Alberto Cavaliere

SELF-ENFORCING VOLUNTARY AGREEMENTS AND ENVIRONMENTAL REPUTATION

September, 1999

Voluntary agreements with industry offer many examples of overcompliance with respect to environmental standards. Such phenomena seem to be irrational but appear less surprising considering firms' strategies are aimed to internalise environmental quality. We model the choice of the environmental quality of products in a one-shot game between a monopolist and consumers, to show the existence of inefficient equilibria where quality is low because of moral hazard. The firm can however change its' equilibrium strategy in a repeated but finite game, in order to build an environmental reputation if we suppose that consumers' information is not only imperfect with regard to quality, but also incomplete with respect to any environmental constraint that may affect the behaviour of firms (like the threat either of a stricter regulation or of potential entry). In a two- periods model we show the existence of a perfect Bayesian equilibrium in mixed strategies where the firm can revert to the production of green products in order to influence consumers' beliefs and acquire an environmentally friendly reputation. Due to the peculiarity of environmental information (green products are credence goods), we claim that an explicit agreement is also necessary in order to establish monitoring and controlling procedures to verify the performance of firms. These procedures can explain per se the diffusion of voluntary agreements that are nevertheless self-enforcing because of the reputation effect .

JEL Classification: Q28, L14, D82, C72

*Università degli Studi di Pavia and FEEM . Corresponding adress: Dipartimento di Economia Pubblica, Universita' di Pavia, Corso Strada Nuova 65, 27100 PAVIA (Italy). E-mail: cavalier@unipv.it

Non technical Abstract

Voluntary agreements with industry in the environmental field offer many examples of overcompliance with respect to environmental standards. Such phenomena seem to be irrational because they generally imply an increase of costs that is not imposed by regulation. Moreover many voluntary agreements are not specified as binding contracts. However some economic foundations of this behaviour can be found considering firms' strategies are aimed to internalise environmental quality when consumers have green preferences. In this case the issue for firms is to persuade consumers that they are selling environmental friendly products. Even in perfectly competitive industries, imperfect information about quality gives rise to market failures, causing inefficiencies due to adverse selection and moral hazard. Typically, these inefficiencies differ with respect to those pertaining to negative externalities because they imply output reductions with respect to the optimal allocation. In these cases, improvements in efficiency are linked to an increase in output and/ or market exchanges, and these same improvements are not only socially desirable but also worthwhile from the firms' point of view. On the basis of these premise, we model the strategic choice of environmental quality, to show the existence of inefficient equilibria where both product quality and posted demand are low because of the adverse incentives that characterise the behaviour of firms when consumers information is imperfect. The firm can however change its strategy in a repeated but finite interaction with consumers, in order to build an environmental reputation if we suppose that consumers' information is not only imperfect with regard to quality, but also incomplete with respect to any environmental constraint that may affect the behaviour of firms. Examples of this constraints are the threat either of a stricter regulation by public bodies or of potential entry by another firms selling less polluting goods. In a two- periods model we show that the firm can revert to the production of green products in order to influence consumers' beliefs and acquire an environmentally friendly reputation that increases the quantity of goods sold on the market and materialises in a larger flow of long term profits. The scope of the firm will be to persuade consumers that it is constrained to produce environmental friendly products even if the firm is aware that there is no actual threat either by the regulators or by the competitors Due to the peculiarity of environmental information (green products are credence goods), we claim that an explicit agreement is also necessary in order to establish monitoring and controlling procedures to verify the performance of firms wanting to establish a reputation. These procedures often account for the main share of cost in a voluntary agreements. They can explain per se the diffusion of voluntary agreements that are nevertheless self-enforcing because of the reputation effect .

1.Introduction.

Voluntary agreements with industry, in the field of environmental policy, offer many examples of overcompliance with respect to environmental standards (see for example Arora and Cason, 1995). The traditional analysis of environmental problems as negative externalities tends to qualify such behaviour as irrational to the extent that it implies an increase in production cost that is not imposed on the firm by regulatory authorities. Moreover voluntary agreements are seldom enforced by the law. In many cases they work as self-enforcing agreements. The explanation of such phenomena still seems to be a puzzle for environmental economists.

For example, Arora and Gangopadhyay (1995) offer a theory of voluntary overcompliance based on the benefits of vertical product differentiation (Gabsewictz and Thisse (1979), Shaked and Sutton (1982)). A firm's choice to sell products of higher environmental quality is then justified on the basis of the increase in economic profit that is due to product differentiation. Although this theory is useful to show that competition by vertical product differentiation is one of the main incentives for firms to provide environmentally friendly goods, it cannot explain the effort of firms to subscribe to voluntary agreements as well.

For analytical purposes it is useful to distinguish between overcompliance with respect to environmental standards and participation in a voluntary agreement, even if for firms the decision to overcomply with environmental standards generally implies the decision to join a voluntary program. We think that participation in a voluntary agreement is necessary for a firm deciding to produce cleaner products, because of asymmetric information between firms and consumers about the environmental quality of products. Indeed voluntary agreements are costly per se and generally require monitoring and reporting procedures that account for the main share in total costs (Storey M., G.Boyd and J.Dowd (1997)).

Even in perfectly competitive industries, imperfect information about quality gives rise to market failures, causing inefficiencies due to adverse selection and moral hazard. Typically, these inefficiencies differ with respect to those pertaining to negative externalities. As in this case, improvements in efficiency are linked to an increase in output and/ or market exchanges, and these same improvements are not only socially desirable but

also worthwhile from the firms' point of view. The question is how to overcome market inefficiencies due to asymmetric information. As far as environmental quality is concerned, participation in a voluntary agreement is helpful from this point of view.

Voluntary programs are often self-enforcing agreements. To show why firms have nevertheless an incentive to respect them - even in the absence of a binding contract concerning environmental quality - we look to non co-operative game theory and particularly to the reputation effect. This is excluded by Arora and Gangopadhyay (1995), assuming that the environmental record of firms is public information. On the contrary, we assume that information about environmental quality is too costly for consumers, so they appoint a public agency to ascertain it. Firms participating in voluntary agreements are willing to release information to the public agency in order to build an environmentally friendly reputation.

Therefore, we model the choice of the environmental quality of products in a one-shot game between a monopolist firm and their consumers, to show the existence of inefficient equilibria where quality is low because of moral hazard problems caused by asymmetric information. The firm can, however, change its' equilibrium strategy in a repeated but finite game, in order to build an environmentally friendly reputation, if we suppose that consumers' information is not only imperfect regarding quality, but also incomplete with respect to some environmental constraints that can affect market competition.

These constraints may concern a real threat - either of a stricter environmental regulation by the government, or of the potential entry of another firm offering higher quality (green) products. Both arguments are often invoked as explanations for regulatory overcompliance (see for example Arora. and. Cason, 1995),. We take account of them in a two-periods model to show the existence of a perfect Bayesian equilibrium in mixed strategies, where the firm can revert to the production of green products in order to influence consumers' beliefs and acquire an environmentally friendly reputation.

As equilibria with reputation are self-enforcing, we can find a reason why no legal enforcement of environmental quality is required in many voluntary agreements with industry. However, due to the peculiarity of environmental information (green products are often credence goods), we claim that a reputation viewed as an implicit contract is not sufficient in this case, and an explicit agreement is then necessary in order to establish

monitoring and controlling procedures to verify the performance of firms. These procedures can explain per se the firms' necessity of acquiring credibility by also subscribing to voluntary agreements.

In section two we define voluntary agreements, then we classify the environmental characteristics of products on the basis of consumer information (section 2.1). We then model strategic interaction between consumers and a monopolist firm in a one-shot game concerning the choice of environmental quality of a product, given asymmetric information (section 2.2). In section three we extend our analysis to cover repeated games, so that we may consider the reputation effect both in models with a finite and an infinite horizon. We shall discuss this last case introducing firstly the idea of incomplete information about the environmental constraints faced by firms (section 3.1). In section 3.2 a two-period reputation model is presented to show how the reputation effect arises. Some conclusions are established in section four.

2. Voluntary Agreements, Environmental Quality and Information.

Despite the existence of different kinds of voluntary agreements, in order to qualify them we refer to the definition that has been given by Storey, Boyd and Dowd (1997): *An agreement between government and industry to facilitate voluntary action with a desirable social outcome, which is encouraged by the government, to be undertaken by the participant based on the participant's self interest*. A particularly interesting point in this definition is the idea that firms participate in a voluntary program on the basis of their pure self-interest. Indeed, even if some voluntary agreements are actually binding contracts that can be legally enforced, many of them are, however, self-enforcing agreements.

In the case of voluntary agreements that are based on negotiated targets that are legally binding, the self-interest of the participant may be a pre-emption of less desirable regulations. But if there are no credible threats of future regulation, self-interest can only be connected either to present or future profits. Even these general benefits are valuable because they will give rise to profits in the long run.

While legally enforced voluntary agreements have already been explained in the economic literature, with reference to bargaining models (Segerson and Miceli, 1997), the self-enforcing nature of many voluntary agreements still lacks an economic interpretation. Which is the nature of the economic profits that arise in this case? Why is it necessary to

undertake a voluntary agreement in order to reap these profits? In our opinion, voluntary agreements are grounded on an implicit contract between firms (generally represented by a trade association) and consumers (represented by a public authority or an environmental association). They concern the environmental quality of products offered in the market, given imperfect information about the quality itself, and incomplete information about some institutional or structural feature of the competition in the market. In this framework it can be valuable for firms to acquire the reputation of a manufacturer of clean products.

2.1 Consumers' Information about Environmental Quality

In what follows we shall adopt Lancaster's approach (1966) and suppose that any environmental impact of products represents a characteristic of the product itself which affects consumers' utility. We call this characteristic "environmental quality", and for simplicity we do not consider other characteristics that can be relevant for the consumer as well.

Consumers often lack information about the environmental quality of products. In some cases quality can be ascertained by consumers before purchase. Products of this type are called *search goods* to highlight the fact that there is nevertheless a search cost for consumers who want to find the best deal in terms of both quality and price. From the point of view of environmental quality, products are seldom *search goods* (an example could be paper bags substituting plastic bags in supermarkets). In most cases they are *experience* (Nelson, 1970) or even *credence goods* (Darby and Karni, 1973). Often environmental quality depends on the environmental impact of the manufacturing process adopted by the firm, and as such it cannot be ascertained directly by consumers, even after purchase. Only public authorities, consumers or environmental associations have the necessary amount of resources and expertise to verify firms' claims relating to environmental quality.

In the past, firms' claims of this kind, contained in *green* advertising messages, have been attacked by environmentalists, underlining the fact that even those products that incorporated some ecological improvements were still contributing to pollution in many other ways (McDougall (1993)). The repercussions concerning consumers' perceptions about environmental quality of products can be very dangerous even for firms that are actually contributing to the protection of the environment.

Incremental contributions to the reduction of pollution affecting just one type of environmental impact, (be it the reduction of green house gases or of waste disposal), are part of voluntary agreements with industry today. In many cases participation in voluntary agreements automatically assures firms about independent monitoring and reporting procedures concerning the real effort of firms to achieve the aims of the program. As reported by Storey, Boyd and Dowd (1997), monitoring and reporting activities in one form or another characterise all Voluntary Agreements. In addition some types of Voluntary Agreements do not have targets as such but rather commitments to monitor and report information[1]. The same authors underline the fact that in the USA, monitoring and reporting requirements are moreover one of the primary costs faced by industry in participating in Voluntary Agreements.

So even if from the point of view of environmental quality, products are generally credence goods, participation in voluntary agreements assures firms of a procedure to produce and diffuse information about the progressive achievements of environmental goals from period to period, so that products can be compared to experience goods.

2.2 *The Choice of Environmental Quality of Products with Asymmetric Information*

Moral hazard in quality selection arises when consumers are imperfectly informed about quality before purchase (Klein and Leffler, 1980). In fact, the potential gains from trade are increasing in the quality chosen by the firm, but - information being asymmetric - the producers' incentives prevent the potential gains from trade from being fully exploited in equilibrium.

The strategic aspects of this problem can be captured in the following non co-operative static game between a monopolist firm and consumers (Overgaard, 1991) The monopolist firm produces the goods X and can employ one of two strategies: to produce goods of a high environmental quality (we label this strategy with H), or to produce goods of a low environmental quality (we label this strategy with L). Consumers can choose between a High demand strategy (X_L) or a Low demand strategy (X_H) strategy. Payoffs are given by economic profits for firms and utility for consumers. A convenient specification for profits could be:

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[1] The same authors underline the fact that in the USA, monitoring and reporting requirements are moreover one of the primary costs faced by industry in participating in Voluntary Agreements.

(1) $\Pi_{q,i}$ (P) = (P - C$_q$) X$_i$ (P) $q \in \{L, H\}$ $i \in \{L, H\}$

This specification of the profit function shows that profits are decreasing in quality - as producing goods of high environmental quality is costly ($C_H > C_L$) - and increasing with the demand expressed by consumers. For that which concerns the demand side we suppose that consumers are identical and therefore can be represented by the representative consumer. Consumers' utility can be represented in turn by any indirect utility function U_i (X,P) that is increasing in quality and quantity and decreasing in price.

To introduce moral hazard we suppose that the quality choice is made by the monopolist before that market interaction takes place and consumers are unable to observe the level of quality before posting their demand. On the other hand, the firm makes the quality choice without knowing the demand schedule. Quality and the demand to be posted are chosen simultaneously. The firm's profit maximisation then determines the price-quantity pair. Strategic interaction in the market for one-round of play can be represented in the following strategic form one-shot game:

<div align="center">Consumers</div>

		X$_H$	X$_L$
	H	Π_{HH} U$_{HH}$	Π_{HL} U$_{HL}$
Firms	**L**	Π_{LH} U$_{LH}$	Π_{LL} U$_{LL}$

In order to solve the game we present the ranking of payoffs for both players. From the point of view of the firm the ranking of payoffs is the following: $\Pi_{LH} > \Pi_{HH} > \Pi_{LL} > \Pi_{HL}$. In fact, given the profit function, profit is maximal when the monopolist chooses L and consumers post X$_H$. Potential gains from trade are however increasing in quality and the firm prefers co-ordination with consumers ($\Pi_{HH} > \Pi_{LL}$) than the opposite ($\Pi_{LL} > \Pi_{HL}$). Moreover we suppose that the firm will incur a loss when choosing H, if consumers post X$_L$ ($\Pi_{HL} < 0$).

From the point of view of consumers the ranking of payoffs is the following: $U_{HH} >$ $U_{HL} > U_{LL} > U_{LH}$. Consumers prefer to be matched with the firm ($U_{HH} > U_{HL}$) and potential gains from trade are increasing in quality for them too ($U_{HL} > U_{LL}$). The worst case for consumers is when they post X_H and the monopolist chooses L. In this case consumers incur a loss: $U_{LH} < 0$.

From the payoff ranking description it is easy to realise that the best response for consumers depends on the action chosen by the firms. On the contrary, the firm has a dominant strategy: to choose L. Then consumers rationally expect the play of L by the monopolist and so they would be better to play X_L . We then get a Nash equilibrium that is characterised by the payoff couple (Π_{LL} , U_{LL}). However, this equilibrium is inefficient. Both players could increase their payoffs by choosing H and X_H respectively. But these choices are unfeasible because of the adverse incentive that leads the monopolist to play L in any case.

Given this market failure, the monopolist could commit himself to the production of high quality goods and exploit the related gains from trade by signing a binding contract with consumers or some public authority representing them. However, this does not seem to be the most widespread solution in market economies. There are probably high transaction costs that make the enforcement of such a contract quite difficult. Quality regulation can be an option, but as it is well known in the field of environmental policies, there are problems related to finding the "optimal" standard, especially if it should be equal across firms.

Implicit contracts with consumers concerning product quality are another option. In this case a firm can be bound to supply high quality products just on the basis of a self-enforcing agreement with the demand side of the market. The credibility of firms' claims to environmental quality only depends on the evaluation of the firms' self-interest in following this strategy. This evaluation depends, of course, on the increase in economic profits. As we shall see in the next section, to acquire a reputation for environmental quality is just a way for a firm to implement an implicit and self-enforcing agreement with consumers concerning product quality.

3. *Environmental Reputation in Supergames*

As far as the quality of an experience good is concerned, and as long as strategic interaction between consumers and the monopolist takes place repeatedly in the market, buyers are able to observe product quality after purchase. In this case the monopolist could choose to stick to high quality if the discounted stream of future profits emanating from this choice were to be greater than the maximal profit that can be obtained in just one period (Π_{LH}), by cheating (sticking to L when posted demand is X_H) and then being fired from the market in all subsequent periods. This discounted stream of profits is precisely the advantage of acquiring a reputation (Klein and Leffler, 1981 and Shapiro, 1982, 1983).

Considering the non co-operative game model of the last section the reputation effect can be obtained given infinite repetition of the same one-shot game.Thanks to the *Folk Theorem* (Fudemberg and Maskin, 1986) it is possible to show that the Pareto efficient allocation can be obtained as a subgame perfect equilibrium of the Supergame if the discount factor is sufficiently close to one (namely, if players are sufficiently "patient"). However the robustness of these results is questioned both because of the multiplicity of equilibria and the assumption of an infinite horizon. Whilst the Pareto efficient allocation can be sustained as a Sub-Game perfect Equilibrium of the Supergame, so can an infinite (and uncountable) set of Pareto-inefficient allocations. Concerning the horizon instead, under finite repetition backward induction implies that the unique subgame perfect equilibrium coincides with the Nash equilibrium of the one shot game in each period (Selten, 1978) and no reputation effect arises in this case.

However the reputation effect is widespread in many markets and can render many economic exchanges easy, which would be rather difficult to carry out without it. In order to give a satisfactory theoretical explanation for the reputation effect, we must consider some further issues relating to consumer information. We assume that consumer information is not only asymmetric with regard to quality, but also incomplete in some institutional features that affect firms' behaviour in markets. This is equivalent to saying that players are not sure about the game they are really playing and are then uncertain as to what their payoffs really are.

3.1 Incomplete Information about Environmental Constraints

Consumers, operating in so many markets, are usually considerably less informed about the constraints that are actually faced by competitors in each market than are the firms. This assumption is particularly true for that which concerns environmental constraints, either at the institutional or at the competition level.

Consumers can then put a probability ω (even if it is small) on the occurrence of some constraints on firms' behaviour making the production of polluting products an unprofitable one. If these constraints were really relevant, the firm would always choose to increase the environmental quality of its' products. While consumers are not completely informed about the fact that the low quality choice is actually feasible, firms may know much better if they can afford to sell polluting products or not.

Therefore we present two examples showing that it could be rational for firms to produce goods of high environmental quality (at least with some probability) in order to acquire an environmentally friendly reputation if consumers are uncertain about the constraints on firms deriving from potential entry or environmental regulation:
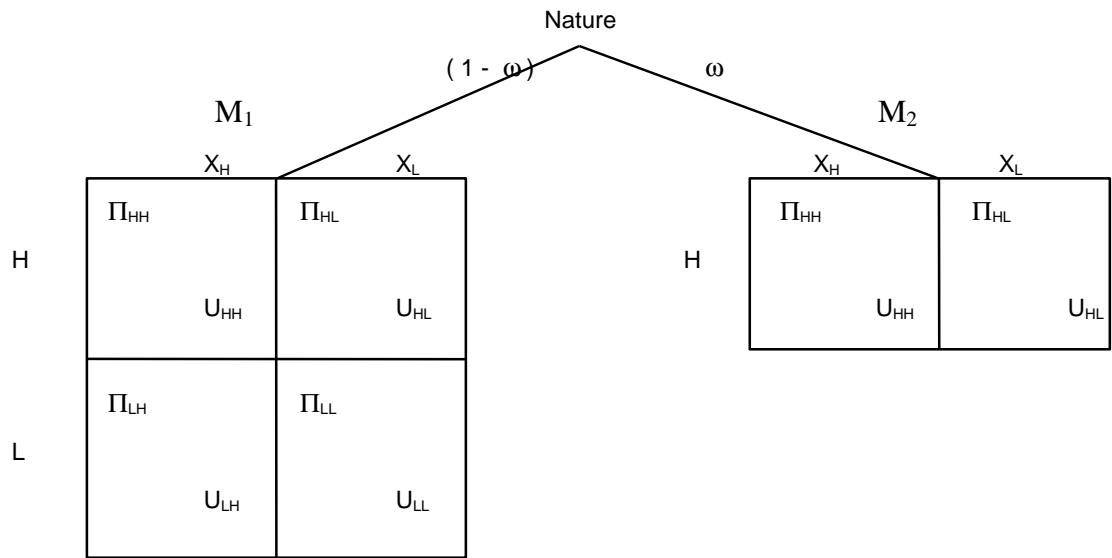
a) **Potential Entry** If consumers perceive that a potential competitor could enter the market offering a product of higher environmental quality, the monopolist could alter significantly his strategic choice concerning environmental quality. If the monopolist has always chosen H in the past there is no reason why brand loyalty should be reduced if a potential entrant enters. But if the monopolist had chosen L, of course some consumers could decide to apply to the new entrant. Until the monopolist chooses H and no potential entrant has entered, consumers remain uncertain about the efficacy of the entry threat. The monopolist could try to take advantage of consumers' uncertainty, even if he is aware that there is no credible entry threat. He could be interested in confirming consumers' beliefs that his choice would be H, at least with a certain probability. Then he will behave like a monopolist that fears entry, choosing H with a certain probability and pursuing this strategy for a period of time, the length of which depends on consumers' beliefs about the probability of entry. This explanation for environmental overcompliance is not completely new in economic literature. In fact, the voluntary increase of the environmental standard of their products enables firms to augment the entry cost of any new firm (Arora e Cason, 1995). These actions can make entry more difficult, or can at least anticipate the environmental innovations of a

potential entrant. From our point of view no credible entry threat is really required to exist in order to give rise to overcompliance. What is really relevant is the existence of consumers' beliefs about such a threat.

b) **Potential Threats of Environmental Regulation.** Consumers may think that a Public Agency could impose more pressing rules on firms that produce low quality goods, at least from the environmental point of view. Firms characterised by a good environmental performance can avoid these regulations. But in principle any firm could decide to revert to the production of low quality goods after having chosen H for a long time. In this case consumers would be uncertain about the intervention of the Public Agency in order to constrain the firm to choose H. Thus this uncertainty would extend to payoffs and could be exploited by the monopolist who can choose H (with a certain probability) in order to confirm consumers' beliefs that he fears the imposition of a stricter environmental regulation, even if the monopolist is aware that any intervention can be excluded. By keeping the consumers uncertain, the monopolist can enjoy the benefits associated from being recognised as a firm that will stick to high quality. Also in this case there is an analogy between the explanation of regulatory overcompliance as a means of acquiring an environmental reputation and a typical explanation which is currently given for the decision of firms to undertake a voluntary agreement. In fact, a popular explanation of voluntary agreements is connected to the regulatory threat of public agencies which induces firms to anticipate stricter standards with a negotiated agreement, in order to influence the regulatory process itself.

3.2 The Reputation Effect in a two-periods Model.

In order to introduce the idea of incomplete information in the static game represented in fig.1, let us suppose that before the game starts a third player - Nature - determines if the monopolist actually is disposed or not to take the opportunity of choosing L. We can then assign a positive probability (ω) to the event that there may be constraints (of the type described in last section) which prevent the firm from choosing L, so that this option is not included in the strategic space of the firm. On the contrary, with probability (1 - ω), no constraints are operating on the monopolist and the game would be as before. Strategic interaction between consumers and the firm can then be represented as in the following static game of incomplete information:

Nature

$(1 - \omega)$ ω

M_1 M_2

	X_H	X_L
H	Π_{HH} U_{HH}	Π_{HL} U_{HL}
L	Π_{LH} U_{LH}	Π_{LL} U_{LL}

	X_H	X_L
H	Π_{HH} U_{HH}	Π_{HL} U_{HL}

Let us suppose that there are two types of firm: type1 (M_1), with no environmental constraints, can choose between H and L; type 2 (M_2), is constrained to choose H. Consumers' best response is dependent on their beliefs about the type of firm they are facing. Prior beliefs are represented by the probability distribution assigned to the choice of Nature: ω, $(1-\omega)$. Considering the static game with incomplete information, if ω is high enough it would be possible to obtain efficiency at equilibrium. Let us consider the following example:

	X_H	X_L
H	9 11	-1 3
L	11 - 1	1 1

$(1 - \omega) = 0.5$

	X_H	X_L
H	9 11	- 1 3

$\omega = 0.5$
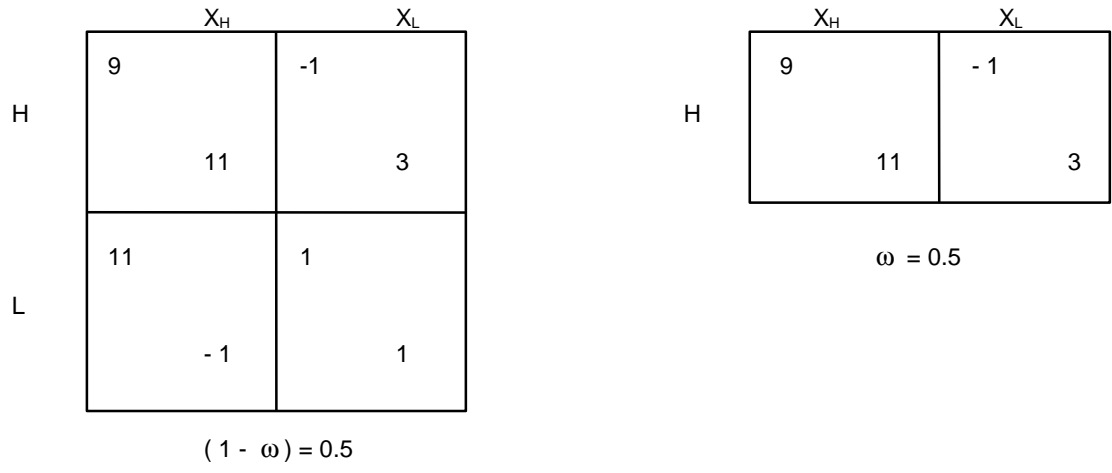
In this game the strategy profile consisting of M_1 choosing L, M_2 choosing H and consumers choosing X_H and the prior distribution $\omega = 0.5$, $(1 - \omega) = 0.5$ are part of an

efficient Nash Equilibrium in pure strategies . But if ω is very low (ω = 0.1, for example) consumers will choose X_L and the equilibrium is no more effcient. However in the repeated version of the game with incomplete information, even the monopolist who faces no serious environmental constraints and is supposed to choose L could find it convenient to persuade consumers that he is constrained to choose H. The monopolist could then affect consumers' beliefs by his choice of observable actions in the course of play in order to build an environmental reputation.

If strategic interaction takes place between period 0 and period T (T finite), in each round of play ω_t represents the probability assigned by consumers to the event that the monopolist is of type M_2. As such ω_t also represents the reputation of the monopolist at time t. If t = 0, ω_0 = ω represents the prior probability that we suppose to be common knowledge. Cases in which ω is high enough, like in our last example, can conform to the idea that the monopolist does not need to build an environmental reputation to induce consumers to select X_H. More generally for any value of ω, in every subsequent period t, prior beliefs can be updated by observing the actions chosen by players and using Bayes' rule. Then even with a very small value of the prior probability ω, we can show the existence of equilibria where consumers can choose X_H because they assign a posterior probability greater than ω to the event that the monopolist type is M_2.

In order to show how the reputation effect arises we consider a simplified version of the reputation model where T = 2. In this case intuition leads us to think that the monopolist would be interested in choosing H in the first period in order to establish an environmental reputation, and then choose L in the second period, when consumers have been lead to select X_H. There is an advantage in building an environmental reputation if: $\Pi_{HL} + \delta \Pi_{LH} > (1 + \delta) \Pi_{LL}$ ($\delta = 1 / (1+r)$ being the discount factor). The results of the repeated game with incomplete information are summarized in Proposition 1 and Proposition 2.

Proposition 1. Given that $\omega U_{HL} + (1- \omega) U_{LL} > \omega U_{HH} + (1- \omega) U_{LH}$, no equilibrium in pure strategy exists for the Supergame consisting in the repetition for two periods of the constituent game with incomplete information with these parameters values.

Proof. Given that: $(1 - \omega) U_{LL} + \omega U_{HL} > \omega U_{HH} + (1 - \omega) U_{LH}$, if there were only one period consumers would post X_L. Let's then suppose that an equilibrium in pure strategies exists in which the monopolist chooses H in the first period. Then in period two consumers would have learnt nothing about the type of monopolist they face and their choice cannot change with respect to the first period. So there are no incentives for type M_1 to choose H. Let's suppose that there exists an equilibrium in pure strategies in which M_1 chooses L in the first period. But then if consumers observed H in period one, they could be sure to deal with M_2 and would then choose H in period two. So even type M_1 would find it convenient to choose H in period one to gain the advantage of an environmental reputation. Thus an equilibrium cannot exist in which M_1 chooses L in period one.

Proposition 2. Given the constituent game with incomplete information represented in fig. 2, the Supergame consisting in the repetition of the constituent game for two periods has a Perfect Bayesian Nash Equilibrium in mixed strategies that can be characterised as follows: (a)Consumers choose X_L in period one. (b.1) In period two consumers choose X_L if they observed L in period one; (b.2) In period two consumers randomise between X_L and X_H if they observed H in period one; (c) M_2 chooses H in both periods; (d) M_1 randomises between H and L in period 1 (e) In period two M_1 chooses L.

Proof of Proposition 2:

The strategies that we labelled (c) and (e) are, without doubt, optimal. In fact, for M_2, choosing H is a dominant strategy. For M_1, it is optimal to choose L in period 2, as this is also the last round of play. Also the strategy (b.1) is optimal, because if consumers observe L in period one they can be sure to deal with M_1. Concerning strategy (b.2), in order to assess optimality let $\Pr\{H|M_1\}$ be the conditional probability that the monopolist chooses H, given that his type is M_1. Following Bayes' Rule we can then compute $\Pr\{M_2|H\}$:

(1) $\Pr\{M_2|H\} = \Pr\{H|M_2\} \Pr\{M_2\} / (\Pr\{H|M_2\} \Pr\{M_2\} + \Pr\{H|M_1\}\Pr\{M_1\})$

         $= \omega / (\omega + \Pr\{H|M_1\} (1 - \omega))$

In order that consumers are prepared to randomize between X_H and X_L, the following condition is required to hold:

(2) $\Pr\{M_2 | H\} \, U_{HH} + (1 - \Pr\{M_2 | H\}) \, U_{LH} = U_{LL}$

and from (2) we can obtain:

(3) $\Pr\{M_2 | H\} = (U_{LL} - U_{LH}) / (U_{HH} - U_{LH}) > 0$

and equalising (1) and (3) we obtain:

$\Pr\{H | M_1\} = \omega \, U_{HH} / U_{LH} (\omega - 1) > 0$

Then, in period two the probability that the monopolist is of type M_2, will increase of an amount just necessary to let the consumer be indifferent between X_H and X_L.. Concerning (d) the following condition must hold:

(5) $\Pi_{HL} + \delta (\Pr\{X_L | H\} \Pi_{LL} + (1 - \Pr\{X_L | H\}) \Pi_{LH}) = \Pi_{LL} (1 + \delta)$

On the basis of condition (5) we can compute $\Pr\{X_L | H\}$:

(6) $\Pr\{X_L | H\} = 1 - (\Pi_{LL} - \Pi_{LH}) / \delta (\Pi_{LH} - \Pi_{LL})$

Concerning the optimality of (a) the following inequality must hold

(7) $\omega U_{HL} + (1 - \omega)(\Pr\{H | M_1\} U_{HL} + (1 - \Pr\{H | M_1\}) U_{LL}) \geq$
$\omega U_{HH} + (1 - \omega)(\Pr\{H | M_1\} U_{HH} + (1 - \Pr\{H | M_1\}) U_{LH}$

Even in a two-period model, the features of the reputation effect are very clearly displayed: although the prior beliefs that the monopolist type is M_2 are given by ω (even very small), in equilibrium the monopolist will choose to produce goods of high environmental quality with a probability greater than ω. This is due to the fact that not only

the monopolist of type M_2 selects H, but also M_1 does to get the benefits of environmental reputation, thereby inducing the consumers to randomise between X_L and X_H in period two

As our model is limited to two periods, the second period is also the last one and when it is reached the monopolist "milks" immediately its reputation and selects L. However, the benefits of keeping a reputation increase with T and in models characterised by n periods (Kreps and Wilson (1982) e Overgaard (1991)) even M_1 will find it convenient to select H (as part of a pure strategy) for several periods and reveal its true type only when the end of the game is approaching.

4.Conclusions.

Regulatory overcompliance can then be based on firms' efforts to acquire a good environmental reputation when consumers information is both imperfect with respect to environmental quality and incomplete with respect to the environmental constraints firms are actually facing, either at the competition or at the institutional level.

What is especially worth noticing is that acquiring an environmentally friendly reputation is like arranging an implicit contract between firms and consumers concerning the environmental quality of products. This contract is self-enforcing. Thus voluntary agreements are self-enforcing because they are founded on the aim of acquiring an environmentally friendly reputation. However, they represent an *explicit* agreement. We have found a reason for the explicit nature of voluntary agreements connected to the specific nature of environmental information, which is very difficult to assess by single agents, even after consumption (environmental quality often is often a credence good). Special technical procedures are necessary to monitor the environmental record of firms. This kind of monitoring procedure then needs to be performed by independent institutions, and is actually part of any voluntary agreement. Moreover, the cost of information seems to be the main cost of voluntary agreements and the need to assure and independent verification procedure is seen as the main reason why some voluntary agreements are arranged.

Given the very important role assigned to the cost of information, to monitoring and to the verification procedure in the framework of voluntary agreements, it appears less relevant to compare the environmental objectives which seem to be reached because of voluntary agreements with those results that firms could have probably reached anyway,

without subscribing to any agreement with the government. On the basis of our theory this comparison appears useless to the extent that any firm wanting to reach some environmental record in order to acquire an environmentally friendly reputation needs an independent verification and monitoring procedure to make credible its claims concerning the environmental concern of their product and manufacturing process. The best thing to do would then be to subscribe to a voluntary agreement.

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