



5 Choosing damage: the long run versus the short run

So far I have assumed that the firm cannot influence the amount of damage per unit of production of the good. In the short run this might be plausible, but in the long run the firm should be able to choose damage per unit of production itself. In the short run, the firm might unexpectedly face consumers that have newly become aware of the fact that the product they consume causes harm to the environment. As an example one could think of a material like asbestos, whose detrimental effects were only discovered after the material had been used for several years. When the firm started the production of the good, its choice of d was based on other considerations than the consumers' attitudes about the environment. In that case it is reasonable to assume that the consumers attach an *a priori* probability that the good causes either a low damage or a high damage. However, in the long run, e.g. when the firm builds a new plant, the environmental awareness of the consumers may be an important issue. Consequently, in a perfect Bayesian Nash equilibrium the consumers must have expectations about the level of damage that is consistent with the decision of the firm concerning the level of damage per unit of production. As we will see, this drastically changes the role of the EG.

So, I allow the firm to choose $d \in \{d_L, d_H\}$ in period 0 instead of Nature. For the remainder of this Section I will assume that if the firm is indifferent between choosing d_L and d_H, then it will choose d_H. While this will seem to drive the result, one should remember that if the marginal cost of producing the clean good would be infinitesimally higher than the marginal cost of producing the dirty good, then the firm would prefer d_H.

In absence of an EG, the firm must choose d_H. The reason for this is almost trivial. Suppose the firm mixes its strategy in period 0 and with probability ρ chooses low damage. Observe that if $x_L = x_H = 0$, then the firm's profit does not depend on the actual value of d. So in period 0, the firm is indifferent between d_L and d_H and by assumption will choose d_H.

Note that in a perfect Bayesian Nash equilibrium, the consumers' belief about which damage level the firm chooses must be consistent with the firm's choice. Hence, if the firm chooses d_H, then the consumers also believe that damage is d_H. Consequently, the profit of the firm in this equilibrium is $\frac{(V-p^*)(p^*-c)}{d_H}$.

Now suppose that the EG can advertise. I will show that the EG can without cost force the firm to choose d_L. Consider the following strategy by the EG: $x(d_L) = 0$ and $x(d_H) = L$. Furthermore, suppose that the strategy of the firm is $p(d_L) = p(d_H) = p^*$ and choose d_L with probability ρ in period 0. Also the beliefs of the consumers given p^* are:

$$\mu(x, p^*) = d_L \quad \text{if } x < L, \tag{33}$$

$$\mu(x, p^*) = d_H \quad \text{if } x \geq L. \tag{34}$$

The analysis in Section 3 shows that conditional on the firm's choice of ρ this is a OSE where the EG informs. Regarding the firm's decision of ρ in period 0, the following considerations must be taken into account. If the firm chooses d_L, then its profit will be $\frac{(V-p^*)(p^*-c)}{d_L}$. And its profit will be $\frac{(V-p^*)(p^*-c)}{d_H}$ if it chooses d_H. Observe that its profit will always be higher if the firm chooses d_L. Hence, it sets $\rho = 1$ and the product will be clean. Moreover, since $d = d_L$, the EG never actually advertises.

The difference with the short-run analysis is that now the advertising equilibrium is a Pareto improvement over the benchmark equilibrium with no advertising. The firm and the consumers still benefit from advertising by an EG, but since the EG only threatens to advertise, it incurs no losses. Hence the presence of an EG increases social welfare.

6 Conclusion

In this paper I studied informative advertising by an EG. A monopolist sold a good which causes a certain damage per unit of production to the environment. The consumers care about this damage, but are unable to discern the level of damage. An EG subsequently uses an advertising campaign to disseminate information about product quality.

First, the case in which the firm did not choose the damage level of the good that it produced is considered. In this case, I find that the EG is able to transmit information about the level of damage to the consumer. However, the ability of the EG to inform consumers is not beneficial for the EG. I showed that if the EG could commit to a silent strategy this would improve its situation. The EG is hurt by its own power. A further result is that the EG will punish the bad firm by advertising only if damage is high and not praise the good firm although this is in principle possible. This result follows here directly from the incentive constraints. The social welfare results are less clear: unlike the EG, the firms and the consumers on average benefit from advertising. However, numerical calculations suggest that often the gains of the firms and the consumers are smaller than the loss of the EG.

Second, the case in which the firm was able to choose damage is considered and, hence, the firm could possibly preempt. If the firm can choose damage before the EG can advertise, then advertising is effective; in equilibrium the EG only threatens to advertise and helps the firm maintain a low level of damage. This equilibrium is comparable to the 'entry deterrence'-equilibrium as discussed in Heijnen and Schoonbeek (forthcoming).

A natural interpretation of being able to choose damage (or not) is the long run versus the short run. I have shown that for the EG the long-run cost, unlike the short-run cost, is improved by advertising. Moreover, profit and consumers' surplus are not harmed by advertising. The interpretation would be that pressure by an environmental group, while harmful in the short run, may in the long run push society in the right direction.

The implications in the short run for the policy of the EG itself seem dour: the EG cannot engage in campaigns aimed at supplying consumers with information and be better off. However, since the cost of campaigning is created by the EG's lack of credibility, a possible solution might be the building of a reputation. A possible way in which this might be done is, if the claims of an EG are occasionally verified by a trustworthy authority. Then maybe the EG could inform consumers at substantially lower cost. The results in this paper stress the need for some kind of reputation building.

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