The Role of Asymmetric Information in Environmental Policy Settings: Three Applications

by

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Declaration

These doctoral studies were conducted under the supervision of Prof. Anthony Heyes.

The work presented in the thesis "The Role of Asymmetric Information in Environmental Policy Settings: Three Applications" is the result of original research carried out by myself, in collaboration with Prof. Anthony Heyes, whilst enrolled in the Department of Economics at Royal Holloway, University of London as a candidate for the degree of Doctor of Philosophy.

This work has not been submitted for any other degree or award in any other university or educational establishment.

Gian Paolo Ansaloni

Abstract

We present three models of the role of asymmetric information in environmental protection. Chapter one considers the market for a green credence good – a good whose environmental characteristics are not observed by the consumer, even ex post – in the presence of environmentally-conscious consumers. Producers may choose to advertise their products. However, if communication is not regulated it can degenerate into 'cheap talk'. We explore the scope for credible transmission of environmental information by green producers, and the limits on it. In Chapter two we develop some similar themes in an experimental setting, with the focus again on consumer reactions to producer-provided information on the environmental attributes of goods, and the potential role of government to improve social welfare by manipulating the use of certification. In Chapter three the focus is somewhat different, whilst maintaining the theme of the role of information asymmetries in an environmental policy setting. In the model here a regulator has to decide whether or not to regulate a polluting activity with imperfect information regarding the net benefits of so doing. In making her decision, the regulator can listen to an adviser, who may or may not be biased. We look at how the decision maker can exploit the adviser's incentive to build reputation to achieve better decisions. As a whole the thesis further underscores and illustrates the critical role that availability and distribution of information plays in policy making aimed at environmental protection.

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Introduction

Markets for environmentally friendly goods or services are often characterised by imperfect information. This is due to several concurring facts. In particular: (i) many "green" characteristics cannot be verified easily; (ii) scientists do not appear to agree on the costs of environmental damages. This creates two problems for society overall.

Firstly, people will take **suboptimal decisions**. Consumers are not able to assess the green characteristics they desire in a product (organic, dolphin free, recycled...); they therefore may end up buying something different from what they expect. For example: a consumer goes to a market wishing to buy locally produced apples; each stall vendor offers apples claiming to be grown locally, while only some of them are actually telling the truth. For him, all the products are the same and he will therefore choose a seller randomly. Or again, the government has to decide about the implementation of a new environmental policy (eg. banning a pollutant, tightening environmental standards...) but it does not hold all the relevant information regarding its costs and benefits. Then it has to take a decision, knowing that there is a risk of reducing social welfare, both by acting or keeping the *status quo*. Obviously, this outcome implies that utility would have been higher by making a different choice. This can lead to under-consumption of green products or even the possibility that the market fails completely to form.

Secondly, it creates the possibility for **opportunistic behaviour**. If one party can profit from the other party's ignorance, this is likely to happen. If brown producers know that the consumer cannot distinguish between green

and brown products and that he is willing to pay a premium for the former, then they may wish to persuade him that their products are green.

The environmental agenda is becoming more and more pressing. On the one hand, the overexploitation of free goods (due to the lack of or insufficient governmental intervention) has created critical situations in many different areas (species endangerment, climate change, air pollution...). On the other, people's green awareness has increased and they demand green products and they expect the government to act to safeguard the environment.

The policy maker and the market have tried to find ways to improve the information quality and availability in order to overcome the suboptimal situation. However, different circumstances present different problems and therefore allow for different remedies.

In this work, we look at two different types of information structures. The literature distinguishes among markets for ordinary goods (the characteristics of which are common knowledge), search goods (the characteristics of which are available but *ex ante* research is required to gather it), experience goods (some characteristics of which are known to consumers only *ex post*) and credence goods (some characteristics of which cannot be known even after consumption). We consider the latter two.

Environmental feature are often **credence**: consumers do not hold all the information before purchase and even after consumption, they cannot determine all the characteristics of the good (or it would be disproportionately expensive to find out). Producers have the opportunity to fill the informational gap by using labels. However, labels can convey true information, especially if awarded by a third party, or not.

The first two Chapters look at the welfare effects of the use of different types of labelling as a solution to the market failure caused by credence goods.

Chapter One starts by providing an extensive review of labelling, both in the economic literature and in its use in the real world. The model presented

looks at the strategic choice made by two competing firms in a market for a green credence good. Each firm can choose to produce goods using a green technology and have them certified by a third party or use a brown technology and use self-certification. Consumers only buy products perceived to be green; however, as they have no prior information on the labels, firms have to exercise some effort to convince consumers. Education becomes the main driver of the market and it also represents another important assumption: information availability is not sufficient to ensure consumers are informed. We will show the conditions that lead to the firms' choice and see how they affect social welfare. Our focus will be on how a policy maker can affect the market efficiency. One of the features of this model is that the type of certification is strictly connected with the choice of technology chosen (green products are certified by a third party; brown are self-certified). We find that in equilibrium green products may not be produced at all, but that is not necessarily detrimental to social welfare. We also conclude that a single label for the whole market is not always welfare maximising. According to the different situations, we look at the decision maker's best policy to achieve higher social welfare.

Chapter Two explores a similar market in an experimental setting; however, several important features differentiate this model from the previous. Firstly, we look at the behaviour of buyers and sellers alike; furthermore, some of the buyers are not interested in the green characteristic; technology is determined exogenously and so are consumers' preferences; finally, labelling choice is defined differently: sellers can decide to use labels or not. If they wish to do so, self certification is available to all sellers, whilst third party certification only to green sellers. We compare markets with different availability of additional information. We find that allowing for cheap talk and certification decreases welfare, although the latter increases efficiency. We also highlight the scope for policy maker's intervention, as green products are consistently exchanged

less.In particular, a change in the cost of the certification would have a positive effect on social welfare.

It is also important to note how the goods in this market are not pure credence: in fact, at the end of each period, consumers realise what type of products they have purchased. This would make this a market for experience goods. However, as they cannot distinguish sellers from one period to the next, they are not able to use this information.

Experience goods (and even more services) are fairly common. We consider in particular the market for advice. **Chapter three** consider a situation in which a policy maker has to decide whether or not to regulate a polluting activity, which depends on a future state of the world. The policy maker realises the state of the world only ex post. However, he has access to a perfectly informed adviser. The decision maker has imperfect information on the adviser's agenda, which can coincide with his, welfare maximisation, or it could be the protection of the interests of a part of the economy. If advice is sought for more than one period, then reputational concerns may arise. Our aim will be to assess what the best strategy is for the adviser and, in light of these findings, try to understand how much information the government can extract. We find that, according to circumstances, the decision maker can extract full information in period one or, more surprisingly, in period two. We also show how the adviser's effort to improve her reputation may be frustrated by the market structure. We also show how the government in order to achieve higher social welfare has the ability to push the adviser towards the preferred strategy.

As a whole, the thesis further underscores and illustrates the critical role that availability and distribution of information plays in policy making aimed at environmental protection. The paper confirms that in presence of credence goods, communication loses part of its effectiveness, damagin social welfare. This is further exacerbated by two factors: the potential willingness of brown

producers to increase the systemic noise; and the consumers' bounded rationality and their inability to use all the available information.

The dissertation contributes to the existing literature by presenting new approaches on problems previously considered. In particular, it provides conditions in which potentially biased advisers may improve social welfare, as well as the conditions in which noisy labels are welfare enhancing. The conclusions are then used to formulate policy making principles for a welfare maximising decision maker. Chapter three provides particularly interesting and innovative insight on information asymmetry problems, providing unique results for a reputation building game, which should be carefully considered by any policy maker. The dissertation points out the potential role of the decision maker in increasing social welfare by improving the information market, either by reducing its cost or by reducing the noise present in the system. This can be either by making it more difficult for spurious communication to take place or by helping delivering the message of truthful communication.

Finally, this work presents also the caveat that the Government's intervention may not always be indispensable and -sometimes- it may even be welfare damaging. it is important that the policy maker considers the situation carefully, weighting the benefits arising from his intervention against the unintended costs, which may turn out to be higher. Several policy instruments are presented throughout the work, according to the specific situation: the government should analyse carefully what the situation requires.

Chapter 1

Public policy optimisation in Markets with information asymmetry

1.1 Introduction: General overview of the problem

In the last few decades, people have become more and more aware of environmental issues. Only a few years back, environmentalists were dismissed as idealist tree-huggers or doomsday prophets. Today, in many MDCs, Kyoto Protocol, carbon footprint, organic food have all become front page material. The UK in 2011 presented the world's first annual green budget. Firms boast the massive investment they are making to become greener. In UK, many companies have put a big effort, like energy companies (such as BP, Shell) and supermarkets (*in primis*, TESCO and Sainsbury's).

This change of attitude is caused mainly by two sets of concerns: firstly, some products are (perceived to be) better in quality or better for one's own health (for example organic food: not only the flavour of the product is supposed to be more "as it should be", but the lack of pesticides and artificial products is also healthier). Secondly, products could be better for someone (or something). In this latter category fall products like "fair trade" or "sustainable".

This change in preference has gone hand-in-hand with the firms' interest in producing such goods. The reasons for this are numerous. For example, firms may want to boost their image with environmentally-aware credentials or to exploit the possibility of charging more for this particular product.

But when we talk loosely about "green" products, we indeed refer to a concept that is quite complex. In fact the environmental friendliness of a product is multi-faceted. Let us consider the following different characteristics:

1) Materials: are raw materials recycled? Or recyclable? Or used in a sustainable way? Are all the materials natural or are there any artificial ingredients? Is there anything toxic used somewhere in the production process?

2) Production: how polluting is the technology used? Is the production process using renewable energy? How are workers treated? Are they paid enough to allow them a dignified life?

3) Geography: where does the product come from? What is the carbon footprint implied in its transport? Are there local impacts?

This multidimensionality creates complications: what if a product is produced locally, but with the use of pesticides? What if production is carried out in a poor country, workers earn a good salary and education is provided to the community, but the transport of the products implies thousands of miles transfer, when the same product could be produced closer to the consumers? The combinations of all these characteristics are endless and they are intertwined with all the other "normal" characteristics we expect from a product (appearance, safety, durability, affordability...). Consumers are therefore facing an almost impossible task: ordering different products taking into consideration a very large set of variables, holding only incomplete information.

There is a further complication: often these elusive green characteristics become even more difficult to track down, as they cannot be appreciated by the consumers, even after the product has been bought and used. If we buy an apple, even after eating it, we would not be able to assert whether the fruit was grown in a greenhouse, or if it was genetically modified or if the farmer was paid a fair wage.

A didascalic example to support this: a recurring episode is green grocers selling "ugly" apples as "organic", as that is the way they are perceived to look.

This has two main implications: consumers cannot really find out whether they are consuming products with the desired qualities. And as a consequence, they may not be able to learn anything about the different firms even after repeated consumption. In other words, producers may be willing to provide eco-products but have no way to credibly communicate the information; and consumers may prefer green products but they cannot be sure of the quality of the chosen (or discarded) products. This situation has two negative consequences: on the one hand people will not be able to choose what they prefer; on the other, as environmentally-friendly products tend to be more expensive, there is the risk these goods are driven off the market.

In this situation, it is incumbent upon the producer to start investing in further communication to consumers, generally referred to as *labeling*.

An eco-label is a written statement of the green characteristics of a product, generally found on the product itself. It can take different forms (a symbol, a list of characteristics, data about particular materials...), different awarding bodies (it can be a claim made by the firm, a certification by an external body or the government) and it may be specific to a particular product or shared by different ones. A large share of products carries an acknowledgement of the green features of the goods, and we are now quite used to recognising some of them: "organic", "fair trade", etc.

At first sight, this seems to be the solution to the problem, however it appears communication has broken down somehow: in other words, consumers do not always choose what is best for them. The reasons for this are varied and to some extent have been mentioned already: on the one hand, too much information can literally be *too much* to be processed by consumers and be the tantamount to no information at all; on the other hand, the message can

be blurred by uncertainty: reputation cannot be established, ordering multi-dimensional products may not be feasible (or being subjective). Finally, there can be the possibility that some of the information is unreliable. As consumers cannot determine the quality of the goods, they need to rely on the producers' statements. But the risk of the producers overestimating the quality of their product is high: it would be, as an old saying goes, like asking the innkeeper if she sells good wine. The consequences of this are similar to those seen when there was no communication at all: if communication is unreliable, it is difficult to influence consumers' behaviour; and if it does, it may lead to consumers being misled in their choices.

Solutions to this can be found: building a reputation can be one way; or if that is not possible, then having an independent body vouching for the products' green credentials allows for more credibility.

But once more we are faced with the problem of information-processing. Even if the information is available and reliable, consumers have to be able to find it and process it. When in a supermarket, if a person were to assess all the available information for each item she wanted to buy, she would spend hours during each visit: the opportunity cost to process all the available information would be too high.

Therefore firms may wish to fill in the information/understanding gap by putting in pro-active effort to explain what their products are like and what the label on them means. The number of consumers will be dependent on the effort they exercise. Clearly, nothing is stopping firms producing standard products to try to convince consumers that her products are eco-friendly, but it will simply take more effort. Therefore, firms face the trade-off between producing a more costly (green) product or having more difficulties marketing their (brown) product.

At the same time, a policy maker may be willing to intervene to correct market failure. The mismatch between producers and consumers is one concern;

the possibility for the producers to mislead consumers is another. The issue is that clearly self-declared labels are a cheap way for firms to communicate with the consumers (and cheaper than exogenously-declared ones); however, the possibility that words may be used in a deceitful way is higher. The policy maker has to evaluate what is the best outcome for society (striking a balance between the firms' freedom of communication and restriction in quality of information) and push the market towards that direction.

The paper will present a duopolistic market for a green good, the characteristics of which cannot be detected by the consumer. Firms can decide whether to produce a green, more costly product or a brown cheaper one. Either way, she will engage in communication, the effectiveness of which is proportional to the quality of the good. If the firm chooses to produce the lower quality product, then the communication will be *spurious,* as it aims at deceiving consumers about the real quality of the product. We will try to answer the following questions:

* What is the firms' best strategy? Will cheap talk be chosen or naturally excluded?

* Does a welfare maximising policy maker's preferred outcome coincide with the market equilibrium? If not, what are his best instruments for intervention?

1.1.1 Structure of the paper

Because of the credence dimension of many environmental qualities, green markets will not, in general, reach an efficient equilibrium. For this reason producers are induced to adopt certification. A small number of recent papers recognises that although consumers are interested in purchasing green products, they do not fully understand what labels mean. The novelties in this paper are mainly two: 1) as the underlined assumption that consumers fully understand this information is violated, firms do not only label products, but have also to exert

effort to explain to consumers what the labels mean. Firms choose this effort strategically. We show that those choices interact with the labeling decision itself; 2) spurious labels are judged on an economic (and not ethical) ground, assessing whether the existence of spurious labels may be welfare improving. In the paper, self-declared labels are all considered misleading (spurious). Therefore, if we prove that in particular circumstances, spurious labels may lead to optimal level of social welfare, then *a fortiori* this must be the case when part of these labels convey some information.

The article draws from the literature (1.2) devoted to justify the existence of (voluntary) labels, especially in markets for credence goods. Chapter 1.3 proposes the model used in this paper. (1.3.1) presents the general assumption the model relies upon: different product-quality and labeling; the role of education; the reasons why the traditional Bayesian Model has not been considered adequate to describe our market. (1.3.3) presents the model used; for clarity, a simpler market with one producer and one available technology is introduced; (1.3.4) presents the overall model and (1.3.5 and 1.3.6) derive the solutions of the model.

We then consider the insight that the model brings us: (1.4.1) looks at the producers' strategy, whilst (1.4.2) tries to find general rules a the policy maker who wishes to intervene in this market; (1.4.3) considers a specific function in order to gain a deeper understanding on the possible situation that may arise in this kind of market. Chapter 1.5 summarises and concludes.

1.2 Literature review

As the model takes a fairly different approach from existing literature, it is somewhat difficult to present correlated papers. The following section presents the literature and the evidence behind the most important features of the paper. We introduce credence good markets (1.2.1) and why (1.2.2) labeling may be

a possible solution to overcome the market failure caused by the information asymmetry, concentrating on the main features of labels (1.2.3). In particular, it presents one of the key assumptions of the model, i.e. consumers do not use all the information available to them. This feature separates the current model with the majority of the literature. To overcome the information gap, we propose (1.2.4) that firms proactively try convince consumers via education. 1.2.5 looks at the government role to improve the efficiency of these markets. Finally, 1.2.6 concludes by highlighting the links between our model and the existing literature.

1.2.1 Search, Experience and Credence.

In a classic paper, Akerloff (1970) shows how with imperfect information, adverse selection can occur. In the best case, high quality producers are driven out of the market, whilst in the worst, the market collapses altogether.

The issue is that one agent has information necessary for the other to make an optimal choice, but it is against her private interest to disclose it.

Stiglitz (1994) demonstrates how efficiency is compromised when information is imperfect or costly; the cost can be explicit (the information is available, but at a price) or implicit (the information is not readily available and to obtain it the agent has to spend time and effort to gather it). These findings justify the strive to improve the availability of information, in order to increase the market's efficiency.

Scholars realised that information (or its lack) determines different market structures. Nelson (1970) defines *ordinary* the goods that can be fully appreciated ex ante. He then discriminates between *search* and *experience* goods: the former are goods the quality of which can be easily deducted ex-ante; the quality of the latter, instead, can be fully appreciated only ex-post (that is, after purchase or consumption). Experience good markets therefore can reach an

efficient equilibrium only in specific circumstances, eg. if purchase is repeated, through reputation building.

Following Nelson, Darby & Karni (1973) distinguish a fourth category of goods. *Credence* goods are characterised by the fact that consumers find assessing at least one of its qualities either: a) impossible; b) excessively costly; or c) excessively slow. This means that consumers are not able to determine all the features of a good neither ex ante nor ex post.

The literature on credence goods has mainly focused on services in which diagnosis and treatment are generally given by the same agent. This type of market is rather common. Consider the following examples:

* Taking a car to a garage, the mechanic is at the same time the person assessing what repairs are needed and the one carrying out the repairs: the incentive to over provide services is particularly high;

* Going to a lawyer for legal advice, the lawyer is the person advising whether it is worth pursuing an issue with legal action, and the one actually arguing the case;

It is easy to extend the previous examples to aesthetic surgery, plumbing services, service (phone, insurance, utilities, bank....) upgrades and so forth. Even in Akerloff's market for lemons, cars have strong credence characteristics, as car dealers are the only ones knowing the true characteristics of the cars.

The literature has identified several substantial examples in the real world where credence good theory is very relevant: Domenighetti et al. (1993) report how in Switzerland, where doctors are paid proportionately to the numbers of surgeries they undertake, an average person would undergo 33% more surgical operations than doctors; this is due to the fact that a surgeon will be able to talk her patients into unnecessary surgery, unless the patient is a doctor himself.

Patterson (1992) describes how 9 times out of 10, the employees of a Automotive Centre recommended repairs that were superfluous.

In this way, a consumer may receive unnecessary services (overtreatment); or services of higher than the optimal quality; or pay for high quality, while only receiving low quality (overcharge)[1].

More recently, due to the increase of consumers' interest in green products, credence good theory has been applied to environmentally-friendly markets.

For example: carbon footprint labels report how much carbon has been emitted to bring products onto stores shelves; paper can been produced from sustainable forests[2]; dolphin-free tuna (dolphins captured in the process of catching tune is released), and so on.

The problem with credence goods and imperfect information may be solved (or mitigated) if:

a) *it is possible for sellers to build reputation* (Shapiro, 1982) and therefore separate honest (or high quality) producers from the cheap talkers. However, to be able to create reputation, consumers have to be able to observe, even noisily, the characteristics that in the short run make the good a credence one; in other words, the good has less credence features and more experience ones. Hanson (2003) proves how reputation is hard to establish when a good is highly homogeneous and produced by several small firms (in markets like the ones for agricultural goods or meat). Cason and Gangadharan (2002) show that although increasing (quality) reputation can be enough to create incentives for producers in other contexts, this is not the case for environmental goods.

b) *it is possible to separate advice from treatment* (Emons 1999). If, for example, it is possible to ask a mechanic for his opinion on a car and then go to another to have it fixed: in this way, the first specialist won't have an

[1]Another way to define credence is a situation in which consumers know the quality of the products in the market but they do not know what quality would satisfy their needs. For a recent survey and analysis of the latter, see Dulleck and Kerschbamer (2006). In the rest of the article, we will refer to the former definition of credence good markets, ie. consumers know the quality they need but they cannot determine the quality available in the market.

[2]Where trees cut for paper production are substituted with newly-planted ones.

incentive to lie and the second will not have the opportunity to. Therefore, any time the consumer can obtain the opinion of a seller and purchase the good/service from another, then the information asymmetry can be solved. However, there are often economies of scope between diagnosis and treatment. Sometimes, surgeons need to "open and see" and then make up their mind on the necessity to operate: it would be impractical, if not dangerous, having the operation carried out by another doctor. Or again, for particular technical faults in a car, a mechanic would have to spend considerable time dismantling the engine and assessing the problem. Going to another garage may incur an excessive extra cost. In both cases, the economies of scope are apparent. For the customer it would be non-economical (if non-feasible) to ask for a second opinion.

Dulleck and Kerschbamer (2006) note that authors have often imposed (implicitly or explicitly) one of the following two hypothesis: i) it is possible to verify the quality of the good; or ii) that some sort of liability constraint would prevent consumers from getting an unrequired treatment. It follows that to achieve an efficient equilibrium three conditions have to hold: 1. verifiability (the quality of the good can be assessed ex post) or liability (the producers are impelled to provide the appropriate level of service or quality of a good) assumption; 2. large economies of scope between diagnosis and treatment; 3. consumer homogeneity. If these are not all satisfied, then according to which condition is relaxed the market will have a different degree of inefficiency (up to failing altogether).

Furthermore, the Folk theorem (Nash Equilibrium in a game can be achieved through repetition, often *via* reputation building) cannot be applied to *pure* credence goods: in other words, if it is impossible for a seller to establish reputation or for a consumer to infer anything on the characteristics of the purchased goods even by game repetition, then there would be no premium for the higher quality products. If, as is generally the case, these products have

higher costs of production, then the market for *green* goods will not arise, as in Akerlof's lemons market.

Farrel (1993) points out how it is therefore necessary to have some sort of monitoring in order to avoid any communication degenerating into cheap talk. Scholars have pointed out two other solutions which, however, entail the intervention of the government or of a third party: McCluskey (2000) shows how implementing even noisy monitoring and repeat purchase, a credence good acquires the characteristics of a search good, while Kennedy et al. (1994) proposes that the government simply corrects the market failure caused by the asymmetric information, publicly providing the missing data.

But third party monitoring and/or information-collection can be difficult or costly if not impossible.

Environmentally-friendly products are often pure credence goods, especially when the green characteristics stems from the production process. Thus, even if the government were to ban a particular product, deemed to be too environmentally damaging, enforcement would require a high and continuous effort. Although the majority of environmental features are credence, the contrary does not hold. We have decided to focus on them for two sets of reasons[3]: **1. Green credence markets.** 1.1 Green markets are becoming more and more popular and they are all characterised to some extent by credence features; 1.2 as Gil et al. (2000) point out, the large majority of environmental products are perishable and of common/daily use (often of low unit value) and therefore the credence quality becomes of more importance; 1.3 This is even more so as consumers are willing to pay a premium. **2. Information.** We look at markets in which consumers do not use all the information in the market. This is particularly true for green marketes for several -often unique- reasons (see the paragraph below on Bounded Rationality).

[3]It is of course possible to apply the results of this model to other credence markets, provided they share similar characteristics.

For this particular subset of goods, then, economists have focused on labeling.

1.2.2 Reasons for Labeling

Conventionally, economic analysis has focused on environmental issues as a burden on firms. Since environmentally-friendly products are more costly to produce, firms would only be induced to take on pollution-reducing activities by regulation or other policy intervention.

In recent years, increased emphasis has been placed on the benefits that firms might be able to derive from improving environmental performance and, by implication, on the scope for self-regulation.

These benefits may arise from different channels, which are considered in the next two paragraphs.

Supply side considerations

Producers may gain an edge against their own competitors: Roy and Vezina (2001) highlight how environmental concern can be seen as a diversification strategy. This holds for any good but, most of all, in those markets characterised by high homogeneity of products. A straightforward example can be any agricultural product an apple, corn or a potato cannot be distinguished from the next one. However, through a green diversification, it is possible to create higher loyalty from existing consumers as well as attract a new niche of buyers, interested in the new quality of the product. Porter (1991) and Porter and van der Linde (1995) hypothesise how leading the path in environmental production can lead to a decrease in cost (and therefore comparative advantages) as well as technological leadership. A large branch of literature has been dedicated to the existence of *double dividends*, the possibility to achieve profit and at the same time to improve environmental quality.

Another way to explain Porter's hypothesis is that by producing goods with high environmental standards, it is possible to create a barrier to entry against producers that do not abide to these new green standards. Therefore, companies that carry out animal-tests (in countries where these are not regulated) often have to change their policies to adapt to the situation of the new market. Recently, Chinese producers of motor vehicles had to adapt their production to the stricter standards coming from western producers. Houe and Grabot (2009) suggest how recycled and recyclable materials as inputs may result in barriers to entry against low labour-cost countries and at the same time lead to a competitive advantage, because of the increased consumer awareness of environmental problems (Thogersen, 2002, Teisl, 2002; Mascle and Ping Zhao, 2008).

Ambec et al. (2013) consider the evidence supporting Porter's hypothesis and show the different scenarios in which applies.

On a slightly different note, Codron et al. (2005) point out that retailers may adopt higher quality standards because they're worried about their own reputation. Again, in particular in markets where goods are highly homogeneous, not building a good reputation is the tantamount to a negative reputation and therefore loss of market share. Firms are more or less explicitly expected to care for the environment, to please the consumers' expectations (McAloone, 1998; Argument et al., 1998; van Hemel, 1998).

Finally, Bloom and Krips (1982) suggests that adopting particular green standards could be a cheaper way for firms to advertise the characteristics of their own products. In other words, by advertising either one line of products or some specifics of a product, a firm can promote more cheaply several products or one product to different target audiences.

The firms' growing interest in green markets can be showed, on the one hand, by the interest marketing scholars have in understanding green consumers (among others, Moorthi 2002, Marcus and Adam, 2009, Cegarra-Navarro and

Martínez-Martínez 2009, Moser et al. 2011) and on the other by the pro-active practical approach. In 1986 in the United States, about 1% of the new products were claimed to be green; in less than a decade, the number rose to more than 13%, with peaks in some markets of more than 35%. (marketing Intelligence Ltd., Marketscan Service, cited in Wasik 1996). Globally the amount of environmentally-related certification is growing exponentially: Roy and Vezina (2001) report that in 2001 there were already more than 27,500 different labels. According to Co-operative Bank (2007), in UK alone the green market in 2006 was worth more than £32 billions, with a rather steep increasing trend.

Demand side considerations

An important aspect, both theoretically and empirically, which needs to be considered is also how green products are perceived by consumers.

Bougherara and Piguet (2009) distinguish three kinds of costs consumers face in a credence goods market: (i) *definition costs*: environmental characteristics are not defined by demand side; therefore a consumer needs to assess what a particularly exogenously-defined feature means to himself in terms of utility; (ii) *verifying costs*: these represent the effort to assess the producers' statements' veridicity; and (iii) *signaling costs*: these are the costs consumers incur in order to interpret and understand the information a label incorporates.

Due to these different costs, green markets can exist if and only if there are consumers who are willing to face these additional costs and this would only happen if the utility derived by the goods in question is higher than consuming standard (brown) products.

Recent surveys (CSRwire, 2007 and Co-operative Bank, 2007) show how a niche of consumers can be considered *green,* in other words, that value green features of goods (sustainability, fairness...) and make at least a weekly consumption of such products.

In Switzerland, after only 15 years from their introduction, fair trade bananas represent almost 60% of the market, being often the only alternative in large supermarkets. European Commission (2008) presents the results of a survey, showing that 3 in 4 people in the European Union would be willing to pay a premium to buy some environmentally friendly products. And even if the number dropped to 1 in 5 people who actually recently bought a good with an eco-label, still this represents a sizeable share of the market. Loureiro and Lotade (2005) estimate that in the coffee market the premium for fair trade coffee is between 5 and 20%. Lusk and Hudson (2004) present other evidence for other agricultural markets.

This is because these products are seen as superior, even when the "green" aspects are not patent (e.g. when the difference is in the production rather than in intrinsic characteristics of the final good itself): often environmentally friendly food is proved to be healthier, as it contains less pesticides and artificial ingredients which would justify the reason why some people would prefer them; or white goods may be more energy efficient (implying a lower carbon footprint); other times, though, the environmental characteristic may be intrinsic in some stage of the production and therefore a brown and a green product may be physically identical but the latter is preferred because, for example, it was produced taking care of its producers' welfare, or it was not tested on animals, or it was produced in a sustainable way. The good therefore is perceived as "better" as it is "ethically better" or it internalises part of the negative externality created[4].

Another set of reasons why consumers are interested in green goods depends on different societal interactions:

(a) Nyborg (2000) states that private and social preferences are different and, therefore, we may prefer to do the right thing for society, even if it contradicts the maximisation of personal utility;

[4]These arguments are analysed in detailed in Collier at al. (2010).

(b) McCluskey (2000) points out how consumers may be attracted by green goods not only because these products are (perceived to be) better, but also for fashion or ethical reasons: real fur is probably warmer and fluffier than fake fur, but it is often considered to be "wrong" and targeted by animal-rights groups: therefore even if a consumer may not care for foxes or mink, she would still choose the product that was not the cause of any animal mistreatment;

(c) Brekke et al. (2003) analyse the "warm glow[5] of giving", adding to the theoretical analysis empirical data to show that individuals act not only considering their personal utility function, but also considering an exogenously determined code of conduct. Therefore, the warm glow can be included in the consumers' utility functions. This implies that moral motivation is not necessarily incompatible with utility maximization.

(d) Pedersen (2000) instead focuses on the effect of society's recognition of one's own choices; in other words, a consumer derives utility not only from consumption and the need/desire for "feel-good actions", but also from the appreciation coming from the rest of society. This is a similar argument to the one Codron et al. (2005) describe for producers. Therefore, there is some sort of peer pressure to act in a particular (better) way. This phenomenon is particularly accentuated when consumption has moral/ethical aspects, as in the case of green products (Brécarda et al. 2009). Starr (2009) has added to the analysis with empirical data supporting the hypothesis of the existence of a "warm glow" in the consumption of green products. This particular argument borders closely with environmental psychology (for a thorough survey on the topic, see Vining and Ebreo 2001) and behavioural economics (for a survey see Houe and Grabot 2009).

In the last decade, scholars have started to link psychological and economic perspectives to assess "environmental morale and motivation". Early

[5]The concept was first described in (Andreoni 1990). The author defines it as the increase of private utility due to a particular "morally superior" choice, independent from the actual payoff of this particular choice.

works include Lee and Holden (1999), Thøgersen (1999, 2000), Stern (2000), Grankvist and Biel (2001), Loureiro and Hine (2002): they all concentrated on particular behavioural features that are complementary to the neoclassical utility; in other words, they add on neoclassical theory without breaching any assumption made by it.

Building on this literature, Frey & Stutzer (2006) find that consumers' choices are based on private utility as well as absolute and social principles, fairness and altruism. Berglung and Matti (2006) add that individual decisions depend on ethical values and beliefs, customs, culture and several kinds of social, political and moral values, and also on institutional settings.

Therefore, on the one hand, some consumers are willing to pay a premium for environmentally friendly products and on the other, green producers are willing to offer these products that are (often) more expensive to produce. The reason for this extra economic burden can be seen either as cost-sharing of the information process or as internalisation of externalities.

1.2.3 Labeling

Labeling can be defined as a firm's or third party's policy tool that sets the rules for the producers on how to present specific information of the products to consumers, making available information otherwise only known by producers. In practice, it is often a symbol or a table highlighting the information the producer wants to communicate to consumers.

It is important to remember that (Caswell et al., 2002) consumers make their choices considering the attributes that are intrinsic to the product as well as the extrinsic signposts provided by the sellers, especially when characteristics are difficult to perceive or understand.

Cason and Gangadharan (2002) suggest how one of the main function for these labeling schemes is to reduce transaction costs stemming from the reg-

ulation enforcement and a more precise (i.e. information bearing) use of environmentally related jargon.

Third-party labels, spurious labels & Greenwash

Labels unfortunately are costly for firms. Nielsen (2001) has identified this extra cost as additional abatement-costs, auditing or R&D. Dixit and Norman (1978) interestingly point out how the extra costs may derive from a strategic diversification (therefore changing the product) or from a campaign to raise awareness among consumers.

Cost depends on who is awarding the label. A firm may decide to create a label *ad hoc* for its products (self certification), or it may choose to join an existing scheme, run by a private company or the government (third party certification). A self-certified claim will be cheaper than one certified by an external body: as firms are free to determine their own standards (without adapting their technology to exogenously determined parameters), there is no need to implement monitoring or pay a fee to have the right to use a label and so forth.

The problem with self-certification is that it is less reliable (than third-party certification), as firms producing standard (brown) products try to disguise themselves as green firms. When claims are not regulated, there is an incentive and the possibility for brown producers to pass false information. This particular problem is often referred to as greenwash: firms make dishonest claims about the environmental qualities of their product. Kirchhoff (2000) shows how this problem may not disappear even with the possibility of reputation building, as consumers do not know how producers operates (and therefore their cost functions). When the "green" characteristics are hard to assess for a consumer (O'Brien and Teisl, 2004 and Teisl et al., 2001), and the monitoring costs are particularly high (especially with an ever-increasing number of newly created labels), it is easy to foresee the creation of spurious labels. Spurious

labels aim to make consumers believe that a particular good is green while in reality it is not or at least it is "not as green" as advertised. For example:

(a) Tepelus and Cordoba (2005) mention sustainable tourism, showing how "sustainability is often used in a very lax sense. The core point here is that by using a spurious label a firm can pass a certain degree of false information;

(b) A British coffee shop chain has recently advertised its latest series of fruit smoothies as "*100% natural*": as the word "natural" has no legal meaning, one could at best assume that it is used as antinomy of "artificial". Even so, that does say very little about what is actually in the beverage (technically it could be just tap water);

(c) Detergent products have been for long time under strict scrutiny as they were carrying labels claiming to be "*greener than ever*" or *"50% more environmentally friendly":* the generality of the statements can be hardly proved to be untrue, but it hardly conveys any true meaning.

Farrell (1993) concludes that in a market for credence green goods in which labels are used, without third-party monitoring, there would not be any green market. In fact, communication would degenerate into babbling, consumers would not be able to assess which statements are true or false; even exogenously awarded labels would lose credibility, partly because it is unsure whether the claims have been verified and partly because consumers may not fully understand the difference among the multitude of existing labels.

In general, green producers have an incentive to use labeling to separate themselves. Brown producers will do the same to try to blend in the pool of good producers and harvest the green premium.

However, even third-party certification can represent a noisy form of communication. In other words, it could occur that either the information conveyed by the label is lost on the consumer or brown(green) producers are allowed(excluded) to use third-party certification. This can be explained in

several ways: too many labels, overly complicated information, multidimensionality, misleading advertising, poor monitoring, cost of labeling,...

Mason (2009) makes certification a noisy process in which green producers have more chances to pass the test (but error type I and II are possible). In other words, the monitoring process may be faulty for different aleatory reason which may cause green products to fail the screening or vice versa. The relative costs of the two firms characterise the different equilibria. Mason shows how labeling can actually reduce the number of environmentally-friendly products in the market and still increase the social welfare; on the other hand, mandatory ecolabeling makes social welfare collapse.

This behaviour is partly unavoidable, but sometimes even endorsed by the establishment. In Countries such as the USA, the Congress has set general guidelines for the firms' marketing, but no specific rules on the adopted technology, therefore leaving the possibility for the firm to induce consumers to believe that her products are greener than what they are in reality (Cason and Gangadharan, 2002). While the consumer is not always able to spot a spurious label, he will rely less on self-certification. Heyes and Maxwell (2004) have shown how the coexistence of mandatory exogenously awarded labeling and optional in-house labels can improve the expected social welfare. Lanoie et al. (2011) show that brown firms may benefit from green labels, by purposedly specialising in the production of brown products. Carlsson et al. (2005) using experimental data show how cheap-talk on green attributes decreases consumers' willingness to pay and therefore makes more difficult, or at least less profitable, the existence of green products if costs of production are substantially different. Mahenc (2009) shows how unverified claims dent consumers' trust in all eco-labels, decreasing the effectiveness of communication and therefore the market's efficiency. Bougherara and Piguet (2009) run an experiment to show the effect on market efficiency of different information cost, showing how the different kinds of labels play different roles according to relative cost.

The present paper aims to assess whether there is any economic justification for spurious labels. In the real world, there are several explanations for these kinds of labeling: 1) the regulator cannot be overly strict on what it is allowed and what is not, or the system would lose in flexibility; 2) it is difficult to discriminate between what is a "green label" and what is mere advertisement; 3) firms can fund a third party to be certified, effectively creating a third-party label ad-hoc.

Intuitively, the existence of cheap talk labels would induce consumers to make non-maximising choices and therefore decrease social welfare. The model presented here attempts to clarify whether there are situations in which spurious labels represent the best solution for the market.

Consumers' bounded rationality.

One of the main assumption of the model we present is that consumers do not fully understand the information available in the market via labels. Over the last years, several scholars (among others, Titus and Bradford (1996) and Carrigan and Attala (2001)) have pointed out how information is a more complex issue than theory predicts. When it comes to ethical or environmental purchase, in fact, consumers appear to be slightly helpless and confused, rather than sophisticated as many believe. It is reported how most consumers mention that the declarations of contents are the major source of information when they want to check the environmental performance of a product. Many admit, however, that they do not understand them.

Harbaugh et al. (2011) consider the proliferation of voluntary labels, showing how this tends to confuse consumers (rather than clarifying their ideas) leading firms to strategically choose their labels, according to the quality they want to adopt. These strategic choices, however, backfire as consumers discount the intrinsic value of a label who would accept the endorsement of

products with poor reputation (drawing a parallel to Groucho Marx's famous statement that he would never join a club willing to have him as a member).

AELA (2004) reports how Australian consumers' awareness of different labels is very poor and it varies among different states, according to the importance that is given to environmental issues by each separate administration.

This paragraph presents evidece from existing literature. The reasons behind this behaviour can be summarised as follows:

(a) the green feature may be multidimensional: the greenness of a product is in fact a vector of characteristics only partly dependant on each other. For example, a particular snack could be described according to the following features: 1) genetically modified; 2) organic; 3) fair trade; 4) carbon footprint; 5) sustainability of source of ingredients; 6) recyclable packaging;... It is easy to understand how one product may be superior to a substitute in all but one category bringing into the choice-making a more complex information processing, if not subjectivity. On the one hand, this multidimensionality is indeed more confusing for the consumers and therefore it may lead to non-optimal solutions; on the other, consumers may value differently some characteristics and this leads to different optimal-choices for different people. This heterogeneity, in turn, may be judged non-optimal, as in Economics it is generally assumed homogeneity among consumers. Travisi and Nijkamp (2008) look at how consumers value different credence attributes and show there are no underlying patterns although they can be helped to form.

(b) the green characteristics of a product have to live alongside, if not compete, with all the other characteristics (taste, appearance, practicality, tradition...). In France (example reported in Krarup and Russell, 2005) a label signaling products containing the least superfluous packaging has decreased sale volumes of some products carrying it, as consumers may have preferred the convenience of the previous packaging and committed to recycling. Another example can be found by looking at washing powder: both bio and non-bio

labels are present in the market: the former claims to be green as it is not made using chemicals; the latter finds its green characteristic in the fact that you need less soap and therefore affecting the environment less;

(c) the green feature is difficult to understand *per se.* Certified timber, shade grown coffee, water footprint are all concept that are not of immediate grasp, which can then confuse consumers;

(d) the quantity of labels present in a market may be an additional problem. Even if consumers are perfectly rational and are able to order precisely, different labels in order of increasing quality (and as previously mentioned, this may not be possible), the quantity of information required to make an optimal decision may be too vast to be a feasible option. As much as it is possible to assume that people can collect information about tens of labels in each market, it is not very likely in the real world, considering the high costs involved and the high technical knowledge that may be required to understand them fully. Arunachalam et al. (2009) suggest that a way the market is trying to solve this information overexposure is to creat a "food system", in which more complex certifications are trying to become over-arching best practice.

(e) as already noted, labels may also convey misleading (if not false) information. In the United States, beef can be labeled either "grass fed only" or "grass fed" (if the particular diet was followed only for a part of the animal's life). It is easy to see how the latter can be confused for the former.

Again, the term "organic" refers both to characteristics of the products that can be measured or observed, as well as characteristics of the production process, which may be more difficult to quantify. If the legislation is blurred, the perception of it cannot be clear;

(f) psychological effects may taint consumers' rationality even when characteristics are reported clearly: Kleinmuntz and Sckade (1993) identify a few key factors that can influence the choice of the consumers; for example, the paper shows how, statistically, the same information given in numerical rather

than alphabetical characters has more impact on consumers. In other words, the same product acquires more or less credibility according to the different labels it carries. Jiang and Chia (2010) show how different types of internet certification (interpersonal, formal and anonymous...) have different impacts on consumers, according to the type of good in question (formal works better for experience and search, whilst credence goods are better marketed using informal, personal communication).

It is not surprising, then, that Nilsson et al. (2004) and Bjorner et al. (2004) have drawn attention to how consumers do not fully rely on even the exogenously awarded certification.

(g) labels may convey little information on the green attributes of the good, or these characteristics might not be apparent but rather concerning the production process instead (e.g., the use of renewable energy or resources in general).

(h) buyers may rely on consumers' organisation to trace any sort of malicious advertisement. And it is easy to imagine how these organisations might fail to promptly detect potential spurious labels.

1.2.4 Education

The following paragraph starts by presenting the existing problem buyers have using the information that is made available to them. It then continues presenting the solution for this, which is consumers'education.

Information availability & Information understanding

When it comes to information provision, the traditional assumption made in Economics is that imperfect information can be reduced -if not completely

eliminated- by simply providing the missing information to the market. It follows that the more information, the more efficient is the market; hence, eco-label prolification has to be a positive phenomenon, as consumers have available a full range of classified characteristics.

However, this is not always the case in reality. Palm and Jarlbro (1999) studied the Nordic Swan, one of the most established green labels in Europe. After several years since its introduction, in Finland, Sweden and Norway 60%-75% were aware of it and had a good grasp of what it effectively means: this implies that a quite sizeable share of the population ignored it. Furthermore, in Denmark (which adopted the label few years later than the other countries) only 18% were aware of the label; 95% of the Icelandic population did not know anything about the Nordic Swan. The survey offers two other important facts. 1. Another Danish eco-label (Ø-label, the state controlled label for organic food) was known by roughly a third of the population, implying that Danish people are sensitive to environmental issues and that, therefore, the previous data ought to be affected by other factors; 2. at the beginning of 2001, the Danish Environmental Protection Agency (Miljøstyrelsen) implemented a strong campaign to increase the consumers' awareness of the two main international ecolabels (Swan and EU-Flower). Soon after the campaign, and then after six months, surveys were carried out. Results showed that recognition of the swan increased from 56% to 68% (with knowledge of its meaning raising from 26% to 41%); the EU-flower was recognised by 36% against of the initial 16% (with knowledge increasing from 4% to 16%).

Another survey, reported in EU (2001), affirms that the lack of information is supposedly the single most important obstacle for environmentally conscious purchasing.

The European Barometer (European Commission, 2008) highlights how more than 2 people out 5 is unable to discriminate green from standard product, even when they bear an eco-label.

Finally, some studies have concentrated not on labels, rather on the concepts certified by the labels themselves. Fletcher and Downing, (2011) consider consumers' awareness and understanding the common environmnetal jargon[6]; the result shows how there is a wide gap between the number of people who have heard and have seen any of the terms in question and the number of people who actually know what they mean. Interestingly, the number of people who use these terms to discriminate when buying products is sometimes higher and sometimes lower than the percentage of people who know what the terms actually mean. Firms have been aware of this for a number of years and have reacted accordingly. For a review of the literature in this area, see Bagwell (2007).

We have showed that there may be the need to provide extra information but this may not: a) reach the consumers; b) be trusted; c) be understood; d) lead to consistent behaviour.

While the last of these issues is purely within the realm of Behavioural Economics, the others are extremely relevant to our discussion.

To express the complexity arising in the communication, Leire et al. (2004) differentiate the nine increasing degrees of relation between consumers and eco-labels, from generic knowledge to endorsement[7]. This means that even if producers make information available through labeling, if a consumer lies within the first 8 categories of communication, the information is (at least partially) lost.

Therefore, it is not realistic to assume that information is like a switch in the consumer's head that can be turned on simply by creating labels. Classical economic theory does not predict accurately the market behaviour in this case. If complete information is a necessary condition to an efficient equilibrium,

[6]Such as carbon footprint, ecological, organic,water neutral...

[7]These are: 1. Knowledge of; 2. Noticing; 3. Association; 4. Connotation; 5. Trust; 6. Confidence; 7. Recognition; 8. Interest; 9. Attitude to labels, statements and declarations.

no amount of complex information is sufficient to achieve it. Marette (2010) shows that the existence of different labels and confused consumers lead to the different equilibria that differ in level of efficiency, according to the level of confusion in the market.

Educating consumers.

One way to solve this communication faltering is for firms to invest resources (*effort*) to make the label known and understood to consumers (*education).*

It has been established how producers need to respond with information that reduces implicit costs (in the lack of information) or they lose consumers' confidence. Therefore educational spending and/or improvement in efficiency of educational spending is necessary to increase market share when consumers' search costs are positive. Marketing scholars have studied a similar problem for a long time. For example, Becker and Murphy (1993) present a model in which advertisement and the quality of the good are complement and they find the condition to establish when firms under/over-invest in education.

This relationship between education and market share can be qualified further noting two separate aspects:

a) As it has been pointed out, the fact that information exists does not necessarily imply that a consumer is able to access or to understand it. *Dissemination* is crucial for their efficacy. Edlund et al. (2002) more explicitly asserts how different consumers have different knowledge and understanding of environmental characteristics. In other words, some consumers would require a minimal investment in education, while others would require more

b) Lohr (1998) analyses what happens if there are different, competing labels pushed by different producers. As much as education is still positively correlated to the size of the market, there is also a negative correlation with the effort that the rivals are putting in. This relation has been characterised in literature by Scherer (1979) as *cannibalisation.* In other words, the effort of

a producer to convince consumers that her products are in effect green will attract new people (increasing the size of the market for environmental goods), but also attract consumers who were already in the market, but previously someone else's costumers.

The Bad Education

The optimal level of information is an issue that has been studied extensively (Nelson, 1974; Dixit and Norman, 1978; Glaeser and Ujhelyi 2010), showing how too much information can be detrimental to social welfare.

It is important to note that the problem arising from labelling is not fully resolved by investing in education. In fact, as any firm can decide to pro-actively interact with consumers, then brown firms willing to deceive consumers can do that too.

Hattori and Higashida (2012) summarise the research made in looking at the effect of the noise purposedly created by firms to confuse consumers. Broadly speaking, the effect is similar to the cannibalisation effect discussed earlier.

In our model, if a firm decides to produce using brown technology, we explicitly allow investment in "bad education", as a marketing strategy.

1.2.5 Government Intervention.

Standardisation of labels has been proposed as a solution to the problem: in other words, a third party strictly regulates how to present information and how to guarantee quality. This would be beneficial because it would make it easier to gather information even if consumers have bounded rationality (Teisl & Roe 1998). However the paper points out how too strict a definition may have a lock-in effect on quality standards, where incentives to innovate may be reduced as well as previous investments in alternative technologies or labeling may result in dead weight losses for companies.

However, often governments prefer to purposely leave definitions "loose" or more freedom of action. One of the reasons for this "flexibility" in definitions is to avoid the drawback of loss in flexibility and stimulus to R&D (Antle 1996).

Maxwell (1998) proposes a ban of brown products, in order to avoid labeling costs. This has been possible in particular cases (such as the ban of CFC), but several caveats need to be noted: a) if the ban is not internationally accepted, firms may lose competitiveness in the global market; b) the benefits have to be substantial to compensate for increase in costs of production and potential loss in consumers utility (for all those consumers who preferred the banned goods); c) enforcement has to be easy.

Constantatos and Herrmann (2011) show that setting compulsory standard benefits firms, as the lag between their investments in green technologies and the buyers' realisation of this decreases and therefore the impact on revenue is anticipated.

Scholars disagree on the efficiency of compulsory schemes in improving social welfare. Carlsson et al., (2007) have shown, using a survey on GM-free meat, that mandatory labeling improves on efficiency and social welfare if compared with voluntary labeling, although there may not be a change in the willingness to pay from the consumers. Gracia et al. (2007) finds opposite results analysing the Spanish food market. Galarraga and Markandya (2006) show how society would benefit from the imposition of a Pigouvian tax on regular (non fair trade) coffee and tea, to finance subsidies to fair trade ones.

International NGOs have supported and fostered some of these schemes. In particular the OECD in the last decade has worked hard to influence governments throughout the world to incorporate in their agenda environmental-related issues, establishing standards, publishing research findings and so forth. Among the several projects, it is worth mentioning the long-standing OECD Seed Schemes and the "Worldwide Implementation Now" (W.I.N.) of energy

efficiency that acts as over-arching umbrella for the different schemes (mandatory standards mandatory labels, voluntary labels and voluntary standards)[8].

Caswell and Mojduszka (1996) show how labels can be used and encouraged in order to influence the overall quality of the products in the market. If it is socially better to produce only green goods, then it is possible to see how the creation of MQS (minimum quality standard) or ban of the brown technology can actually be beneficial for the firms (which do not need to spend money on education, diversification or labeling assessments). In the UK, a recent example could be the case of the old incandescent light bulbs which are being phased out gradually, in advance of the European gradual ban starting in 2012. Another example is the ban on plastic bags which has been announced in several countries in recent years.

Andre et al. (2009) justify these voluntary actions as beneficial to all firms, as they solve the coordination issue, which could otherwise lead to excessive competition and non-Pareto efficient equilibria.

For a general overview of the different government intervention see Cole and Harris (2005).

1.2.6 The present model & the previous literature

The model presented here incorporates the concept that the presence of information in a market for credence good is not sufficient to solve the information asymmetry (Titus and Bradford, 1996). Follow the idea expressed by Harbaugh et al. (2011) that labels can confuse consumers and firms exploit the level of confusion to choose strategically their label, we set up a model that analyses this strategic choice.

Considering then Palm and Jarlbro (1999)'s findings, that label administrators can exert effort in order to raise consumers' awareness, we added to

[8]For a comprehensive list of the schemes present in the different countries, see http://www.ecolabelindex.com. The list includes independently verified labels, as of June 2010.

the model the feature that firms have to spend effort to make consumers aware of the characteristics of the products. Although the scholars have looked into this extensively (see literature review), to our knowledge this is one of the first applications to environmental policy making. The final characteristic we added is the interdependence between the two firms' efforts, expressed as in Scherer (1979), ie. cannibalization.

The model assumes that all green producers adopt third-party certification and brown ones adopt in-house (spurious) labels. This assumption is purely instrumental to look at the strategic choices made the firms; our interest in to see whether (1) spurious labels are detrimental to social welfare; (2) green production is always part of the equilibrium mix; (3) the governmental should intervene and, if so, (4) how to do it best. We find that in equilibrium green products may not be produced at all but that, even in presence of negative externalities, this may not require the regulator intervention. However, if it is in society's best interest, the decision maker has several ways to intervene.

According to the different situation, the best policy could be banning one certification, provide a limited amount of licences to use a particular certification, R&D investment, educational campaigns or no intervention at all. We also show how having a unique certification could be beneficial to society, especially if it affects consumers' perception of the labels.

1.3 Deriving the Model

This chapter presents the model we have used. The literature review in the previous chapter has set the context for the aim of this piece of research, highlighting the issues and some of the main findings.

1.3.1 Main Assumptions

The model studies the strategic interaction between two profit maximising firms in a market for a homogeneous credence good, meant for export[9].

Labels. Firms use labels for their products. See 1.3.1 below.

Price. Price is assumed to be constant (there is no price competition on the supply side, and no bargaining power on the demand side). The main reason to assume this is to isolate the effect education has on producers' choices and eliminate any price effect. Furthermore, one could argue that brown firms will exploit the products homogeneity and the information asymmetry to match the green firms' price, as a lower price could be seen as a signal of lower quality; therefore there won't be any price competition. In the same way, green producers may not be able to extract a premium from the market, as consumers are not able to assess whether they are getting anything for the higher price.

Purchasing Condition. Only goods that are perceived to be green are sold. Consumers have no prior belief about the sellers or the labels. Consumers who are not convinced that a good is green will not make any purchase. Therefore, firms spend resources to make buyers aware of the characteristics of the label borne by their own products.

Consumers' heterogeneity. Consumers are believed to have different preferences. Firstly, it is recognised that some consumers may not be interested in consuming green products; however, the model only consider the niche of consumers that do (looking simultaneously at the market for green and brown products could represent an insightful extension of the current model). In other words, heterogeneity is recognised but it is to a large extent eliminated, considering exclusively the market for green products. Secondly, among the people demanding for green products, it is assumed that different individuals will have distronger/weaker preferences/knowledge about the green features of the good. This implies that education will not have a constant return (see below).

[9]This allows us to ignore consumers' surplus in the evaluation of social welfare.

The duopolists make two decisions: **a)** the quality of the product; and **b)** the quantity of effort invested to convince the consumers the product is green. Each of these decisions is analysed in the following paragraphs.

Quality of the Good

As only green goods are sold, firms use labeling. If a firm decides to produce a brown product, then it won't be able to certify her products exogenously, therefore it will use a self-awarded one (cheap talk); producers choosing to go for green products will adopt exogenously awarded label[10]. In other words, firms decide between:

*produce with a **green technology** *and* adopt a *third-party awarded* label;

or

*produce with a **standard technology** *and* adopt an *in-house* certification[11].

All the products will therefore carry a label: a firm deciding to produce a green good **will** adopt a third-party awarded label, whilst a firm producing a brown product will adopt a spurious one.

From this, it follows that "spurious" and "in-house" are considered here as synonyms.

An important assumption is that **green technology is more expensive**. This is a standard condition in the literature, and it is strongly supported by market analysis[12]. This could be explained with two different sets of considerations: **a)** green producers internalise the negative externalities, or use more costly technologies to avoid them altogether, or have higher abatement costs

[10] This can be justified as follows: third-party certifying body can detect green products with no noise. Brown producers cannot access exogenous certification, therefore they implement spurious labeling.

[11] This assumption can be relaxed, as it is discussed in the Appendix.

[12] A simple counterfactual could be: if it were cheaper to produce an environmentally friendly good, and it is also easier to market it, firms would always choose green technologies.

or costs of auditing or **b)** having the goods certified and production monitored is costly (the analysis of these costs has been done in the previous chapter).

On the other hand, a brown firm avoids these additional costs non - internalising externalities and self-awarding certification, making her production costs marginally lower.

Consumers' behaviour. Consumers' behaviour has been "blackboxed": *since* (i) they will only buy products believed to be actually green; (ii) they have no prior belief about the products and (iii) price is unique; *then* the demand of each product is dependent on the level of effort put in by each firm.

Education

Because of the presence of spurious labels, consumers are not always sure of the actual quality of the products, creating market inefficiency, both by committing type I error (consumers not buying green goods thinking they are actually brown) and type II error (consumers buying brown goods assuming they are green).

Consumers face two information-related issues: the existence of spurious labels, and the lack of knowledge about the difference between different labels.

To exemplify the issue, let us consider this situation. A consumer faces the choice between two homogeneous products, only differing for the green seal they bear. One is awarded by an independent, reputable, international organisation (say WWF) and the other is simply something the marketing department of a firm attached to the product. If the consumer does not recognise the difference between the two labels, even looking at the symbols and information, then the information carried by the seals is lost.

Since we assume that consumers have no previous beliefs regarding the products or labels, and since they only purchase products that are perceived to be green, then the demand will be a function of the money invested by the producers in any activity to raise consumers' awareness, which we call

education. If no money is spent, then consumers will not be able to distinguish between the different labels and they will not know for sure whether the goods are green and therefore they will not commit to buy anything.

Effort is costly and has a positive, yet decreasing, effect on consumers' belief that the product is actually eco-friendly. Furthermore, effort is more effective if the good is actually green.

Let us consider these characteristics separately:

1. **Effort has decreasing marginal returns.** This is a rather standard hypothesis (law of decreasing marginal returns). This can be a consequence of different factors: *(i)* some consumers will be more informed than others about existing labels and therefore requiring little further information to be convinced of the green characteristics of a good; a consumer who knows little about that particular good would need to be taught about different labels, the specific product requirement to obtain it and so forth: this will clearly require more effort. *(ii)* a firm may begin to advertise in more dense areas or using more penetrating mass-media, and then eventually target smaller or more remote places where targeted potential consumers are fewer. *(iii)* some consumers may be more gullible than others, or have a lower resistance to believe in advertisement (broadly intended) or put a heavier weight on green qualities and therefore they would be more easily convinced.

Therefore, the most environmentally friendly, the most gullible and the best informed would be the first to be convinced and they are convinced with a small investment. The more skeptical might give in, but after a stronger effort from the producers.

2. **Brown firms are assumed to be less efficient in convincing consumers** of the greenness of their products. This is quite standard in literature. This can be explained in several ways: *(i)* it is easier to convince someone of something true rather than the opposite. One needs only to think at an example: Phillip Morris may find proof that smoking is not really harmful for

one's health, but it surely would take a lot of research and time to find a scientist willing to say so and most probably his credibility will not be of the highest (definitely not after a statement like this). On the contrary, the same amount of educational effort put in by the NHS to convince people who smoking is harmful will have a larger impact. *(ii)* There is a stronger resistance to self-awarded labels, as market research has confirmed. Highly-aware consumers realise the label source and they of course question its reliability. *(iii)* It is difficult for a brown producer to mislead consumers without openly lying, which would unmask them or it would make their statement illegal. In other words, if a firm wants to overstate the green characteristics of her products, she will do so with vague and less convincing statements and often with poor proofs of the facts, in order to not be accused of stating falsities. This weaker certification will influence demand but not as strongly as that of a third-party label.

In the model, it is assumed that firms use a brand-enhancing education effort, therefore the effort spent by a firm increases the awareness of its products only. It is important to notice how the "effort" a company decides to put in will not influence *directly* the reputation of the competitor, as it is assumed that the marginal effectiveness is only a function of one's own effort. However, it is intuitive to see how in a limited market, if a company increases her effort (and her own market share), then, ceteris paribus, the competitor will be left with a shrunken market and, consecutively, the total quantity sold by the latter will decrease.

This relation is incorporated in the model implicitly, as in any duopoly model.

Reputation and Bayesian Consumers

As previously mentioned, the model does not use the classical Bayesian updated consumers' beliefs. This section explains why Bayesian theory is not the best

choice to describe this market, as the description of a *homo oeconomicus'* bahaviour may be approximated more closely by our model rather than by Bayesian theory.

The market considered here is a market for credence (green) goods. Pure credence, as said, is a quite common feature, especially when the green attribute comes from the way the good is produced (e.g. using renewable electricity or resources). Although it might be possible to see whether a book is printed on recycled paper, it would be impossible for a consumer to assess whether the paper comes from a sustainable exploited forest).

This particular feature of the market has two important consequences:

* **Information Asymmetry**: consumers cannot know *ex-ante* the products' characteristics;

* **No reputation:** it is not possible to gather further information *ex-post*.

Contrary to **experience goods**, the green characteristic cannot be inferred after consumption.

But if consumers cannot learn anything about the good they have previously purchased, then Bayesian learning process would be useless, as

$$P(A \mid B) = P(A) \tag{1.1}$$

We can identify diverse scenarios where Eq. 1.1 holds true:

a) **One-off decisions**. If the good is a *durable good*, the consumer creates beliefs about the situation at the moment of the potential purchase and then makes up her mind. By the time of her subsequent purchase, the market will have undertaken so many changes that her prior knowledge is obsolete and therefore of no use, if not even misleading. This knowledge obsolescence could be due by developments in the technology (which could make what it is considered to be a green good today, a brown good in light of new discoveries. For example, what was considered to be an efficient refrigerator 15 years ago

is now considered extremely polluting). Alternatively, the standards (i.e. not the products but just the labels themselves) could be different (e.g. for cars, in the EU the standards change every other year. EURO1, EURO2....) as new pollutants are considered;

b) **Large number of small labels.** Even considering non durable goods, it has been noted how for each particular market, the number of green labels is large and increasing. In this setting, the chance that a consumer always faces the very same set of labels is limited, which implies that even repeated purchase won't make consumers any more informed.

c) **Consumers' bounded rationality.** If we consider the massive amount of different labels existing in the different markets (as mentioned elsewhere in the paper, close to 30.000), it seems like a strong stretching of reality that a consumer would remember how to rank several labels (in terms of green characteristics) for every single market. The problem is two-fold: on the one hand, it is difficult to rank (and remember) hundreds of labels; on the other, the multidimensionality of green characteristics makes ranking difficult, if not subjective (eg. is it better to use recycled paper produced by underpaid under-aged workers, or fair-trade non-recycled paper?)

The implication of applying Bayesian theory to consumers' repeated choice is that it is plausible to assume that every consumer is able to understand, learn and remember all the details involved in previous purchases, but this does not seem to be very realistic. It seems more likely that a consumer would gather easily available information at the moment of each purchase and then make up her mind. Therefore, every time a consumer has to decide what product to buy, it is as if she was facing that choice for the very first time. In view of the specific characteristics of the market, this assumption seems to be more reasonable than a Bayesian learning process.

d) **Credence goods.** The purchase and consumption of goods the quality of which cannot be fully appreciated with consumption will not allow consumers

to become any wiser with consumption. "Homemade" food, "sustainable" (use of forestry; tourism...), fair-trade, organic are all good examples of characteristics which cannot be inferred.

Therefore, every time we consider situations in which the consumer's previous belief will not influence her future belief and therefore influence her behaviour (or do so only very marginally[13]), an alternative to a Bayesian Consumer should be considered.

All the reasons expressed above go a long way to justify why we have excluded reputation building. In credence goods literature the distinction between models in which reputation is possible or not is very clear. Our interest was to look at different choices and we disregarded this option - an example of reputation building model is considered in the last chapter of this dissertation. But how realistic is this assumption? If we consider one-off decisions, then this is very credible. Whatever reputation a company may have is incorporated in the effectiveness of education and there is no interest in what we learn from the experience. The same holds for occasional purchases or markets the consumers is not familiar with (like purchasing something when abroad, where even the reputation of the seller may be unknown). On top of that, if we consider the perfect credence quality of the product, then reputation becomes less credible.

[13]Even considering imperfect credence good markets, applying Bayes' rule to describe consumers' behaviour only slightly improve the precision of the model. Clearly, we can imagine how a consumer *may* learn something through the consecutive processes of buying, but as noticed before, this process would be extremely bumpy and slow. If it is true that there are several labels for each market, by the time that a consumer has faced each possible pairings, several periods have passed while little extra information has been gathered. It is important not to forget that, by assumption, the green characteristics are not detectable even after consumption.

All in all, even if at best there could be the possibility that some extra information may be conveyed through Bayes' learning process in particular circumstances, in terms of economy of the model it would not add much, while it would make things much more complicated. Most of all, though, it is very difficult to assume that that is the mechanism guiding consumers' choices.

On the other hand, "perfect" points to something belonging more to a textbook than reality and it is not impossible to imagine situations in which consumers will try to find ways to best guess what they are purchasing from previous experiences. This could come not from the good purchased, but from the purchasing experience as a whole (ie. that particular retailer is known to be eco-friendly, therefore I assume that its products are likely to be green). This scenario is not considered by the model presented here, although later on we suggest how it could be partly incorporated. Future research could incorporate this in two ways: either by differentiating the effectiveness of education (to reflect the different reputation of the different firms) or by making the one-shot game into a repeated game, in which reputation can be incorporated.

1.3.2 Introducing the model: single producer, single quality.

We now present the model that has been adopted. In the next section we introduce a simplified version of it, where there is only one producer and there only exists one quality of the good. The general maximisation problem is presented, in order to ease the reader into the use of the notation. Paragraph (1.3.4) will then introduce the complete duopoly model with two qualities of products.

A profit maximising firm produces a credence good with a given technology and a given green label. Consumers are interested only in green products. To persuade consumers that her products are environmentally friendly, the firm spends resources in order to make information available and disseminate education.

Therefore, the firm chooses the amount of effort expended in order to inform consumers about the existence and the meaning of her label.

There is a positive correlation between the effort and the share of people who will be convinced that the product is green and that therefore will buy it. Price

is considered constant. Therefore, the demand function is solely dependent on the effort level. It is also assumed a decreasing return to education.

Being e the level of effort of the firm, it is possible to characterize the demand function, η, as follows:

$$\eta = \eta(e) \tag{1.2}$$

$$0 \leq \eta \leq 1 \tag{1.3}$$

$$\frac{\partial \eta}{\partial e} > 0 \tag{1.4}$$

$$\frac{\partial^2 \eta_i}{\partial^2 e} < 0 \tag{1.5}$$

$$\eta(0) = 0$$

$$\lim_{e \to \infty} \eta(e) = 1 \tag{1.6}$$

that is, that the effect of effort is concave. η represents the normalised quantity of consumers believing in the label[14] and that will therefore buy it. It can be observed how when the effort is equal to zero, no one believes the product is actually green and therefore that it takes an infinite level of effort to convince the whole market.

The higher the effort expended by a firm, the higher the number of people who will be convinced that her products are indeed green. However, the effort has diminishing returns. Therefore, the most environmentally friendly, the most gullible and the best informed (or least informed in the case of a spurious label)

[14] In other words, the share of the total Market, rather than the absolute number. Being X the total size of the Market, then N is the amount of people believing in the label, given the level of effort $\bar{e}$:

$N = \eta(\bar{e})X$

As we are not interested in the size of the Market, we look at the relative size of the market, eliminating a parameter from the model, without losing in generality.

would be the first to be convinced and they are convinced with a small investment. The more skeptical might give in, but after a stronger effort from the producers. This implies a very high level of effort to convince the totality of the population (Eq. 1.11). Figure 1.1 graphically summarises these assumptions.

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Therefore, the firm chooses the amount of effort expended in order to inform consumers about the existence and the meaning of her label.

There is a positive correlation between the effort and the share of people who will be convinced that the product is green and that therefore will buy it. Price is considered constant. Therefore, the demand function is solely dependent on the effort level. It is also assumed a decreasing return to education.

Being e the level of effort of the firm, it is possible to characterize the demand function, η, as follows:

$$\eta = \eta(e) \tag{1.7}$$

$$0 \leq \eta \leq 1 \tag{1.8}$$

$$\frac{\partial \eta}{\partial e} > 0 \tag{1.9}$$

$$\frac{\partial^2 \eta_i}{\partial^2 e} < 0 \tag{1.10}$$

$$\eta(0) = 0$$

$$\lim_{e \to \infty} \eta(e) = 1 \tag{1.11}$$

that is, that the effect of effort is concave. η represents the normalised quantity of consumers believing in the label[15] and that will therefore buy it. It can be observed how when the effort is equal to zero, no one believes the product is actually green and therefore that it takes an infinite level of effort to convince the whole market.

The higher the effort expended by a firm, the higher the number of people who will be convinced that her products are indeed green. However, the effort has diminishing returns. Therefore, the most environmentally friendly, the most gullible and the best informed (or least informed in the case of a spurious label) would be the first to be convinced and they are convinced with a small investment. The more skeptical might give in, but after a stronger effort from the producers. This implies a very high level of effort to convince the totality of the population (Eq. 1.11). Figure 1.1 graphically summarises these assumptions.

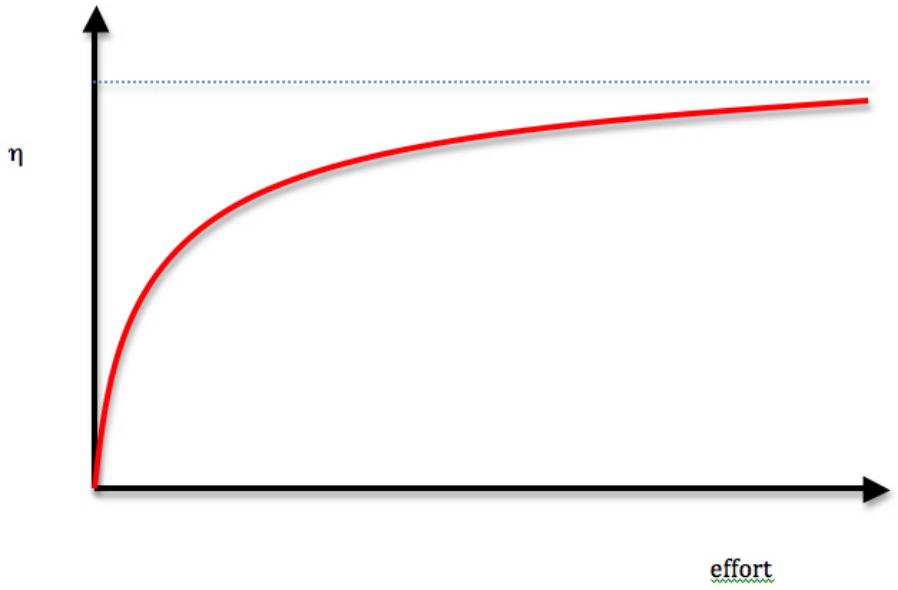
Assuming that production costs are linear, then it is now possible to write the profit function as follows:

[15] In other words, the share of the total Market, rather than the absolute number. Being X the total size of the Market, then N is the amount of people believing in the label, given the level of effort $\bar{e}$:

$N = \eta(\bar{e})X$

As we are not interested in the size of the Market, we look at the relative size of the market, eliminating a parameter from the model, without losing in generality.

Figure 1.1: Education effectiveness



$$\begin{aligned} \Pi &= TR - TC = pq - (cq + e) \\ \Pi(e) &= (p - c)\eta(e)N - e \\ \Pi(e) &= k\eta(e) - e \\ k &= (p - c)N \end{aligned} \tag{1.12}$$

where p is the price of the good and c the marginal cost of production. k represents the maximum achievable profit of production, if education were free. The firm needs only to choose the level effort for which Eq. 1.12 is maximised.

1.3.4 The whole Model

Now that the main mechanisms are sufficiently clear, let us consider the full model.

Two identical profit maximising firms compete in a market, producing an homogeneous good. Goods are meant for export. The good can be produced using two alternative technologies: one environmentally friendly and the other not. The final products are however not distinguishable, either before purchase or after consumption. The market, therefore is characterised by two different products, one green and another brown (determined by the two different technologies), but this element is not detectable by consumers. Regardless of the chosen technology, firms will adopt a label. However, a firm deciding to use the green technology adopts a third party certification, whilst a firm using a standard technology relies on self-certification label.

Production costs are linear. Green products have a higher marginal cost of production than the brown ones. Price is unique in the market.

Consumers are willing to purchase the good if and only if they believe it is green and they do not have any knowledge about the different labels. For this reason, firms invest a certain amount of effort to promote their own products as green.

As we have already discussed, there is a positive relation between the effort and the share of people who are convinced, although there are decreasing returns to education. Consumers believing that both goods are green will randomly choose either one[16]. Consumers' behaviour is therefore stylised, assuming that the share of consumer believing in a given label is dependent on the level of effort and on the technology used. Without any micro-foundation, it is possible to characterise the demand side as follows:

$$\eta_{i,m} = \eta_i(e_m) \tag{1.13}$$

[16]Since the products are homogeneous, apart from the label, and environmental characteristics cannot be inferred, even after consumption.

where η is the share of consumers believing that the goods produced by firm m are green, when the technology adopted by the firm is i and her level of effort is e. We can further describe η as follows:

$$\frac{\partial \eta_{i,m}}{\partial e_m} > 0 \tag{1.14}$$

$$\frac{\partial^2 \eta_{i,m}}{\partial^2 e_m} < 0 \tag{1.15}$$

$$\lim_{e \to \infty} \eta_i(e_m) = 1 \tag{1.16}$$

$$i = g, b$$

$$m = 1, 2$$

that is, that the effect of effort is concave. The higher the effort put in by a firm, the higher the number of people who will be convinced that her products are indeed green. However, the effort has diminishing returns.

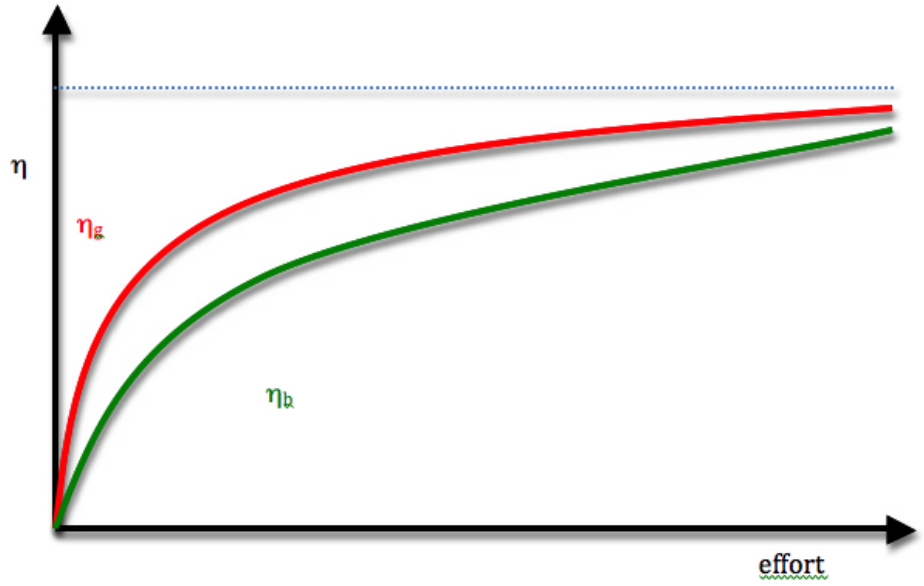
Finally, it is assumed that the effectiveness of education depends on the technology a firm chooses:

$$\begin{aligned} \eta_g(\overline{e}) &> \eta_b(\overline{e}) \\ \forall e &\in]0; +\infty[\end{aligned} \tag{1.17}$$

where g stands for the green technology and s for the standard one. Eq. (1.17) means that given the same level of effort, an exogenously awarded label would convince more consumers than an in-house one, and that this holds for any level of effort. The assumption is consistent with reality. It is easier to convince someone that the product X is green, if the good is indeed green. This is true at any level of skepticism.

This set of assumptions are exemplified graphically in Figure 1.2, where it can be seen that both functions tend to one for high levels of efforts, but education is always more effective if an exogenously awarded label is used.

Figure 1.2: Education effectiveness for different technologies



The distance between the two curves depends from many factors, which contributes to the reputation of the two labels. As it has already been mentioned, we assume that brown products are more difficult to market. We can therefore consider that the difference between the two curves incorporate the reputation of the producer (which will affect the marketability of the product as well). It follows that a firm with a good reputation would have the two curves represented in 1.2 very close to each other, as even producing brown product, she would be able to use her overall reputation. On the other hand, a new entrant in the market (or a company with a low reputation) would have a wider gap between the two of them.

In our model, we have assumed that i differs by technology, but it is the same for the two competitors. This is of course a very convenient simplification, which makes the model more manageable and allows to draw conclusions even before getting to functional specification. However, setting the reputations different for

each company would have enriched the model with the possibility of considering how the reputation of different companies would affect the choice. This is an interesting extension that future research could explore

Since the products are homogeneous, consumers buy products by the firm believed to be green or, should both be believed to use green technology, randomly choosing one of them . In this case, then, η_m represents the relative number of consumers who believe m's goods are green. Regardless of the technology, the normalised quantity sold by the firm m (q_m) can be expressed as:

$$q_m = \underbrace{\eta_m(1-\eta_n)}_{a} + \underbrace{\frac{1}{2}\eta_m\eta_n}_{b} \qquad m,n = 1,2 \tag{1.18}$$

The first term (a) represents the number of consumers who believe that only the firm m produces green products, while the second term (b) represents those who believe that both are using green technology and therefore choose randomly whose products they will buy. It is possible to re-write Eq. (1.18) as:

$$\begin{aligned} q_m &= \eta_m - \eta_m\eta_n + \frac{1}{2}\eta_m\eta_n = \eta_m - \frac{1}{2}\eta_m\eta_n \\ q_m &= \eta_m(1-\frac{1}{2}\eta_n) \end{aligned} \tag{1.19}$$

Let us now look at profit functions. These can be expressed as:

$$\Pi_{ij} = (pq_{ij} - c_i q_{ij})\, N - e_{ij} \tag{1.20}$$

$$c_g \geq c_b \tag{1.21}$$

where i is the technology chosen by the one firm and j is the technology chosen by the other. p is the price of the good which is considered unique and constant; c_i is marginal cost, which is assumed to be linear, as well as the cost of

effort e_{ij}. Eq. 1.21 simply states that producing one unit of green product is no cheaper than producing one unit of product with no environmental properties.

Plugging Eq. 1.19 into Eq. 1.20 and re-arranging, we obtain:

$$\Pi_{ij} = k_i(\eta_i - \frac{1}{2}\eta_j\eta_i) - e_{ij} \tag{1.22}$$

$$\text{where} \quad k_i = (p - c_i)\, N$$

$$\text{and } k_b \geq k_g \tag{1.23}$$

k_i therefore represents the maximum profit of production, excluding therefore the cost of effort: this is the profit obtainable by a firm using the technology i, selling to every single consumer, without any effort to promote its products. Eq. 1.23 is, then, true by definition, considering Eq. 1.21. The closer the costs of production for the two different technologies, the closer k_b to k_g. As mentioned earlier, we would not be interested in the opposite scenario ($k_b < k_g$), as it would generate a simple case in which the standard technology is simply inferior to the green one (more costly and less marketable) and therefore never chosen.

Each firm will choose the technology and level of effort that maximise their profit. The following section will analyse the different scenarios, arising by the combination of the different choices of technologies made by the two firms.

It is important to highlight the fact that if both firms choose to go for a green (brown) technology, it does not mean they will adopt the *same* label, but simply that they will both adopt an exogenously (endogenously) awarded label. When we consider the different policies that can be adopted, we will also see whether it is more efficient for society if firms adopt the same label.

1.3.5 Solving the model: Producers using the same technology.

If both firms were to choose a green (brown) technology, then it possible to re-write the quantity produced omitting the subscript referring to the technology, as:

$$q_m = \eta_m(1-\eta_n) + \frac{1}{2}\eta_m\eta_n = \eta_m - \frac{1}{2}\eta_m\eta_n = \eta_m(1-\frac{1}{2}\eta_n)$$
$$m, n = 1, 2$$

and therefore the profit functions would be:

$$\Pi_m = k_i q_m - e_m$$

$$\Pi_m = k_i\eta_m(1-\frac{1}{2}\eta_n) - e_m \tag{1.24}$$

The two first order conditions then will have this form:

$$\begin{aligned} \frac{\partial \Pi_{ii}}{\partial e_1} &= k_i \frac{\partial \eta_{_1}}{\partial e_{_1}}(1-\frac{1}{2}\eta_{_2}) - 1 = 0 \\ \frac{\partial \Pi_{ii}}{\partial e_2} &= k_i \frac{\partial \eta_{_2}}{\partial e_{_2}}(1-\frac{1}{2}\eta_{_1}) - 1 = 0 \end{aligned} \tag{1.25}$$

Since the level of effort of a firm depends on the other's, we can derive the reaction functions:

$$\frac{\partial e_1}{\partial e_2} = -\frac{\frac{\partial^2 \Pi^1_{ii}}{\partial e_1 \partial e_2}}{\frac{\partial^2 \Pi^1_{ii}}{\partial^2 e_1}} = \frac{\frac{1}{2}\frac{\partial \eta_1}{\partial e_1}\frac{\partial \eta_2}{\partial e_2}}{\frac{\partial^2 \eta_1}{\partial^2 e_1}(1-\frac{1}{2}\eta_2)} \tag{1.26}$$

$$\frac{\partial e_2}{\partial e_1} = -\frac{\frac{\partial^2 \Pi^2_{ii}}{\partial e_1 \partial e_2}}{\frac{\partial^2 \Pi^2_{ii}}{\partial^2 e_2}} = \frac{\frac{1}{2}\frac{\partial \eta_1}{\partial e_1}\frac{\partial \eta_2}{\partial e_2}}{\frac{\partial^2 \eta_2}{\partial^2 e_2}(1-\frac{1}{2}\eta_1)}$$

The reaction functions are symmetrical, which means that the equilibrium is found for equal level of effort by the two firms (and therefore same level of profit). That is,

$$e_1^* = e_2^* = e^* \tag{1.27}$$

It can also be noticed that

$$\frac{\partial e_n}{\partial e_m} < 0 \tag{1.28}$$

as the numerator is always positive, being the two first-derivatives positive by Eq. 1.14 , while the denominator is instead always negative, being the second-derivative negative by Eq. 1.15 and the term in the brackets is always positive considering Eq. 1.8.

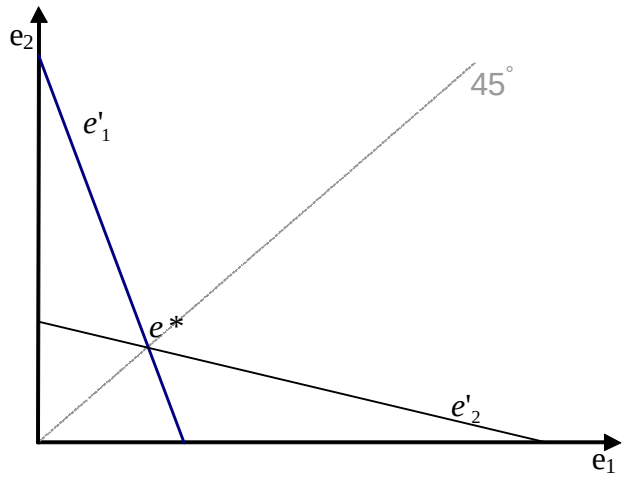
This implies that the firms' products are perfect strategic substitutes. In other words, if firm 1 increases her effort level, then firm 2 will react by reducing hers.

This could be explained by the fact that if firm 1 increases the effort, this will affect firm 2 in two different ways: on the one hand, the unchartered market has now shrunk (first right-hand side term of Eq. 1.18), while the shared market has increased at the expense of firm 2 (second right-hand side term of the same equation). Figure 1.3 represents the reaction functions[17].

Going back to the profit functions, since the effort of the two firms is going to be identical, then we can derive the condition that characterise the optimal effort level as follows:

[17] We have represented linear reaction functions for simplicity of exemplification.

Figure 1.3: Effort level when the same technology is chosen



$$\Pi_1 = \Pi_2 = k_i \left[\eta(1 - \frac{1}{2}\eta)\right] - e^* \tag{1.29}$$

$$\frac{\partial \Pi}{\partial e} = k_i \left[\frac{\partial \eta}{\partial e}(1 - \frac{1}{2}\eta) - \frac{1}{2}\eta\frac{\partial \eta}{\partial e}\right] - 1 = 0$$

$$e^* \mid \eta\prime = \frac{1}{k_i}\frac{1}{1-\eta} \tag{1.30}$$

Eq. 1.30 gives the condition that needs to be satisfied to determine the optimal level of effort for each firm and that will also determine the maximum profit. We can observe that:

$$\frac{\partial e^*}{\partial k_i} > 0 \tag{1.31}$$

This can be easily proved. In fact, if this were not the case, then when k_i increases, e would decrease. But this would imply that η' increases but also that η increases too, which for Eq. 1.30 is impossible, as the left hand side of the equation would increase, whilst the right hand side has decreased.

However, the effect on profit is unsure, as total revenue would increase (as both marginal revenue and quantity produced are increasing) but also total cost (as the effort level would increase, for Eq. 1.31).

It is also interesting to compare the results in the two different scenarios (only green/brown). Our goal is to see whether:

$$\Pi_{gg} \gtrless \Pi_{bb}$$

As it has been observed, it is not possible to determine if

$$e_g^* \gtrless e_b^*$$

without making further assumption on the technology functions. This strictly implies that in equilibrium, quantities produced can be larger when both firms choose one or the other technology. But then, it is not possible to determine univocally this relationship for profit either. To see this, let us assume that the level of effort in both cases is e^*, then:

$$\begin{aligned} \Pi_{gg} &\gtrless \Pi_{bb} \\ k_g(\eta_g - \frac{1}{2}\eta_g\eta_g) - e^* &\gtrless k_b(\eta_b - \frac{1}{2}\eta_b\eta_b) - e^* \\ \frac{k_g}{k_b} &\gtrless \frac{\eta_b - \frac{1}{2}\eta_b\eta_b}{\eta_g - \frac{1}{2}\eta_g\eta_g} \end{aligned} \tag{1.32}$$

By definition, we know that

$$k_g < k_b$$

This can also be expressed as:

$$\begin{aligned} k_i &= (p - c_i)N \\ \frac{k_g}{k_b} &= \frac{(p - c_g)}{(p - c_b)} = \frac{MR_g}{MR_b} \end{aligned}$$

that is that the left hand side of Eq. 1.32 is the ratio of the marginal revenue of the two different technologies. We also know, from Eq. 1.17, that the numerator of the right hand side is smaller than its denominator. This ratio (the quantity sold in each scenario) can also be interpreted as the level of communication inefficiency of the brown producers with respect to the green ones. Re-writing Eq. 1.32:

$$\frac{MR_g}{MR_b} \gtreqless \frac{Q_b^*}{Q_g^*} \tag{1.33}$$

Whilst the right hand side depends on the level of effort, the left hand side is the ratio of two (exogenous) parameters: it is easy to see how, by changing the technology specification and the cost structure, it is possible to change the direction of this inequality.

1.3.6 Solving the model: Producers adopting different technologies.

Let us assume that firm 1 has chosen the green technology, while firm 2 has chosen the brown one. Then the two quantity functions will be in the form:

$$q_1 = \eta_g(1 - \eta_b) + \frac{1}{2}\eta_g\eta_b = \eta_g - \frac{1}{2}\eta_g\eta_b = \eta_g(1 - \frac{1}{2}\eta_b)$$

$$q_2 = \eta_b(1 - \frac{1}{2}\eta_g) \tag{1.34}$$

Deriving the profit functions and first order condition, we obtain:

$$\begin{aligned}\Pi_1 &= \Pi_{gb} = k_g q_1 - e_1 \\ \Pi_2 &= \Pi_{bg} = k_b q_2 - e_2\end{aligned}$$

where the subscripts letters ij under the profit function help to remind, respectively, of the strategy chosen by the firm in question and the one chosen by her competitor. The two first order conditions, then, can be expressed as follows:

$$\frac{\partial \Pi_{gb}}{\partial e_1} = k_g \left[\frac{\partial \eta_g}{\partial e_1}(1 - \frac{1}{2}\eta_b)\right] - 1 = 0 \tag{1.35}$$

$$\frac{\partial \Pi_{bg}}{\partial e_2} = k_b \left[\frac{\partial \eta_b}{\partial e_2}(1 - \frac{1}{2}\eta_g)\right] - 1 = 0 \tag{1.36}$$

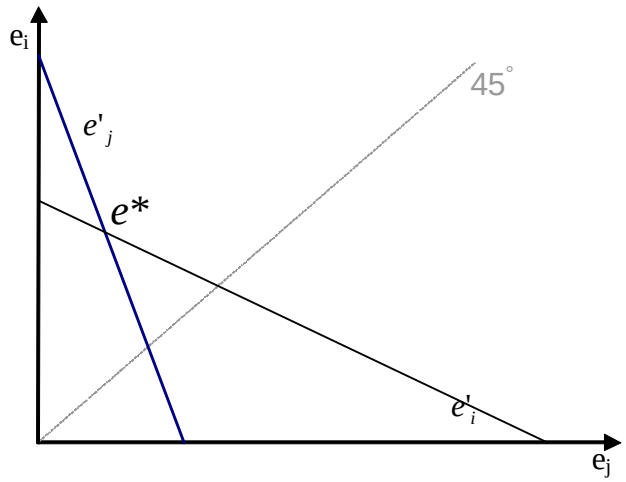
$$\frac{\partial e_1}{\partial e_2} = -\frac{\frac{\partial^2 \Pi_{gb}}{\partial e_1 \partial e_2}}{\frac{\partial^2 \Pi_{gb}}{\partial^2 e_1}} = \frac{\frac{1}{2}\frac{\partial \eta_g}{\partial e_1}\frac{\partial \eta_b}{\partial e_2}}{\underbrace{\frac{\partial^2 \eta_g}{\partial^2 e_1}}_{\gamma}(1 - \frac{1}{2}\eta_b)} \tag{1.37}$$

Similarly,

$$\frac{\partial e_2}{\partial e_1} = -\frac{\frac{\partial^2 \Pi_{bg}}{\partial e_1 \partial e_2}}{\frac{\partial^2 \Pi_{bg}^2}{\partial^2 e_2}} = \frac{\frac{1}{2}\frac{\partial \eta_g}{\partial e_1}\frac{\partial \eta_b}{\partial e_2}}{\underbrace{\frac{\partial^2 \eta_b}{\partial^2 e_2}}_{\gamma_1}(1 - \frac{1}{2}\eta_g)} \tag{1.38}$$

The reaction functions in this case are *not* symmetrical, as the first part of the denominators of Eq. 1.37 and Eq. 1.38 (γ and γ_1) is the second derivative of two different functions. Therefore, the optimal level of effort for the two firms is different. Once again, the reaction functions are downward sloping and therefore the products are imperfect strategic substitutes. Figure 1.4 shows how this condition can be represented graphically.

Figure 1.4: Effort level when different technologies are chosen



It is worth noting how the linearity of the reaction functions has been adopted for simplicity of the representation. Most of all, the axes are labeled e_i and e_j to show that the adoption of one technology does not necessarily imply a higher effort (and therefore production) level.

To prove this, let us consider each case separately and see if they are feasible. The general equilibrium levels of effort are expressed by the following conditions:

$$e^*_{gb} \quad | \quad \eta\prime_g = \frac{1}{k_g}\frac{1}{1-\frac{1}{2}\eta_b} \tag{1.39}$$

$$e^*_{bg} \quad | \quad \eta\prime_b = \frac{1}{k_b}\frac{1}{1-\frac{1}{2}\eta_g} \tag{1.40}$$

Let us now consider the two alternative cases.

i) In equilibrium, the green firm produces more than the brown one.

In other words, we want to see whether it is possible that in equilibrium:

$$e^*_{gb} > e^*_{bg} \tag{1.41}$$

Then, if this is the case, it must it follow that:

$$\eta_g > \eta_b$$
$$\frac{1}{1-\frac{1}{2}\eta_b} < \frac{1}{1-\frac{1}{2}\eta_g}$$

We know that k_g is smaller than k_b (Eq. 1.23). Then, we can consider a subgroup of the values that k_g can assume which is defined as follow:

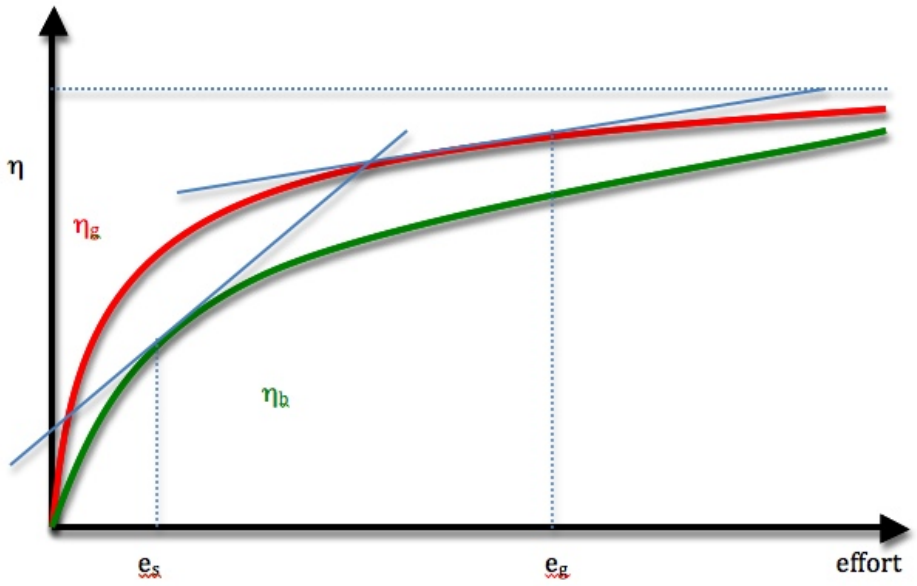
$$k_g = k_b \frac{1-\frac{1}{2}\eta_g}{1-\frac{1}{2}\eta_b} + \epsilon$$
$$\forall \epsilon \in]0; \frac{k_b}{2}\frac{\eta_g - \eta_b}{1-\frac{1}{2}\eta_b}]$$

Then, by Eq. 1.39 and Eq. 1.40:

$$\frac{k_g}{1-\frac{1}{2}\eta_b} < \frac{k_b}{1-\frac{1}{2}\eta_g}$$
$$\rightarrow \eta'_g < \eta'_b$$

These conditions are summarised in Figure 1.5. The figure shows that $e_g > e_s, \eta_g > \eta_s, \eta'_s > \eta'_g$, which proves that it is possible to have an equilibrium described by Eq. 1.41.

Figure 1.5: Marginal education level for different technologies and effort levels (1)



ii) In equilibrium, a brown firm produces more than the green one.

We now turn to consider the opposite case, and we try therefore to see if it possible that:

$$e_g < e_b \tag{1.42}$$

If we assume that is the case, by the way technologies have been defined, it is still unsure whether:

$$\eta_g \gtreqless \eta_b$$

But, then, it can be true that the left-hand side is smaller than the right-hand side. This implies that it is possible that:

$$\begin{aligned} \eta_g &< \eta_b \\ \frac{1}{1-\frac{1}{2}\eta_b} &> \frac{1}{1-\frac{1}{2}\eta_g} \\ \frac{1}{k_g}\frac{1}{1-\frac{1}{2}\eta_b} &> \frac{1}{k_b}\frac{1}{1-\frac{1}{2}\eta_g} \end{aligned}$$

since we know that

$$k_g < k_b$$

is true by definition. We now have to show that:

$$\eta'_g > \eta'_b$$

By definition, we also know that:

$$\exists \tilde{e} \mid \forall \bar{e} < \tilde{e} \rightarrow \eta'_g(\bar{e}) > \eta'_b(\bar{e})$$

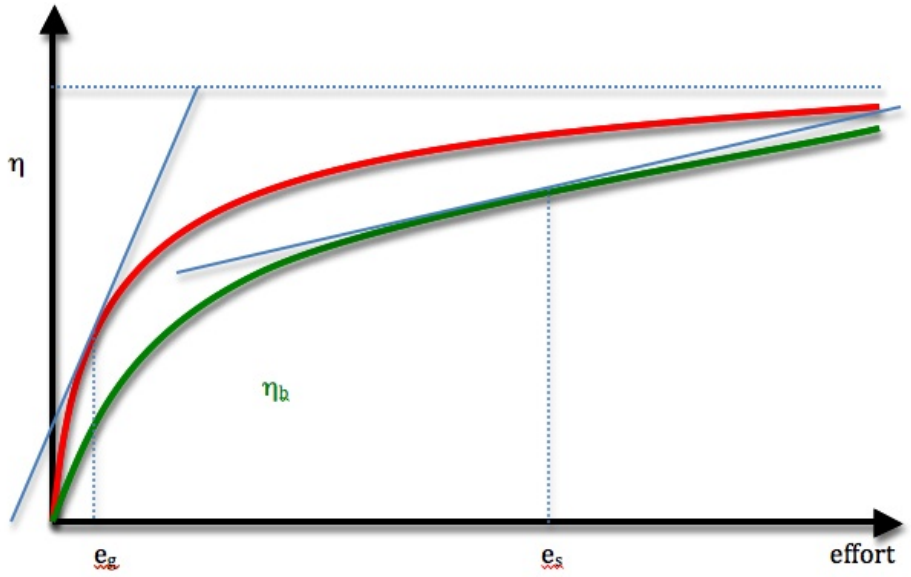
As η'_i is continuous and decreasing, whenever the equilibrium level satisfies the condition $e^* < \tilde{e}$. Then,

$$\eta'_g(e_g) > \eta'_b(e_g) > \eta'_b(e_b)$$

which is shown in the Figure 1.6. The figure shows that $e_b > e_g, \eta_b > \eta_g, \eta'_g > \eta'_b$, which is what we wanted to prove.

Conclusion 1 *If firms choose different technologies, it is not possible to determine which of the two will produce more, unless technology functions are further specified.*

Figure 1.6: Marginal education level for different technologies and effort levels (2)



It is important to note that this example is particularly general, as no further hypothesis has been made on the shape of η_i.

Lemma 2 *If firms choose different technologies, it is not possible to determine who will make the highest profit, unless more assumptions are made.*

This is already a very important result, as it implies that with no coordination possible, it is difficult to determine what the final outcome would be, should this be the equilibrium[18].

[18]Suppose that the payoff matrix is as follows:

	G	B
G	$2,2$	$4,5$
B	$5,4$	$3,3$

Pareto equilibria are $(B,G),(G,B)$. However, as there is no possibility of communication between the two players, chances are that the solution to this game would be (B,B). But again, if the NW and SE payoffs were inverted, the likely solution would be (G,G), proving the statement just made.

1.4 Results

We now present the findings of this model. The next two paragraphs will draw broad conclusion derived from the solution of the general model, describing the producers' dominant strategy (1.4.1) and the policy maker's alternatives to maximise social welfare (1.4.2). Paragraph 1.4.3, finally, presents a functional specification, in order to exemplify in more detail the main results.

In the previous section, we have presented the model and the equilibrium conditions according to producers' choices. We are now ready to address the two main questions, namely:

1. What technology is each producer going to adopt?

2. What is the best policy the government can adopt in order to achieve social optimum level?

To answer the latter question, we need to (a) define a social welfare function; and (b) answer the first question. As we are mainly interested in the supply side of the market, we have assumed that goods are meant for export; in this way, we can disregard consumers' utility. Social welfare, therefore, can be defined as follows:

$$SW = \Pi_1 + \Pi_2 - d \tag{1.43}$$

where Π_i is the profit of the firm i and d represents any eventual damage caused by the production of brown goods. As we have assumed that consumers are beyond the scope of this paper, then the damage has to come from production practices.

1.4.1 Producers' strategy

In this section, we will try to establish how a firm chooses the technology to adopt. A firms' goal is to maximise their own private profit. As d represents external costs, firms will not consider it when choosing their technology, implying that profit maximisation may lead to results which are not social best. Let us consider firstly the case in which firms choose the same technology and then the case in which they choose different technologies.

Same technology.

Going back to Eq. 1.27, we have noticed that it has a straightforward interpretation. When the two firms adopt the same technology, their levels of effort, and therefore quantity produced, are equal. Therefore the profit function can be written as:

$$\begin{aligned} \Pi^*_{ii} &= k_i \left\{ \eta_i(e^*_{ii}) \left[1 - \frac{1}{2}\eta_i(e^*_{ii}) \right] \right\} - e^*_{ii} \\ \Pi^*_{ii} &= k_i \left[\eta_i(e^*_{ii}) - \frac{1}{2}\eta_i^2(e^*_{ii}) \right] - e^*_{ii} \\ i &= g, b \end{aligned} \tag{1.44}$$

As η_i is concave, Eq. 1.44, is maximised for finite and positive values of e^*_{ii}. We have also previously showed that

$$e^*_{gg} \gtrless e^*_{bb}$$

Then, the optimal level of profit in the market when both firms choose the technology i can either be larger or smaller compared to the profit level when both firms choose technology j, depending on relative marginal profits of production $(k_g - k_b)$ and the relative effectiveness of the effort (η). In fact,

considering Eq. 1.21 and Eq. 1.17 , even considering the same level of effort the disequality could take either directions. In other words

$$\Pi_{gg}(\hat{e}) \gtrless \Pi^*_{bb}(\hat{e})$$

Different Technologies.

Even more ambiguous is the interpretation of the results when the two firms choose different technologies, as the profit functions depend on both optimal effort levels and different effectiveness of effort.

In the previous section, we have showed (Eq. 1.33) that, in equilibrium, the firm putting the highest effort may have adopted either technology. It is now straightforward to show that, in equilibrium, when the firms adopt different tecnologies, either can be the one making the highest profit, that is:

$$\Pi^*_{ij} \gtrless \Pi^*_{ji}$$

as, *ceteris paribus*, green producers have a lower marginal revenue ($k_g < k_b$) but a higher return to education ($\eta_g > \eta_b$), and vice versa. If more assumptions are not made, it is not possible to evaluate which technology will maximise private profit.

Once the exogenous parameters (shape of η_i, k_i) are set, firms' choices of technology and effort are univocally determined. For firms, choosing a green or a spurious technology is relevant only to the extent that it leads to the maximum profit. The choice of one over the other has no other ethical or strategic concern. Which means that the change in one of the parameters might imply a switch of technology. No concerns on potential externalities are present.

Furthermore, we have pointed out how the products of the two firms are always strategic substitutes: if a firm decides to increase her effort (and therefore production), the competitor will be reacting by decreasing her effort (and production).

Remark 3 *The model presented here explicitly excludes the possibility that a firm may opt for the green technology for marketing or reputational reasons. This is because we are focusing on a market in which social welfare depends on the perceived quality of products, rather than the real quality, as the truth is never known by consumers. The main objective for the firm is to maximise profit; green technology is one way to convince consumers more quickly to make a purchase.*

Conclusion 4 *In a market for pure credence good, the choice of technology is not dependent on any consideration but profit maximisation.*

This could give a different meaning to the warm glow of giving, as firms do the "moral" thing purely for private interest, as there may be the chance this may never be found out.

Conclusion 5 *Firms may maximise profit by adopting any of the three possible combination of technologies (both green, both brown, one brown and one green).*

Conclusion 6 *Once exogenous parameters are set, firms' choice of technology is univocally determined.*

Conclusion 7 *Technologies are considered strategic substitutes: if a company increases her effort (production), the other reacts by reducing her own.*

Conclusion 8 *Due to the characteristics of the market, reputation building is neither useful nor possible.*

1.4.2 Public policy

We can turn now to the second question. How can a policy maker push the economy towards the maximum level of social welfare? Social welfare has previously been defined as:

$$SW = \Pi_1 + \Pi_2 - d$$

The first consideration is that as producers have not got an *a priori* preferred option, it is impossible for the policy maker to take a policy resolution applicable to all circumstances. We therefore try to analyse the different scenarios and see what the policy maker's best response is.

We start separating two cases, according the value of d[19].

Public policy with no externalities

We start looking at the special case, in which

$$d = 0$$

Proposition 9 *If there are no externalities, then private profit maximisation is likely to coincide with social optimum equilibrium.*

In fact, social welfare is simply the sum of producers' private profits. Firms act rationally and therefore they make choices that maximise their own profit. As consumers' surplus is not included in our definition of social welfare, then it

[19]The no externalities case is presented here as a benchmark for the other -more interesting- scenario, as very often credence goods have some sort of externalities and therefore the assumption of zero externalities may sound unrealistic. However, one could consider this particular assumption in a different way: if the external costs happen at time of consumption, and the products are exported, then the government would have no incentive to legislate to protect people outisde its sovereignty. In other words, d=0 if only production is considered, making this scenario not only realistic but also relevant to policy making.

is unimportant if some consumers buy brown products believing they are green instead. In the given setting, the market becomes similar to a neo-classical market. There may be the possibility that, due to strategic interactions, firms may end up in non-Pareto efficient equilibria, as we will discuss further on.

Proposition 10 *An equilibrium with no third-party labels not only is feasible, but it could also be a socially optimal equilibrium.*

It is feasible that social welfare can be maximised with no green products in the market and therefore the government shouldn't intervene. This case is particularly evident as we assumed that there are no production-related externalities. More generally, it is possible that the external damage is lower than the difference between the the private profits for (B, B) and the second best alternative.

Let us consider the payoff matrix reported in Table 1.1.

Table 1.1: Payoff Matrix

	G	B
G	Π_{gg}, Π_{gg}	Π_{gb}, Π_{bg}
B	Π_{bg}, Π_{gb}	Π_{bb}, Π_{bb}

To have a market with only brown products as a stable equilibrium, it has to be true that:

$$\begin{aligned} \Pi_{bb} &> \Pi_{gb} \\ \Pi_{bg} &> \Pi_{gg} \end{aligned}$$

which guarantees that B is a dominant strategy and (b, b) the only Nash Equilibrium. If, then, it is also true that:

$$\Pi_{bb} > \Pi_{gg}$$

then (B, B) is Pareto efficient as well. Finally, if

$$2\Pi_{bb} > \Pi_{gb} + \Pi_{bg}$$

then (B, B) is also social optimum and therefore the government ought not intervene.

Beyond the mathematical derivation, it is important to see when this could be the case in the real world. This could happen if any of the following four condition applies:

a) communication is very noisy and/or consumers are very confused. If this is the case, green producers would have to spend a lot of effort trying to convince consumers of their veridicity. Put in another way, a brown producer may use the confusion in the market to easily attract consumers to her stores;

b) products are multi-dimensional. Consumers care about the certified characteristic, but there are other features -often even green ones- which are taken into consideration at the moment of purchase and therefore consumers' choice may not be univocal. This is not necessarily due to consumers' lack of information, but it could be due to bounded rationality or to incomplete information. Even the most careful of consumers would be hard pressed to choose the greenest product between organic Australian beef coming from free grazing animals and non-organic British beef (or any other combination). Some of these characteristics may as well be self-certified.

c) if all the firms in the market advertise extensively, the risk is cannibalisation; therefore, the market's return to advertising becomes negative. In other words, firms increase effort, but the market does not increase in size; this is a

cost both for the firms (as effort is costly) and for society. This also implies that it may be the case that adopting a more expensive (green) technology may not pay off;

d) the cost of the green technology is particularly high; or, put in other terms, the benefit coming from the green technology are small. For example, many local producers find that affiliation to "Fair Trade" is not worth it, even when they already tick all the boxes to qualify, as the certification per se is too costly.

Proposition 11 *Banning brown production may not be advisable.*

If the policy maker were to prefer green production over brown (on moral grounds or because of externalities), then it may be still possible that if the Government were to ban spurious labels, social welfare could deteriorate.

In other words, if (B, B) is Nash (and Pareto) equilibrium, *ceteris paribus*, banning the brown technology may not improve on social welfare.

However, it is important to consider of the implication a ban of the brown technology would have on conusmers' behaviour; in other words, whether this ban would alter the effect of education (the shape of η). Let us consider the different possible cases:

1. Spurious labels are banned and η is unchanged: in this case, the only solution possible is (G, G); by assumption this solution was inferior to (B, B) and therefore social welfare decreases;

2. η changes if brown technology is banned. (Spurious labels are banned and consumers facing only the truthful label are more receptive towards it). A numerical example should help. Let us consider the profits reported in Table 1.2.

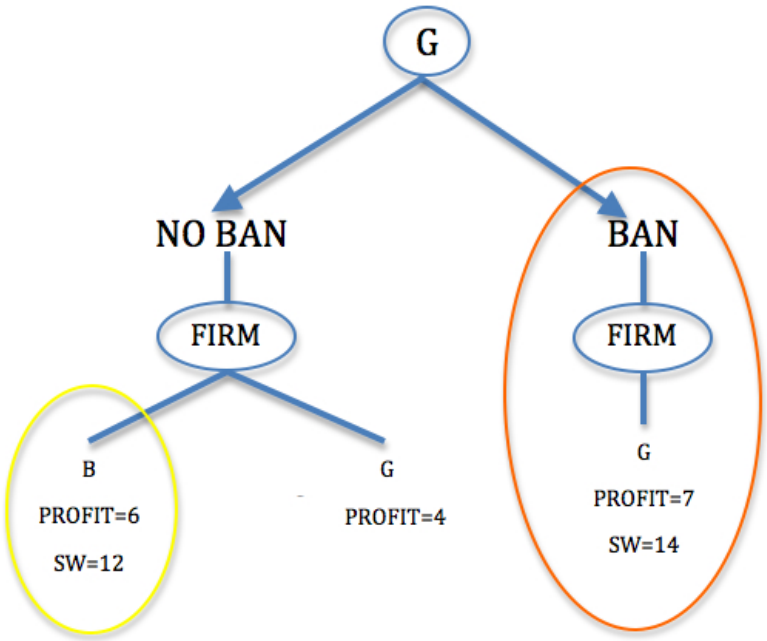
where (B, B) is Pareto and Nash Equilibrium. However, if the government were to ban the brown technology, then consumers might be less confused, reading the ban as a *de facto* endorsement of the other products and therefore

Table 1.2: Payoff Matrix

	G	B
G	$4, 4$	$2, 5$
B	$5, 2$	$6, 6$

education becomes more effective and η_g is going to shift upward. This may be due to the fact that consumers are aware that there is now a tighter control on the veridicity of labels. In this way, in equilibrium each firm will make a profit of -say- 7.

Figure 1.7: Game Tree: Government/Producers interaction



As no other solution is possible, Figure 1.7 represents the decision the government faces. The firm would opt for (B, B) in the no-ban scenario. If the policy maker enforces the ban, then the only solution is (G, G); the solution of

the game is then for the government to "ban" (and for the firm to use green technology) maximising social welfare. However, this clearly depends on the effect the ban has on η[20].

But an important lesson comes from this:

Remark 12 *If the government is able to affect the effectiveness of education, it is possible to improve social welfare by banning brown technology, even when the latter was previously Pareto optimal.*

3- (B, B) **is a Nash equilibrium, but not Pareto efficient.**

Remark 13 *If* (B, B) *is Nash Equilibrium but not Pareto Efficient, banning in-house certification will impact positively on social welfare.*

Let us suppose that the profits pattern is a prisoner's dilemma (Table 1.3).

Table 1.3: A Prisoner's dilemma Payoff Matrix

	G	B
G	$4, 4$	$2, 7$
B	$7, 2$	$3, 3$

In other words, if b is dominant strategy but (G, G) is Pareto superior to (B, B), then government intervention (eg. via minimum standards, or making third-party labels compulsory) increases social welfare and also private profit.

In the real world, this is one of the reasons a policy maker may tighten environmental standards, which is the tantamount to banning brown producers. This may effectively lead to a change in the consumers' perception of the newly created standards, as they are guaranteed by the government.

[20]It is easy to see how the change could have been lower making (G, G) inferior to (B, B).

Remark 14 *The concession of a limited number of licences may be a better option than a total ban, when a dominated strategy would lead to a Pareto optimal equilibrium, which is not a Nash equilibrium.*

Banning brown production in the previous example leads to a Pareto superior solution, but it may not lead to social optimum, as it may be the case that:

$$2\Pi_{gg} < \Pi_{gb} + \Pi_{bg}$$

as it is showed in table 1.3 ($4 * 2 = 8 < 9 = 2 + 7$).

In this case the equilibrium with the highest social welfare is the scenario in which each firm chooses a different technology. As coordination is not possible, this is a more difficult equilibrium to obtain.

This is a particular case, possibly less easily applicable to the real world. However, one could imagine how a policy maker could award only one company with governmental endorsement (be it via license, or awarding the best practice in the market,...). This company however may have particular limitation (total size of the market, geographical distribution, multidimensionality of the products...) which would imply steep decreasing returns to education (or more in general, fast increasing marginal costs), leaving space for a second cheaper alternative[21].

Similarly to the case just made, it is important to highlight:

Remark 15 *Banning green technology could be welfare improving if* (G, G) *represents a Nash equilibrium but it's not Pareto efficient.*

[21] Considering a similar situation, outside the green market, in the UK, particular retailers are awarded with "Royal Appointment". This is a sign of distinction and allegedly higher quality. However, the geographical localisation or the scale of the business may make it non-economical for them to serve the whole country.

It is easy to show how in theory that is easily attainable[22]. As the two technologies are substitutes both for firms and government and there are no externalities, the policy maker should not hesitate to ban the green technology, unless there are other issues at stake. This seems counter-intuitive, but it may be the case that producers are pushed into a "green trap", where playing environmental true blue is the only acceptable strategy. A recent event exemplifies the situation quite closely: after many British supermarkets have created a brand for their own "bags for life", it has turned out that the costs of these bags is actually higher than the damage coming from the poor disposal of normal plastic bags. Firms were under consumers' pressure, and therefore they chose the greener-looking alternative. If the government had intervened, private profit, as well as social welfare would have improved.

Taking stock, we have outlined the different circumstances in which the government ought to intervene to increase social welfare, highlighting how to best do so, when the market has no negative externalities.

Public policy in presence of externalities

Let us now consider the case

$$d \neq 0$$

Generally speaking, due to the negative externalities, governmental intervention is *more likely* to be welfare enhancing.

Examining the discussion in the previous paragraph, whenever there was a case for the policy maker to intervene, then *a fortiori* he should intervene in this case.

[22]Looking at table 1.3, one only needs to swap the names on columns/rows.

If, instead, there are some externalities, then the government will respond to the producers' choice, if it does not lead to a desirable outcome. It is important to see what these results imply in terms of policy intervention.

Proposition 16 *If* (B, B) *is the Nash Equilibrium but not Pareto efficient, then if externality exists,* $(G, G) > (B, B)$ *and banning in-house labels would improve social welfare.*

This is rather self-explanatory. If instead (B, B) is also Pareto efficient, then the social optimum could be either scenario, depending on the veridicity of the following condition:

$$\Pi_{gg} > \Pi_{bb} - \frac{d}{2} \tag{1.45}$$

If the condition above is *not* satisfied, then even in presence of externalities, it may still be best for society to opt for the brown product, provided the damages are either very small or inflicted outside the borders. If the condition above is true, then social welfare can be increased by either banning the brown technology or by a Pigouvian tax. The two in theory would have the same effect in equilibrium. However, if the former affects consumers' behaviour (see previous discussion), then the ban would be superior to the tax.

In general,

Proposition 17 *If the policy maker is able to make the producers internalise the externalities, then the market will behave as a perfect competitive market, reaching social optimum. This may be via the use of either labels.*

This could be an indirect way to sort the issue: by charging a Pigouvian tax, the policy maker forces producers to take the external costs into consideration. This increases the cost of adopting brown technology; again to see which

alternative leads to social optimum, one has to consider condition 1.45. This is of course nothing new. However, it is interesting to note that in the real world, when the externalities are low, the policy maker may decide not to intervene, due to the risk of miscalculating the effective level of externalities and for the burden of enforcing the tax or regulation, which may offset the gains from the internalisation of externalities. The other problem in this kind of market is the main distinguishing characteristic of credence: it would be hard for the government to distinguish brown products from the green ones. This would be simple to fix in his model, as it would only require to tax products with in-house labels. However, in the real world, the scenario is clearly more complicated, as green products may hold with in-house labels.

One, centralised label

Finally, we consider two (connected) aspects of this market, ie. a centralised label and the role of industry level certification.

Many people advocate the centralisation of labels, in order to cut the number of schemes present in a market. In our model, it is implicitly assumed that if the two producers adopt the same *kind* of label, they do use different labels. To see if a single label works better than two of the same kind, we compare the amount of people convinced by the two firms with the number of people convinced by a larger producer using a double level of effort[23]. This is expressed by the following condition:

$$2\eta(e) - \eta^2(e) > \eta(2e) \tag{1.46}$$

If the condition does not hold, then it is better to have a unique label, meaning that the policy maker could impose a centralised label to whomever wanted a third-party certification. Re-writing the equation, we obtain:

[23] In other words, we are looking for potential (dis)economies of scale.

$$2\eta(e) - \eta(2e) > \eta^2(e)$$

On the left-hand side we have a measure of the diseconomies of scale: as effort has decreasing returns, then a single body educating consumers would be marginally less effective. On the other hand, on the right-hand side we have the "wasted" efforts of the two rival companies who excercise part of their effort on the same audience. This overlapping, of course, does not exist if there is only one label.

It has been noted how markets are flooded with different green labels and it has also been noted how consumers are bounded rational. One could assume that a reduced number of labels would make it easier for consumers to discern the available information. But this assumption should be tested.

We have therefore presented the condition for which firms would be better to join efforts and create one single label. Another connected issues, is the role of the industry as an entity. It is a fact that in many markets, firms are aligning their strategies and creating a industry-wide response to the certification issue. This enhances credibility of each single firm and it also helps to reduce the costs of keeping up the label, via economies of scale. The focus of this paper is on the choice between third party certification and a spurious label and therefore looking at industry level lies to some extent outside the remit of this model. However, we brie‡y consider how much (or little) the current model should be adapted to include that.

A simple way to do so would be to give each firm the choice between the existing labels and a third one. The features of this new industry-wide label would be that its marketability is higher than both the brown and green labels. In other words,

$$\eta_{ind} > \eta_g > \eta_b \tag{1.47}$$

where *ind* stands for industry. On top of that we would assume that the cost of these products is higher than the one for the brown product (for the same reasons used to define green/brown costs), but it would be cheaper than the existing green products, as the industry-level scheme can exploit economies of scale. This means that:

$$c_g > c_{ind} > c_b \tag{1.48}$$

but considering conditions 1.47, 1.48 and 1.46, then it must be true that the new scheme is strictly superior to the existing green label (and more marketable but more expensive than the brown one). This implies that the choice for a firm would be still between two technologies. For this scenario, the existing model would hold pretty much unchanged, once the definition of green label has been adjusted.

However, if condition 1.41 holds, then the model would have to be expanded significantly, by adding a third option for the firms, adding assumptions on how η_{ind} would change if one (or both) firms join the scheme, and so on. Future research could start from the results presented here to look into this.We believe that, despite the augmented complexity and extra scenario, the quality of the results should be unchanged. This means that for given values (k, η), firms will choose different technologies, whilst for other they will go for the same, for some values the brown one and for some other the alternative(s).

1.4.3 Functional specification

Let us consider now a function specification to gain more insight into the considerations just made. As much as this is a considerate restriction of generality, it will be shown that the quality of the results reflects the general model for which different values of the unknown parameters will make the optimal choice different in terms of level of effort and in terms of technology.

As has been shown previously, the generic function does not allow us to make any more considerations on the profits in each scenario and therefore on the level of efforts and technology that firms will choose. Let us now consider a function specification of the generic one. In particular, we define:

$$\eta_i(x_m) = 1 - e^{-\alpha x_m} \tag{1.49}$$

α is a measure of the relative inefficiency of the effort of a standard firm, with respect to a green one. Explicitly, it is possible to re-write the previous equation as:

$$\begin{aligned} \eta_g(x_m) &= 1 - e^{-x_m} \\ \alpha_g &= 1 \end{aligned}$$

$$\begin{aligned} \eta_b(x_m) &= 1 - e^{-\alpha x_m} \\ \text{where } \alpha_b &= \alpha \\ 0 &< \alpha \leq 1 \end{aligned}$$

The higher the inefficiency, the harder for a firm using the standard technology to convince consumers that her products are green. The closer α is to 1, the closer η_b is to η_g and therefore the less incentive to choose a green technology (as the marginal profit of production is lower and it has similar marginal return to education).

It is also easy to see that this particular function satisfies the initial hypothesis. In fact

$$\begin{aligned} \eta_i\prime &> 0: & \frac{\partial\left(1-e^{-\alpha x_m}\right)}{\partial x} &= \alpha e^{-\alpha x_m} > 0 \rightarrow \forall x \\ \eta_i\prime\prime &< 0: & \frac{\partial^2\left(1-e^{-\alpha x_m}\right)}{\partial^2 x} &= -\alpha^2 e^{-\alpha x_m} < 0 \rightarrow \forall x \end{aligned}$$

$$\eta_g(\overline{e}) > \eta_b(\overline{e}): \qquad 1-e^{-\bar{x}} > 1-e^{-\alpha\bar{x}} \tag{1.50}$$

$$\bar{x} > \alpha\bar{x} \rightarrow \forall x \tag{1.51}$$

$$\exists\tilde{e} \mid \forall\overline{e} \in [0;\tilde{e}] \rightarrow \quad \eta\prime_g(\overline{e}) > \eta\prime_s(\overline{e})$$

$$e^{-x_m} > \alpha e^{-\alpha x_m} \tag{1.52}$$

$$\rightarrow x < \frac{\log\alpha}{\alpha-1} \tag{1.53}$$

Re-writing now the profit function,

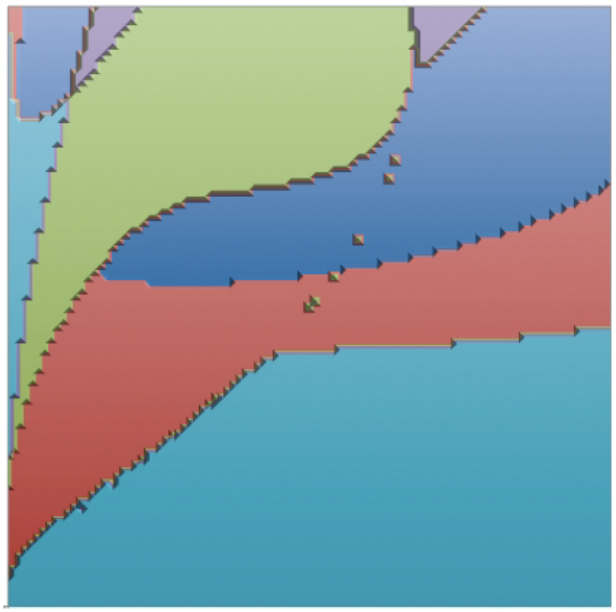
$$\begin{aligned} \Pi_{mn} &= k_m\left\{1-e^{-\alpha x_m}\left[1-\frac{1}{2}\left(1-e^{-\alpha_n x_n}\right)\right]\right\}-x_m \\ \Pi_{mn} &= k_m\left[1-\frac{1}{2}e^{-\alpha x_m}\left(1+e^{-\alpha_n x_n}\right)\right]-x_m \end{aligned}$$

It is possible to simplify further the notation by setting:

$$\begin{aligned} k_b &= 1 \\ &\longrightarrow k_g = k \quad 0<k<1 \\ \Pi_{g,i} &= k\left[1-e^{-x_g}\left(\frac{1}{2}+\frac{1}{2}e^{-\alpha_i x_i}\right)\right]-x_g \\ \Pi_{b,i} &= 1-e^{-\alpha x_b}\left(\frac{1}{2}+\frac{1}{2}e^{-\alpha_i x_i}\right)-x_b \\ i &= g,b \end{aligned}$$

It is not straightforward to find the values for which a firm would choose one or the other strategy. We therefore present a graphic solution. In the Appendix

Figure 1.8: Strategic Equilibria



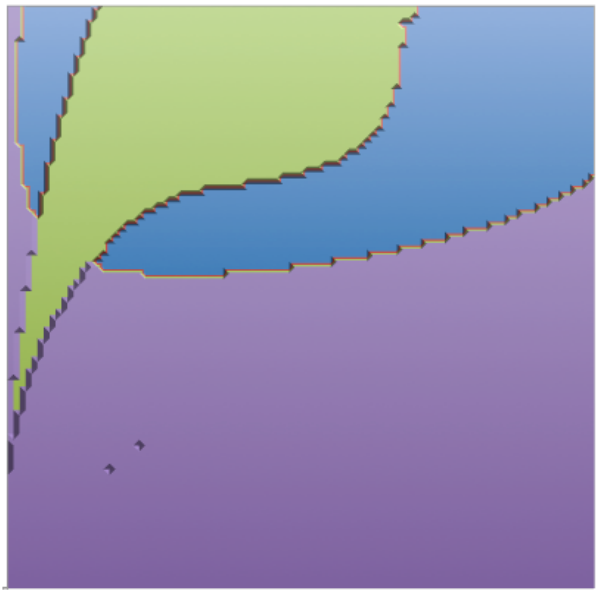
the mathematical derivation is presented. The different scenarios are represented in Figure 1.8.

α is represented on the y-axis and k on the x-axis. The light blue area represents the values for which both firms choose the green technology; the purple area represents the values for which both firms choose brown technology and the green where firms choose different technologies. Red and Blue areas show the values for which there are two equilibria (G;G) and (B;B); the different colours show when profit is higher if both choose green technology (red) or brown technology (blue).

Graph 1.9 instead represents the maximisation of social welfare. Social welfare is maximised if both firms choose green technology (purple), brown technology (blue) or different technologies (green).

The main information we can derive from the first graph is that firms will choose their strategies according to the change of the effectiveness of education

Figure 1.9: Outcomes maximising Social Welfare

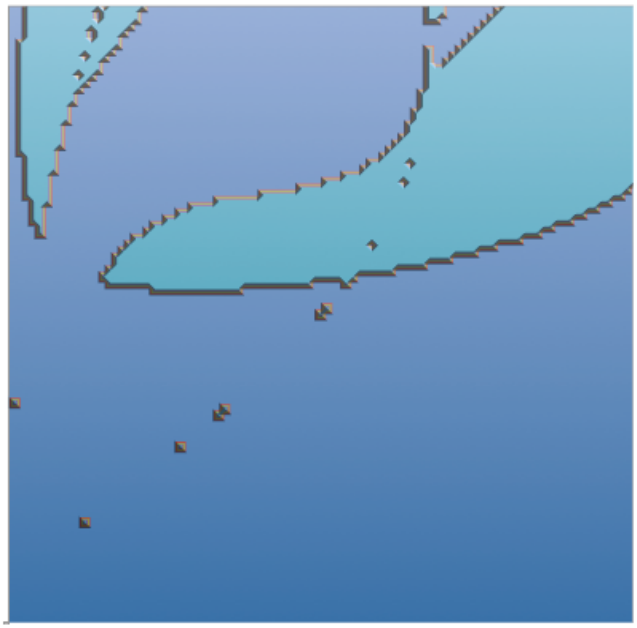


and relative cost of production. Similarly, the second graph shows that the policy maker will be interested in pursuing different outcomes to maximise social welfare. As a direct conclusion of these two considerations, it is obvious that the government (i) may or may not need to intervene to improve on social welfare and (ii) if she wishes to do so, best policies may vary.

Combining the two previous graphs, we obtain Graph 1.10, which shows when Government ought to intervene to maximise social welfare (light blue area) and when, instead, intervention is not require (dark blue).

It is important to highlight at this point how this numerical example is purely qualitative, rather than quantitative. In other words, the size of the areas do not want to guide the policy maker on the frequency with which she should intervene, but rather simply raise the attention to the fact that (i) the market alone may lead to optimal outcome and (ii) this outcome may be any of the three possible ones.

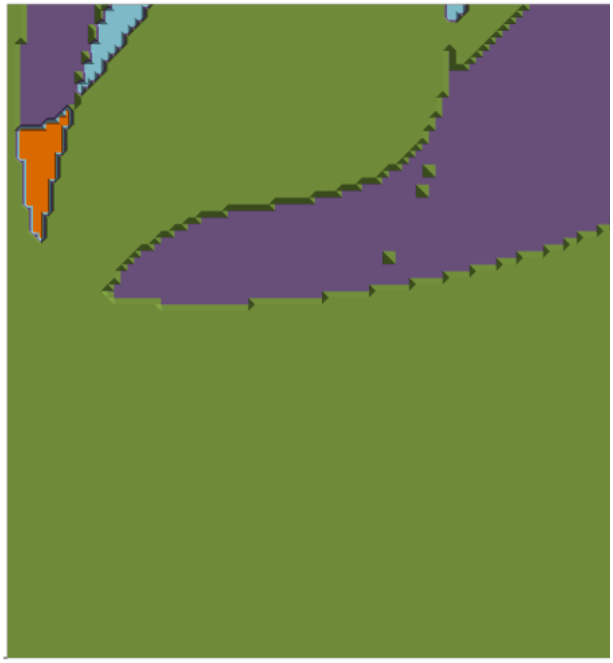
Figure 1.10: Should the Government intervene?



Graph 1.11 gives us a more in-depth vision of the previous graph, representing specifically what kind of intervention is required. The green area shows where social welfare is obtained by leaving the firms choosing freely their strategies. In the blue area, social welfare is maximised when firms choose different technologies, but they would rather both produce brown products; in the purple area social welfare is instead maximum with only brown products, whilst firms would choose different technologies. Finally, the red area represents the situation in which firms would choose to produce only green products, but social welfare is maximised with the production of only brown products. We have already discussed in the previous section what policy implications these results would have.

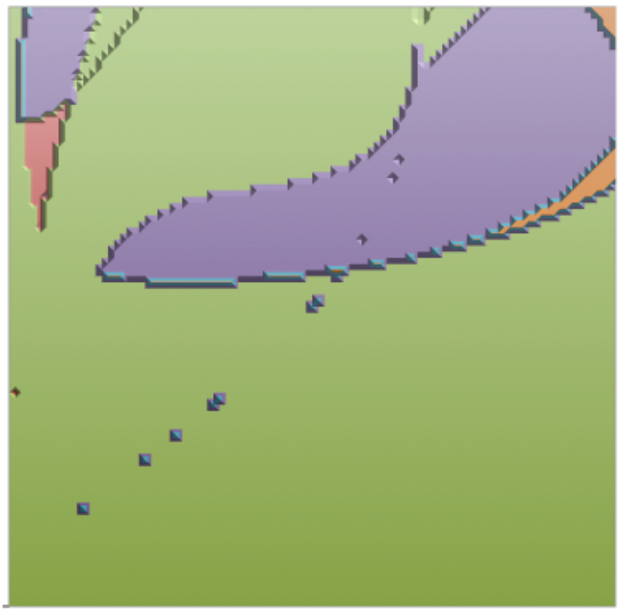
To conclude this simple exemplification, let us now consider the case in which there are externalities.

Figure 1.11: Best Policy Maker intervention with No Externalities



Graph 1.12 and 1.13 shows how policy maker's best strategy changes when the production of a unit of brown products has low (former graph) or high (latter) externality. It is possible to see how the scenario in which only green products are produced becomes more likely to be maximising social welfare (orange area, when firms would opt for different technologies and blue when they would both opt for brown technology). The green area still represents where social welfare is maximised by private behaviour; the shrinking purple and red areas are still where social welfare is maximised by only producing brown products, whilst firms would choose different technologies (purple) or only green products (red). Finally, the brown area is where social welfare is maximised by the use of different technologies, but firms would choose to produce brown products.

Figure 1.12: Best Policy Maker intervention with Low Externalities

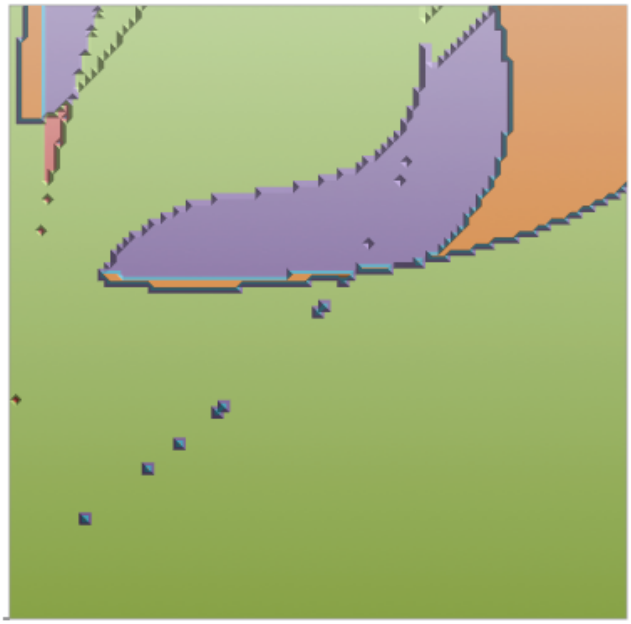


This numerical example was presented to reinforce the results presented in the paragraph before. We are now ready to put our findings together and conclude.

1.5 Conclusions

Let us summarise the results presented in the previous paragraph. In this paper, we have departed from the larger part of the literature and have assumed that even if information is available in the market, consumers may not be aware of it. We consider a market for a green credence good. Consumers only purchase goods believed to be green. As a consequence, firms must adopt a label to provide the missing information to the market, and then they also have to invest in costly effort in order to convince consumers. Firms choosing to produce brown products adopt a spurious, self-certified label, whilst green producers adopt a third-party certification. Firms choose their technology strategically.

Figure 1.13: Best Policy Maker intervention with High Externalities



Brown products are cheaper to produce but more difficult to market (ie. lower marginal return to education). There is no possibility to create reputation (if not through effort) and therefore intrinsic motives are ruled out.

We have noted that products are strategic substitutes: if firms choose the same technology then the products will be perfect substitutes. Our first important conclusion is that, according to the costs structure and the levels of effort efficiencies, the strategy that maximizes profit changes. In other words, it is not possible to say *a priori* whether the market will offer exclusively green products, or brown products or a mix of the two.

This is very important for the policy maker, as a market with no green products is not only feasible, but it could represent a stable equilibrium. The important question is, then, whether the government should intervene or not.

We showed that government's intervention is not always advisable, as a market with only brown products could be better for society. This could be

due to mainly two factors: (1) green products are relatively too expensive to produce; (2) the information market is too noisy.

If the government has a preference for a market that offers green products, then it can either invest in R&D (in order to reduce green technology costs) or invest in education (reducing the efficacy of brown firms in convincing consumers). However, in the short run, we showed how banning brown technology would be detrimental to social welfare.

Of course, the higher the externalities created by brown products, the higher the government's inclination towards solutions including green production. In the case in which the market does not reach social optimum, the government can intervene in order to move the equilibrium to a more desirable solution.

If social optimum is achieved by having the firms adopting different technologies, then the government could consider allowing for only one green license or, alternatively, it could put a quota on the brown products.

The introduction of a Pigouvian tax, as in any other market with externalities, would solve the issue, as it would completely solve the market failure and it the market could then be relied upon to allocate resources efficiently. However, when externalities are low and in particular for goods that are pure credence, this option becomes less practicable.

If social welfare is maximised by the exclusive production of green goods, then the policy maker could consider banning spurious labels, or setting minimum standards (effectively banning brown products). Three important considerations have to be made here:

1) Banning one type of labels could change consumers' perception of the remaining label. As the ban could be perceived as an implicit endorsement of the third party, education could become more effective. If this is the case, then social welfare would increase also for the reduction in the firms' total costs.

2) It is important to note how government's intervention could make firms better off, even if it may imply internalising externalities. In fact, the policy

maker can avoid the market to get stuck in a "green trap" or in a "prisoner's dilemma".

3) Forcing all companies to obtain a third-party certification can have a side-effect: firms may create ad hoc bodies, aimed at certifying as green their brown products (in other words, creating spurious third party awarded labels).

The previous point is of particular interest, as we have shown that there is evidence of this practice taking place. One solution to this would be to have a governmental label.

We have not explicitly looked at this situation, but we can draw some conclusions about it, using the results we have derived. Firstly, we have to remember that this would be a potentially good solution exclusively if green products would increase social welfare. Having a centralised label could bring advantages, as it would cut off cannibalisation completely. On the other hand, due to the decreasing return to education the net effect is uncertain. A positive effect could come from the change in consumers' behavior. If that were to happen, then for the same level of effort, more consumers would purchase the goods. This effect could be probable. On the one hand, there is evidence that the high quantity of labels creates confusion in the consumers. On the other, it has also been proved how government-backed labels acquires more credibility.

The model shows that there is ample space for the government to improve the market performance but that its intervention is not always required, nor it should necessarily be to foster environmental production. By increasing consumers' awareness (making it more difficult for brown companies to cheat consumers) or by decreasing the production cost differential, the government can make the market freely move towards an equilibrium with higher green production.

Firms should consider carefully their choices. As we have showed, adopting a spurious label could be more profitable than producing green products and

go for third-party certification. However, in reality this is a particularly risky strategy for large firms, as if unmasked, the reputational damages could be substantial. Furthermore, the policy maker is more and more keen to make legislation and monitoring tighter, meaning that the effectiveness of spurious labels will depletes in time.

Labels administrators could benefit from this analysis too, according to what their goal is. If they are interested in maximise the sales of green products, then it could be better to set a limit to membership, if the introduction of a separate label would attract more consumers. Alternatively, they could lobby for stricter rules on labelling or higher minimum standards: this would make more likely for any firm entering the market to choose to produce green products.

Our results also suggest that a green label is geographically diversified from others, then it is likely to be more effective remaining independent than by merging with a rival.

This also sets potential guiding lines for governments, as it shows that having one, unified label (eg. Euro Flower) and ban of brown production may not necessarily be the best available solution to maximise social welfare. Future research should look into the effect of market changes on the effectiveness of labels (η) to give a more precise answer to these additional questions.

The model presented here could be used as a base for future research. In particular, as it has been already noticed, it could be useful to allow for different marginal effort for each firm. This extension would allow for the model to take into consideration firms'different standing (or label schemes) in the market, as well as consumers'attempt to use past information. In this strand of extension, we can include the inclusion of a industry-level scheme, as previously described.

Another way to explicitly include reputational updates would be to make the game a repeated one, rather than a one-shot game. Another possible extension is to consider the whole market, ie. including the demand for brown prod-

ucts. In this case, price differentiation should be introduced, be it exogenously set or endogenised. But adding a different kind of consumer requires a better description of consumers' behaviour. That could be obtained, for example, by allowing firms to also engage in general advertising; or by defining the demand curve for brown products in terms of price; and so on. Obviously, all the extensions suggested would add layers of complexity which may require stronger assumptions somewhere else.

One final set of extension can come from relaxing the perfect credence feature of the good considered. This on the one hand is partly connected with reputation building, but it also allows for more and different government interventions. In fact, it would possible to endogenise a more pro-active role for the government, like minimum standards, monitoring/penalties and so on.

Chapter 2

Green Coated Chocolate - An Experiment on Information Behaviour in a Market for Environmental Credence Goods

2.1 Introduction

We have seen in the previous section that is very common for environmental features to be credence, especially when the "green" characteristic is connected with the production process or resources. These features are not apparent in the quality of the final goods/service. This means that even the most discerning buyer will not be able to tell if a product is (for example) organic, neither before the purchase nor after having tasted it, because the "organic" feature is not detectable in the product at any stage.

This is of big concern to buyers as well as sellers. On the one hand, there are consumers willing to buy "green" products, often at a premium price; on the other, we have sellers willing to provide them, but, since all the products in the market look homogeneous (as the "green" characteristic is imperceptible), the market fails, with the likely consequence that the green market will not be able to form altogether.

For this reason, some firms decide to engage in costly communication in order to pass the relevant information to interested consumers - *labelling*. By filling the communication gap and by providing consumers with all the relevant information, firms hope to attract more consumers or to charge a premium. Consumers are now able to discern the goods they prefer and consequently may be keen to pay more to get what they want.

Reliability however becomes a problem: a producer can pass on misleading information, giving the impression that goods have characteristics they do not actually possess. Obviously, if a firm makes a statement regarding the quality of their own product, it is free to make unsubstantiated statements. The incentive to mislead consumers lies in the premium or in any competitive advantage arising from the green quality.

To increase the reliability of the certified information, independent bodies are created to award labels and give quality assurance to the process. Therefore, the need to fill the information gap leads to labelling, whilst the need to increase communication reliability has lead to the creation of third-party certification.

Theory predicts that self certification is disregarded by consumers and therefore not used by producers. It is also predicted that complete information is sufficient to reach an efficient equilibrium.

In this section, we continue to analyse credence markets, but changing approach and focus. We create a market in which buyers and sellers interact, in different informational settings.

Using a laboratory experiment, we test how sellers use different labels and how buyers perceive the information available. We have also tested the effect different labels have on the overall efficiency of the market with respect to theoretic predictions. Our main goal is to examine how laboratory results compare to theoretical predictions. From these results we are then interested in drawing policy recommendations.

After **section 2.2** has set this paper in the perspective of the relevant literature, **section 2.3** presents the hypothesis on which our model is based and the experimental design, concluding with economic theory predictions. **Section 2.4** presents our empirical results, discussing their relation with the theoretical results and **section 2.5** discusses policy implications and concludes.

2.2 Literature Review

As a large part of the relevant literature has been presented in the previous section, we focus here on aspects not yet considered. Paragraph 2.2.1 looks at how efficiency can be improved in the credence markets. Paragraph 2.2.2 focuses on labelling. Firms decide to engage in further (often costly) communication, in order to signal the quality of their product. For our purposes, we are interested in distinguishing labels according to who is assessing the quality of the product: self-declarations and third-party certifications. Theoretical literature has proved how unregulated advertisement has at best no effect on the equilibrium of a market. Empirical studies are more divided. Furthermore, theory predicts that an improvement in the level of (reliable) information has a positive effect on welfare. Paragraph 2.2.3 summarises the main findings of the papers in this branch of literature (empirical, experimental and theoretical). Our interest is the effect of these two kinds of communication on the market efficiency. Paragraph 2.2.4 summarises the relevant findings of the paper.

2.2.1 Efficiency

The line between experience and credence goods is often blurred in experimental literature. We therefore present them jointly. Authors have tried to find conditions to improve efficiency in these markets. Grossman and Stiglitz (1976 and 1980) show how equilibrium is reached in markets with asymmetric and costly information. Information is treated like a normal good, the price of which, in equilibrium, will be equal to the marginal utility of its consumption. The authors conclude that because of this transaction cost, the equilibrium quantity of information will be less than optimally efficient.

Huck at al. (2010) show in their experiments that whenever it is possible for the seller to build reputation, then efficiency is improved. Reputation is built by providing good quality in subsequent periods and providing a signal for the

quality offered in future periods[1]. Reputation-building is however not possible in markets for pure credence products. This is due to the fact that (pure) credence qualities are undetectable. It is necessary for the good to have some features of experience goods (ie. to have imperfect credence characteristics).

Dulleck et al. (2011) highlight four characteristics that help solve market failure in credence good markets: liability (the necessity to always provide at least the quality needed by consumers), verifiability (consumers can correctly assess sellers' actions), reputation (buyers can identify a seller's trading partners and remember the quality offered in the past) and competition (free choice of trading partner among a set). The authors find that although theory predicts that verifiability is an important factor to improve efficiency, in their experiment, liability and competition are by far the most important factors. Liability has a strong impact on efficiency: without it, even if trade increases, efficiency may drop because of under-treatment. Competition is the next most important driver for an efficient market. However, these characteristics are not sufficient to reach full efficiency.

McNulty and Huffman (1996) draw from Stigler (1961) and show that the market equilibrium price is affected by the actions of decision makers acquiring optional amounts of information.

2.2.2 Signalling and labelling

Firms may be willing to volunteer information, if they have the opportunity to get a private benefit (premium, fidelisation of consumers, competitive edge etc...). Miller and Plott (1985) consider an experimental market in which sellers can engage in costly signalling. Quality of sellers is exogenous and information cost is higher for lower quality sellers. Signalling for low quality products is more expensive, as it is more difficult for low-quality producers to convince people of something that is not true. In other words, signalling becomes only

[1] A reputation building model is presented in the last part of this work.

partially informative (as low-quality sellers can use it too). It is shown that a separating equilibrium is achieved only if the difference in marginal cost of signalling is significantly high.

Signalling is necessary in markets for environmentally friendly products. In the last 30 years, green labels have grown very rapidly and there are now tens of thousands of claims made by producers about the environmental qualities of their products. Firms producing high quality products want to separate from the rest of the producers to be able to claim the premium. Larson (2002) empirically shows that if a seller can create a credible label, then the market will split into two fragments (green and brown products) with different demand curves and prices of equilibrium. This is possible as sellers can build a reputation.

On the other hand, low quality producers have an incentive to pool with the high quality ones, by engaging in further communication to make their goods look greener than they are.

But if unverifiable, any sort of communication may deteriorate into babbling, where communication does not convey any information and it is not connected to anyone's payoff (cheap talk) - in environmental economics terms, **greenwash**[2]. Terrachoice (2009) found that 98% of the 2219 labels considered in the report perpetrates some degree of greenwashing. It is also worth noting that, in general, it is very difficult to prevent subtly misleading communications, when the seller is actually not lying about the product.

For example, a company may have started to recycle paper within its offices, and therefore claim that its products are "now more environmentally friendly than ever!!", even if production has not been changed. The claim is therefore true, but consumers may assume that the degree of eco-friendliness of the products is higher than it actually is. Or the label could simply introduce graphics

[2]Greenwashing can be then defined as the effort producers put into making consumers believe a product is more environmentally friendly than it actually is. Self-reporting green characteristics of a product is very common. The term is attributed to J. Westerveld, who seems to have used the term for the first time in a series of articles in 1986.

that may be associated with eco-friendliness. A large British supermarket chain recently changed the packaging of one range of its eggs: all the writing is now in different shades of green and a stylised tree has been added. The tree is commonly associated with paper recycling and more broadly with eco-friendliness. However, at a closer look, the product has no particular green characteristics.

To avoid greenwashing, scholars (see for example, Kuhn (2005)) have highlighted that not all the labels have the same effectiveness. In particular, labels are divided according to who awards them: (a) in-house, if the statement is self-declared; and (b) third-party, if an independent organisation is certifying this particular quality.

Apart from the misleading use of self-declared labels, some green producers may decide to use in-house advertisements to promote real features of their products. For instance, many companies have become weary of paying the large fee to be part of the "fair trade" network and have decided instead to improve the conditions of their workers and then advertise the change (among the most notable cases, Nestlé and Lavazza).

In literature, greenwashing has gained interest in the last 30 years. Cason and Gangadharan (2002) show in their experiment that greenwashing can be explained as the effect of the looseness in environmental claims regulation. Crawford and Sobel (1982) and Farrell and Rabin (1996) investigate when communication becomes cheap talk: if the interests of sellers and buyers are different enough, then communication has no effect on the efficiency of the market.

Mason (2009) characterises certification as a noisy process in which green sellers are more likely to pass than brown ones, under the assumption that monitoring cannot be continuous.

Due to the uncertainty about labels reliability, consumers may struggle to interpret them. Boulding and Kirmani (1993) show that, in an experimental market for environmentally friendly products, consumers may even look at

warranties as a non-credible signal. But, if (i) signalling is costly and (ii) the information is lost, then not only there is going to be pooled equilibrium (if not a market for lemons), but efficiency may be even lower than in a market with no communication, because of the waste of resources in communication. Paradoxically, the extra provision of information depletes social welfare instead of increasing it.

In most real world markets, the two kinds of labels coexist.

2.2.3 Welfare implications of introduction of labels

Laboratory experiments testing the efficiency of labels in credence good markets are not abundant and tend to give a rather mixed outcome. Cason and Gangadharan (2002) show that in their experiment sellers opt for verifiable certification (even if costly) over cheap talk, delivering more clean products and enhancing efficiency. Reputation plays an important role in striving for efficiency. Mahenc (2009) points out how, empirically, the presence of unsubstantiated claims in a market creates scepticism in consumers, undermining the credibility of eco-labelling and therefore decreasing the level of efficiency of the market. If the eco-label is fully trusted, then the cost of labelling can be seen as a *Ramsey tax*.

Dosi and Moretto (2001), instead, question the statement that labelling necessarily improves market efficiency and they demonstrate when that is not the case. The authors focus on how labels affect investment choices for a firm that decides to adopt certification for part of its products. Mason (2009) finds that eco-labelling is not necessarily increasing market efficiency and that green sellers' payoffs are more volatile when certification is introduced, due to the noise in label awarding. Henriksen (1998) shows that the change in social welfare caused by the introduction of certification depends on the relative change in demand for green goods with respect to its supply. If demand is larger than

supply, then certification increases social welfare, otherwise it creates dead-weight losses. If the demand is not affected by the introduction of labels, then only green buyers benefit from it.

Larson (2002) empirically shows how an increase in the demand for certified goods would decrease the demand for non-certified goods and therefore their price. The new price differential would attract some of the green consumers back to the non labelled products: this process may erode the chance for green sellers to command a premium for their products. The size of this phenomenon clearly depends on the price elasticity of demand. Björner et al. (2004) mention the risk of the shift in the demands of labelled and unlabelled goods, causing social welfare to drop, even when green products may push brown ones out of the market.

Bougherara et al. (2003) point out, in their empirical research, another risk of perverse side effects coming from the introduction of (labelled) green products: if consumers are interested only in the marginal social cost coming from the consumption of a product, the shift to greener products may lead to a higher overall consumption which may, in turn, create an even higher negative externality than before the introduction of signalling. In other words, consumers move from brown to green products, reducing the unit externality, but if overall consumption increases, this may lead to a higher total level of externality.

Finally, Bougherara and Piguet (2009) study, with a laboratory experiment, the effect of different information costs on the efficiency of a market for credence goods, in which buyers can demand further information for a fee. The paper finds that if the cost of certification is low enough, then adverse selection can be avoided, but, after a certain threshold, green products are driven out of the market. The authors also consider the role of self-declarations, finding that these labels improve market efficiency, by increasing sellers' payoffs (compared with both the scenario of no signalling and one in which only costly certification

is allowed; efficiency is however lower than in the case of cheap certification). This is due to the cost differential of the two communications (cheap talk is assumed to be free)[3]. Furthermore, when information cost is particularly high, then the demand for information decreases and the buyers rely more on self-declared labels. These results are explained by the authors as an effect of the use of self-declared labels as proxy for the expensive certification or as an effect of reputation-building.

2.2.4 Summary and motivations for this paper.

In the experiment we present here, the traded good is characterised in a manner to make it as close as possible to a pure credence, and therefore of the characteristics highlighted by Dulleck et al (2011), liability, verifiability and reputation are ruled out, whilst competition is possible only via price.

Our model is somewhat similar to Larson (2002), as it presents a "reputable" label, but our is so by definition, while Larson's becomes trustworthy via reputation. Our aim is to see if reputation in exogenised, markets still separate. Similar results are obtained by Cason and Gangadharan (2002); in this last paper not only the market separates but the green sellers, when offered the opportunity to choose between third-party and self-certification, they always choose the former. In our model, we provide the choice between two similar labels, but on the one hand, again, reputation is ruled out. On the other, our third-party certification is non-noisy. We are interested in comparing our results with Mahenc (2009) and Mason (2009). The first shows that spurious labels create noise which causes efficiency to decrease; the latter highlights how green buyers' and sellers' payoffs are more volatile and green markets tend to be less efficient than the ones without certification. Finally, Bougherara and Piguet

[3]In other words, certification allows for more good matches between high quality products and consumers, but as certification is costly, the overall efficiency decreases.

(2009) show how self-certification is used as a proxy for third-party certification, when this is too expensive. The difference with our model is that we make self-certification costly. Finally, most of the experiments consider homogenous consumers, whilst we describe two separate kinds of consumers (green/brown).

This paper adds to the literature in several ways:

* it introduces goods that are pure credence goods. Buyers find out whether their purchased goods are green or not at the end of each period (when they find out their payoffs), but they are not able to use the information in the following period (as sellers are non recognisable);

* we analyse whether and why cheap talk[4] is effectively used. Despite theoretical predictions, empirical literature has pointed out that (especially when this is free or relatively inexpensive) this communication is used. We will try to see whether we can infer what the driving force is in the adoption of cheap talk: on the one hand, it could be that consumers are only partly rational; on the other, it could be that green sellers may use this communication as a cheaper way to signal their quality;

* furthermore, we make cheap talk a costly process for the seller, in order to see whether there is still an incentive to adopt it;

*a market with perfect (free) information is always going to have higher social welfare; we build a market in which if information is complete, profit for green sellers is higher, but social welfare is lower than if no information is purchased and we look at the effect that non-noisy (costly) labels and cheap talk (costly but cheaper) labels have on efficiency. The model assumes that a market with certification is overall less efficient. To make more general considerations

[4]It is to note, one for all, that the use of the term *cheap talk* is partly imprecise. Cheap talk should have no direct impact on private profit or social welfare. This implies that this kind of communication ought to be free. However, in literature the term is used even when it is costly. It is used to represent the fact that the communication does not convey any information.

about the different scenarios, we then look at the relative efficiency of each scenario, in order to remove the influence of the specifications of the model.

The results will then be used to give policy recommendations on how to create better regulations in credence goods markets.

2.3 Experimental Design

The experiment simulates a market for credence goods. Some of the sellers produce green goods and some brown. Some of the buyers care for the greenness of the products, others do not. The treatments differ from each other only in the kind of communication allowed. In the baseline treatment no communication is allowed. Then, unverified advertisement and certification are introduced, first separately and then jointly.

The next paragraph (2.3.1) sets out the main assumptions made in the model and the hypothesis we want to test.

Paragraph 2.3.2 describes the experiment: 2.3.2 focussing on the common features of the treatments, whilst each of the other sub-paragraphs (**??**-2.3.2) describes one of the four different treatments. Paragraph 2.3.3 sets the main feature of the experiment environment. Finally, 2.3.4 presents the expected (ie. theoretical) results.

2.3.1 Characteristics of the model and hypothesis

In this paper we are interested to see how sellers choose different labels and how buyers respond to them. To do this, we consider a market in which there are two qualities of product (green/brown) and at least one seller willing to produce each of them. On the other side of the market, a subset of consumers cares about the green quality. We further assume that the products are pure credence goods and therefore buyers cannot distinguish green goods from the

brown and sellers cannot build reputation. For this, verifiability and liability are also unattainable.

To isolate the behaviours we are interested in, we have explicitly made some assumptions:

1- Technology and preferences (green/brown) are exogenous;

2- There is an equal number of sellers adopting each technology.

These choices were made because our main focus is on the sellers' approach to different kinds of labelling; therefore, having a market with both kinds of sellers will make the sellers act strategically purely considering the different types of communication. Furthermore, it was felt that asking the sellers to first choose technology and then the type of communication; finally the price would have made their task too complex, with the risk of blurring the rationality of the choice.

3- The number of consumers caring for the green characteristic is the same as those not caring for it.

This assumption mirrors the previous ones.

4- Green is substituted with "high quality" and brown with "standard quality".

The experiment was set with green markets in mind. But it can clearly be applied to any kind of credence good. When setting up the experiment we had to decide whether to use environmentally-related wording or something more neutral. We decided to go for the latter, for three reasons: (1) literature is fairly unanimous in recognising that environmental labels are more effective than generic ones. Therefore, using words like "green" and "brown" would have likely showed strong results, but adding little to the common knowledge; (2) linked to the previous point, we are interested to see whether consumers are able to use all the information provided and see how they react to the two different labels. Having a "green effect" would have made it difficult to separate it to the other variables; (3) the use of words with a strong connotation (that overlaps

their denotations) is important when we want to mould people's preferences. In our experiment preferences are set and therefore buyers simply have to unerstand their profit functions and the information they receive.

Future research could look into the same experimental setting but using environmentally-related words to see if indeed it impacts significantly on results.

In some of the treatments we allow for additional costly information. In particular, we allow for two different kinds of eco-labelling. One will be called **advertisement**; the other **certification**. Advertisement represents self certification and therefore can be adopted by any seller, regardless of the quality of the goods. Certification is instead a third-party awarded label and can only be used by green sellers. There is a trade off between reliability and affordability. As it has been observed in the real world, certification is more expensive than self-awarded labels, as standards are imposed externally, costing companies, in terms of money and effort. On the other hand, having someone else guaranteeing the quality of our product is a safer guarantee than having the same statement made by the seller without any moderation.

5- Certification has no noise.

In other words, only high quality sellers can purchase this kind of label and consumers know for sure that a product bearing this label is positively green. We have ruled out the possibility of type I errors (low quality sellers able to purchase certification). This was done as it would have been more difficult for consumers to deal with two differently noisy signals: this would have added uncertainty (rather than explanatory power) to our results.

6- Sellers cannot build a reputation.

A buyer consuming a good with pure credence characteristics never finds out whether the consumed good has (or not) that particular feature. A large part of the previous literature on information asymmetry has concentrated on the importance of reputation building. Its effect is well known both in theo-

retical and experimental research. Reputation is often sufficient to outweigh asymmetric information, allowing the market to reach a (more) efficient equilibrium. This in the real world is possible because either goods are not perfectly credence (but more leaning towards experience) or because consumers look for proxies. This could be for example the distributors'reputation, a celebrity who decides to be associated with a particular product and so forth.

We purposedly chose to steer away from this branch of literature[5]. This does not want to deny the fact that consumers would still try to create their own beliefs, but we preferred to consider other aspects. Firstly, we felt that experimental economics has largely disregarded such markets; another side to the same coin is that, on the contrary, recreate a market in which sellers can create reputation would have not added much to the existing knowledge, as we know that reputation is good for the market. Of course, this market was created not merely because it was a theoretical novelty, but because it mirrors existing markets. For a discussion of these markets, see the previous section 1.3.1. Not allowing for reputation has finally another advantage: it allows to isolate the different effects of certification and advertisement, which is what this research is aiming to do.

For this reason, we have chosen not to allow consumers to knowingly pair with the same sellers: in this way, it is possible to make the market closer to a credence good market.

However, to create the right incentive (and rational behaviour), in our experiment buyers do find out what the utility coming from their consumption is (and therefore they can figure out how many units of high quality good they have purchased) but by not being able to recognise who sold it, they would enter the market in the following period none the wiser. It is important to stress here that even though consumers learn something about the goods purchased

[5]The last section of this work presents a reputation building model, using a fairly different setting.

(eg. two out of three are HQ), this is information does not give any insight when it comes to the choice in the following period. Therefore, the goods in our market cannot be considered experience goods, rather credence goods.

2.3.2 Description of the experimental market

Defining the market

We consider a market composed of six sellers and six buyers in which one good is traded. They trade for ten consecutive periods a good that is homogeneous except for one unobservable characteristic[6]. Goods with this feature are called H (high) and the others S (Standard). Quality of production is determined exogenously: three sellers produce H goods and three produce S ones. Production costs for H products are higher than for S. Marginal costs increase for both technologies. Each seller (he) sets the price for his own goods ($p \in \mathbb{N}$) and he can sell up to four units, provided that the marginal cost is not higher than the asking price. Table 2.1 represents the cost functions for the sellers.

Table 2.1: High/Standard Quality sellers' costs

	$1st$	$2nd$	$3rd$	$4th$
HQ	7	8	9	10
SQ	5	6	7	8

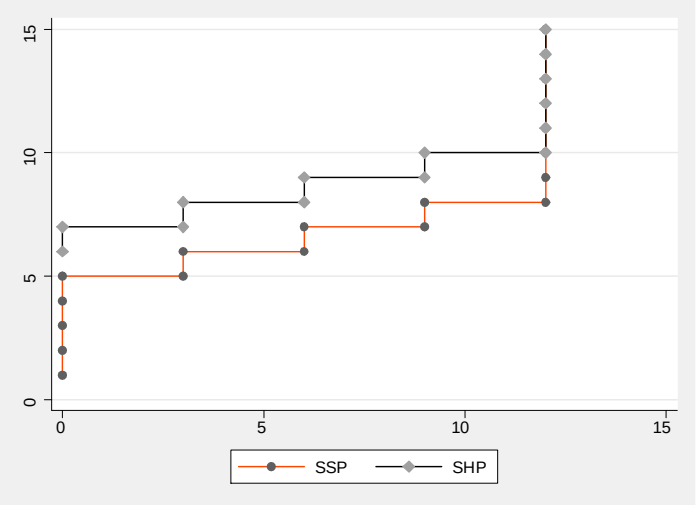
Each row shows the cost of producing the n-th unit of product of the named quality (HQ/SQ).

[6]Number of people: we needed 4 groups with the same amount of people. 8 people would have not allowed for enough dynamics, whilst 16 would have meant that each session would have lasted too long and the risk was to alienate the participants. For this reasons, we set the number of participants to 12.

Number of trading periods: 10 is fairly standards. We discussed whether to alter it. The trade off was between giving more time to the participants to understand the game and the risk of wearing the participants out and/or the necessity to pay them more.

If, for example, an H Seller sets a price of 9, he can sell up to 3 units of the traded good. If, on the other hand, an S seller chooses a price of 9, he can sell up to 4 units. Using this information, we can represent the supply curve for the 2 kinds of suppliers, as Figure 2.1 shows.

Figure 2.1: Supply curves for the two kinds of suppliers



Payoffs are as follows:

$$\Pi_j = \sum_{i=1}^{10} (p_{ij} q_{ij} - C_{ij}) \tag{2.1}$$

$$\Pi = \sum_{j=1}^{6} \Pi_j \tag{2.2}$$

where p_{ij} is the price asked by seller j in period i, q_{ij} is the number of units sold, and C_{ij} is the total cost of producing the sold units (in that period)[7].

Let us now consider the demand side. Three of the six buyers have higher utility if they consume H products (H buyers), the other three have no extra utility (S buyers). Buyers' type is determined exogenously. Marginal utility is

[7]This implies that if a seller sells less than the maximum she was willing to produce, she will only face the cost of the sold units.

decreasing for both kinds of buyers. Each buyer can buy up to three units of good, from one or more sellers. This means that each buyer may buy products of a different quality and at a different price. Table 2.2 and 2.3 shows the utility function for each kind of buyer.

Table 2.2: Utility of H-type buyers

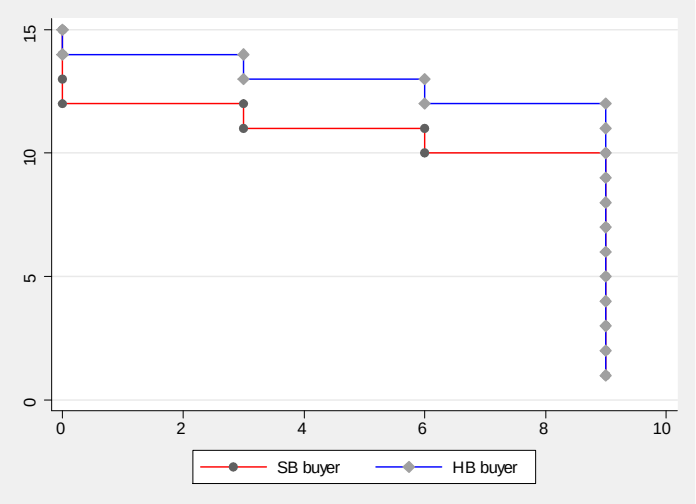
	$1st$	$2nd$	$3rd$
HQ product	$14-p$	$13-p$	$12-p$
SQ product	$12-p$	$11-p$	$10-p$

Table 2.3: Utility of S-type buyers

	$1st$	$2nd$	$3rd$
HQ/SQ product	$12-p$	$11-p$	$10-p$

The demand curves are represented in Figure 2.2.

Figure 2.2: Demand curves for the two kinds of buyers



It is important to note that the blue line represents the demand for HQ products by HQ buyers, whilst the red one represents SQ buyers' demand (but also the demand for SQ products by HQ buyers).

Buyers' utility is computed as follows:

$$u_j = \sum_{i=1}^{10}(a_{ji} - p_{ji}) \tag{2.3}$$

$$U = \sum_{j=1}^{6} u_j \tag{2.4}$$

where a_{ji} is consumer j's utility in the i^{th} period, and p_{ji} is the money she's spent in that period.

Baseline treatment: no information

Each seller decides what price he wants to charge. In this treatment no communication is allowed. Products are presented to the buyers (she); for each price she will know how many units are available for purchase, but she won't have any information about the quality or the identity of the seller. Buyers are randomly ordered and one at a time they decide how much to buy. Once a buyer has finished her purchase, the following buyer is presented with whatever is left in the market. At the end of each trading period payoffs are computed. H-Quality buyers will now be able to deduce how many units of high quality products they have purchased, but as sellers are unnamed, they won't be able to use this information in the following period. Each session is composed of 10 trading periods.

Ad treatment (cheap talk)

Sellers decide what price to charge for their products; after that, each seller (regardless of the quality produced) has the opportunity to advertise his product as high quality. Advertisement is costly (2 ECU) and it tells buyers the product may be H goods. Buyers are presented with the list of goods ordered by price and the relative quantity of product offered. Furthermore, it will be highlighted which product is advertised as H. The purchasing process develops as described above.

(Third-party) certification treatment

Sellers decide their price. In this stage, H sellers (but not S-sellers) can adopt a costly[8] (4 ECU) certification to signal the high quality of the products. When buyers are presented with the list of sellers, their prices and the quantity offered, they will also see the sellers who decided to go for certification: they will then know that certified goods are surely H. Purchasing process develops as described above.

Advertising and certification treatment

Sellers choose their price. S-Sellers can decide whether to engage in advertising (or not). H-Sellers are offered the possibility to certify, advertise or do nothing. The features of the two communications are as in the previous treatments. Buyers are presented with the price list of products, which highlights which units are advertised and which have been certified. Certified products are surely high quality, whilst the advertised can be either. The purchasing process develops as described above

2.3.3 Implementation

All the participants were undergraduate students from Royal Holloway University of London from various disciplines. The participants had no previous knowledge of game theory and had no experience in market experiments. Overall we conducted twelve sessions with twelve participants each. The sessions took place in March 2009[9] at the experimental economics laboratory at Royal Holloway.

[8]We wanted to keep the information easy to play with. Therefore the difference between green and brown is two units. Regarding the cost of the labels, we wanted certification to be proportionately much larger than advertisement. We felt that charging 1 unit for Ad was too little and people would have considered the cost more as a token than really something affecting their utility. Hence we went for 2. Consequently, Certification was charged twice as much, at 4. This cost is low enough to make it worth while for the green sellers to buy it and still make a profit.

[9]In February 2009, we had two dry runs, to test the programme, length and accessibility of the instructions and the task. The two sessions highlighted few minor

The program was written and run using z-Tree (Fischbacher, 2007). Instructions used neutral wording, which did not make reference to the environmental aspects that the experiment was trying to tackle, in order to avoid behavioural bias. In this way, subjects' choices were not affected by (anti) environmentalist ideas.

The instructions (presented in the Appendix) were handed out in hard copy and then read aloud. There are four different sets of instructions, each describing a different treatment. The wording was the same for describing the aspects of the experiment that were common to the different treatments. At the end of the reading out, a short questionnaire was presented to check the understanding of the participants. Twelve repetitions have been carried out (three for each of the four treatments), each composed of ten trading periods. Sessions lasted on average 60 minutes (between 50 and 75 minutes). Trade in the experiment was made using ECU (Experimental Currency Unit) which was then converted into GBP using the following conversion rate:

Buyers 1 ECU= £0.1

Sellers 1 ECU= £0.1

A show-up fee of £4 was paid to all the participants. Monetary payoffs ranged between $£5 - 20$[10] (average £13).

2.3.4 Theoretical predictions

In this paragraph we present what the theory predicts should happen in the different scenarios and the implication in terms of policy making. In the following chapter we will then present the experiment outcomes and compare and

points to straighten, as not completely clear. Overall, there was a strong agreement that the instructions were clear and straightforward. From the debriefing we picked up that people realised that green sellers had the toughest job, but that it was manageable if one were to put the effort to do some thinking and that, ultimately. time was the best teacher.

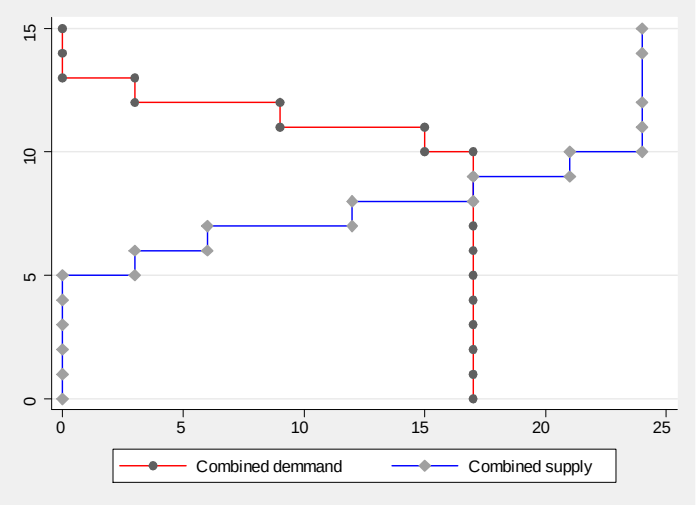
[10]The payoffs were set to be higher, but close, to what a student can earn in an occasional job on campus.

contrast them with the theoretical results. This will then lead to (i) explain the differences in the results; (ii) present recommendations for the policy maker.

Baseline treatment

In this treatment, as noted above, sellers have no way to communicate with the buyers. This implies that they will compete within the same market. In the same way, buyers will compete for the cheapest products, as green buyers are not able to discern any signal about the quality of products. The aggregate demand and supply curves are represented in Figure 2.3.

Figure 2.3: Baseline Treatment Equilibrium



The market can clear at $p^* = \{8, 9\}$, with all buyers purchasing three units (the maximum allowed), adding up to $q^* = 18$. If all the sellers set a price $p = 8$, then brown sellers will sell 4 units each, making a profit of

$$\Pi_{b,p=8} = (8 * 4) - (5 + 6 + 7 + 8) = 6 \tag{2.5}$$

The green sellers will only be able to provide 2 units and their profit is:

$$\Pi_{g,p=8} = (8 * 2) - (7 + 8) = 1 \tag{2.6}$$

However, sellers realise that at this price no seller can actually produce more, and therefore if she increases her price to $p = 9$, nobody will be able to undercut her. When all the sellers follow suit, potential supply has now increased to $q = 24$ and therefore each seller will sell 3 units[11]; note that even brown sellers will be better off:

$$\Pi_{b,p=9} = (9 * 3) - (5 + 6 + 7) = 9 \tag{2.7}$$

$$\Pi_{g,p=9} = (9 * 3) - (7 + 8 + 9) = 3 \tag{2.8}$$

As both green and brown sellers are better off at this higher price, there is no incentive to defect and undercut the competitors. Therefore the equilibrium price will be $p^* = 9$.

Brown consumers' utility is computed as follows:

$$U_b = (12 + 11 + 10) - (9 * 3) = 6 \tag{2.9}$$

Buyers will have a probability of 0.5 to randomly buy a green product[12]. Then, green buyers' expected utility is:

$$E(U_g) = (12 + 11 + 10) + (2 * 3) * 0.5 - (9 * 3) = 9 \tag{2.10}$$

Social welfare is therefore simply the sum of the utilities of the players:

[11] We assume that on average all sellers will sell the same amount, as the products are homogeneous and the price is the same.

[12] This is shown in the demand curve in Figure 2.3 with some consumers willing to purchase goods at $p = 13$.

$$SW = (9 + 3 + 6 + 9) * 3 = 81 \tag{2.11}$$

To conclude, let us benchmark this result with the social welfare in a market for a search good (or to put it in other terms, a market in which certification is free); the market would not suffer from deadweight losses, due to lack of information: green buyers would buy exclusively green products and social welfare would be 90[13].

Ad treatment

To analyse this scenario, we start making this consideration: if no seller purchases advertisement, then the equilibrium, utilities and profits are the ones described in the previous section.

However, sellers may consider purchasing advertisement, in the hope of attracting more buyers. This may happen either (i) due to a change in willingness to pay (and therefore giving the seller the possibility to charge a higher price) or (ii) if green buyers attach an increased probability of a product being green if it bears advertisement (in other words, between two goods with the same price, if the green buyer is more likely to buy the one with advertisement than one that does not).

(i) Green buyers change behaviour if they think that their probability of choosing a green good increases. Therefore, they compute the probability:

$$P(seller = green \mid Ad) = 0.5 \tag{2.12}$$

[13] $SW = (\Pi_b + \Pi_g + U_g + U_b) * 3$.
All the terms are like the ones computed above, except:
$U_g = (12 + 11 + 10) + (2 * 3) - (9 * 3) = 12$
$SW = (9 + 3 + 12 + 6) * 3 = 90$.

and therefore, since no information is derived by the advertisement, buyers will not change their behaviour and carry on choosing randomly among sellers who are charging the same price.

(ii) If buyers were not to change their willingness to pay, but decide to give preference to advertised products, this would allow a seller to sell 4 units at the equilibrium price of 9. But this will lead to a profit for a brown seller of:

$$\Pi_{Ad} = 9 * 4 - (5 + 6 + 7 + 8) - 2 = 8 \tag{2.13}$$

which is lower than the expected profit of a seller who does not advertise (as we have showed in Eq. 2.10).

Sellers are rational and know that buyers will not be fooled by the advertisement: ultimately, each seller will sell the same amount of products but sellers who purchased advertisement have a lower profit.

Therefore, no seller will buy advertisement and the equilibrium is, as previously mentioned, identical to the baseline treatment.

This is no surprise: by the way advertisement has been characterised, it is tantamount to *cheap talk*. The reason for calling this differently is threefold: the term may have affected the behaviour of the players (the connotation of "advertisement" is surely more neutral than that of "cheap talk"); also, one of the reasons why we have run this experiment is to effectively test whether, in a market of this kind, communication is indeed recognised and treated as cheap talk. Finally, (as mentioned before) this advertisement is not strictly cheap talk, as it is costly for the seller.

Certification treatment

As it has been previously noted, if the good were ordinary (or if certification were free), then we would have the creation of two separate markets and optimum levels of social welfare.

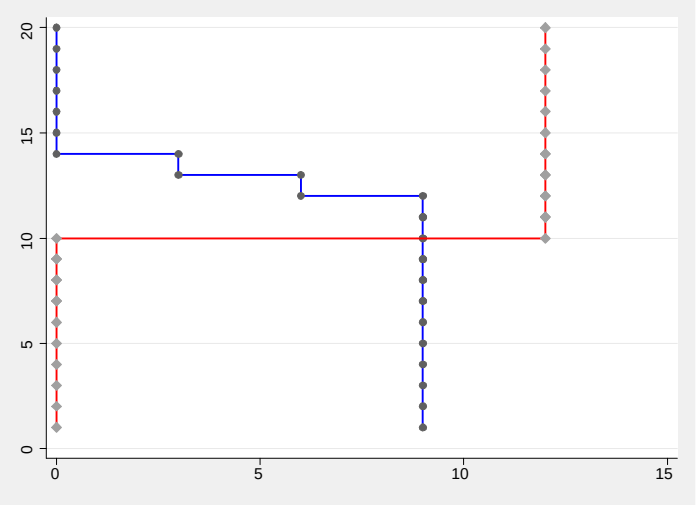
In this case, information is asymmetric and costly, which means that if the three green sellers buy certification, then total social welfare would be lower than in the perfect information scenario.

Furthermore, when information is bought, social welfare is even lower than in the baseline scenario. In fact, maximum social welfare in the case of free information is $SW = 90$. But information costs $C = 4 * 3 = 12$ making total welfare only $SW = 90 - 12 = 78$, whilst in the baseline scenario it was 81.

So the question is whether green sellers would invest in certification. The answer is positive, provided they are better off.

Let us then suppose that all the green sellers purchase certification; if this were the case, the two markets reach separate equilibria (Figure 2.4 and 2.5).

Figure 2.4: Certification treatment: green market, all green sellers buying certification



The supply curve in Figure 2.4 has this shape because of the cost of certification. For any price $p < 10$, the seller would make a negative profit and therefore is better off not entering the market, as Table 2.4 shows.

Figure 2.5: Certification treatment: brown market

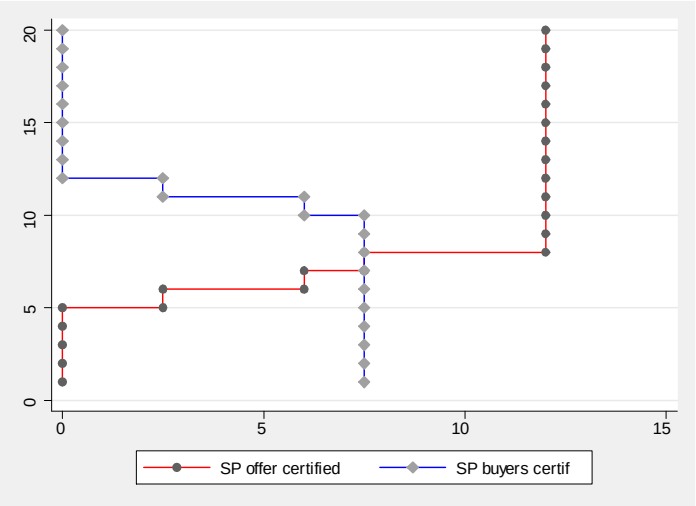


Table 2.4: Profits for different prices for a green seller buying certification

p	$Quantity$	$Revenue$	$Cost$	$Profit$
7	1	$7 * 1 = 7$	$7 + 4 = 11$	-4
8	2	$8 * 2 = 16$	$(7 + 8) + 4 = 19$	-3
9	3	$9 * 3 = 27$	$(7 + 8 + 9) + 4 = 28$	-1
10	4	$10 * 4 = 40$	$(7 + 8 + 9 + 10) + 4 = 38$	$+2$

To see what the best strategy for green sellers is, let us see what their profit would be in the separate equilibria and then benchmark the other solutions against it. If the markets are separate, the green market clears at:

$$\begin{aligned} p_g &\in [10, 12] \\ q^* &= 9 \end{aligned}$$

If the sellers set the price $p = 12$, then profit is going to be:

$$\Pi_{g,p=12} = (12 * 3) - (7 + 8 + 9) - 4 = 8 \tag{2.14}$$

which is higher than the profit they would make in the pooled equilibrium, where no information is bought.

To see if this is the equilibrium price, we try to consider the alternatives. If one of the green sellers were to try to undercut the other sellers, then his profit would be:

$$\Pi_{g,p=11} = (11 * 4) - (7 + 8 + 9 + 10) - 4 = 6 \tag{2.15}$$

implying that there is no incentive to drop the price.

Green buyers' utility for a price of 12 is:

$$U_g = (14 + 13 + 12) - 12 * 3 = 3 \tag{2.16}$$

Clearing price in the brown market:

$$p_b \in [7, 10]$$

If brown sellers charge a price of 10, then their individual profit is:

$$\Pi_{b,p=10} = (10 * 3) - (5 + 6 + 7) = 12 \tag{2.17}$$

If one of the sellers were to try to undercut the others, then the profit of this seller would be:

$$\Pi_{b,p=9} = (9 * 4) - (5 + 6 + 7 + 8) = 10 \tag{2.18}$$

Even in the brown market there is no incentive to undercut and therefore the equilibrium prices are:

$$p_g^* = 12$$
$$p_b^* = 10$$

Each brown buyers' utility is:

$$U_b = (12 + 11 + 10) - 10 * 3 = 3 \tag{2.19}$$

like the green buyers.

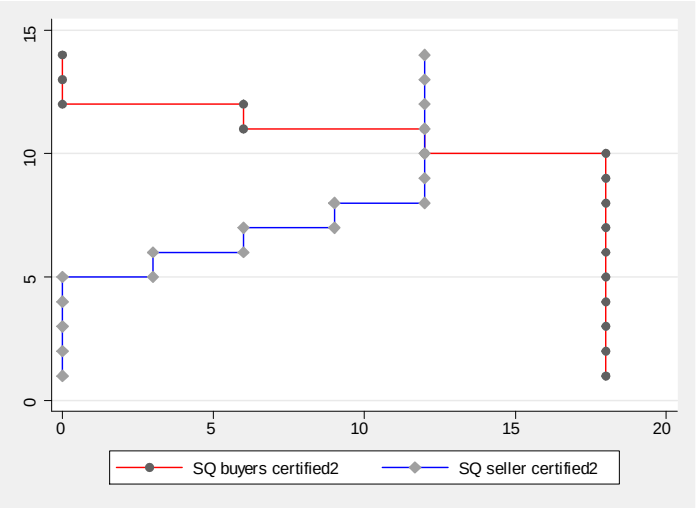
However, green buyers can always decide to buy goods in the brown market. If they do so, then demand for the green goods would drop, making profits drop and potentially the price too (attracting buyers back). However, their total utility would be unchanged, as even though the price in the brown market is two units lower than in the green market, their utility to consume a brown product is also two units lower. Therefore, for a green buyer it would not make any difference to be purchasing in one market or the other. The question is, then, whether this is a credible threat for the green sellers to drop their price. As there is no chance of coordination, if all the green buyers were to leave the green market, then the brown market would look like Figure 2.6.

Brown sellers charge $p = 11$, and profits and utilities in the market would be:

$$\Pi_{b,p=11} = (11 * 4) - (5 + 6 + 7 + 8) = 18 \tag{2.20}$$
$$U = (12 + 11) - 11 * 2 = 1 \tag{2.21}$$

In this case, there is an excess of demand in the brown market and an excess of supply in the green market. Green buyers could buy a unit of green product

Figure 2.6: Certification Treatment: Brown Sellers and all the Buyers



at price 12, but although social welfare would increase, their net marginal utility would be zero (as $MU_{q=3} = 12$). Therefore, it is not convenient for the green buyers to migrate to the brown market and green sellers do not believe in this threat and keep $p_g^* = 12$.

To see, however, if this is a stable equilibrium, it is important to consider what happens to profit if one (or more) green seller were to decide not to purchase certification and therefore compete with the brown sellers. Table 2.5 summarises the different pay-offs of a seller who has to decide whether to certify or not. The first payoff is referred to this seller, whilst the second to any other green seller. The rows show the two different options the green seller has, while the columns show the three different scenarios he could face (ie. no other green sellers buy certification, one buys it or both the other sellers buy certification). When nobody chooses certification, her profit is 3, as this is identical to the baseline scenario.

Table 2.5: Dominant strategy for the seller

	No Cert	1 Cert	2 Cert
Cert	$\underline{14}, 6$	$\underline{10}; 5$	$\underline{8}; 8$
No Cert	$3; 3$	$6, 14$	$5; 10$

The underlined profits show how "Certification" is strictly dominant, regadless of the opponents' strategy, meaning that all the green sellers choose to certify. Social welfare is then:

$$\begin{aligned} SW &= \sum(\Pi_g + \Pi_b + U_i) \\ &= 3 * (8 + 12 + 3 * 2) = 78 \end{aligned} \tag{2.22}$$

It is worth mentioning that the process that leads to profit maximisation has been shown to be fairly complicated. Thinking of an experimental setting and the inevitable learning curve, one could expect that it would require considerable time for sellers to realise their best strategy via trial and error.

Advertisement and certification treatment

As we have mentioned earlier, the players are all rational. Therefore, they realise that advertisement does not convey any information and therefore it is not used at all. This implies that the equilibrium in this treatment is identical to the Certification treatment analysed in the previous paragraph.

Theoretical policy conclusions

Taking stock of the theoretical predictions presented so far, a policy maker would have important hindsight in how to shape regulation.

1. Cheap Talk

1.1 As the market disregards this kind of communication, it is not essential to do anything about it, as it will not be adopted anyway. Therefore, banning cheap talk would not only be redundant, but it would also have implementation and compliance costs, along with non economic reputational cost (red tape).

1.2 However, if the policy maker were to gag only brown producers, then green producers could adopt cheap talk, separate themselves from the brown producers and increase social welfare; as advertisement is cheaper, social welfare would increase by 6 units. The problem with this is that the government would have to have clear information on the sellers' technology. As the market failure is caused by the lack of this information in the first place, it would be difficult to actually achieve this, without a costly monitoring.

2. Certification

2.1 By reducing the cost of information, welfare increases. In other words, the governement could try to invest in R&D or any other form of centralised help to drive down the cost of certification. As the information cost represents a net loss in social welfare, this would increase the efficiency of the market.

2.2 Having a unique large producer (with constant return to scale as the three separate sellers) would increase social welfare, as information cost would be reduced. If all the green sellers bought certification, the information cost on society would be threefold; if there were only one large green seller, she would have to pay for certification only once and provide all the green goods. Social welfare would hence increase by 8 units (the cost of the two foregone certifications). The problem with this alternative is potential monopolistic behaviour.

However, two considerations ought to be made: on the one hand, in this particular case, if the monopolist were to increase her asking price (ie. $p = 13$) then the demand for her product would drop ($q = 6$) and the profit would drop as well, as Table 2.6 shows.

Table 2.6: Profit for a green monolopolist

	revenue	cost	profit
$p = 12$	$12 * 9 = 108$	$(5 + 6 + 7) * 3 + 4 = 58$	50
$p = 13$	$13 * 6 = 78$	$(5 + 6) * 3 + 4 = 37$	41

Furthermore, even considering a different profit structure in which the green sellers were better off by increasing the asking price, the monopolist's price strategy is further constrained by the potential competition coming from the sellers in the brown market. In fact, if the price differential in the two markets is higher than 2, then green buyers are better off purchasing brown products. Taking stock, allowing for a single green monopolist would improve the market efficiency. Different demand curve could create incentives for the seller to mark up the price for his products with respect to the competitive green market. The monopolistic behaviour is limited by the price differential with the brown market. If some green buyers move to the brown market, then two things may happen: the brown market could absorb the excessive demand from the other market, resulting in an equilibrium at $q = 18$ and redistribution of surplus in favour of the sellers (and in particular the green monopolist); if the excess of demand from the green market is larger than the 3 units (which is the excess of supply in each market), then competition among buyers would push the price in the brown market up.

2.3 If cost of certification cannot be reduced and it is not possible/viable to create a green monopoly, then banning certification would actually increase social welfare.

This is a rather interesting result. If information was costless, then certification would improve social welfare. However, as the cost of information is higher than the sum of the surplus coming from green buyers consuming green

products, then forbidding the use of certification would increase social welfare (and, as it has been noticed earlier, green buyers still have a 50/50 chance of randomly buying green products). This result is clearly dependant on the choice of the model we have made.

2.4 The quantity of green products exchanged in the market does not change in the different treatments; this is (at least partly) due to the fact that technologies are exogenous. Green producers often make lower profits than the brown ones, implying that in the long run (if they had the possibility) some would swap for the brown technology and therefore reduce the amount of green products exchanged. If the policy maker has some intrinsic reasons to prefer green products (say that there is an externality that has not been considered in our model), then this would be an unwelcome outcome, which should be dealt with.

3. Externalities

3.1 Externalities have been explicitly excluded[14] from this model. However, green (brown) markets are often characterised by external benefits (or costs). Therefore, the quantity consumed of the green (brown) products would actually positively (negatively) affect social welfare. In our model, in equilibrium, 9 brown and 9 green products are exchanged. However, if there were to be any positive externality connected with the consumption of the green products, then social welfare would increase if the government encouraged brown buyers to swap to consuming green products, as green sellers are able to supply 3 further units. To do so, the government should subsidise each buyer of at least 2 units in order to make the brown buyer indifferent to brown and green products. In this way, green production would increase to 12 units, whilst the only 6 goods would be exchanged in the brown market. In the real world, in the long run, brown producers may find it convenient to change technology and social welfare could increase, provided the externality were big enough to offset the

[14]This is because we wanted to focus on the sellers' and buyers' choices.

potential drop in total consumption (as brown buyers may be partly driven off the market) as well as welfare losses from raising money for the subsidy through taxes. This also holds for the feasibility of the subsidies: if the externality is lower than 2 units, then the subsidies would lower social welfare.

2.4 Results

Let us now turn to the analysis of our results. Given that our main goal is to assess whether the introduction of a certificate enhances the outcome efficiency, we begin by comparing the theoretical prediction to the observed market outcome under each of the treatments implemented. Then, we present the results of non-parametric tests, followed by the regression analysis.

2.4.1 Efficiency

In paragraph 2.3.4, we have presented the predicted equilibria for each treatment. This set of equilibria represents what should happen if the participants in the experiment were perfectly rational and if there were no other variable affecting their behaviour.

Table 2.7 compares the empirical results with the theoretical predictions across treatments. It is common, in experimental markets, that individuals learn the optimal strategy as they get trading experience, which implies that at the end of the session one observes *closer-to-equilibrium* behaviour. Therefore, we also look at the empirical mean of the last five periods and the one of the last trading period. The table presents the average social welfare and the efficiency achieved as a percentage of the theoretical prediction.

As mentioned in the previous section, the maximum social welfare attainable in Baseline and Ad treatments is higher than in the other treatments. For this reason we look at the relative efficiency in each treatment[15]. This has two

[15] % Efficiency $= \frac{\text{Empirical SW}}{\text{Expected SW}} * 100$

Table 2.7: Social Welfare in the different treatments Treatment: Expexted vs. Empirical

	Baseline		**Ad**		**Cert**		**Ad+Cert**	
	SW	%Eff	SW	%Eff	SW	%Eff	SW	%Eff
Expected	81		81		78		78	
Empirical Mean	67.6	83.5	58.7	72.5	63.1	80.9	59.7	76.6
Last 5 periods	69.5	85.8	61.1	75.4	64.3	82.5	62.9	80.6
Last Period	69.7	86.0	59.3	73.2	56.0	71.8	62.3	79.9

practical advantages: it removes any bias given by the structure of the chosen model; and it allows extrapolating more easily the effect of unaccounted factors (eg. externalities). The results show that under none of the treatments implemented do the markets achieve full efficiency. Nonetheless, the deviation from full efficiency is never too large. Across all treatments, the average in the last 5 periods is higher than the average among the 10 periods. The Ad treatment, and the last period of the Certification treatment, are the exceptions, since in those cases efficiency is below 75% of the value predicted by microeconomic theory. In the three treatments with communication, the last period's social welfare is lower than the average of the last five periods[16]. Behaviour is closest to the theoretical prediction in the Baseline treatment.

A Kruskal-Wallis test for the session average social welfare suggests that social welfare does not differ across treatments (MW = 5.359; p-value = 0.15; N = 12). To assess the effect of cheap-talk information on social welfare, ideally, we should compare social welfare in Baseline and Advertisement treatments, and Certification and Ad+Cert treatments. However, due to the limited amount

[16]And in the Certification treatment, it is even lower than the 10 periods average.

of independent observations[17], these tests would have low statistical power[18]. For this reason, we pooled the data of the treatments with cheap-talk advertisement and compared them with the pooled data of the other treatments. The result of the Mann-Whitney test for the session average social welfare suggests that Advertisement affects negatively social welfare compared to the treatments where this was not allowed. (MW = 2.08; p-value = 0.04; N = 12)[19]. This result is in line with Mahenc (2009)'s results. The same process[20] has been applied to see whether certification has any impact on social welfare. The Mann-Whitney test for the session average social welfare suggests that social welfare does not differ across treatments (MW = 0.32; p-value = 0.8; N = 12).

It is also interesting to look at each side of the market separately. Tables 2.8-2.10 present the predicted sellers' profit, the achieved payoff (PO) and the

[17]As each participant interacts with all the other subjects throughout each session. Therefore each session constitutes a single independent observation.

[18]The issue of the low number of observation is common to the majority of the results. Due to the limited resources available for this experiment, it was not possible to run more sessions. This may have an impact on the results presented. For this reason, we would like to highlight two things: (1) all the conclusions presented are very conservative. Therefore, it is never claimed anything that is not fully substantiated by data; (2) appreciating that the lack of data may hide some interesting results, we will often show the data graphically to show what *may* be going on.

We are currently working on a project to replicate the same experiment (at least partly keeping it identical); the results of that experiment will strengthen the results presented.

In passing, we have tried to calculate the averages presented in the tables above, removing the data of the people who did not understand the game (see the last paragraph of this section) and the results for the sessions with Cert are closer to the expected values, making the difference in efficiency more marked. Again, this result has limited statistically significance and therefore it is not presented formally., but it gives a powerful insight.

To conclude, although more observations could strengthen the results presented, we believe that they are not only robust but interesting as they stand.

[19]Given that we are interested in an improvement on social welfare, we report one-tailed Mann-Whitney results.

[20]Comparing the pooled data of the two treatments in which certification was allowed with the remaining two treatments.

Table 2.8: Sellers' Profit in the different treatments Treatment: Expexted vs. Empirical

	Baseline		**Ad**		**Cert**		**Ad+Cert**	
	PO	%Eff	PO	%Eff	PO	%Eff	PO	%Eff
Expected	36		36		60		60	
Empirical Mean	40.5	113	42.5	118	34.9	58	37.8	63
Last 5 periods	38.8	108	42.3	118	36.6	61	37.5	63
Last Period	36.0	100	37	103	37.7	63	36	60

Table 2.9: Green Sellers' Profit in the different treatments Treatment: Expexted vs. Empirical

	Baseline		**Ad**		**Cert**		**Ad+Cert**	
	PO	%Eff	PO	%Eff	PO	%Eff	PO	%Eff
Expected	9		9		24		24	
Empirical Mean	12.8	142.2	12.7	141.1	12.0	50.0	10.8	44.6
Last 5 periods	12.1	134.4	13.7	152.2	10.9	45.4	11.7	48.8
Last Period	9.6	106.7	16.7	185.6	12.7	52.9	10.3	42.9

relative efficiency achieved by the sellers in each treatment. As we did for the social welfare, we present the treatment average, the average for the last five trading periods and the average for the last period. It is possible to note that in the Baseline and Ad treatments sellers achieve a higher-than-expected profit. However, surprisingly, when certification is introduced their surplus plummets below expected levels; this is true for both types of sellers. Another interesting point is that looking at relative payoffs, green sellers make higher profit than brown sellers in treatments in which certification is not allowed.

As data shows, sellers are better off when there is no possibility to truly signal the type of good that they produce. We first test treatment differences for

Table 2.10: Brown Sellers' Profit in the different treatments Treatment: Expexted vs. Empirical

	Baseline		**Ad**		**Cert**		**Ad+Cert**	
	PO	%Eff	PO	%Eff	PO	%Eff	PO	%Eff
Expected	27		27		36		36	
Empirical Mean	27.6	102.2	29.8	110.4	22.8	63.3	26.8	74.4
Last 5 periods	26.8	99.3	28.7	106.3	25.7	71.4	15.3	42.5
Last Period	26.4	97.8	20.6	76.3	25.0	69.4	16.8	46.7

the sellers' profit (by session). The result of a Kruskal-Wallis test suggests that there are no significant treatment differences across sellers' profits, (KW = 3.92; df = 3; p-value = 0.270; N = 12). Additionally, looking at the average profits by sellers' type, the Kruskal-Wallis test suggests that low quality sellers make, on average, higher profits than high quality sellers across treatments (KW = 16.8; df = 1; p-value =0.0002; N = 12). Profits in the last period are lower than the average of the last five periods in all treatments but Certification.

Table 2.11: Buyers' Surplus in the different treatments Treatment: Expexted vs. Empirical

	Baseline		**Ad**		**Cert**		**Ad+Cert**	
	PO	%Eff	PO	%Eff	PO	%Eff	PO	%Eff
Expected	45		45		18		18	
Empirical Mean	27.1	60	16.1	35.8	28.2	157	21.9	122
Last 5 periods	30.7	68	18.9	42.0	30.9	172	25.4	141
Last Period	33.7	75	20.0	44.4	29.3	163	26.3	146

We now turn to analyse buyers' performance. Tables 2.11-2.13 show the theoretical prediction and the empirical results for buyers' payoff across treatments. Unsurprisingly, as it can be seen in the table, and opposite to what

Table 2.12: Green Buyers' Surplus in the different treatments Treatment: Expexted vs. Empirical

	Baseline		**Ad**		**Cert**		**Ad+Cert**	
	PO	%Eff	PO	%Eff	PO	%Eff	PO	%Eff
Expected	27		27		9		9	
Empirical Mean	14.7	54.4	10.6	39.2	16.2	180.0	12.4	137.8
Last 5 periods	17.9	66.3	12.1	44.8	17.6	195.6	13.8	153.3
Last Period	19	70.4	16.3	60.4	15.3	170.0	14.2	157.8

Table 2.13: Brown Buyers' Surplus in the different treatments Treatment: Expexted vs. Empirical

	Baseline		**Ad**		**Cert**		**Ad+Cert**	
	PO	%Eff	PO	%Eff	PO	%Eff	PO	%Eff
Expected	18		18		9		9	
Empirical Mean	12.5	69.4	5.5	30.6	11.9	132.2	9.5	105.6
Last 5 periods	12.9	71.7	6.8	37.8	13.2	146.7	11.5	127.8
Last Period	14.4	80.0	3.7	20.6	13.9	154.4	12.0	133.3

happens with the sellers, buyers are better off when they can get a truthful signal of the product type and if they are green. Nevertheless, a Kruskal-Wallis test comparing the average surplus across treatments suggests that there are no treatment differences (KW = 5.66; df =3; p-value = 0.129; N=12). Looking at the last period, it is interesting to note how in Ad and Certification treatments surplus is lower than the average in the last five periods.

To understand better how surplus is formed, we look at two more variables: prices and quality purchased. Price is obviously an important determinant for surplus and profit alike. Quality purchased is important to determine the surplus of HQ buyers.

Figures 2.7-2.10 show the period-average price charged by each category of seller in the four different treatments. After a learning process, prices seem to slowly converge in Baseline and Ad treatments, whilst they are quite different in the other two treatments (roughly one unit of difference). As mentioned

Figure 2.7: SQ/HQ Average price in each period in Baseline treatment

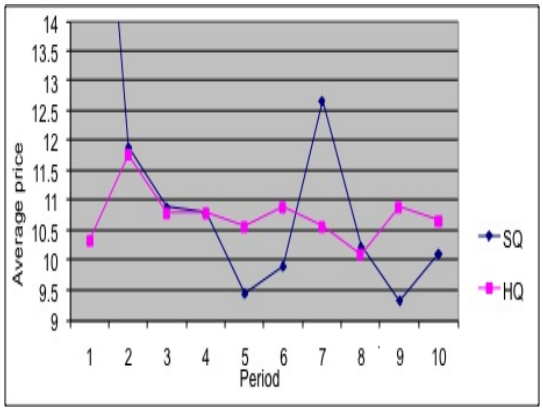
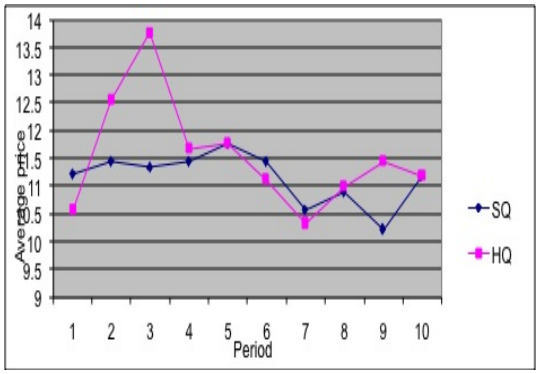
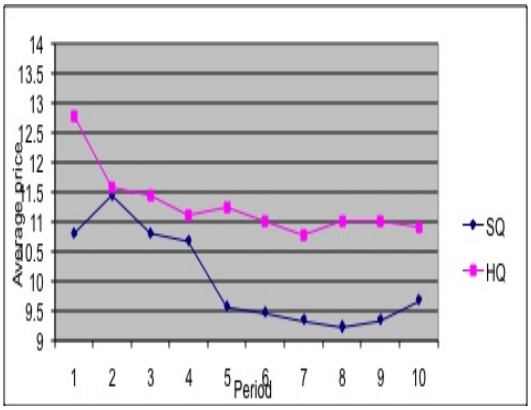


Figure 2.8: SQ/HQ Average price in each period in Advertisement treatment



before, the independent observations are too few to run statistically significant tests. We cannot conclude anything univocal; however, to have a better understanding of the situation, we have computed the treatment average according to technology for the last five periods. The results are reported in figure 2.11. Average price in Baseline and Ad treatments are very close to each other, with the latter slightly higher than the former. In the treatments where certification is allowed the prices charged by the two kinds of sellers are quite different, with the difference being larger when advertisement is not allowed (1.16 against 1.60 difference).

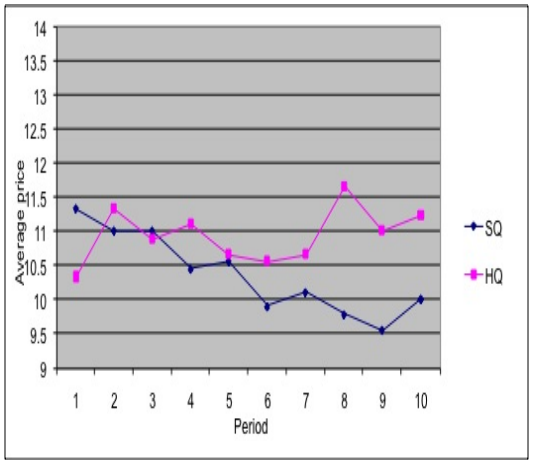
Figure 2.9: SQ/HQ Average price in each period in Certification treatment



Let us look at figure 2.12: it shows the share of pairing seller-buyer according to type and divided by treatment. The blue bars show how many transactions took place between green (HQ) sellers and HQ buyers, red bars exchanges between brown (SQ) sellers and SQ buyers and so on. As expected, green buyers were able to effectively purchase more green goods when certification was allowed and especially if advertisement was barred (increasing the HQ-HQ matching by a third). On the other hand, in the Ad treatment the HQ buyers fell for the cheap talk and ended up buying more SQ products than in any other treatment.

However, looking only at the transactions made by HQ buyers and differentiating when they buy HQ products from when they buy SQ ones, there are no significant differences across treatments, meaning that green buyers do not manage to identify the HQ products more easily when different types of information are available. The Kruskal-Wallis for HQ-HQ exchange across treatments suggests that there is no significant difference in the mean number of HQ products bought by HQ consumers in each treatment (KW = 5.144; df = 3; p-value = 0.16; N = 12). The highest rank corresponds to the Ad+Cert

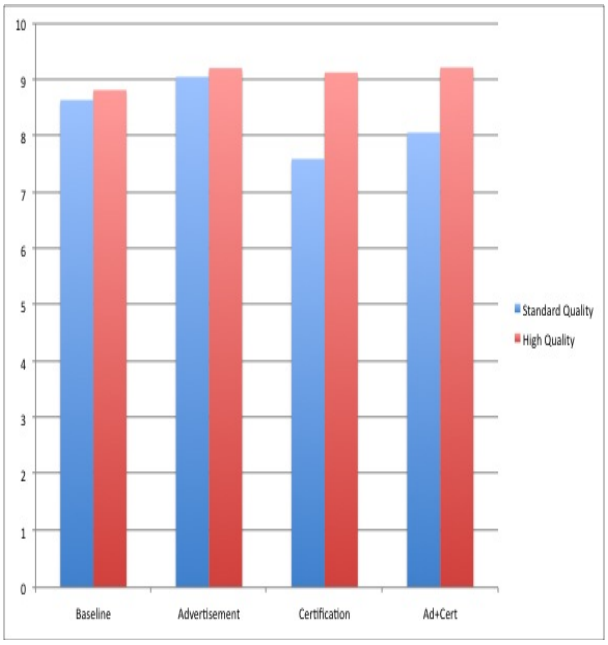
Figure 2.10: SQ/HQ Average price in each period in Ad+Cert treatment



treatment and the lowest to the Ad treatment. As for the HQ buyer-SQ seller transactions, the highest rank corresponds to the Ad treatment and the lowest ranks correspond to the Ad+Cert and the Certification treatment. This means that cheap talk introduces noisy information that biases the HQ buyers towards SQ products. The Mann-Whitney test for pairwise comparison on HQ-HQ exchange is only significant for the comparison between Ad and Certification treatment, suggesting that there is more HQ-HQ exchange in the Certification treatment than in the Ad treatment (MW = 1.99; p-value = 0.0463; N = 6). These results seem to partly confirm Larson (2002) and Cason and Gangadharan (2002)'s results that markets will tend to separate and prices to diverge; however, our data is not completely conclusive.

It is also interesting to look at what kind of products were actually sold. In our experiment, we have not considered any externality. However, often in reality the difference between the two categories is that green products internalise some externality. Therefore, if we ultimately want to see the effect of different government policies, we are not only interested in the total quantity

Figure 2.11: SQ/HQ Average price per treatment



of products exchanged (which is one of the main determinants of social welfare) but also in the quality of the products exchanged.

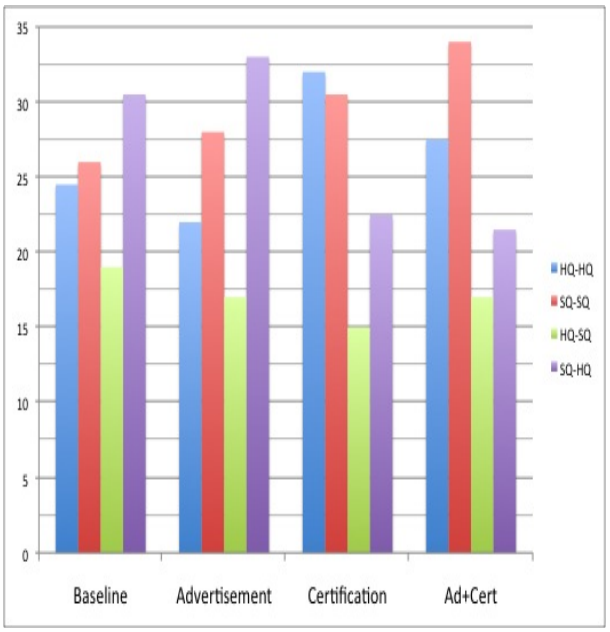
Of the 1,715 units sold over all the experimental sessions, 42% of them were HQ products.

Table 2.14: Quantity of green products sold per treatment

	Baseline	Advertisement	Certification	Ad+Cert
# Green	180	156	200	194
# Brown	258	227	244	256
% Green	41.1	40.7	45.0	43.1
%Eff	66.7	57.8	74.1	71.9

Table 2.14 shows how the quantity sold was composed in terms of quality of products. The share of green goods of the overall product sold is fairly constant for the different treatments. Compared to Baseline, green goods are exchanged more frequently in Certification treatment and less frequently in Ad treatment,

Figure 2.12: Match Seller (S)/Buyer (B) according to their type per Treatment as percentage of Total



but no difference is statistically significant. Looking at the absolute quantity, more green products were sold when certification was allowed. By contrast, when only advertisement is allowed, the number is the lowest. The last row compares the amount of green exchanges that effectively took place with what the theory predicts, creating an efficiency index which echoes the ones presented earlier: this standardisation allows for a clearer comparison among the different scenarios. The total number of units sold in each session (by treatment) does not differ significantly across treatments (KW = 5.00; df =3; p-value = 0.172; N = 12). The same result holds for HQ and SQ products separately (for HQ products, KW = 5.09; df = 3; p-value =0.165; N=12 and KW = 5.54; df = 3; p-value =0.136; N =12 for SQ products)[21]. Due to the low degree of freedom,

[21]Within treatment, the Mann-Whitney test for pairwise comparisons of per-session averages of quantities sold suggests that in all but the Ad+Cert treatment, SQ products are sold significantly more than the HQ products (MW = 1.964; p-value

despite the large difference in units sold in each treatment, the differences are not significantly different from zero.

Finally, we also look at the use of the costly cheap-talk advertisement and the certification. Figure 2.13 shows the use of advertisement over time, in the two treatments where this kind of communication is allowed. The first thing to note is that in neither treatment does there seem to be a clear trend (although the average use of advertisement in the last five periods is lower than the average in the first five). Secondly, there does not seem to be a difference in the use of advertisement in respect to the possibility of the use of certification.

Figure 2.13: Use of advertisement over time in different treatments - average number of Ad per period

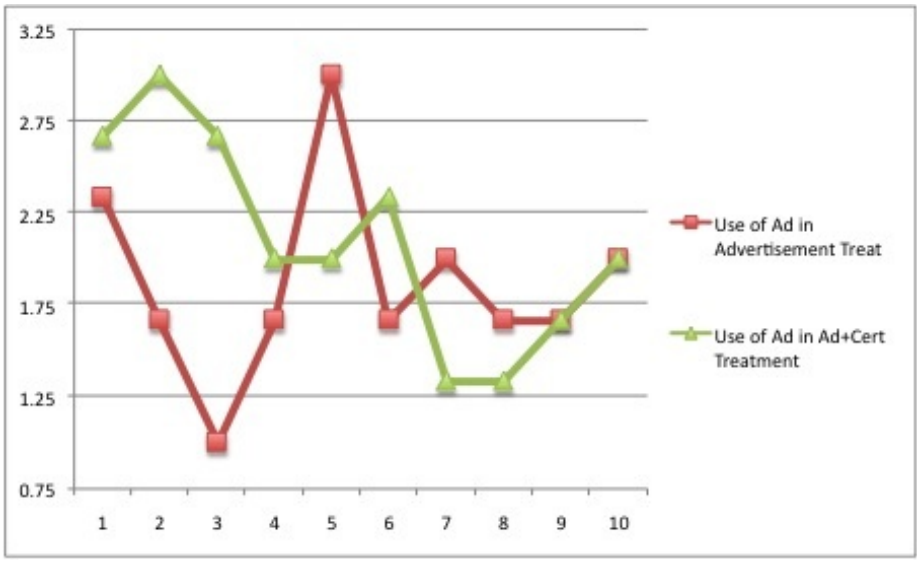
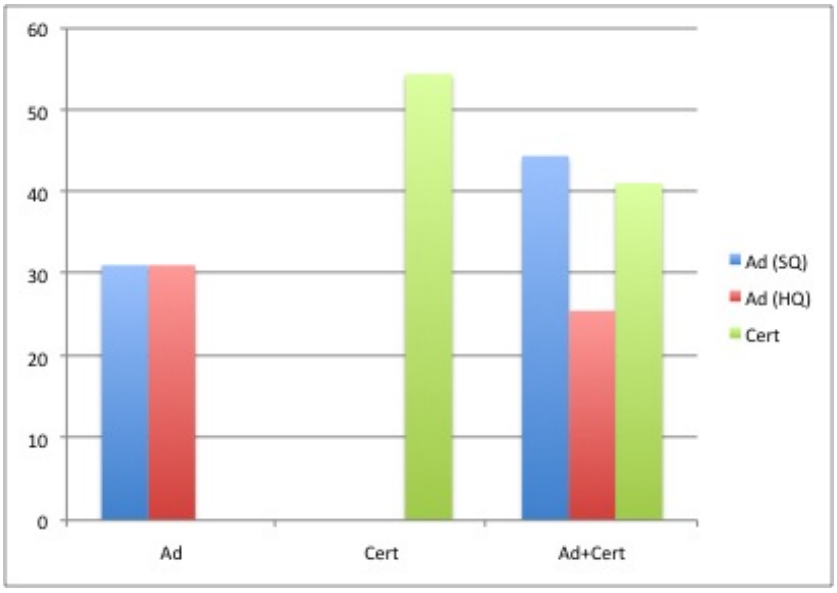


Figure 2.14 represents the relative frequency of the use of each signal in the different treatments[22]. It is possible to see how in the Ad treatment the amount of advertisement bought by HQ and SQ sellers is the same (31%). In the Certification treatment, a larger proportion of HQ sellers choose to invest in the certificate (54%). Finally, in the Ad+Cert treatment, in 66% of the cases,

= 0.0495; N = 6 for baseline and Ad+Cert, and MW = 1.091; p-value = 0.275; N = 6 for Ad and Certification).

[22]% of X-quality sellers purchasing Y over total quantity of that seller kind.

Figure 2.14: Use of Additional information per technology per Treatment as percentage of the Total



HQ sellers engage in some sort of signaling; however, in only two thirds of these situations do the HQ sellers buy certification while in the other cases they invest in advertisement. So, overall, it seems that sellers are willing to invest in some type of signalling. This seems to be in line with Bougherara and Piguet's results: green sellers are keen to diversify themselves from the brown sellers and -to a certain extent- they try to use Ad as a proxy for Certification. More than half of the HQ sellers invest in the certificate when that is the only possible signal, but the possibility of the advertisement in the Ad+Cert treatment crowds-out the use of the certificate ($\chi^2 = 3.21$; p-value $= 0.073$). When comparing the use of advertisement by the HQ sellers between the Ad+Cert and the Ad treatment, the incidence of the ad is lower than in the Ad treatment, but the difference is not significant (one-sample χ^2 test, $\chi^2 = 3.27$; p-value $= 0.19$).

Additionally, SQ sellers (nearly in 43% of the cases) buy cheap-talk advertisement, more often than in the Ad treatment ($\chi^2 = 3.40$; p-value $= 0.065$)

and more often than the HQ sellers (χ^2= 7.06; p-value = 0.008). SQ sellers therefore compete with the HQ sellers investing in this signal even more than in the Ad treatment.

Figure 2.15: Average use of signals made by the HQ sellers in the Ad+Cert treatment by period

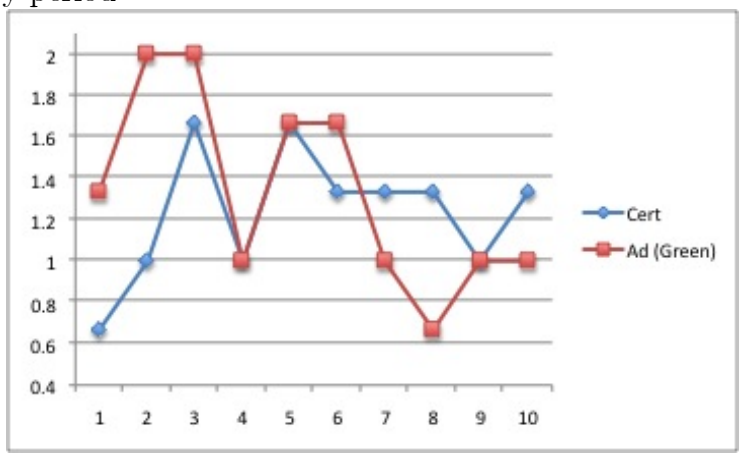
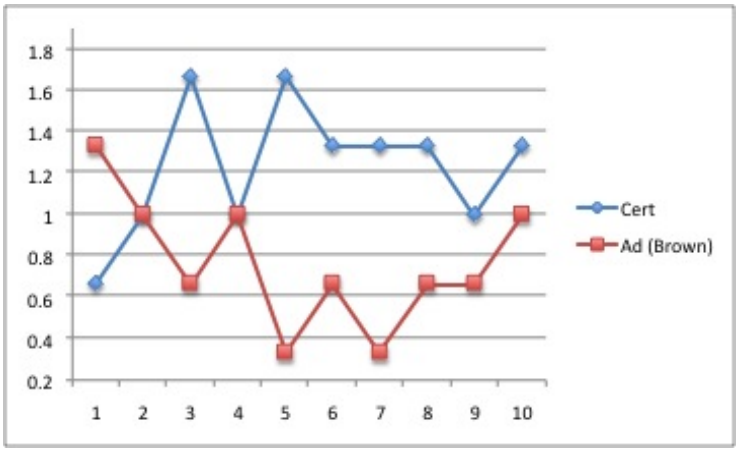


Figure 2.15 shows the HQ seller's average use of each signal in the Ad+Cert treatment by period. While there is not a clear trend, the use of the (cheap-talk) advertisement declines, while the use of the certificate increases over the periods. The average of the last five periods of Certification (Advertisement) is higher (lower) than the average of the first five periods. Figure 2.16 compares the average use of certificate with the average use of advertisement by the SQ sellers in the Ad+Cert treatment by period. Again, there is no clear trend; certification is used more frequently than advertisement, after period two; furthermore, the data seems to suggest that the SQ sellers use the advertisement to try to compete with the certificate of their HQ competitors.

Figure 2.16: Average use of certificate and advertisement by period in Ad+Cert treatment



2.4.2 Regression analysis

Table 2.15 shows the effect of different determinants of sellers' profit. Results suggest that, ceteris paribus, on average HQ sellers make lower profits than SQ ones. The regression results also show that the effect of price on sellers' profits is nonlinear. The effect of price is positive, though small, while the effect of the price squared is negative. This suggests that for low prices, a higher price is associated with a higher profit, and after a point, a price increase implies a lower profit, due to the negative effect on units sold.

Regarding treatment effects, the only significant effect is the one of the Certification treatment; sellers in the Certification treatment make on average 1.4 ECUs less than one in the baseline treatment. However, if an HQ seller who buys certification will earn almost 2 ECUs more than the average, making him better off than the average seller in Baseline treatment. This also fills part of the gap between predictions and experimental results: because of the (bad)

Table 2.15: Tobit of Sellers' Profit

Green	-5.98
	(0.52)***
Price	2.90
	(0.87)***
Squared Price	-0.14
	(0.04)***
Ad Treatment	-0.36
	(0.73)
Cert Treatment	-1.42
	(0.81)**
Cert+Ad Treatment	-0.37
	(0.66)
Using Ad in Ad	-0.44
	(3.80)
Using Ad in Cert+Ad	-2.06
	(2.53)
Using Cert in Cert+Ad	-0.11
	(1.56)
Using Cert in Cert	1.99
	(0.84)**
G using Ad in Ad	0.92
	(2.42)
G using Ad in Cert+Ad	1.20
	(1.35)
Cons	-5.39
	(4.64)
N	720

choice of HQ sellers to not invest in certification, social welfare decreases and the gap among different treatments blurs.[23]

Table 2.16 analyses buyers' payoff. As we expect, green buyers have, on average, a higher surplus: this is because they always have the opportunity

[23]If green sellers do not use certification, then the market will be identical to the baseline scenario; but as they are better off in a completely separating equilibrium than in the baseline, then it is in their interest to use the certification.

Table 2.16: Tobit of Buyers' Surplus

Green Buyer	1.09
	(0.56)**
Ad Treatment	-2.37
	(0.40)***
Green Buyer in Ad	0.71
	(0.85)
Cert Treatment	-0.19
	(0.46)
Green Buyer in Cert Tr.	0.47
	(0.72)
Ad+Cert Treatment	-0.97
	(0.47)**
Green Buyer in Ad+Cert Tr.	-0.10
	(0.82)
Constant	4.14
	(0.26)***
N	720

to buy a higher quality product and enjoy a higher utility. Additionally, on average, the consumer surplus is significantly lower in the treatments where cheap-talk advertisement is possible, compared to the Baseline treatment. Both the dummy for the Ad treatment and the dummy for the Ad+Cert treatment have a significant negative coefficient.

As for the quantity sold, let us consider Table 2.17: once again, unsurprisingly, price and technology have a negative impact. Buying advertisement (in either treatment) has a positive effect: this means that it actually has an effect on consumers. It may be the case that when confronted with goods of the same price (some with and others without advertisement), a buyer would opt for the advertised one. However, very interestingly, advertisement in the Ad+Cert

Table 2.17: Regression on Quantity Sold

Using Ad in Ad	1.51
	(0.57)***
Using Ad in Cert+Ad	-1.86
	(0.74)***
Using Cert	1.25
	(0.74)**
Using Cert in Cert	1.51
	(0.92)*
HQ	-1.63
	(0.28)***
Price	-0.77
	(0.12)***
Ad Treatment	-0.21
	(0.34)
Cert Treatment	-0.65
	(0.39)*
Ad+Cert Treatment	0.16
	(0.45)
Constant	10.31
	(1.27)***

treatment has a significant negative effect on the numbers of units sold (almost 2 units less). Certification has a positive effect (1.25), but the effect is somewhat larger when certification is bought in the Certification treatment (1.51). Green consumers exploit the available information but, advertisement still has a (negative) impact on the effectiveness of the certification, probably because it introduces noise. This is reflected in the green buyers' lower surplus. Finally, in the Certification treatment production is slightly lower with respect to the Baseline treatment. This is probably because prices are higher.

2.5 Discussion and Conclusion

We are now ready to address the main questions we have raised at the beginning. The rest of the chapter is organised as follows: paragraph 2.5.2 will provide the answers to the core questions, drawing from the results presented

earlier, while paragraph 2.5.3 will extrapolate the policy implications of these results. Paragraph 2.5.4 summarises and concludes, providing some indications for future research. Before starting with the interpretation of our results, paragraph 2.5.1 discusses the hypothesis of rational behaviour within our experiment.

2.5.1 Were subjects rational?

One of the main assumptions in economics is that subjects behave rationally. Therefore, it is important to assess whether this is indeed true, in order to be able to generalise the results we have come to. We expect subjects in a laboratory experiment not to be perfectly rational. As we have mentioned before, the quantity of information as well as the ability to interpret it may limit the optimality of an individual's decisions. Understanding if, how much and why people do not behave rationally is very important to improve theoretical predictions and, ultimately, policy making.

The first consideration comes from recognising that, as results differ from the predicted outcomes, subjects have not fully used the available information. The important thing is, however, to see whether the issue was with the way the experiment was set or in the nature of the subjects. The former is clearly a concern, as it would imply that either the results cannot be considered general or that, at least, some relevant aspects have not been considered fully. The latter is instead something to look at closely, as it could give us insight into better policy making.

The first test we have run was to see whether people who did not understand how the game worked actually performed worse than the others. We have therefore looked at the questionnaire participants compiled after the experiment and we looked at the people who declared either that they did not understand the game or declared to have used a tactic that did not make sense. We then ran a Mann-Whitney test for the sellers and one for the buyers. The tests

showed that the people who did not undersand the game earned significantly less than the rest of the group (sellers: $z = -3.299$, significance level 99%; buyers: $z = -1.957$, significance level 95%). The relation is stronger for the sellers: this could be explained by the fact that sellers had a more difficult job and therefore understanding well the game was more important to achieve good results. Future research could find ways to make sure that the number of people who do not know what they are doing is minimised (in our experiment they were 22) and see this has effects on the results. We have not tried to run regressions removing this data, as it would have reduced the number of observations significantly.

We present here some more insight on specific data. The considerations have not been statistically tested.

How do we know when a subject has been completely irrational?

A thing that we have not been able to explain is what looks like a "last period effect". Although statistically insignificant, social welfare in the last period is almost always lower than the average of the last five periods (whilst we would expect it to be higher, if we consider a positive learning process). The market has no particular mechanism that can lead to a different behaviour in the last period. As sellers cannot be identified throughout the experiment, there is no reputation to be exploited in the last period. As already noted, the difference is not statistically significant but it would be interesting to see whether the difference is indeed coincidental or appears to be statistically non significant because of the low degrees of freedom. Other scholars have experienced a similar event, although fairly marginal. Looking at the questionnaire participants were asked to compile at the end of the session, we have found out that a number of participants have expressly mentioned that they "tried their luck" in the last period.A future iteration of the experiment could try to ask participants to play for 11 periods and see whether the there is a difference between our results and the first 10 periods of the new experiment.

Another way to assess rationality is to consider when a subject has made a loss in one period. On the one hand, sellers were advantaged, as the programme would not allow selling under price. Therefore, their only possibility to make a loss would be purchasing further communication and then being unable to cover the cost with the sales. This is, however, an entrepreneurial risk which cannot be considered completely irrational. Of the number of times sellers made a loss, 16 times[24] were brown sellers and 30 green. Losses were below two for the former and below four for the latter, meaning that part of the investment in information was recovered and that price was set high enough to allow for this recovery (in other words, behaviour can be considered rational). On the other hand, buyers were allowed to purchase products even when the price was too high to give them a net benefit. This treatment asymmetry is justified by the intrinsic nature of the problem that the experiment is trying to address: telling a buyer that she was overpaying for an item would defeat the purpose of certification. Just above 4% of times, buyers made a loss. Of these, green buyers made a loss on 13 occasions. Green buyers may make a loss as they can buy goods assuming they are high quality but the goods are instead low quality. Going back to paragraph 2.3.4, a green buyer expects to randomly buy a green product 50% of the time and therefore she is willing to pay a bit above her marginal utility for a brown good. From equation 2.10, we know that the maximum amount she is willing to pay is one unit per good purchased. Having said that, a third of the losses were well beyond three units (ie. the buyers have not behaved rationally). Even more surprisingly, 16 brown buyers (roughly one in 20!) made a loss. Considering that brown buyers care only about price, they should have always known the maximum price they were willing to pay: brown buyers making a loss has therefore no logical explanation.

[24] "16 times" means that, in the whole experiments, 16 "end of period" payoffs.

Finally, we have looked at the "impossible prices". One in 10 sellers (exactly 10%) have priced outside the acceptable ranges[25]. The majority (64%) were prices higher than the maximum buyer was willing to pay for one unit of product (the only justification for this is that sellers expected buyers to behave highly irrationally. This happened roughly one time in ten); ten times a green seller has tried to ask for less than seven (production cost for first unit) and twice a brown seller has tried to charge less than five, therefore not entering the market.

All these behaviours seem to point to the fact that some of the subjects had not fully understood how the experiment worked. Is the behaviour correlated with the complexity of the task? On the one hand, brown buyers had the easiest task and yet it was the category making the highest number of losses. On the other hand, we have considered in which treatments buyers have gone out of their pockets more often . Considering the structure of the game, Baseline treatment is the easiest to understand and Ad+Cert is the toughest, with the other two treatments in the middle. Five losses have been experienced in Baseline, only three in Cert treatment and eleven and ten for Ad and Ad+Cert respectively. Furthermore, sellers seem to have made mistakes evenly across the treatments. Therefore, there does not seem to be a strict correlation between the errors and the complexity of the experiment. It is difficult to ascertain whether it is the uncertainty or the complex information that has caused the irrational behaviour, but one thing can already be concluded: by reducing one or the other, behaviour should become more sensible and therefore increase social welfare.

To conclude, we have experienced a small share of irrational behaviour. Part of this has to be factored in, due to human nature or pure errors[26]; some circumstances were driven by the complicated information.

[25]For green sellers [7,14] and for brown ones [5,12] or [5,14] in case of pooled equilibrium.

[26]One subject erroneously typed a price of "100" instead of "10".

It is important to raise two final caveats: firstly, the analysis here only considers behaviour that is completely irrational. Anything that is within the feasible range but still not profit/utility maximising is not being considered here. Therefore, it is possible that simpler/clearer information may have an impact on improving the efficiency of this category of behaviour (which is the majority of the cases). This is analysed in the rest of the chapter. Finally, some of the irrational behaviour may have significantly affected our results[27]. Due to the low number of observations, the relatively low number of non well-behaved behaviour and the fact that errors were made in both directions (therefore partly cancelling each other out), we have not eliminated any of the observations.

2.5.2 Verifying our predictions

The paper has tried to verify statements derived by a purely theoretical analysis of this model. Here are the answers, based on the results of our experiment:

Claim 18 *Self-certification is ruled out of the market, as costly and conveying no information*

The first prediction that the theory suggests is that the market should rule out cheap talk. The results previously presented have shown that this was not the case in the experiment. The use of advertisement, although marginally lower in the latter part of the experiment, does not tail out. This is true both when the advertisement is the only possible communication and when certification is allowed too.

Claim 19 *Self-certification has no effect on social welfare or private profit of a part of the market*

[27] Going back to the example raised in the previous note, a seller in Baseline treatment has set a price of 100. Weighted average price for that particular treatment (considering the three sessions this treatment has been tested) is nearly 0.5 higher than without this observation.

Due to the limited number of independent variables, we cannot compare Baseline with Ad treatment and Certification treatment with Ad+Cert. By simply looking at the average social welfare it looks like advertisement has a negative effect in both cases. Pooling together these two pairs, we have found that, effectively, cheap talk has a negative impact on social welfare. Considering that cheap talk was indeed used, the fact that it is costly *and* it bears no information explains why social welfare is statistically lower when advertisement is allowed.

Claim 20 *When enough information is available, the markets separate and green products are exchanged at a premium price*

Unless perfect information is achieved, a perfect separation of the markets is impossible. Considering the learning process within an experiment and the partially rational behaviour of the participants, we did not really expect to see a surgically separated market. We start observing that in every treatment where further communication was available, more than half of the sellers would engage in labelling: we can infer that green sellers are keen to separate and brown may resist this, trying to extract higher profit. In order to judge to what extent the markets have separated, we look at two things: (i) the amount of matches between sellers and buyers of the same kind; and (ii) price. When treatments with certification are compared with the ones without, it is possible to note how the transactions between green sellers and buyers increase. Statistically, the number of these transactions is significantly higher only for certification treatment compared to Ad treatment[28]. Looking at price, we have seen how the market converges to a unique price when certification is not allowed, but green sellers are able to charge a premium when this is allowed. This makes us conclude that the markets do tend to separate and sellers are able to extract a premium. The price differential is higher than one unit but lower than two.

[28] As previously noted, despite the large difference among the different values, the low degree of freedom does not lead to conclusive results.

This means that sellers are able to pass onto buyers nearly all the difference in production costs.

Claim 21 *The quantity of green and brown products is always the same*

Throughout the experiment, green products have consistently been sold less than the brown (overall 42%). When certification was allowed, overall exchanges would increase and so would the relative share of green products. Regression analysis also points out how green sellers would sell less units, *ceteris paribus*. However, none of these differences is statistically significant.

Claim 22 *Certification always improves the efficiency of the market*

One of the main goals of this paper was to assess whether a market with a potentially higher level of information was more efficient. We have pointed out that for the way the experiment was set up, the maximum social welfare (in equilibrium) achievable in Baseline/Ad treatment was higher than the one obtainable in the other treatments. This point is, however, immaterial as we have then looked at relative efficiency, rather than the absolute level of social welfare. In this way, we can see whether more information was achievable (and therefore more desirable exchanges).

The results point to some interesting conclusions: (1) looking at efficiency Ad+ Cert is slightly higher than Ad treatment (indicating that allowing certification when only advertisement is present is beneficial to society). However, Certification treatment is less efficient than Baseline, which goes against the reasoning just mentioned; (2) statistically, there is no difference between the efficiency of treatments with or without the possibility to use certification; (3) certification has a strong negative effect on sellers' profit. This is quite interesting. In Baseline treatment, sellers sometimes make more than the expected profit, whilst they only get about 60% of the available profit. Now, considering that certification is optional and, if not adopted, the market degenerates in a

Baseline market, it is slightly against logic that sellers would settle for lower profit. What makes this even more striking is that green sellers' payoff (see above) is lower relatively to the brown sellers'. As it is up to the green buyers to decide whether to buy extra certification, this seems quite disconcerting. One possible explanation for this is that the game was too complicated for the sellers to assess what the best outcome was. Going back to our theoretical prediction (see paragraph 2.3.4), it is clear that green sellers had the hardest task. Considering the time-limit, even the most conscientious participant would have struggled to get to the solution. This may mean that longer repetitions may have lead to more rational results[29].

Claim 23 *Self-certification may act as a proxy for certification, when the latter is too expensive*

In literature, it has been shown that cheap talk may be used as a cheaper signal, when certification is too costly. In our experiment, when both kinds of communication were allowed, some of the green sellers have swapped from the use in certification to advertisement. However, the "swap" was only partial. Furthermore, as brown sellers were allowed to purchase advertisement too, the proxy did not work effectively.

[29]To informally test this, I have run the test using exclusively economist graduates, some with MSc and all with at least one-year work experience. I have only rewarded the best performing in relative terms with a £150 prize, which was just below the average paid in each of the previous experiments. Participants had about 15 minutes to read the instructions and take notes. The experiment consisted of 15 periods and the treatment administered was the Ad+Cert. The results showed a slow but more marked improvement of efficiency over time. Last period's pay off was lower than the experiment's average. However, the use of certification did not show any particular trend. Advertisement was avoided by everyone in the first period (probably as any good economist figured out that it was cheap talk and that they were not expected to choose it) but then it entered the market, although it was less used than in the data reported in this article.

2.5.3 Policy implications, revisited

Having highlighted how our empirical results differ from the theory predictions, let us now turn to see what effect this would have on policy-making, comparing with those in 2.3.4.

1. Cheap Talk

1.1 In theory, nobody uses advertisement and therefore a ban would be redundant. However, sellers often engage in cheap talk, to the detriment of social welfare. Therefore, banning this kind of communication would improve social welfare. This would be particularly beneficial if the use of certification is allowed, as more information is extracted.

In practice, it is virtually impossible to ban cheap talk, as it often borders marketing details, packaging or advertisement. However, the policy maker could try to set more stringent rules on the use of particular words, so that if a firm were to try to deceive consumers, her efforts would be less effective, because the message would have to be more vague to follow the legislation. Going back to the model presented in the previous section, this would be like decreasing η_g or, in the setting of this experiment, would have the effect of an increase in price of Ad. This would make it less appealing for brown sellers and green sellers would find comparatively more appealing to use Certification.

1.2 If it were possible to gag brown sellers, then the green ones could use advertisement as a proxy of the more costly certification. We have not tested this assumption directly. However, we have noted how, due to the credence nature of the goods, it would be very difficult to discern green and brown sellers.

2. Certification

2.1 We have not tested the effect of changing the cost of certification. However, as it is used (when allowed) and directly affects social welfare (both by reducing the cost to sellers and by increasing the possibility to create HQ-HQ

exchanges), it is most likely going to be good for society. Although social welfare seems to decrease, the market performs more efficiently. Further research would be helpful to establish, as the results seem to suggest, whether decreasing information costs would actually enhance social welfare as well.

2.2 We have seen that green sellers may swap from certification to advertisement. If the price differential were to be lower, the incentive would be lower and more information would be conveyed. This could also lead brown sellers to lose incentive to use advertisement the more green sellers use certification, increasing social welfare even further.

2.3 Another important thing the regulator can do is simplify or clarify the information available in the market. We have noticed how some of the participants have not acted in a rational way. This may be due to human nature, but we have also pointed out how particular circumstances can be accounted for the large amount/complexity of information in the market.

2.4 It was concluded before that if nothing can be done in terms of information cost, then banning certification would have been beneficial to society. Our experiment, if not conclusive in favour of compulsory certification, showed how certification does not seem to negatively affect social welfare.

2.5 Green sellers do make lower profit than brown sellers. Furthermore, the quantity of green products sold is consistently lower. This could be a concern for the policy maker, should the green products be deemed to be "better" in the policy maker's eye. We will discuss this below. We have pointed out how by banning advertisement the difference between the quantities of the two kinds of product shrinks and overall quantity increases as well.

2.6 An industry-wide scheme would allow to reduce costs to firms (via economies of scale) but keeping the label's effectiveness high[30].

3. Externalities

[30]This should increase market efficiency, although the current experiment has not modelled this feature in. For more discussion on the role of industry-wide labels, see previous section.

If negative externalities are present in the market, the policy maker would want that at least green buyers consume only green products. This could be obtained either by (a) decreasing production costs for green firms or (b) decreasing information noise (lower certification cost or via buyers' education, ie. make the connection between quality and certification more accessible). If information is too complex, the reduction of the types of labels (ie. banning Ad) could be a way forward. With respect to the brown buyers, things are slightly different, according to the size of the externality. If this is lower than two units, then social welfare is maximised when brown consumers buy brown products. It is important to note that banning brown products would likely reduce social welfare, as they cater for half of the existing market.

Without over-elaborating on the different scenarios that have not been part of our primary analysis, it is important to realise the trade off present here. In fact, we have noticed earlier that in the Certification treatment consumption of green products increases, but so does the consumption of brown products (and therefore the externality). If, instead, green producers were to substitute brown producers, then the issue would be that due to the higher costs of production, social welfare could still deteriorate.

2.5.4 Conclusions

Let us summarise and conclude our discussion. Information asymmetries are present in most markets: sellers know what they sell, whilst buyers learn some of the features only after purchase. Green products are often credence goods, since the green characteristic is frequently connected with the production process or resources. Firms may decide to engage in costly communication, in order to pass the relevant information to interested consumers, fill the communication gap and obtain a premium. This raises the issue of the reliability of the information provided: in the absence of a third party certification, brown firms have the incentive to mislead consumers.

In this paper we explored whether in a market for credence goods, different types of labels improve or hinder social welfare. In order to do so, we conducted a market experiment in which there were two types of sellers (high-quality sellers and low-quality ones) and two types of buyers (those who care about quality and those who do not). We implemented four different treatments, where we varied the quality of information available in the market, but it was not possible to build reputation. In the Baseline treatment participants had to interact in a market where signalling was not possible. In the Ad treatment, any seller could, costly, advertise her product as high-quality. As this possibility was available to all sellers, the advertisement could be considered cheap-talk. In the Certification treatment, information was more expensive than in the previous treatment, but only the high-quality sellers were allowed to buy it. This constitutes a non-noisy signal of high quality. Finally, in the Ad+Certificate treatment, both types of information were available. These treatments relate to different real-life scenarios. Baseline treatment represents a situation in which both qualities of the product exist, but sellers are not aware of the fact that buyers are interested in that particular feature. Ad treatment depicts a market in which sellers know some buyers care for a particular feature of the product, but communication is at best loosely regulated, or when the information is conveyed with the use of self-certification. Certification is tantamount to third-party awarded labels. An independent, reputable organisation will not have any incentive to award undeserving sellers with their own seal of approval. Often in markets, both kinds of labels are present, but sometimes legislation can be tight enough to forbid unsubstantiated claims, effectively banning self-awarded labels.

Our results suggest that consumers are worse off in any scenario with information. However, they are significantly worse off in the treatments where the cheap-talk advertisement is allowed. Due to the cost structure of the experiment, social welfare is higher in the baseline scenario than when certification

is allowed; the experiment confirmed this; when only advertisement is allowed, social welfare is significantly lower, whilst when certification is permitted the market gets relatively closer to the efficient equilibrium, implying that a different cost structure may make this treatment superior.

The most important findings of the papers can be summarised as follows:

Conclusion 24 *: Against theoretical predictions, the ban of advertisement would impact positively on social welfare. Certification does not seem to have a significant effect on social welfare, but it improves efficiency in the market.*

Conjecture 25 *By reducing the cost of information social welfare should increase, in relative and absolute terms (ie. the market would be more efficient than if there was no communication at all).*

Conjecture 26 *A single seller would potentially improve efficiency, due to the reduced cost in certification. This can also be interpreted as the creation of a single exogenously-awarded label.*

Conclusion 27 *By banning certification (but not advertisement), social welfare would decrease.*

Conclusion 28 *If there are externalities, the market would be more efficient if subsidies (which have to be lower than the unit externality) are paid to green producers.*

Chapter 3

Environmental lobbying: Decision making when the adviser may be biased

One can only give an unbiased opinion about things that do not interest one, which is no doubt the reason an unbaised opinion is always valueless. The man who sees both sides of a question is a man who sees absolutely nothing. (*Oscar Wilde)*

3.1 Introduction

In many policy settings, a decision maker has to balance different interests and points of views, without having all the required information to take the decision. Information may be private or too costly to obtain, and therefore the policy maker has to seek advice from an informed party. Let us consider this example: a lake is being polluted by the factories surrounding it. The people living in the vicinity, concerned by preservation of the natural setting, angling and the value of their properties - and the environmental organisations, concerned about biodiversity, asked the local administrators to take action. They claim that if pollution continues, the environmental damage will go beyond critical values and the lakeside will become wasteland. On the other hand, the owners of the polluting firms claim that the pollution emitted is not greater than that produced in the last decades and (in any case) well below the legal limits. Furthermore, banning production would have a significant impact on the local economy, in term of employment and local tax revenue.

The decision maker has to take a difficult decision for the good of society, considering the overall net impact. Typically, he is unlikely to have enough information or technical knowledge of the matter to take an informed decision. He may therefore seek advice from someone better informed. This could be a think-tank, an NGO or an academic: someone who is better informed as to the best decision to take. If the chosen adviser has in mind the social interest, then she will pass on her information and the local administrator can act accordingly. However, some advisers may have different agendas. They may live in the area or they may like fishing in the lake; or, to the contrary, they could be married to someone who works in one of the factories. Therefore the information she passes to the decision maker may be biased.

The local administrator will consider the advice but also is likely to take it with a pinch of salt, as he knows it may be insincere. As the adviser (be she biased or not) knows she will not be fully believed, she will try to cultivate her own reputation for being unbiased. The more the decision maker considers her unbiased, the more weight he attaches to her advice.

An expert who advocates a particular cause is often referred to as a *lobbyist*. The etymology of the word points to the derogatory connotation of its use: it refers to the practice of networking in the entrance halls of legislative chambers, in order to influence politicians. As much as we may feel the 20th century has invented the practice, according to the Oxford English Dictionary, the term was in use already in the 1790s, meaning that the practice is likely to even pre-date that.

In passing, the uninformed decision maker/potentially biased informed adviser situation can also be recognised in different settings: (a) a policy maker who needs to decide how to legislate on a particular issue; (b) a governmental department has to decide how to allocate its budget among the different policy areas; (c) a Treasury that needs to allocate central resources among different activities, and so on.

The common denominator in these situations is that the decision maker has to make a decision without all the relevant information and therefore, he seeks advice from agents who have relevant private information, to improve welfare.

This chapter looks into this situations precisely: an uninformed decision maker who wants to maximise social welfare has to take two consecutive unrelated decisions. Can he extract any information from advices received by a potentially biased, fully informed adviser? The decision maker has noisy prior about the type of adviser he is facing and subsequent events will affect this belief. The model presented considers the circumstances in which a biased adviser decides to invest on reputation and when she does not. A known finding in this kind of literature is tha the adviser may decide to discloser her information in the first period (even if this goes against her interest) to gain credibility as unbiased adviser, to then have more influence in the second period. With this model, we show that, although this holds true, we can reach some new, interesting conclusions. Firstly, an adviser investing in reputation in the first period enters the following period with unchanged reputation. Then, we show that the decision maker can extract full information in the first period and, more surprisingly, in the last period.

Our interest here is in the application of these in environmental policy settings. This is particularly relevant in such situations, as we will discuss below (3.1.1); 3.1.2 sets the difference between absolute and relative bias and how these concepts are considered in our context and 3.1.3 will present the literature review on environmental lobbying and the broader literature to which this paper belongs.

3.1.1 Lobbying and green issues.

The need for a government to seek advice from an expert is true in many policy making contexts. This paper will focus on the application of lobbying problems on environmental issues. We believe there are at least two good reasons to do

so. First, the characteristics of many environmental decisions fit this particular structure well; second, green lobbying has become more and more common. Let us consider these two arguments separately.

Lobbying in enviromental settings

This paragraph presents the reasons why the model is applied to environmental issues. To do so, we consider its two main assumptions and see how they fit green markets. The key assumptions for the need of external advice are:

(a) **the decision maker lacks at least some of the information required to make the best decision.** Several factors contribute to a very imperfect market for information:

* the multidimensionality of the green issue[1]. Green characteristics pertain to very different features of the product. Ordering them is to a degree subjective (is it better to buy washing powder bio or non bio? Which of these is greener? Organic, recyclable or low carbon footprint? etc);

* the rapidly evolving state of knowledge: science in the field is advancing rapidly, but dissemination amongst stakeholder groups happens at varying rates;

* scientists do not agree on the science. New reports are often questioned by other experts and confuted by other data. This adds to the confusion to what the state of knowledge is. The impact is even wider as the general public (who strongly influence political decision) may be even less informed, as the media may present particular statistics more prominently than others (be it because it is more sensational or because of the political agenda of part of the press);

* economists do not agree on the economics: most of the controversy is based on the difficult valuation of non-market goods or services. Their monetisation is therefore difficult. Another difficulty is to quantify environmental damages.

[1] See previous sections for more discussion about this.

For example, the reason why CFCs were banned in the '80s is that as they were responsible for the hole in the ozone layer and this, in the long run, would have made the Earth uninhabitable: therefore, the costs were assessed to be infinite. The Montreal Protocol is now being updated to incorporate all the gasses that have similar effects to CFCs, but as economists do not agree on their overall impact, a total ban does not seem to be convincing all parties. Another important variable when it comes to environmental appraisal (which is almost unique) is discounting; as environmental impacts lasts for a very long time (if not forever), assessing correctly future values becomes critical. Economists have strongly disagreed on how to value future costs and benefits. Stern (2006) presented the impact of climate change on the British economy; however, its results were highly criticised, due to the author's choice of a very low discount rate[2].

To name only one example, recently in the UK, the National Environment Audit (UK NEA, 2011) has been published. The pioneering work assessed the value of Britain's natural capital, using the innovative ecosystem service approach (ESA). In principle, ESA allows to compute the value of each service the environment provides to society and, therefore, the monetary-equivalent impact of any policy intervention. The values presented were striking, adding up to many billions of pounds. If this values are accepted as robust, then policy making in the UK would steer majorly from its current course. However, many dispute their validity, on the basis that a large part of these values are driven by the value attached to biodiversity, which is considered highly subjective.

b) **there is at least one informed agent and her preferences are not common knowledge and they may differ from the decision maker's.** Environmental issues have been part of the economic discussion only relatively

[2]To understand the importance of this issue, let's consider a quick example. Let's assume that the extinction of a bird will create a loss to society of £1 billion in 150 years' time. If the cost is valued using Stern's assumption, then the cost would be roughly £1 billion; but if we use HM Treasury's guidance, this would have a discounted value today of roughly £5 million, 200 times lower.

recently. In the next paragraph, we present more evidence regarding this; here we only highlight the fact that, as in our initial example, the tension between public benefits and private costs lead to the creation of different interest groups. This is also confirmed by the wide differences among the political parties' manifestos and then between one party's stance at local and national level.

Environmental lobbying in real world

As public opinion has increasingly become weighted in favour of the environment and the values attached to environmental damages are increasing, green pressure groups are increasingly influential in the public debate.

Lobbying activity has lead to several changes. For instance, in Britain, the work of Green Alliance (a politically-independent lobby group) has pushed every major party in the UK to publish its green agenda in the political manifesto before general elections; lobbying by NGOs has led to voluntary agreements among supermarkets (from the early ban of incandescent light bulbs, to the phase-out of F-gases in refrigeration, etc). To have an idea of the growth of the phenomenon, in the USA, the number of companies recruiting lobbyists for green issues increased in the period 2000-2008 from 4 to 291 (Mullins, 2008).

However, tighter environmental policies often imply higher costs for producers or changes in the labour market structure (which in the short run may imply unemployment). This has increased the strength of counterbalancing groups to push the private industries' interests. These groups are often referred to as "brown lobbyists", as they advocate lower environmental standards. Looking at brown lobbyists, the figures presented above seem to pale: only in 2009, fewer than 800 companies hired 2340 lobbyists to fight against the "cap and trade" reform (Public Integrity, 2009).

It is important to note how the evidence reported so far merely shows how different groups exercise effort to present evidence supporting their causes. At the same time, sometimes lobbyists have been accused of overexercising this

influence. The IPCC has been accused of publishing data which differed from that previously approved by its scientists' panel, in order to make the impact of their reports stronger (Seitz, 1996). More recently (The Economist, 2010), the IPCC has again been under fire for allegedly misrepresenting the effect of climate change on the Himalayas and later for quoting Greenpeace funded research, without questioning its assumptions (The Economist, 2011). Davies (2009) notes that Greenpeace has been accused to use unsubstantiated arguments in favour of climate change. On the other hand, UCS (2007) reports how ExxonMobil in 7 years gave more than $15 millions to organisations aimed at disseminating false information on climate change. Energy companies have lobbied governments and the EU to invest in shale gas in order to reach the EU 2050 CO_2 targets allegedly at a fraction of the cost of its alternative (ie. renewable sources). Oreskes (2004) presents data on brown industries promoting scientific dissent on climate change for financial reasons. The claims are based on a highly publicised report (EGAF, 2011). However, Howarth et al. (2011) suggests that shale gas is likely to be even more polluting than burning carbon.

A lobbyist would use her special access to decision makers to persuade them to act in protection of her interests. Alternatively, this could be an opportunity for interest groups who would otherwise have little public voice to be heard and bring to the discussion table all the relevant issues. In many environmental settings, even though the stakes are extremely high, there is often no way to establish who is right and who is wrong, even by looking at data and scientific reports.

The influence of lobbying is generally considered to be negative for social welfare, as it protects one particular interest group, without consideration for the rest of society. Typical examples are the weapon and tobacco industries in the US or farmers' associations within many European countries. Recently, in several countries, the role of the lobbyist has been questioned, as it appears to go beyond the common good and rules regarding their operations promulgated.

In every country, it is possible to identify a numberof pressure groups which is deemed to be more or less influential in political decision making. In the USA the practice of "cash for access" is legal, while in the majority of the EU countries it is not. In the UK, the government nominated in 2012 a lobby minister, in order to regulate the industry. The difficulty is, of course, twofold: the legislator does not want to silence potential sources of precious information, but wants to limit the practices which can be deemed as corruption.

3.1.2 Advisers & Economics: absolute bias and our model

Economists have long discussed the importance of lobby groups in the decision making process: in a nutshell, lobby groups (more or less disguised) would try to influence policy decisions to increase their own utility. It may look counter-intuitive and definitely contrary to common belief, but lobbying is actually considered a good thing from an economics' point of view, since it facilitates the transmission of information, albeit imperfectly. This can enhance choices. This is even more so in presence of irreversible limits (almost unique to environmental issues, and against general assumption of standard economics), as the damage of taking the wrong decision is enduring.

We will begin by analysing the lobbyists' behaviour. As it has been said, while the government tries to take into *fair* consideration the interests of each component of society, a lobbyist prioritises the interests of *one* group above all the others. This is the key to the bias in the evaluation of events. We could distinguish a *relative bias,* when a lobbyist weighs less the utility of a subset of members of society, from an *absolute bias,* when the utility of a subset of subjects is completely disregarded. In the UK, associations like Greenpeace are considered to be in the latter category, pursuing any environmental cause, no matter the cost. Green Alliance, on the other hand, may be in the former group, presenting reports that take into consideration the effects of their recommendation on the whole economy.

A trivial example of these two different categories can be found looking at football fans. Die-hard supporters would defend their team even after a disastrous game (absolute). More balanced fans would show their bias only in less clear-cut situations, but recognise the superiority of another team, after a humiliating performance (relative).

This has important implications for us. If the adviser's interest is completely uncorrelated with the state of the world, then her advice conveys no information at all. Let us consider our initial situation. If the local authority has to decide what to do about the lake pollution, it will seek external advice. If the lobby group supports the interests of the factories, then the advice will be not to further intervene, regardless of the situation or the potential social and environmental costs. The lobbyist would concentrate on the potential extra profit of the group she represents, attaching no value to the economic, social and ethical cost required to achieve it.

In other words, the lobbyist would give the same advice, regardless of the state of the world, to maximise her own utility or to limit her future losses, as she would be directly harmed by an adverse state of the world.

Despite the risk of receiving a biased advice, decision makers often rely on external advisers, rather than making an uninformed decision.

It becomes essential, then, to understand when truthful advice is more likely to be given and if there are ways to induce the adviser to disclose her information more frequently. One way to do this is to ask the same adviser for her opinion in consecutive separate events, creating in this way reputational concerns: the adviser knows that if she misleads the decision maker today, tomorrow she will be completely disqualified as adviser.

Then, there may be the case that an adviser may decide to tell the truth in the initial period, in order to increase her influence in the last period. This means that if we consider the situation in which an adivser has to give two consecutive advices, then giving the first advice she will use a relative bias,

while for the second, she will have an absolute bias. The partial interest for the opposite cause in the first decision is purely instrumental to improve her reputation in the following period.

This means that the decision maker increases the chances of getting truthful advice in the first period. However, this incentive mechanism (reputation building) creates also an opportunity for the adviser (potentially backfiring on the decision maker). As an unbiased adviser passes on her information more frequently, every time a biased adviser gives truthful advice, her reputation improves for the following period. But if the biased adviser then lies in the last period, then she will divert the decision more from the optimal solution.

In fact, if on the one hand social welfare may increase in the initial period(s) because of the good advice, then in later period social welfare may decrease, as bad advice will be relied upon more heavily. This paper analyses (i) the conditions determining the adviser's strategy; (ii) how much (if any) information the principal can extrapolate from the signals of a potentially biased adviser who has perfect information; and (iii) how the government can infer social welfare.

3.1.3 Literature review

As previously noted the literature has not focused on this particular topic. The paragraph presents the literature that more closely relates to this paper, although it does not refer in specific to environmental economics. Before that, the next section briefly gives an overview of the literature on green lobbying which, however, is not stricty related to our model.

Environmental lobbying

To our knowledge, literature on environmental lobbying is mainly focused on two areas:

a. Macroeconomics

The vast majority of papers are applied to macroeconomics. They focus mainly on the effect lobbying has on green policies in political situations (ie. when a decision maker wants to be re-elected). In other words, very often, environmental policies are seen as bargaining chip to play to decide electoral battles. Scholars do not seem to consider them on the same level as other policy decisions. As most papers refer to climate change (and more specifically to international agreements), the models in this branch of literature use open economies models. Air pollution being an international issue, the attention is focused on the effects of the decisions taken by different countries.

The general debate is about trade liberalisation and its effect on environmental regulation. On the one hand, green supporters believe that free trade pushes governments to a race to the bottom: for the fear of losing competitive edge, due to higher costs, governments relax the stringency of their national environmental regulation. For this reason, the international community should impose agreed policies to regulate markets. On the other, neoclassical economists believe that by increasing countries' openness, markets create a surplus that can then be reused in eco-friendly policies. The policy insights coming from this literature focus on level of environmental taxation and the effect of lobbying on economic efficiency and social welfare.

Aidt (2010), Fredriksson (1997), Damania (2003) and Persson (2012) look at small open economies. Aidt (2010) looks at the effect of different environmental taxes on the market and on the voters' reaction. The paper shows how a brown lobbyist may opt for the revenue of this tax to be devolved to voters, as even low level of taxations may please the voters. Damania develops the existing model to endogenise the level of a nation's corruption into the model and shows how higher levels of corruption are inversely proportioned to environmental regulation stringency. This is due to the fact that it is assumed that corruption is more likely to come from brown lobbyists. Furthermore, it finds that the trade liberalisation decreases incentives for lobby groups (brown and

green alike) to influence the decision maker, if the country has a comparative disadvantage in the production of the polluting good. The model is confirmed by empirical analysis based on data from several countries. Persson (2012) confirms the results in Damania, using a more general model. In particular, corruption decreases the incentive to consider externalities. International openness affects environmental taxes positively but with intensity that is inversely proportionate to the level of local corruption (in other words, in more corrupted economies, a freer international trade will increase a lot ecotaxes).

Grossman and Helpman (1994) Schleich et al. (2000) and Conconi (2003) focus on large open economies.

Schleich et al. and Conconi use a Grossman-Helpman model, in which two large nations trade a good, which creates trans-boundaries negative environmental externalities (in either production or consumption). Governments decide on internal policies as well as trade patterns. They can behave cooperatively or not. Lobbyists intervene to affect the efficiency of the system in order to maximize profit. Schleich et al. (2000) show that lobbying can offset the comparative advantage and lead to inefficient outcomes. The authors show that if governments cooperate, higher welfare may be obtained but environmental protection may be lower than in non-cooperative settings. Conconi (2003) shows that overall environmental quality depends on governmental cooperation but also on coordinate actions from the lobbyists and the size of the spillovers. If governments opt for free trade and one lobbyist pushes for more stringent environmental regulation, national standards improve but the overall level of pollution may increase.

b. Motivation to lobby

Another, more diverse, set of papers looks at lobbyists' motives and strategies. Shapiro (2011) shows the effect of an increase in the reputation of an unbiased adviser, if a lobbyist has the opportunity to pay to substitute her opinion. An imperfectly informed unbiased expert sends his message to the

decision maker. However, a biased lobbyist may decide to costly substitute the expert's message with her own. This means that there is a limit to the level of information that the expert is allowed to have without triggering the lobbyist to intervene, meaning that investing in better information is fruitless. This model is then used to explain the current situation concerning climate change.

Polk and Schmutzler (2005) develop the model in Rodrik (1986), which looks at the interaction of two lobbyists representing different sectors but both interested in the reduction of environmental taxes. They have two ways to affect policy-making: one trying to lower the environmental standards, the other creating exceptions (loopholes) to the general rule only to advantage the sector they represent. An increased effort to create a loophole for a sector makes the other lobbyist's effort more costly. The paper concludes that general lobbying tends to be underprovided and that loophole lobbying may effectively push environmental standards up.

Finally, a number of articles looks at the motivations that lead to caring for the environment. Scholars have mainly focused on monetary incentives (for example, Laffont, 1995). Benabou and Tirole (2006) show however that intrinsic incentives like warm glow can be applied to environmental protection. The authors point out how, if there is no financial gain beyond these intrinsic motives, agents rely on their improved reputation. People who note a noble behaviour that is not rewarded economically will trust this agent more in the future. Banerjee and Shogren (2012) expand this model and study the role of reputation as an incentive to internalise environmental externalities. The paper defines crowding out as the reduction of an agent's reputation, due to monetary motives behind environmental care. Therefore, the government has to find ways to stimulate brown (low reputation) firms with economic incentives and green (high reputation) firms by refraining from making any transfer to them, as they would act anyway and the payment may reduce their credibility in the eyes of the public. The authors show that brown firms may sacrifice

information rent and be willing to invest on reputation. They also show that the more the information about contribution is public, the higher the voluntary contribution.

The model presented here is not easily associable with any of the existing literature. There exists a large, anecdotal and often non-academic, series of publications looking at how lobby groups have affected particular governments, both by preventing or fostering environmental regulation. The rest of the literature review will look at models that share similar features to ours but that are not applied to environmental economics.

Reputational concern and cheap talk

The model presented falls into the broad class of models incorporating *cheap-talk.* A cheap-talk game is a signalling game in which none of the payoffs **directly** depends on the adviser's message but only on the principal's decision. This implies that: (a) the signalling is costless (otherwise it would affect the adviser's payoff); (b) the principal is free to do whatever he wants with the message received. He could follow it completely or disregard it altogether. Or anything in between. Finally, (c) although the payoffs are not affected directly, the principal's decision is a function of the agent's signal and this decision will eventually determine both final payoffs. Let us explain this with an example: a firm puts a label on its product stating "greener than ever". The communication has no additional cost for the firm. Consumers read the label and they make their decision. However, consumers know that the label may not convey any real meaning and therefore they can choose to take it into consideration or not.

The literature on cheap talk and reputation building is relatively new but quickly expanding, due to its relevance for so many real world settings. The research in this field can be grouped in many different ways. We distinguish

between models in which the informed player has perfect or noisy information about the state of the world.

Noisy signal.

Crawford and Sobel (1982), Benabou and Laroque (1992), Prat (2005) and Morris (2001) all present models in which the adviser can have only one type of bias and noisy information (ie. advisers know that the state of the world is going to assume a particular value with probability $p \in]0.5; 1]$). Crawford and Sobel (1982) provide the seminal analysis of cheap-talk games. Their main finding is that in presence of noise in the system, with one possible bias (opposite utility to the principal), the signaling equilibrium is more informative the closer the congruence between the preferences of the adviser and the advisee. Benabou and Laroque (1992) expand Sobel (1985), allowing for reputation to fluctuate. Morris (2001), formalising a concept first expressed in Loury (1994), shows how a partially informed adviser (with identical preference to the principal's) has an incentive to reveal completely her information; however, if the principal is unsure about her preferences, and therefore he thinks she could be biased, it might be in the adviser's interest not to disclose her information in order to 'signal' her unbiasedness.

Morris considers the case in which the principal knows that the agent is either unbiased or racist. Therefore, in this model all the information might be lost (degenerating in a *babbling equilibrium*). In the repeated version of this game, the adviser could lie in order to boost her reputation in later periods. This phenomenon is referred to as *political correctness*. The paradox here is that although the two players have exactly the same utility function, the adviser wishes to signal she is not biased, and therefore she does not disclose information that might taint her reputation. Two important assumptions are made in the model: firstly, giving non-politically correct advice lowers the adviser's reputation, independently by the realised state of the world. Secondly, regard-

less of the true state of the world, there is a particular outcome with intrinsic value, that makes it superior (or more desirable) than all the alternatives[3].

A number of papers (among which, Shin (1998), Dewatripont and Tirole (1999), Ely and Vālimāki (2003), Battaglini (2004) and Li (2010)) presents models in which the principal uses more than one adviser. Battaglini (2004) deals with the equilibrium when several advisers -with different and noisy signals- are used by the principal. The paper is particularly interesting because it shows that complete extrapolation of information is impossible in equilibrium: this is because of a trade off between information precision and the elimination of uncertainty about the reputation of the adviser. Dewatripont and Tirole (1999) show the conditions under which a decision maker can extract the maximum information by asking information to two imperfectly informed advisers (each advocating a particular cause). In a similar setting, Shin (1998) shows how the decision maker is not better off by spending effort undertaking his own research in the matter, but he should rather rely on advocates.

Farrell (1995) and more extensively Farrell & Rabin (1996) characterise the equilibria obtained by changing the players' preferences and skills. They find that at the extremes, Pareto efficiency and no information loss is achieved (if the agents have the same preferences) or a *babbling equilibrium* (where all information is lost). Babbling equilibria are always possible, but it is also possible to achieve an equilibrium where part of the information is passed on. This will happen for two reasons: either because the principal will not trust completely the signal received or because the agent will simply not disclose all the information in her possession. Finally, equilibrium is shown not to be unique.

Another set of papers looks at situations in which the players's interest is her own reputation only.

[3]For example: a genetic discovery linking red hair to ill temperament would surely be frowned upon, even if it is proved to be a scientific fact.

Ottaviani & Sørensen (2006) recognize that an adviser is often interested in her own reputation rather than the final outcome of the game. They present a model with imperfectly informed advisers and continuous advice and state of the world. It is shown how the signal that gives the highest reputational outcome does not coincide with the observed one and therefore part of the information available is lost. Political correctness here can be applied, with a slightly different connotation: the goal is not to pass the information that maximize one's own final payoff but, simply a concern for one's own reputation *per se;* in other words, reputation is the aim and not the mean. Furthermore, it is derived how in equilibrium, the adviser will indicate the right direction of the signal but not its real intensity. Another case of distorted incentive is presented by Leaver (2009). The paper analyses reputational concerns when reputation can also be damaged by truthful advice. The author applies the model to civil servants advising policy makers. To avoid thorny issues and potential reputation backlashes, civil servants may settle for less than optimal advice to please the public and politicians. In both cases, reputation concerns make the adviser less likely to disclose information.

Finally, a large branch of game theory concentrates on models in which cooperation may lead to mutual gain (or non-cooperation to larger losses). In these games, both players have to build reputation for being cooperative. Fundenberg and Maskin (1986) show how in the context of a prisoner's dilemma, cooperation is sustainable in the long run. Hausken (2005) and Skaperdas and Syropoulos (1996), on the other hand, show how to establish a reputation, cooperation is not achieved, proportionately with the importance of the future periods.

Finally, Hausken (2007) illustrates the conditions under which the reputation for patience of one player leads the other one to cooperate.

Non-noisy signal

The model presented here deals with reputational concerns in a situation in which the adviser receives a non-noisy signal. In other words, where the adviser knows for sure what the state of the world is going to be.

Sobel (1985) describes the equilibrium in repeated game where signaling is costly. The adviser is either good (identical interests as the decision maker) or bad (opposite interests). Wrasai and Swank (2007) show that the policy maker's power to fire his adviser (who can be either good or bad) after receiving bad advice is not always efficiency enhancing. Frisell and Lagerlof (2007) present the model most similar to ours, when it comes to characterise the adviser, who can have different biases.

Setting the advice binary and a perfectly informed adviser are hypotheses previously made in literature in different context. We have decided to take this direction for several reasons. Firstly, it simplifies the model. But mostly, it is believed not only that the two work well together, but they do not deprive the model of much explanatory power.

By allowing the adviser to give only yes/no advice, the decision maker forces the adviser to either tell the truth or lie. This is also in line with the fact that if the adviser is fully informed, it would not make sense for the adviser to give advice which differs from one of the possible outcomes (as she know exactly what is going to happen).

Authors who have used noisily informed advisers have raised the point that the opposite assumption implies that the adviser can be "damned" forever for deviating only one time, whilst allowing for noisy information, the adviser's reputation can fluctuate indefinitely.

But the principle with which the models are constructed are the same and the differences do not seem to add much to the model. In fact, our model maintains intact the three characteristics of the relation between adviser and policy maker, that is:

1. The adviser will tell the truth if by doing so her present and future payoffs will be affected positively;

2. The adviser will tell the truth if by doing so her current loss will be lower than her future gains;

3. The adviser will not disclose her information if this will affect negatively her overall payoff.

These are the conditions that an adviser with a noisy signal would consider as well. In the context of the model presented, it was not felt that the further complication of an imperfectly informed adviser would add much to the findings.

3.1.4 The model and its context

The model follows Morris (2001) in its general setting, but we apply it to an environmental context. A decision maker (he) has to take two consecutive, independent decisions in a particular matter, the outcome of which is a Bernoulli trial. As we mentioned before, this could be whether to stop pollution of a lake or not. The net benefit of the ban may be positive or negative. Social welfare is maximum when the true state of the world is guessed. To improve the quality of the decision, he seeks the advice of a perfectly informed adviser. The decision maker has a priori imperfect information on the adviser's utility function. The adviser can be unbiased (and therefore share the government's aim of welfare maximisation) or biased, preferring a particular state of the world. She is green if she always prefers the government to act, while she is brown if she prefers the government not to stop pollution. The adviser can only give binary advice which is communicated costlessly. The principal takes into consideration the advice and the adviser's reputation and then takes a decision. After the decision is taken, the true state of the world is realised and the adviser's reputation is updated.

This paper adds to the known existing literature in four different ways. (1) the adviser can be unbiased or have one of the two existing biases. In Morris's model, the unbiased lobbyist could only be confused for one kind (say - *green).* In the model presented here, he can either be unbiased, *green* or *brown.* Incorporating this assumption, the results obtained are rather different. Also, (2) this is different from the papers in which advisers can be good or bad. In this branch of literature, it is assumed that an adviser's utility would always (or never) be aligned with the decision maker's; in our model, a biased adviser's ideal outcome could be the same as the decision maker's but not in the following period. So, in a way, our biased advisers are similar to the *advocates* in Dewatripont and Tirole (1999) or Shin (1998), as they would always support the same side, which may or not be the best choice for social welfare. However, in our model only one adviser is chosen and the decision maker does not know which side she is supporting. (3) The model presents another difference with the existing literature: the weight of the second period is not restricted to be below one. Existing literature considers this parameter as time discounting. In our model, the weight has two further explanations: on the one hand, it represents the situation in which the second outcome is more important than the first even after discounting. On the other, the second period could be considered as the sum of pay-offs of a series of future periods. Finally (4), the adviser's reputation update presented here is more complex, for two reasons: firstly, because the adviser can belong to three, and not two, distinct categories; then because in each period the government has the chance to update the adviser's reputation twice (after the advice is received and after the state of the world is realised).

The model presented here falls into the category of reputation building with non noisy signal. It enriches existing literature in several ways: (1) to our knowledge, it is the first paper on reputation building specifically applied to environmental issues; (2) it presents the situation in which the adviser can be of

three different types: unbiased, green or brown. This is important, as it removes the possibility for the unbiased adviser to signal their type via political correctness; (3) we show that the principal can extract complete information in the first and -more surprisingly- in the second period. This is due to the fact that, as all parameters are known at the beginning of the game, the decision maker knows what the best strategy for a biased adviser is. (4) Interestingly, when the adviser's preferred strategy is going for reputation, she enters the second period with unchangeds reputation. We also highlight how (5) to increase social welfare, the decision maker can affect the adviser's strategy when the latter is indifferent between her two possible strategies.

3.2 The Model

In this section we present the model. All the full mathematical derivations are included in the Appendix.

A decision maker (he) has to take two consecutive, uncorrelated decisions on a particular situation. The state of the world is the result of a Bernoulli trial:

$$\begin{aligned} w_i &= \{0;1\} \\ i &= 1,2 \end{aligned}$$

where i represents the period. Going back to out example, the decision maker has to decide whether or not to allow pollution of the lake. He needs to know if the current state of things is sustainable and therefore no intervention is needed ($w = 0$) or if critical values will be crossed and action is required ($w = 1$).

Knowing the state of the world, the decision would be consistent with it. He can take a decision (d) in the continuous interval:

$$d_i \in [0; 1]$$

d represents the intensity of regulation, where $d = 1$ regulation is the tightest and pollution has to stop completely. This means that, unless $d = 0$, pollution activities are at least partly restricted. The policy maker is interested in taking the right decision, according to the state of the world, regardless of which one it is: in other words, there is not a more socially, morally or politically acceptable decision. £1 of environmental damages weighs as much as £1 of avoidable costs to the private sector.

The government has no information on the future outcome and therefore he has no grounds to make an informed decision. For this reason, he seeks the advice from a perfectly informed adviser. The adviser (she) may be unbiased, or biased. If she is biased, she may prefer one or the other state of the world. The government does not know which type she is, but he has a priori belief on her reputation, ie. the probability that the agent is unbiased (p) or if biased $(1-p)$, the probability she is an environmentalist (g) always preferring $w = 1$, or industry-lobbyist $(1-g)$ preferring $w = 0$.

In other words, the probability of the government facing each type of advisor can be expressed as follow:

$$P(unbiased) = p \tag{3.1}$$

$$P(green) = (1-p)g \tag{3.2}$$

$$P(brown) = (1-p)(1-g) \tag{3.3}$$

Furthermore, to simplify the model, we assume:

$$g_0 = \frac{1}{2} \tag{3.4}$$

where the subscript represents the sequence of updates the reputation (0 therefore refers to the initial reputation). Eq. 3.4 means that, at the beginning,

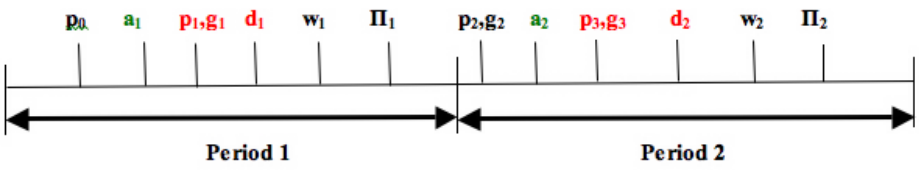
the government has no information on the probability that a biased adviser is green. A green lobbyist wants the government to always intervene and set more stringent environmental laws; a brown lobbyist instead wants the government to never intervene, as new laws would imply extra costs for firms.

The adviser has perfect information about the state of the world and, considering that and her utility function, she provides binary advice $\{0; 1\}$ to the decision maker. After receiving the advice, the government updates his beliefs on the adviser and takes a decision. Reputation updates are made using Bayes' rule.

At the end of each period, the true state of the world is observed and payoffs are calculated. The government considers if the advice he received was correct or not and adjusts once more his beliefs on the adviser's reputation. The second period follows the same pattern.

Figure 3.1 shows the sequence of the moves in the game on a time-line.

Figure 3.1: The Sequence of Events



Period 1.: The advisor knows what the state of the world is going to be. She decides what to communicate to the government. According to this advice, G updates his belief on the *potential kind of bias* the agent may have; he then takes a decision. At the end of the period, the true state of the world *w* is observed. G updates his belief on the *biasedness* of the agent and payoffs are computed. **Period 2.:** The agent finds out what the state of the world is going to be in this period. The advisor chooses her last advice and communicates it to the government. The government adjusts once again his beliefs on the *potential kind* of bias and take his final decision. At the end, the second state of the world is realised and total payoffs are computed.

Before addressing the solution of the model, in the following sections we will describe the main characteristics of the model: 3.2.1 presents the different

utility functions; 3.2.2 the different kinds of advisers; 3.2.3 reputational concerns; 3.2.4 reputation updates. 3.2.5 presents the decision rule for the adviser. Finally 3.2.6 discusses the solution of the model and its implication on social welfare.

3.2.1 Utility Functions

Let us now introduce the different utility functions of the players. The game is played by a principal, the local administrator in our example, and an agent, the lobbyist. The decision maker -the principal- cares about social welfare. Going back to the example we have given before, if a rare species of animal lived in a lake which is polluted by a firm, the government would have to decide whether to implement new, more stringent environmental policies (if the pollution might lead to extinction of this species) which represents a cost for the firm, or leave things as they are. The government cares exclusively about taking the right decision. We rule out political correctness or intrinsic preferences.

If we define the state of the world in period i as w_i,for $w_i = 0$, there is no need for intervention by the principal: although the lake is being polluted, there is no risk of endangering its ecosystem; for $w_i = 1$, on the contrary, the environmental damages are so high that this species will eventually die out; it is in society's best interest for the government to intervene and impose more stringent environmental regulation (hence increasing the cost for the firm). We can capture this with the simple function:

$$SW = \quad -\sum_{i=1}^{2} \beta_i \left(w_i - d_i\right)^2 \tag{3.5}$$

Social welfare is the weighted sum of the welfare in the two different periods. d_i is the decision taken in period $i = 1, 2$. The weights are expressed by β_i. Since there are only two periods, we can express the weight on the second

period relatively to the one on the first ($\beta_1 = 1$ and $\beta_2 = \beta$) and re-write the previous equation as:

$$SW = -\left(w_1 - d_1\right)^2 - \beta\left(w_2 - d_2\right)^2 \tag{3.6}$$

As said, if $w_i = 1(0)$, then the current level of pollution is (not) going to *further* affect the environment negatively and it would be in society's best interest (not) to intervene.

d_i is continuous, twice differentiable and its derivatives are continuous. The function can take values included in the interval $[0; 1]$. d is a function of the advice (a), the reputation of the adviser of being unbiased (expressed by the probability that the adviser unbiased, p) and the probability of green bias (g).

The value of d represents the effort of the government to offset potential social cost (which depends on the occurrence of the state of the world $w = 1$), which creates private costs for a particular group of individual in society. The decision rule will have the form:

$$d = d(a, p, g)$$

Later we will consider the best decision rule for the decision maker. But prior to that, we can make some general observations about it.

a) The higher the reputation of the adviser of being unbiased, the closer the principal will follow her advice:

$$\begin{aligned} \frac{\partial \mid d - a \mid}{\partial p} &< 0 \\ \lim_{p \to 1} \quad \mid \quad d - a \mid &= 0 \end{aligned}$$

Clearly, if the government knows for sure that the adviser is unbiased, then he will follow her advice fully. But the higher the possibility she is biased the more the government will be cautious in accepting her advice blindly.

b) The more the government is convinced the adviser is biased, the more his decision will approximate the uninformed choice of $\frac{1}{2}$[4].

$$\begin{aligned} \lim_{p\to 0} d &= \frac{1}{2} \\ \lim_{p\to 0} \quad | \quad & d-a \mid = \frac{1}{2} \end{aligned} \tag{3.7}$$

c) If $g > \frac{1}{2}$ (i.e. if the adviser *is* biased, she is more likely to be green than brown), then the government will give more weight to her advice if it is $a = 0$.

$$\begin{aligned} p &= \bar{p} \qquad g = \bar{g} > \frac{1}{2} \\ &\rightarrow \quad d(0,\bar{p},\bar{g}) <\mid d(1,\bar{p},\bar{g}) - 1 \mid & (3.8) \\ \wedge \; g &= \bar{g} < \frac{1}{2} & (3.9) \\ &\rightarrow \quad \mid d(1,\bar{p},\bar{g}) - 1 \mid < d(0,\bar{p},\bar{g}) & (3.10) \end{aligned}$$

or expressed in other terms:

$$g_1 > \overline{g} \rightarrow d(0,\bar{p},\overline{g}) > d(0,\bar{p},g_1) \tag{3.11}$$

$$g_1 > \overline{g} \rightarrow d(1,\bar{p},\overline{g}) > d(1,\bar{p},g_1) \tag{3.12}$$

The expressions in 3.8 and 3.10 simply state that if the government considers the adviser to be more likely green (brown), then he will weight her advice more if it is $a = 0(1)$, as it is more likely to be against her interest.

[4]If the government has no information, then his problem is to maximise social welfare, considering the two state of the world equally probable. In other words,
$\max(w-d)^2 = \max[\frac{1}{2}(0-d)^2 + \frac{1}{2}(1-d)^2]$
F.O.C. $d^* = \frac{1}{2}$.
giving the optimal decision.

This is simple to understand through example. The government has to decide whether to increase tax on CO_2 emissions of cars and he seeks external advice. The government has strong beliefs the adviser is a green lobbyist. If she advises to increase tax, the government will follow the advice, but weighting heavily the possibility that the advice may convey no information. But if she were to advise against the increase, then the government will give more weight to the advice, as seemingly against her own interest (and therefore increasing the chance the adviser is unbiased). If a supposedly brown lobbyist recommends to the government that the species living in the lake is endangered and action ought to be taken, the government will take the advice into consideration more than if it suspected her to be green-biased.

Finally,

d) For any given reputation of the adviser,

$$d(1, \bar{p}, \bar{g}) > d(0, \bar{p}, \bar{g}) \tag{3.13}$$

This simply means that, everything else constant, the decision is higher if the advice is 1 rather than 0. The principal may take into consideration a lot, or very little the advice, but since there is a possibility that this conveys information about the true state of the world, the condition must hold.

The social welfare function is convex; this implies that the loss increases more than proportionately, the larger the mistake is in guessing the real state of the world. Furthermore, the government's costs of deviation are symmetrical. In other words, social welfare decreases in the same way whether it over/under-legislates: the important thing is *how far* his decision is from the ideal one. As it is expressed by the Eq. 3.5, the government has no preference for either state of the world, provided he is able to forecast it correctly: there is no intrinsic preference for either a cleaner world or a more industry-oriented one.

One last note on social welfare. The function is the sum of the costs borne in each period by society: Eq. 3.5 represents the net social cost arising from (i) a particular situation, and (ii) the decision that is preventively taken. The government will have set all his other policy to maximise social welfare, considering all the other aspects of the economy. In other words, when considering social welfare, we do not define it as the sum of the players' utilities.

Let us consider now the adviser's pay off functions. For a lobbyist, this is an opportunity to influence the government to pursue her private interest. The unbiased adviser has similar preferences to the principal's, i.e. she is motivated by social welfare.

$$PO_u = -\sum_{i=1}^{2} \beta_i \left(w_i - d_i\right) \tag{3.14}$$

where u stands for unbiased. It is easy to see that the function is maximised when $w = d$; an unbiased adviser does not have preferences for a cleaner environment or the contrary. He cares for the true state of the world.

If instead the adviser is biased, then she will want the government to weight a particular interest more (the environment welfare or the minimisation of costs for the firm), regardless of the state of the world.

The biased advisers will have similar function, independent from the realised state of the world; in particular:

$$PO_b = -\sum_{i=1}^{2} \check{\beta}_i d_i \tag{3.15}$$

$$PO_g = -\sum_{i=1}^{2} \hat{\beta}_i \left(1 - d_i\right) \tag{3.16}$$

where the subscript b, g stands for *brown* and *green*. The period weighs β, $\check{\beta}, \hat{\beta}$ need not be the same for the government and the different advisers (hence the different notation). However, for simplicity, they are assumed to be identical; from now we will call them β.

We can imagine that the utility functions 3.14, 3.15 and 3.16 are actually identical but for the biased advisers the *actual* state of the world is substituted with the *most desired* state of the world (0 in the case of the brown adviser and 1 for the green one): the farther the decision is from what the adviser wishes for, the worse off she is.

On the one hand, a brown lobbyist wants to be sure that firms will not face increased costs by an imposed adoption of new greener policies, regardless whether current practice is seriously harming the environment or not: the social costs are completely disregarded.

On the other hand, an environmentalist seeks to eliminate those damages, regardless of the implied costs for the firms. For a green lobbyist payoff is highest when the government plays 1, imposing more stringent environmental policies, even when the extra burden on firms is disproportionate to the foregone environmental damage.

We have previously defined this as an absolute bias. Looking closely at it, it *may* look as though the green adviser is more of a firm-hater, disguised as environmentalist. This is a common assumption in this branch of literature. Let us assess how realistic this assumption is.

As much as it is possible to identify a handful of existing organisations that can actually fall into this category, our aim is to describe an agent whose utility derives by an unbound love for a cause, rather than an irrational hate for something. Indeed, it is possible to explain this characteristic in a more realistic and compelling way. As we have mentioned before, we are characterising *absolute* biased advisers. This implies that their advice will be completely independent from the actual state of the world, and therefore constant even when the state of the world changes.

Additionally, it is also easy to add further explanatory power to this function. As we have said, w_i represents the state of the world of a particular phenomenon that may (or may not) affect the environment. An environmentalist

would prefer the government to always take action, regardless of the possibility of the endangerment of a species: she will prefer a cleaner environment, regardless of the necessity or economic efficiency of the action. In other words, even if that particular animal is not in danger, for the green adviser cleaner is always better. Are we then describing an irrational behaviour? The answer is no, as this behaviour can be explained if we consider different preferences and different discounting.

The bottom line here is that, unlike many applications of biased advisers, this particular setting has an almost unique characteristic: the cost borne by the firm has the effect of improving the environment and therefore increasing the utility of an environmentalist, regardless of the state of the world. This characterisation of the green environmentalists draws similarities with Morris's *political correctness*: one state of the world holds intrinsic features for some people in society which makes it preferable, regardless of reality.

One final note: as we will see, game repetition will make this behaviour less radical.

3.2.2 Adviser and advice

At the beginning of period 1, the government knows that the probability of choosing each category of adviser is as follows:

$$\begin{aligned} P(unb) &= p_0 \\ P(green \mid biased) &= g_0 = \frac{1}{2} \\ P(b\,\mathrm{row}\,n \mid biased) &= 1 - g_0 = \frac{1}{2} \\ P(green) &= (1-p_0)\frac{1}{2} \end{aligned}$$

As we have already mentioned, for simplicity we assume that the initial probability of facing a green and brown adviser is the same.

The adviser is (perfectly) informed about the future state of the world. The government asks for a binary advice. The agent therefore has to decide what is in her best interest and then communicate the advice as:

$$a_i = \{0; 1\} \qquad\qquad i = 1, 2$$

If she is unbiased she will always truthfully disclose her information.

On the other hand, if the adviser is biased and the outcome is contrary to her best interest, then she has to make a strategic decision: if she lies she will get a higher payoff in the current period; however, when the government realises the bad quality of the advice, he will downgrade her reputation and disregard her advice in the following period. Alternatively, she could decide to disclose the truth and gain more trust for the following period. This part will be developed analytically in the following sections.

The government adjusts his beliefs on the adviser and then takes his decision. A green adviser is more likely to recommend action, while a brown one is more inclined to advise to leave things as they are.

3.2.3 Information Update

The government updates the adviser's reputation in each period in two different ways, in response to the two information he receives: (a) the advice; and (b) the state of the world. On the one hand, he will consider the advice *per se*, i.e. which of the two state of the world is advised; then he will evaluate the *quality* of the advice, i.e. if the forecast was accurate or not. Probability updates are made using Bayes' rule.

In particular:

a) after the advice is announced,

$$p_{i+1} = P(unb \mid a_i = a) = \frac{P(a_i = 0 \mid unb)P(unb)}{P(a_i = a)} \quad (3.17)$$

$$g_{i+1} = P(green \mid a_i = a) = \frac{P(a_i = 0 \mid green)P(green)}{P(a_i = a)} \quad (3.18)$$

b) after the first state of the world is observed,

$$P(unb \mid a_i = 0 \wedge w_i = 0) = \frac{P(a_i = 0 \wedge w_i = 0 \mid unb)P(unb)}{P(a_i = 0 \wedge w_i = 0)} \quad (3.19)$$

$$P(unb \mid a_i = 0 \wedge w_i = 1) = 0 \qquad \Rightarrow g = 0 \quad (3.20)$$

Let us consider these general expressions and make some considerations. In period 1, if a brown adviser finds out that $w_1 = 1$, she knows that by telling the truth, her payoff in the current period would be lower than if she would lie. This can be seen by plugging Eq. 3.13 in Eq. 3.15 show. However, the price to pay for her honesty is attenuated, as Eq. 3.18 and 3.11 shows. In fact, as the advice is $a_1 = 1$, then the probability the adviser is green increases (as a proportion of the biased advisers) and therefore the decision maker will discount this by decreasing his decision. This latter effect is the first component of the reputation strategy.

Eq. 3.20 conveys an important condition about the reputation update.

As the adviser is perfectly informed, if the advice turns out to be wrong, then the government knows that she is biased and therefore he also knows that the advice in period 2 will surely not convey any information and hence take the decision to disregard the advice in the last period.

If in period 1 a brown adviser chooses not to disclose her information ($a_1 = 0$ when $w_1 = 1$), then this implies that as the adviser is perfectly informed, she cannot be unbiased $(p = 0)$[5] nor green $(g = 0)$, as only a brown adviser would lie and communicate 0 when the state of the world is actually 1.

[5]In fact $P(a \neq w \mid unb) = 0$.

The government in this model utilises his information fully, conditioning to two different information the probability of the adviser to be unbiased. It is important to note that if the government were to update only conditional to the fact that the advice is actually equal to the state of the world, he would put together the two distinct alternative options:

(1) $a = 0$

(2) $a = 1$

But clearly a green (brown) adviser will advise 1(0) more frequently. Once the policy maker knows that $a = 0$, the probability that the adviser is green decreases, as a green adviser would advise against her interest less. This leads to the above expression which uses all the available information.

Period 2 provides the opportunity for two updates, but only one will feed in the quality of the decision: once the second state of the world is observed, the game is finished and the information cannot be used to improve on the decision making. When -instead- the second advice is revealed, then the update will be the same as in (a) above. However, solving Eq. 3.18, we can note that:

$$\begin{aligned} P(green \quad &| \quad a_2 = 0) = 0 \\ P(b\,\mathrm{row}\,n \quad &| \quad a_2 = 1) = 0 \rightarrow P(green) = 1 - p_3 \end{aligned}$$

As there is no reputational concern in period 2, one of the two biases can be ruled out. This means that this period will be identical to the second period in Morris's model.

3.2.4 Adviser's strategies

Unbiased adviser

If the adviser is unbiased, there is actually no strategic decision to take: in fact the actions in her best interest are actually also maximising social welfare. She will choose to disclose her information in both cases.

The adviser gives truthful advice. If the principal could know that the adviser is unbiased, he will follow the advice fully and social welfare would be:

$$\begin{aligned} d_i &= a_i \qquad i = 1, 2 \\ PO_u &= SW = -(w_1 - a_1) - \beta (w_2 - a_2) \\ \text{as } a_i &= w_i \rightarrow SW = 0 \\ & \quad \text{which is the maximum attainable as} \\ SW &\leq 0 \end{aligned}$$

meaning that all the information has been passed to the principal and social welfare (and private profit) maximised.

However, this is not possible, as the type of the adviser is unknown to the principal. Therefore the decision will reflect the reputation of the adviser (p) and her advice. We can state that

$$\frac{\partial PO_u}{\partial p} * \frac{\partial SW}{\partial p} > 0 \tag{3.21}$$

At the end of period 1, the payoff will reflect this information asymmetry. In period 2, the reputation of the agent will be higher and therefore the payoff higher, as a direct consequence of the condition expressed in Eq. 3.21 and of the fact that the advice will once more be truthful.

BIASED ADVISER

More interesting is the case in which the adviser is biased. In this case, since her profit function differs from social welfare, disclosing her information may not be in her best interest. Let us consider the case of a brown adviser[6]. She may face two different scenarios:

a) $\mathbf{w}_1 = 0$. In this case, it is irrelevant that she is biased. In period 1, she will (truthfully) advise the government to intervene, as their profit functions coincide. In fact, recollecting Eq. 3.14 and Eq. 3.15:

$$\begin{aligned} SW_1 &= -(w_1 - d_1) = -d_1 \\ PO_{b,1} &= -d_1 \end{aligned}$$

As in the case of the unbiased adviser, the closer the decision is to the advice, the higher the profit in this period. However, there is a major difference. In fact, the biased adviser will enter period 2 with a higher reputation of being unbiased (which is untrue). In the second period, whatever the state of the world, she will advise to play 0, as there is no room for punishment afterwards, being there "no tomorrow" to apply it. This also implies that if the true state of the world is 1, the adviser will have a higher profit, but social welfare will decrease. If, instead, the state of the world in Period 2 is once again 0, then goals coincide, information is passed fully and social welfare is maximised (taking into consideration the constrain of the information asymmetry).

b) $\mathbf{w}_1 = 1$. This event poses a dilemma to the adviser. In fact, if she sends an advice $a_1 = 0$ and lowers the decision in period 1, the government takes a decision in the wrong direction. However, in the following period, the decision maker will know that she is definitely biased and play $d_2 = \frac{1}{2}$.

[6]As the model is perfectly symmetric, we present only the case in which the adviser is brown. *Mutas mutandis*, the following discussion holds for a green adviser.

Alternatively, the adviser discloses her information in period 1 sending the message $a_1 = 1$, and have a lower payoff in period 1; this would however improve her reputation for the following period and therefore increase her payoff in period 2. Her choice will depend upon which option will give her the highest payoff. This choice is presented in the next paragraph.

3.2.5 Adviser's decision rule

As we have seen in the previous paragraph, a biased adviser may find herself in the situation in which she has to decide whether to build reputation in period 1 and harvest it in period 2, or go for a larger payoff in period 1 and then pay the consequences in period 2. The adviser will see which alternative will give the highest payoff.

$$PO_{rep} > PO_{norep} \tag{3.22}$$

where *rep* stands for "reputation (ie. disclose information) and *norep* the opposite situation.

If Eq. 3.22 is satisfied she will opt to bank on her reputation and if it is not, she will lie in Period 1 and pay the consequence in Period 2. Using Eq. 3.15, we can specify the previous inequality:

$$-d_1(1) - \beta d_2(0) > -d_1(0) - \beta\frac{1}{2} \tag{3.23}$$

The first term on each side represents the payoff in period 1, depending whether the advice is 1 (left hand side) or 0 (right hand side). The second term represents the payoff in period 2. If the adviser chooses to disclose her information, her reputation is now higher (hence, the government will listen to her more); in the other case, the government knows for sure the adviser is (brown) biased.

To solve the inequality 3.23, we need to find the decision rule for each period. Let us start from period 2. If the adviser has given bad advice in period 1, then the government knows that:

$$p_2' = P(unb) = 0$$

This also implies that the government's decision will be[7]:

$$d_2 = \frac{1}{2} \qquad \forall a_2$$

If, instead the adviser has played a truthful advice in period 1, then her reputation is higher than zero. As we have assumed her to be brown, then in period 2 she will play 0. The decision maker will update his beliefs as follows:

$$P(unb \mid a_2 = 0) = p_3$$
$$P(b\,\mathrm{row}\,n \mid a_2 = 0) = 1 - p_3$$

as a green adviser would never play 0, this category is ruled out.

Table 3.1: Strategies after the second advice is equal to 0

	$w_2 = 0$	$w_2 = 1$
unbiased	0	1
biased (brown)	0	0

Table 3.1 summarises the decision maker's information after he receives the advice. It is important to note how at this stage, this model departs from previous literature. In fact, in Morris's model government knows that if he receives an advice $a_2 = 0$, then the adviser is unbiased; in this case, this certainty is impossible, as if the government does receive $a_2 = 0$, then he

[7]See condition 3.7 and demonstration in footnote.

would have to rule out the possibility that he is facing a green adviser and his set of information can be written as reported in table 3.2.

Table 3.2: Strategies after the second advice is equal to 1

	$w_2 = 0$	$w_2 = 1$
unbiased	0	1
biased (green)	1	1

Therefore, the second advice does improve the decision maker's information, ruling out one possible bias, but it does not allow him to be sure that in a given case the adviser is unbiased. Table 3.3 summarises the information the decision maker has after he receives the second advice.

Table 3.3: General strategies after the second advice is disclosed

	$w_2 = i$	$w_2 = j$
unbiased	i	j
$\frac{\text{Green } j=1;\ i=0}{\text{Brown } j=0;\ i=1}$	j	j

Then, the government will update his beliefs as follow[8]:

$$p_3 = P(unbiased \mid a_2 = 0) = \frac{\frac{1}{2}p_2}{\frac{1}{2}p_2 + (1 - p_2)g_2} \tag{3.24}$$

Now he can make his final decision, by determining the probability that the advice is truthful, namely:

$$p^{**} = P(w_2 = 0 \mid a_2 = 0) \tag{3.25}$$

$$p^{**} = \frac{1}{2 - p_3} \tag{3.26}$$

[8] $p_2 = P(unbiased \mid a_2 = j)$
$= \frac{P(a_2 = j \mid unbiased)P(unbiased)}{P(a_2 = j)}$
$= \frac{\frac{1}{2}p_0}{\frac{1}{2}p_0 + (1 - p_0)} = \frac{p_0}{2 - p_0}$

The decision rule is simply the weighted average of (i) following the advice (times the probability the adviser is telling the truth) and (ii) the alternative (times the probability that the adviser is lying[9]).

$$d_2 = p^{**}a_2 + (1-p^{**})\overline{a}_2 \tag{3.27}$$

$$d_2(a_2 = 0) = \frac{1-p_3}{2-p_3} \tag{3.28}$$

$$d_2(a_2 = 1) = \frac{1}{2-p_3} \tag{3.29}$$

Eq. 3.28 and 3.29 represent the solution to period 2. It is easy to see what happens when $p = 0$ ($d_2 = \frac{1}{2}$) and $p = 1$ ($d_2 = 1$).

Now that we have solved period 2, we can go back to the first period. The adviser communicates her first advice and the policy maker will update his beliefs as follows:

$$p_1 = P(unb \mid a_1 = 0) = \frac{P(a_1 = 0 \mid unb)P(unb)}{P(a_1 = 0)} = p_0 \tag{3.30}$$

$$p_1' = P(unb \mid a_1 = 1) = \frac{P(a_1 = 1 \mid unb)P(unb)}{P(a_1 = 1)} = p_0 \tag{3.31}$$

$$g_1 = P(green \mid a_1 = 0) = \frac{P(a_1 = 0 \mid green)P(green)}{P(a_1 = 0)} = \alpha \tag{3.32}$$

$$g_1' = P(green \mid a_1 = 1) = \frac{P(a_1 = 1 \mid green)P(green)}{P(a_1 = 1)} = 1-\alpha \tag{3.33}$$

where α is the probability that a biased adviser will disclose a harmful information in period 1.

$$\alpha = P(a_1 = 0 \mid green)$$

[9]In passing, this is the same as the weighted average of the advice times the probability of the adviser being unbiased and playing $\frac{1}{2}$ multiplied the probability the adviser is biased.

α is strictly dependent upon the values of β and p_0. For higher β, the adviser has a higher incentive to suffer a loss in the first period to enjoy a better reputation in the following period and therefore α increases. The relation between α and p_0 is more complex and it will be analysed later in this section.

It follows that α can be further qualified as follows:

$$\alpha \epsilon [0; \frac{1}{2}] \tag{3.34}$$

The decision maker now has to make his decision. This will be in the form of Eq. 3.27.

$$\begin{aligned}
p^* &= P(w_1 = 0 \mid a_1 = 0) && (3.35)\\
p^* &= \frac{1}{2}\frac{p_1 + (1-p_1)(2\alpha^2 + 1 - \alpha)}{\frac{1}{2}p_1 + (1-p_1)(2\alpha^2 + 1 - 2\alpha)} && (3.36)\\
d_1 &= p^* a_1 + (1-p^*)\overline{a}_1 && (3.37)\\
d_1(0) &= 1 - \frac{1}{2}\frac{p_1 + (1-p_1)(2\alpha^2 + 1 - \alpha)}{\frac{1}{2}p_1 + (1-p_1)(2\alpha^2 + 1 - 2\alpha)} && (3.38)\\
&= \frac{(1-p_1)\,(2\alpha^2 - 3\alpha + 1)}{p_1 + 2(1-p_1)(2\alpha^2 + 1 - 2\alpha)} && (3.39)
\end{aligned}$$

For the symmetry of the model, it is easy to see how:

$$\begin{aligned}
p'^* &= P(w_1 = 1 \mid a_1 = 1) && (3.40)\\
p'^* &= \frac{1}{2}\frac{p_1 + (1-p_1)(2\alpha^2 + 1 - \alpha)}{\frac{1}{2}p_1 + (1-p_1)(2\alpha^2 + 1 - 2\alpha)} = p^* && (3.41)\\
d'_1(1) &= \frac{1}{2}\frac{p_1 + (1-p_1)(2\alpha^2 + 1 - \alpha)}{\frac{1}{2}p_1 + (1-p_1)(2\alpha^2 + 1 - 2\alpha)} = 1 - d_1(0) && (3.42)
\end{aligned}$$

After the true state of the world is observed, the government updates again the adviser's reputation:

$$p_2' = P(unb \mid a_1 = 0 \neq w_1) = 0 \tag{3.43}$$

$$p_2 = P(unb \mid a_1 = 0 = w_1) = \frac{p_0}{\alpha(2\alpha - 1)(1 - p_0) + 1} \tag{3.44}$$

$$g_2' = P(green \mid a_1 = 0 \neq w_1) = 0 \tag{3.45}$$

$$g_2 = P(green \mid a_1 = 0 = w_1) = \frac{\alpha^2}{\alpha(\alpha - \frac{1}{2})(1 - p_0) + \frac{1}{2}} \tag{3.46}$$

We have now derived all we need to solve the adviser's dilemma. Going back to the expression 3.23, we can re-write it as follows:

$$-d_1(1) - \beta d_2(0) > -d_1(0) - \beta\frac{1}{2} \tag{3.47}$$

$$\beta[\frac{1}{2} - d_2(0)] > 1 - 2d_1(0)$$

$$\beta > 2\frac{\frac{1}{2} - d_1(0)}{\frac{1}{2} - d_2(0)} \tag{3.48}$$

Eq. 3.47 uses the symmetry of the model, for which:

$$d_1(0) = 1 - d_1(1) \tag{3.49}$$

Condition 3.48[10] tells us that if β is larger than the expression on the right hand side, then the adviser chooses to tell the truth in the first period. However, to solve the condition above, we need to determine the value of α. α is the value for which condition 3.48 is exactly satisfied.

[10]If the adviser is green then:

$$-d_1(0) - \beta d_2(1) > -d_1(1) - \beta\frac{1}{2}$$

$$\beta[\frac{1}{2} - d_2(1)] > 1 - 2d_1(1)$$

$$\beta > 2\frac{d_1(1) - \frac{1}{2}}{d_2(1) - \frac{1}{2}}$$

By using Eq. 3.49, it is easy to see how this is the same condition expressed in Eq. 3.48.

$$\beta = 2\frac{d_1(1) - \frac{1}{2}}{d_2(1) - \frac{1}{2}} \tag{3.50}$$

For each value of β and p_0, Eq. 3.50 is solved for a different value of α. In passing, we can define α as:

$$\alpha \mid PO_{rep} = PO_{norep}$$

that is the value which makes the adviser indifferent between the two strategies. This means that if this value is within the range of feasibility $[0; \frac{1}{2}]$, then the adviser is indifferent to the two strategies. If the equation is satisfied for $\alpha < 0$, then the adviser will choose not to disclose information in the first period, whilst if $\alpha > \frac{1}{2}$, then the adviser will go for reputation.

Conclusion 29 *Once the parameters are set, the adviser's strategy is univocally set. When the value of α is included in the feasible range, the adviser is indifferent to her possible strategies.*

Conclusion 30 *When the critical value of α is higher than 0.5, then the adviser always prefers to go for reputation. The vice versa holds true if α is instead below zero.*

Let us try to express Eq. 3.50 only in terms of α and p_0. Plugging in Eq. 3.29 and 3.42 into Eq. 3.50 we obtain an equation[11] which cannot be explicitly solved for α.

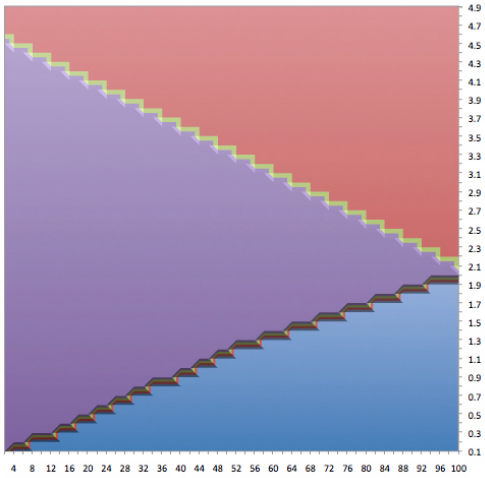
To gain a better insight into how the model works, we solve this graphically: we substitute β with different values and graph the function in terms of α and p_0 and using a surface graph, we can find the equilibrium values of α[12]. Putting

[11] $\beta = -\frac{2(2\alpha + p_0 - 2\alpha p_0)}{p_0} *$
$\frac{\left(-8\alpha^4 p_0 + 8\alpha^4 + 4\alpha^3 p_0 - 4\alpha^3 - 2\alpha^2 p_0^2 - 2\alpha^2 p_0 + 4\alpha^2 + \alpha p_0^2 - \alpha p_0 + p_0\right)}{(2\alpha^2 - \alpha + \alpha p_0 - 2\alpha^2 p_0 + 1)\,(4\alpha + p_0 - 4\alpha^2 - 4\alpha p_0 + 4\alpha^2 p_0 - 2)}$

[12] These graphs can be found in Appendix 3.

together all the information, we can then derive a single graph. Figure 3.2 shows a biased adviser's the preferred strategy for different combination (β, p_0).

Figure 3.2: Summary of a Biased Adviser's strategy



The x-axis represents p_0 and β is represented on the y-axis. The blue (bottom right) area represents the combinations for which the adviser is better off not going for reputation. The red (top right) area shows the values for which she is better off invest in reputation and the purple (central) area where she is indifferent between the two strategies.

Let us consider figure 3.2: for low values of β, as the second period is not so valuable compared to the first, reputation building is relatively non important. Therefore, if the initial reputation is high, the marginal gain in reputation in period 2, arising from disclosing information will not be high enough to offset the loss made in period 1 (which is very high, as the decision maker will give great consideration to her advice, since her reputation is so high): it is better to bank on the initial reputation and then, in period 2, the adviser knows that her "punishment" is going to be $\frac{1}{2}$. However, $d_2 = \frac{1}{2}$ is less damaging than

disclosing her information in period 1, as $d_1(a=0) << \frac{1}{2}$, being her reputation high.

Conclusion 31 *For values of β lower than 2, there is always a certain value $\overline{p}$ for which if $p_0 < \overline{p}$ then the adviser is indifferent between the two strategies, whilst if $p_0 > \overline{p}$, then the adviser opts for not disclosing her information in period 1.*

In other terms, we can express that $\beta < 2$:

$$\frac{\partial \bar{p}}{\partial \beta} > 0$$

Furthermore,

$$\lim_{\beta \to 0} \bar{p} = 0 \tag{3.51}$$

$$\lim_{\beta \to 2} \bar{p} = 1 \tag{3.52}$$

Condition 3.51 is intuitive: if the second period has no value at all, then the adviser will try to extract as much profit from period 1 and not care about the consequences at all. Condition 3.52 can be understood easily too. In fact, by substituting $\beta = 2$, in condition 3.50, we obtain:

$$d_2(1) = d_1(1) \tag{3.53}$$

which is satisfied for $\bar{p} = 1$.

Conclusion 32 *The closer β to 2, the closer $\overline{p}$ to 1. The closer β to 0, the closer $\overline{p}$ to 0.*

For $\beta = 2$, the adviser is always indifferent to the two strategies, for any value of p_0.

If we now consider $\beta > 2$, after the critical value of $\overline{p}$, the value of α for which condition 3.50 is satisfied is higher than $\frac{1}{2}$. Remembering that α is probability with which a green (brown) adviser would send the signal 0(1), it means that the adviser always discloses her information and opts for reputation. This is because, as β increases, so does the cost of lying in period one. Here the more her reputation increases, the more the biased adviser wants to invest in her reputation, as the gains in period 2 are very high. This is true even if the higher p the lower the marginal gains in reputation. In passing, we can also note that:

$$\begin{aligned} \frac{\partial \overline{p}}{\partial \beta} &< 0 \\ & \lim_{\beta \to +\infty} \overline{p} = 0 \\ & \lim_{\beta \to 2} \overline{p} = 1 \end{aligned}$$

Conclusion 33 *For values of β higher than 2, there is always a certain value $\overline{p}$ for which if $p_0 < \overline{p}$ then the adviser is indifferent between the two strategies, whilst if $p_0 > \overline{p}$, then the adviser opts for reputation in period 1. The closer β to 2, the closer $\overline{p}$ to 1. The higher β, the closer $\overline{p}$ to 0.*

3.2.6 Government's Decision and Strategy

We are now ready to see what the government's decision is and his possible strategies. As we know, the government updates his beliefs using Bayes' rule and his decisions are the welfare maximising ones, as described in Eq. 3.27. The adviser will make her choice has described in paragraph 3.2.5.

The government will get good advice if: (a) the adviser is unbiased; (b) if the state of world is favourable to the biased adviser; or (c) in period one if it is in the biased adviser's best interest to disclose her information.

However, as his information about the type of adviser is noisy, he does not know when he actually gets good advice and part of the information he receives is lost. Even so, it is possible to identify situations in which full extraction of information is possible. These will be presented separately in the next paragraphs.

The adviser's best strategy is reputation

As the decision maker knows the values of β and p_0, then knowing the different advisers' utility functions, he can infer what the biased adviser's best strategy is. In fact, we have showed how the decision depends on what value α assumes. This in turn is determined univocally by β and p_0, parameters that are set at the beginning of the game. If this is "reputation", then the decision maker knows that the message is true with probability one. In fact, if the state of the world is 0, the unbiased and green advisers will pass on their information (as it is always in their interest) and so would the brown adviser (as going for reputation is her best strategy).

This is particularly interesting for two reasons. Firstly, because the optimal decision becomes:

$$p^* = P(w_1 = 1 \mid a_1 = 1) \tag{3.54}$$

$$p^* = 1 \tag{3.55}$$

$$d_1 = p^* a_1 + (1 - p^*)\overline{a}_1 \tag{3.56}$$

$$d_1 = 1 = a_1 \tag{3.57}$$

$$SW_1 = 0 \tag{3.58}$$

What previous literature seems to have overlooked is that as p_0 and β are known parameters, then α is known and this leads to this situation in which full extraction of information is possible in period 1.

Conclusion 34 *For a subset of the feasible* (β, p_0)*, in period 1 the decision maker can extract all the information from the adviser, achieving maximum social welfare.*

The other side of the coin is -however- about reputation. Deriving the updated reputation, we obtain:

$$p_1 = P(unb \mid a_1 = 0) = \frac{P(a_1 = 0 \mid unb)P(unb)}{P(a_1 = 0)} = p_0 \tag{3.59}$$

$$g_1 = P(green \mid a_1 = 0) = \frac{1}{2} = g_0 \tag{3.60}$$

$$p_2 = P(unb \mid a_1 = 0 = w_1) = \frac{p_0}{\frac{1}{2}(2\frac{1}{2} - 1)(1 - \frac{1}{2}p_0) + 1} = p_0 \tag{3.61}$$

$$g_2 = P(green \mid a_1 = 0 = w_1) = \frac{\frac{1}{2}^2}{\frac{1}{2}(\frac{1}{2} - \frac{1}{2})(1 - \frac{1}{2}p_0) + \frac{1}{2}} = \frac{1}{2} \tag{3.62}$$

$$p_2 = p_0 \tag{3.63}$$

$$g_2 = g_0 \tag{3.64}$$

Eq. 3.63 and 3.64 show the consequence of using fully the available information in period 1: there is no information update entering period 2. In other words, by choosing to invest in reputation, a biased adviser makes a sacrifice in period 1 simply to enter period 2 with her initial reputation. This is still a rational decision, as the alternative would be to signal her biasedness and drive her reputation to zero. In terms of social welfare, this is a cost, should the adviser be unbiased, but also an opportunity, if the adviser is biased.

Conclusion 35 *Whenever* $[\beta; p_0]$ *are so that a biased adviser would decide to opt for reputation, the adviser enters period 2 with unchanged reputation.*

$$p_3 = \frac{\frac{1}{2}p_0}{\frac{1}{2}p_0 + (1 - p_0)\frac{1}{2}} = p_0 \tag{3.65}$$

$$p^{**} = \frac{1}{2 - p_0} \tag{3.66}$$

$$d_2(a_2 = 1) = \frac{1}{2 - p_0} \tag{3.67}$$

Eq. 3.65 shows that after the second advice is communicated, the reputation has not changed (the only variation is that if $a_2 = 1 \rightarrow g_3 = 1$ and *mutas mutandis* in the other scenario). This result offers a very interesting insight: even when the adviser has a poor reputation, the decision maker may achieve the position of taking a good decision.

The adviser's best strategy is to lie in period one

If the decision maker knows that the adviser won't disclose painful information (ie. $PO_{norep} > PO_{rep}$), then his updated beliefs are as follows (obtained by substituting $\alpha = 0$ in the original expressions):

$$a_1 = 0 \tag{3.68}$$

$$p_1 = p_0 \tag{3.69}$$

$$g_1 = 0 \tag{3.70}$$

$$p^* = \frac{1}{2}\frac{p_1 + (1 - p_1)}{\frac{1}{2}p_1 + (1 - p_1)} = \frac{1}{2 - p_0} \tag{3.71}$$

$$d_1(0) = \frac{1 - p_0}{2 - p_0} \tag{3.72}$$

$$p_2' = P(unb \mid a_1 = 0 \neq w_1) = 0 \tag{3.73}$$

$$p_2 = P(unb \mid a_1 = 0 = w_1) = p_0 \tag{3.74}$$

Eq. 3.70 shows yet another interesting feature of this subset of the solution: as the policy maker knows that a green adviser would never play $a = 0$, after receiving such signal, he knows that the adviser is either brown or unbiased. Eq. 3.74 gives another insight into the solution of the game. In fact, the probability that the adviser may be unbiased (p) is unchanged. This is quite obivous. As we have ruled out the possibility that the adviser is green, then both unbiased

and brown adviser would disclose their information with the same probability $(= 1)$.

Conclusion 36 *If $[\beta; p_0]$ are so that a biased adviser would not go for reputation, then the decision maker can rule out one of the type of biases after he receives the first advice.*

Conclusion 37 *If the adviser's best strategy is not to disclose her information, but the advice in period 1 is correct, the adviser enters period 2 with unchanged reputation.*

Once period 1 is over, the state of the world is revealed. If the adviser lied in period 1, then the decision maker knows she is biased and would discount completely whatever advice he receives (and play $d_2 = \frac{1}{2}$). If, instead the advice was truthful, he updates his belief. When the second advice is announced, the decision maker makes the following update (according to the advice):

$$p_3 = P(unb \mid a_2 = 0 \wedge a_1 = 0) = \frac{p_0}{2 - p_0} \tag{3.75}$$

$$d_2 = \frac{2 - 2p_0}{4 - 3p_0} \tag{3.76}$$

$$p_3' = P(unb \mid a_2 = 1 \wedge a_1 = 0) = \frac{\frac{1}{2}p_2}{\frac{1}{2}p_2 + (1 - p_2) * 0} = 1 \tag{3.77}$$

$$d_2' = 1 \tag{3.78}$$

Eq. 3.75 and 3.76 show the reputational update and decision, if the advice is the same as the one received in period 1. More interesting are however Eq.

3.77 and 3.78. As in period 1, the advice was 0, the policy maker could rule out that the adviser was green. In this period, since the advice is 1, he is sure the adviser is unbiased, as a brown adviser would never play $a_2 = 1$. This has an important and unexpected consequence: in the situation in which a biased adviser is better off not disclosing her information in period 1, the policy maker can either face the possibility of having a *babbling equilibrium* or he could be in a position to extract complete information from the advice.

Conclusion 38 *If the adviser is unbiased, if the biased adviser's best strategy would have been witholding information in period one and if the states of the world in the two periods are different, then the decision maker can extract full information in period 2, obtaining the maximum social welfare possible in that period.*

The adviser is indifferent between the two strategies.

Finally, there is the case in which the adviser is indifferent between the two strategies. This is the situation that has been discussed in the existing literaure. In particular, if the adviser opts for reputation, then she will enter period 2 with a higher reputation. For any value of α, the adviser enters the last decision process with an improved reputation. This will lead to a decision closer to the advice. Alternatively, if she chooses to bank in period 1, she will be disqualified as adviser in period 2.

The question is, then: what can the decision maker do to improve social welfare? He knows that the adviser is indifferent between the two strategies. If we assume the adviser is self interested (but not "evil"), we could then expect she would choose the decision maker's preferred option. If that is the case, the adviser will choose to maximise social welfare.

Conclusion 39 *If the adviser is self-interested and indifferent between the two strategies, her choice will maximise expected social welfare.*

However, we could also assume that the adviser may randomise her choice. In this scenario, the decision maker does not know which strategy the adviser has gone for. This means that expected social welfare becomes:

$$E(SW) = \frac{1}{2}SW_{rep} + \frac{1}{2}SW_{norep} \tag{3.79}$$

The decision maker could try to modify the adviser's decision process in order to influence her advice. We propose here a way this could happen.

Firstly, the decision maker has to evaluate whether he has any preference between the two strategies. The reasoning behind this decision is as follows: if the decision maker pushes the adviser towards no reputation, the risk in period 1 is to get a bad advice, but then minimise the loss in period 2, by simply playing $d_2 = \frac{1}{2}$. If the advice was instead correct, then on top of the good choice made in period 1, period 2 offers two opportunities and a threat. In fact the decision maker has now $\frac{1}{2}p$ to obtain a different advice than in period 1 and therefore he will be able to fully guess the state of the world. Alternatively, he has 50% chance[13] to get a good advice and play a decision that is closer to the truth (as reputation has improved after period 1). There is also the case that $\frac{1}{2}(1-p)$ times he will get a bad advice and, since he is relying more on this advice he will reduce social welfare. If he, instead, opts for reputation, then he will achieve maximum social welfare in period 1 and enters period 2 with the initial reputation, and therefore reducing the potential losses (and gains) with respect to period 2 in the other scenario.

More formally, he will choose by seeing which strategy leads to the highest social welfare:

[13] $\frac{1}{2}p$ that the state of the world is the same as in period 1 and the adviser is unbiased plus $\frac{1}{2}(1-p)$, that is the probability that the adviser is biased but the state of the world is favourable to her and therefore she gives good advice.

$$SW_{rep} > SW_{norep} \tag{3.80}$$

$$-[w_1 - d_1(0)]^2 - \beta[w_2 - d_2(1)]^2 > -[w_1 - d_1(1)]^2 - \beta\frac{1}{4} \tag{3.81}$$

$$\beta > \frac{1 - 2d_1(0)}{(d_2(1) - \frac{1}{4})^2} \tag{3.82}$$

d_1 and d_2 depend on p_0, β and α. However, as we have said α has already been univocally determined by the adviser's preferences and the others are parameters. Therefore, the decision maker knows at the beginning of the game the sign of the condition 3.82[14]. As it is not possible to find α explicitly, it is not possible to solve this condition either. However, we can offer an example.

Let us consider Figure 3.2. If we assume that $\beta = 2$ and $p_0 = 0.8$, then the adviser is indifferent between the two strategies. The value of α is found by substituting these values in Eq. 3.50. We obtain:

$$20\alpha^5 + 22\alpha^4 + 6\alpha^3 - 10\alpha^2 + 32\alpha - 10 = 0$$

By interpolation, we find that $\alpha \simeq 0.3294$. Substituting the values of p_0, β and α in Condition 3.82, we find that the condition is satisfied, meaning that the decision maker prefers the adviser to disclose her information in the first period. The decision maker could then try to persuade the adviser to choose his preferred strategy by offering to play a decision in period 2 defined as follows:

$$\tilde{d_2} = d_2 - (-1)^{a_2} * \varepsilon$$

ε is a small positive number which satisfies:

[14] In passing, it is interesting to note how the sign of this condition is not univocal, meaning that social welfare could be maximised by either strategy.

$$\varepsilon \quad | \quad \frac{1}{2}SW_{rep} + \frac{1}{2}SW_{norep} < SW(\tilde{d}_2) \tag{3.83}$$

$$-\beta[w_2 - \tilde{d}_2(1)]^2 < -\beta[w_2 - d_2(1)]^2 - [w_1 - d_1(1)]^2 - \beta\frac{1}{4}$$

$$\varepsilon < \frac{\frac{1}{2} - d_1(1)}{\beta} - \frac{1}{2}(\frac{1}{4} - d_2^2) \tag{3.84}$$

in other words, the difference between the social welfare in the two different scenarios[15]. In this way, the adviser will choose to go for reputation, receiving a payoff of

$$PO_{rep}(\tilde{d}_2) > PO_{norep} = PO_{rep} \tag{3.85}$$

Condition 3.85 shows that the incentive would be worth it for the adviser. To see if this is a credible promise, we need to see how this modification of the decision rule affects social welfare:

$$SW_{rep} > SW_{norep} \tag{3.86}$$

$$\frac{1}{2}SW_{rep} > \frac{1}{2}SW_{norep} \tag{3.87}$$

$$\frac{1}{2}SW_{rep} + \frac{1}{2}SW_{norep} = E(SW) > SW_{norep} \tag{3.88}$$

Finally, using Eq. 3.83, we obtain the desired condition:

$$SW_{rep}(\tilde{d}_2) > E(SW) > SW_{norep}$$

Expression 3.86 tells us that social welfare in the presence of incentives is higher than the one obtained if the adviser lies in period 1, but most importantly that social welfare is higher than the expected social welfare using the

[15]The full expression would be: $-[w_1 - d_1(0)]^2 - \beta[w_2 - \tilde{d}_2(1)]^2 < -[w_1 - d_1(0)]^2 - \beta[w_2 - d_2(1)]^2 - [w_1 - d_1(1)]^2 - \beta\frac{1}{4}$.
The first term on each side is identical and therefore evened out.

initial decision rule. This means that the incentive is credible and the equilibrium a stable one.

Conclusion 40 *If the adviser is indifferent between her strategies and if she randomises her choice, then the decision maker can offer her an incentive to choose the strategy that maximises social welfare, increasing her payoff as well as expected social welfare.*

On the other hand, let us consider whether:

$$SW_{rep} \lesseqgtr SW_{rep}(\tilde{d}_2) \tag{3.89}$$

We have assumed that social welfare is maximised when the adviser discloses her information in period 1. If the adviser lies in period 2, as with the new decision rule relies more on the advice, social welfare will be lower than the one obtainable with old decision rule. However, it is interesting to note that if the adviser is unbiased, or if the state of the world is favourable to the biased adviser, then $a_2 = w_2$ and therefore

$$(w_2 - \tilde{d}_2)^2 < (w_2 - d_2)^2$$

meaning that the decision is closer to the state of the world and therefore social welfare obtained by offering incentives to the adviser is higher than the one we would have got with the original decision rule.

Conclusion 41 *If a biased adviser would be indifferent to which strategy to play, the decision maker can provide an incentive in order to make her choose the option that leads to the higher social welfare. Furthermore, if the state of the world is favourable to the biased adviser or if she is unbiased, then not only is the adviser's payoff higher, but the incentive will increase the achieved social*

welfare; furthermore it will be higher than the one potentially achievable with the original decision rule.

One final observation. By changing the decision rule, the policy maker leads this third scenario (adviser being indifferent to the two strategies) back to the initial two: if the policy maker's preferred strategy is for the adviser to go for reputation, and he offers her the right incentive, then he knows that using the new decision rule he will get a truthful advice in period 1 with probability 1.

3.2.7 Civil Servants

As an extension of the main model, let us consider how the role of civil servants may affect the model presented. The British Government is the nation's largest employer of professional economists (along with many other experts of different disciplines). It seems therefore plausible to assume that these specialists may provide some sort of filter to the adviser's messages. As they become more and more knowledgeable in their departments, they may be able to realize when an adviser is not being truthful or –to some extent- to act as deterrent for a biased adviser. In literature, this role has been already considered. Hubbard (1998) and Emons (1997) and Dulleck et al (2001) all point to the fact that if the person who is going to purchase an experience good or service has some knowledge in the field would be less likely to be overcharged (or undersold). The examples presented vary from mechanics services to surgical operations.

It is important to answer two questions. (a) Could this be credibly applied to our case? And if so, (b) how does this affect our results.

The answer to the first question is: possibly, but unlikely. The reasons for this are diverse: (i) as Leaver (2009) has pointed out, a civil servant may not whistle-blow, as "minimal squawk" may be best for his career; (ii) civil servants may not have the freedom to dismiss information, due to bureaucratic rules; (iii) decisions on environmental issues often require advanced multidisciplinary

knowledge which is very difficult to find in a single individual and collating information from different people would be costly, time consuming and difficult considering tight resources available; (iv) issues are often based on new data and research which may have had limited circulation or peer review. It would therefore be unlikely that a GES member would be able to have an informed opinion on the issue (knowing that Error Type I are more accepted and Type II); (v) problems (and solutions) may not be always straight-forward. This means that correct results that look counter-intuitive may be deemed as flawed, even by a well-meaning civil servant. As example, a report from a consultant to Defra has reported how air pollution has a net positive impact on agriculture: although it may sound "wrong", the analysis behind it is considered the best available and completely sound.

If we, however, assume that civil servants may be able to act as partial filter for the adviser's message, then we need to distinguish two cases:

1. The adviser is able to improve the decision maker's level of information regarding the biasedness of the adviser (p_0). In this case, our model would be able to incorporate this role with no real change;

2. The adviser is able to improve the decision maker's level of information regarding the type of biased the adviser may have (g_0). As the model presented relies on the initial symmetry of the two potential biases, the results presented here would be affected. Future research could see whether the change would affect the qualitative outcomes. We believe that this change would indeed increase the generality of the model, but it should not affect the overall results.

3.3 Discussion and Conclusions

The aim of this chapter was to look at the possibility of extracting information from a potentially biased adviser. In many occasions, policy makers have to take decisions with a limited amount of information. In particular, we have looked at an environmental context, where the wrong decision could cause

irreparable damages to an ecosystem or biodiversity or else it could affect negatively the economy. Informed advisers are available to provide their knowledge. However, the decision maker cannot distinguish unbiased advisers from biased ones. Green lobbyists would want the government to always tighten environmental regulation; brown lobbyists, instead, prefer no change to the status quo. Government and unbiased advisers care to take the right decision. We look at a model in which the decision maker asks to consecutive advices to the same agent. As the policy maker updates his beliefs on the adviser after realising the true state of the world in period 1 and as the decision is function of this beliefs, a biased adviser may have the incentive to disclose her information in period 1, in order to be able to influence more strongly the decision in the last period.

We have shown that unbiased advisers and biased advisers, facing favourable states of the world, always disclose their information. We have then focused on the situation in which biased advisers face an adverse state of the world; they have the two alternatives of either lie in period one or invest in reputation. In other words, a lobbyist protecting the industries' interests may find that encouraging the government to tighten environmental regulation today may lead the government to think of her as balanced and unbiased and therefore he will take her advices more into consideration in the future.

Firstly we have noted how, although in theory, the adviser has to make a choice between the two strategies, once the parameters are set, she has only one logical alternative.

We have showed that, according to the different values of her reputation and the weight put on the second period, either strategy could be profit maximising. We have also showed that under particular conditions, the adviser may be indifferent between the two. When the second period has high importance with respect to the first, then the adviser will be better off (or at least as well off) by investing in reputation. If, instead, the second period is less than twice as

important than period one, then the adviser will be better off (or at least as well off) by not disclosing her information.

In terms of reputation building, we have showed something quite interesting: if a biased adviser would prefer not to go for reputation, then the policy maker learns something about the adviser as soon as he receives the first message. However, although he can rule out one of the two types of bias, he does not improve his knowledge about the honesty of the adviser, even after finding out that the first advice was correct. What is more surprising is that if the adviser does go for reputation, she will enter period 2 with her initial reputation: in other words, when the adviser has a preferred strategy, then whichever her strategy, it will not affect her reputation (unless, of course, she lies in period 1). The only situation in which if the adviser chooses to go for reputation she can actually improve it is when she is indifferent between the two strategies.

In terms of policy making, we have showed that not only reputational concerns lead to more frequent disclosure in period 1, but that the decision maker can eliminate the uncertainty regarding the message he receives and maximise social welfare. More surprisingly, in the situation in which a biased adviser would have not gone for reputation, we showed that the policy maker could extract full information in period 2. This result, in a way, is similar to what Morris (2001) found in his paper: I say one thing now, in order to be believed more in the future when I state the opposite. In our case, however, in both periods the adviser discloses her information and, more importantly, in our model in the last period the decision maker plays a $d_2 = a_2$. To our knowledge, no other paper has come to fully informative equilibrium in the last period of similar reputational games.

These are very interesting and reassuring results: the decision maker improves the quality of his decision and he is able to obtain unbiased advices. If we consider situations in which critical values can be surpassed and cause irreparable damages to the environment, these findings are important. The

decision maker can use the information available and be more likely to avoid wrong decisions. This is even more so when the adviser is indifferent between the two strategies. In fact, in this case, the choice falls in the decision maker's hand. According to his preferences, he can induce the adviser to opt for one or the other. In particular, we showed how by providing a small incentive, it is possible to achieve level of social welfare that are higher than the expected social welfare and, in particular circumstances, even better than the best possible scenario with the original decision rule.

The analysis presented can also be used to achieve particular policy objectives. Let us suppose that the decision maker wants to be sure that the first decision is not only as correct as possible, but completely precise. Let us consider that it is possible that by not stopping the exploitation of a particular area, biodiversity will be affected irreversibly. If regulation is tightened, but not completely, the degradation will slow down but it will still lead to irreversible damages. On the other hand, the costs of doing so are very high. For the decision maker, playing anything that is not "no change" or "complete change" is a losing game: it is either going to be an extremely costly and unrequited cure or it will be costly and insufficient. The decision maker should then try to increase the adviser's interest in period 2 or trying to invest in research about the adviser's reputation.

To conclude, let us make some considerations on how to extend this model to fit a wider range of real life situations. In reality a decision maker has to take more than two decisions. We can briefly sketch how our model can be useful in these settings. If we consider Period 2 as the sum of all the future decisions, then the value of β is likely to be high. In this context we have seen that if the reputation of the adviser is sufficiently high, then she will disclose her information in the first period. In the following period, period 2 can be considered as the first period and the new period 2 as all the following periods. It follows that the decision maker can tie the adviser to be truthful for

several consecutive periods. When the adviser provides an untruthful advice, then he can change adviser and start the 2-periods game again. In this way, the decision maker does not need to seek the advice of several advisers to obtain information.

Another final consideration can be made. We have assumed that the intertemporal weight, β, is the same for the decision maker and the adviser. In the real world, lobbyists may discount the future more heavily: this could be due to the necessity of showing to the stakeholders they are protecting that they are obtaining results. In this case, then, it is more likely that, if her reputation is high enough, then she will be better off by not disclosing her information. Should the policy maker prefer the adviser to disclose her information in period 1, then, he can again try to increase her interest in future decisions, in order to make her indifferent between the two strategies (see graph 1) and then adjust the payoff in order to make her better off by disclosing her information.

Appendix A

Demonstrations Chapter 1

Both Green

$\Pi_{gg} = k(1 - e^{-x}\left(\frac{1}{2} + \frac{1}{2}e^{-x}\right)) - x$

$\Pi'_{gg} = k(\frac{1}{2}e^{-x} + e^{-2x}) - 1 = 0$

$e^{-x} = g$

$g^2 + \frac{1}{2}g - \frac{1}{k} = 0$

$e^{-x} = \frac{1}{4}(\sqrt{\frac{1}{k}(k+16)} - 1)$

Both Brown

$\Pi_{bb} = 1 - e^{-\alpha x}\left(\frac{1}{2} + \frac{1}{2}e^{-\alpha x}\right) - x$

$\Pi'_{bb} = \alpha e^{-2x\alpha} + \frac{1}{2}\alpha e^{-x\alpha} - 1$

$e^{-\alpha x} = b$

$\alpha b^2 + \frac{1}{2}\alpha b - 1 = 0$

$e^{-\alpha x} = \frac{1}{4\alpha}\left(\sqrt{\alpha(\alpha+16)} - \alpha\right)$

$\Pi_{bb} = 1 + \frac{1}{4\alpha}\left(\alpha - \sqrt{\alpha(\alpha+16)}\right)\left(\frac{1}{2} - \frac{1}{8\alpha}\left(\alpha - \sqrt{\alpha(\alpha+16)}\right)\right) +$

$+\frac{1}{\alpha}\log(\frac{1}{4\alpha}\left(\sqrt{\alpha(\alpha+16)}\right) - \alpha)$

$\Pi_{bb} = -\frac{1}{16\alpha}\left(\sqrt{\alpha(\alpha+16)} - 17\alpha + 8\right) + \frac{1}{\alpha}\log(\frac{1}{4\alpha}\left(\sqrt{\alpha(\alpha+16)}\right) - \alpha)$

One green, One brown

$$\begin{aligned}\Pi_g &= k(1 - e^{-g}\left(\frac{1}{2} + \frac{1}{2}e^{-\alpha b}\right)) - g \\ \Pi_b &= 1 - e^{-\alpha b}\left(\frac{1}{2} + \frac{1}{2}e^{-g}\right) - b\end{aligned}$$

$$\Pi'_g = k\left(e^{-g}\left(\frac{1}{2}e^{-\alpha b} + \frac{1}{2}\right)\right) - 1 = 0$$

$$e^{-g} = \frac{2}{k\left(e^{-\alpha b}+1\right)}$$

$$\Pi_b = 1 - e^{-\alpha b}\left(\frac{1}{2} + \frac{1}{k\left(e^{-\alpha b}+1\right)}\right) - b$$

$$\Pi_b' = -\frac{e^{-2b\alpha}}{k}\frac{\alpha}{\left(e^{-b\alpha}+1\right)^2} + \alpha e^{-b\alpha}\left(\frac{1}{k\left(e^{-b\alpha}+1\right)} + \frac{1}{2}\right) - 1 = 0$$

$$e^{-b\alpha} = y$$

$$\frac{\alpha y}{k\left(y+1\right)} + \frac{\alpha y}{2} - 1 - \frac{\alpha y^2}{k\left(y+1\right)^2} = 0$$

$$-2k + 2y\alpha - 4ky + ky\alpha - 2ky^2 + 2ky^2\alpha + ky^3\alpha = 0$$

$$e^{-b\alpha} = q_1 + q_2 + q_3$$

$$q_1 = \sqrt[3]{-\frac{2}{3k\alpha} + q_4 + \frac{2}{9\alpha} + \frac{4}{9\alpha^2} + \frac{8}{27\alpha^3} + \frac{2}{3k} + \frac{1}{27}}$$

$$q_2 = \frac{\frac{4}{9\alpha} + \frac{4}{9\alpha^2} - \frac{2}{3k} + \frac{1}{9}}{q_1}$$

$$q_3 = \frac{1}{3k\alpha}\left(2k - 2k\alpha\right)$$

$$q_4 = \sqrt{\frac{4}{9k\alpha} + \frac{8}{9k\alpha^2} - \frac{40}{27k^2\alpha} + \frac{16}{27k\alpha^3} - \frac{4}{27k^2\alpha^2} + \frac{2}{27k} + \frac{8}{27k^2} + \frac{8}{27k^3}}$$

$$e^{-g} = \frac{2}{k\left(e^{-\alpha b}+1\right)}$$

Appendix B

Instruction Chapter 2

B.1 Baseline Treatment

You are about to take part in an experiment. If you read the following instructions carefully, you can, depending on your and other participants' decisions, earn a significant amount of money. It is therefore important that you take your time to understand the instructions. Please do not communicate with the other participants during the experiment. Should you have any questions, ask us.

You will be called to make one or more decisions. You will have to make your decisions without knowing other participants' decisions. Other participants will not know your decisions either.

You should take your time to make your decision. All the information you provide will be anonymous.

Your earnings will be paid to you in cash at the end of the experiment. Earnings will be confidential.

Below is presented the general functioning of the experiment. You will also find some questions to allow you to check that you have understood the mechanisms correctly.

The Experiment simulates the functioning of a Market. You and the other participants in the room will be randomly divided between Sellers and Buyers. The computer will randomly determine your role (Buyer or Seller) and you will keep that role until the end of the experiment. There will be 6 Buyers and 6 Sellers. There is only one product sold and bought. However, the product can

	$1st$	$2nd$	$3rd$	$4th$
H	7	8	9	10
S	5	6	7	8

be Standard Quality or High Quality. The experiment consists of 10 consecutive trading periods.

Below you will find a thorough description of the Seller and Buyer's roles and of the functioning of the market.

SELLERS

Sellers will be randomly divided into 2 groups: one will produce High quality products (that are also more costly to produce), while the other group will produce Standard quality products. For brevity, we will call H-Seller the one selling High Quality products and S-Seller the ones selling Standard quality products. Sellers need to decide what price they will charge for their products. Price has to be an integer (1;2;3... not 2.8; 7.5 etc...)

Sellers spend money to produce products (seller's costs) and receive revenue from the sales of the products. Their final monetary payoff depends on their profit (revenue minus costs). In other words, the higher your profit in each single trading period, the higher you monetary reward of the experiment!

Take a moment to consider the table below. It represents the cost to Sellers of producing each unit. 'H' is the row of unit costs for the H-Sellers and 'S' for the S-Seller. Costs of production for each unit of product increase with quantity. Therefore, the first unit will be cheaper than the second, and so on.

If a H-Seller sells 2 products at a price of 12, then his total profit is going to be:

Revenue=12*2=24

Cost=7+8=15

Profit=24-15=9

If a S-Seller sells 3 products at a price of 10, then his profit is:

Revenue=10*3=30

Cost=5+6+7=18

Profit=30-18=12

In the experiment, you can produce up to 4 units for each trading period. The only condition is that you must cover your production cost. Going back to the previous table, if you are a S-Seller and you decide to charge a price of 20, then you will produce 4 units. However, if you decide to charge a price of 6, then you will be able to produce only 2 units (as, if you were producing a third unit, the cost of production would be higher than your revenue!!). In the experiment the computer will check this for you and will determine the amount you will produce in each period accordingly.

However, you may not be always able to sell all the products brought to the Market. In this case, you will pay only for the costs of production of the sold products.

So, if a H-Seller produces 4 products but sells only 3 at a price of 14, then the profit will be:

Revenue: 14*3=42

Costs: 7+8+9=24

Profit: 42-24=18

BUYERS

Buyers are divided into two groups as well: some do not care about the quality of the product (High or Standard), while others prefer High quality. For brevity we will call the former SQ Buyers and the latter HQ Buyers.

Buyers' final monetary payoff depends on the satisfaction they get from consuming the items purchased. In other words, the higher satisfaction at the end of each single trading period, the higher your monetary reward at the end of the experiment!

	$1st$	$2nd$	$3rd$
$HQ/SQ\ product$	$12-p$	$11-p$	$10-p$

A HQ Buyer will get higher satisfaction buying higher quality products; on the other hand, a SQ Buyer will get the same satisfaction from a High quality and a Standard quality product. Total satisfaction is given by the sum of the satisfaction obtained consuming each unit of product minus the cost of purchasing the products. Consuming the first unit gives higher satisfaction than consuming the second and so on. Each Buyer can purchase a maximum of 3 units.

Below you can find a table representing the satisfaction of the Buyers consuming products of the two different qualities and p denotes the price the consumer paid for each unit bought.

Satisfaction is higher for the consumption of the first product and it decreases for each extra unit consumed:

If a SQ-Buyer buys 2 units of High Quality products at a price of 7, then his satisfaction is going to be:

Satisfaction: (12-7)+(11-7)=5+4=9

Looking at the table, it is easy to see how the same satisfaction is obtained by buying 2 products of Standard Quality as the numbers are the same.

Again, if a SQ Buyer buys 1 unit of High Quality products at a price of 10 and 2 of Standard Quality products, at a price of 11 the total satisfaction is:

Satisfaction= (12-10)+(11-11)+(10-11) =2+0-1=1

It is important to notice how purchasing the 3rd unit of the product is actually decreasing the total satisfaction. If the Buyer had bought only 2 products at the same price, his satisfaction would have been actually higher; in fact:

Satisfaction= (12-10)+(11-11)=2+0=2

HQ-Buyers, though, do get more satisfaction if they buy High Quality products. In particular, for each unit of High Quality product they buy they have an extra 2 of satisfaction.

If a HQ-Buyer buys 1 High Quality product at a price of 8, his satisfaction is going to be:

Satisfaction: (12-8)+2=6

It is easy to see that if he buys 1 Standard Quality product at the same price his satisfaction (12-8=4) is actually lower.

If, again, he buys 2 units of High Quality products at a price of 8 and 1 unit of Standard Quality product at a price of 7, then his satisfaction is:

Satisfaction: (12-8)+(11-8)+(10-7)+(2*2)=4+3+3+4=14

Market functioning

At the beginning of the experiment the computer will randomly assign you and the other participants in the room one of the four possible roles: S-Sellers, H-Sellers, HQ-Buyers and SQ-Buyers. Following that, the sellers will decide what price they want to charge for their own products. Given the chosen prices, the computer determines the production of each seller as already explained above.

Then, the products are presented to the Buyers. Buyers are ordered randomly and one by one they will choose how many products they want to buy. So each Buyer in the list will only be able to choose among the products that are left after the previous Buyer has bought what he wants. Once all the Buyers have made their choices, profits and satisfactions are calculated.

The same procedure is repeated 10 times. Every new trading period, producers will be able to change their prices and Buyers will be able to buy up to 3 units. At the end of the 10th trading period the experiment will finish, the computer will calculate your earnings and the experimenter will come to your desk and pay your earning in cash. You will be paid the earnings of ALL trading periods.

Before starting the experiment, please answer the following Questionnaire to check that the game has been explained clearly. You are asked to use the tables presented before.

*A H-Seller produces and sells 4 products at a price of 15.

His profit is.....

* What is the maximum amount of units a Seller can sell?.....

* What is the maximum amount of units a Buyer can buy?.....

*A S-Seller produces 4 products but only sells 2 at a price of 12.

His profit is.....

*A HQ Buyer buys 2 High Quality products at 13 and 1 Standard Quality at a price of 10.

His satisfaction is.....

*A SQ Buyer buys 1 High Quality product at 12, and 2 Standard Quality at a price of 9.

His satisfaction is.....

B.2 Cheap Talk Treatment

You are about to take part in an experiment. If you read the following instructions carefully, you can, depending on your and other participants' decisions, earn a significant amount of money. It is therefore important that you take your time to understand the instructions. Please do not communicate with the other participants during the experiment. Should you have any questions, ask us.

You will be called to make one or more decisions. You will have to make your decisions without knowing other participants' decisions. Other participants will not know your decisions either.

You should take your time to make your decision. All the information you provide will be anonymous.

Your earnings will be paid to you in cash at the end of the experiment. Earnings will be confidential.

Below is presented the general functioning of the experiment. You will also find some questions to allow you to check that you have understood the mechanisms correctly.

The Experiment simulates the functioning of a Market. You and the other participants in the room will be randomly divided between Sellers and Buyers. The computer will randomly determine your role (Buyer or Seller) and you will keep that role until the end of the experiment. There will be 6 Buyers and 6 Sellers. There is only one product sold and bought. However, the product can be Standard Quality or High Quality. The experiment consists of 10 consecutive trading periods.

Below you will find a thorough description of the Seller and Buyer's roles and of the functioning of the market.

SELLERS

Sellers will be randomly divided into 2 groups: one will produce High quality products (that are also more costly to produce), while the other group will produce Standard quality products. For brevity, we will call H-Seller the one selling High Quality products and S-Seller the ones selling Standard quality goods. Sellers need to decide what price they will charge for their products. Price has to be an integer (1;2;3... not 2.8; 7.5 etc...)

Sellers spend money to produce goods (seller's costs) and receive revenue from the sales of the goods. Their final monetary payoff depends on their profit (revenue minus costs). In other words, the higher your profit in each single trading period, the higher you monetary reward of the experiment!

Take a moment to consider the table below. It represents the cost to Sellers of producing each unit. 'H' is the row of unit costs for the H Sellers and 'S' for the S-Seller. Costs of production for each unit of product increase with quantity. Therefore, the first unit will be cheaper than the second, and so on.

	$1st$	$2nd$	$3rd$	$4th$
H	7	8	9	10
S	5	6	7	8

If a H-Seller sells 2 products at a price of 12, then his total profit is going to be:

Revenue=12*2=24

Cost=7+8=15

Profit=24-15=9

If a S-Seller sells 3 products at a price of 10, then his profit is:

Revenue=10*3=30

Cost=5+6+7=18

Profit=30-18=12

In the experiment, you can produce up to 4 units for each trading period. The only condition is that you must cover your production cost. Going back to the previous table, if you are a S-Seller and you decide to charge a price of 20, then you will produce 4 units. However, if you decide to charge a price of 6, then you will be able to produce only 2 units (as, if you were producing a third unit, the cost of production would be higher than your revenue!!). In the experiment the computer will check this for you and will determine the amount you will produce in each period accordingly.

However, a seller may not be always able to sell all the products s/he brings to the Market. In this case, s/he will pay only for the costs of production of the sold goods.

So, if a H-Seller produces 4 goods but sells only 3 at a price of 14, then his/her profit will be:

Revenue: 14*3=42

Costs: 7+8+9=24

Profit: 42-24=18

After you have made the decision about the price, you will be asked whether you want to advertise. Advertisement is costly (it will cost 2, for every period you advertise, but regardless of the units of products you sell). However, by advertising, you signal yourself to be selling High Quality products. This does not need to be necessarily the case. So whether you are a H-Seller or S-Seller, you can still decide to advertise.

BUYERS

Buyers are divided into two groups as well: some do not care about the quality of the product (High or Standard), while others prefer High quality. For brevity we will call the former SQ Buyers and the latter HQ Buyers.

Buyers' final monetary payoff depends on the satisfaction they get from consuming the items purchased. In other words, the higher satisfaction at the end of each single trading period, the higher your monetary reward at the end of the experiment!

A HQ Buyer will get higher satisfaction buying higher quality products; on the other hand, a SQ Buyer will get the same satisfaction from a High quality and a Standard quality product. Total satisfaction is given by the sum of the satisfaction obtained consuming each unit of product minus the cost of purchasing the products. Consuming the first unit gives higher satisfaction than consuming the second and so on. Each Buyer can purchase a maximum of 3 units.

Below you can find a table representing the satisfaction of the Buyers consuming products of the two different qualities and p denotes the price the consumer paid for each unit bought.

Satisfaction is higher for the consumption of the first product and it decreases for each extra unit consumed:

	$1st$	$2nd$	$3rd$
$HQ/SQ\ product$	$12-p$	$11-p$	$10-p$

If a SQ-Buyer buys 2 units of High Quality products at a price of 7, then his satisfaction is going to be:

Satisfaction: (12-7)+(11-7)=5+4=9

Looking at the table, it is easy to see how the same satisfaction is obtained by buying 2 products of Standard Quality as the numbers are the same..

Again, if a SQ Buyer buys 1 unit of High Quality products and 2 of Standard Quality products, at a price of 11 the total satisfaction is:

Satisfaction= (12-10)+(11-11)+(10-11) =1+0-1=0

It is important to notice how purchasing the 3rd unit of the product is actually decreasing the total satisfaction. If the Buyer had bought only 2 products at the same price, his satisfaction would have been actually higher; in fact:

Satisfaction= (12-10)+(11-11)=1+0=1

HQ-Buyers, though, do get more satisfaction if they buy High Quality products. In particular, for each unit of High Quality product they buy they have an extra 2 of satisfaction.

If a HQ-Buyer buys 1 High Quality product at a price of 8, his satisfaction is going to be:

Satisfaction: (12-8)+2=6

It is easy to see that if he buys 1 Standard Quality product at the same price his satisfaction (12-8=4) is actually lower.

If, again, he buys 2 units of High Quality products at a price of 8 and 1 unit of Standard Quality product at a price of 7, then his satisfaction is:

Satisfaction: (12-8)+(11-8)+(10-7)+(2*2)=4+3+3+4=14

One more thing. Some Seller will invest in Advertisement. This is a costly activity for them to make their products stand out. You will find this information in the table with prices and quantity. However, you should be aware that (a) advertisement may not be truthful and (b) a H-Seller may decide not to advertise.

Market functioning

At the beginning of the experiment the computer will randomly assign you and the other participants in the room one of the four possible roles: S-Sellers, H-Sellers, HQ-Buyers and SQ-Buyers. Following that, the sellers will decide what price they want to charge for their own goods. Given the chosen prices, the computer determines the production of each seller as already explained above. Sellers also decide if in this particular period they wish to advertise.

Then, the products are presented to the Buyers. A table will present the quantity available for each price and it will also highlight which of the Sellers have decided to advertise or not. Buyers are ordered randomly and, one by one, they will choose how many products they want to buy. So each Buyer in the list will only be able to choose among the products that are left after the previous Buyer has bought what he wants. Once all the Buyers have made their choices, profits and satisfactions are calculated.

The same procedure is repeated 10 times. Every new trading period, producers will be able to change their prices and Buyers will be able to buy up to 3 units. At the end of the 10th trading period the experiment will finish, the computer will calculate your earnings and the experimenter will come to your desk and pay your earnings in cash. You will be paid the earnings of ALL trading periods.

Before starting the experiment, please answer the following Questionnaire to check that the experiment has been explained clearly. You are asked to use the tables presented before.

*A H-Seller produces and sells 4 products at a price of 15 and decides to advertise.

His profit is.....

* What is the maximum amount of units a Seller can sell?.....

* What is the maximum amount of units a Buyer can buy?.....

*A S-Seller produces 4 products but only sells 2 at a price of 12.

His profit is.....

*A HQ Buyer buys 2 High Quality products at 13 and 1 Standard Quality at a price of 10.

His satisfaction is.....

*A SQ Buyer buys 1 High Quality product at 12, and 2 Standard Quality at a price of 9.

His satisfaction is.....

B.3 Third-party Certification Treatment

You are about to take part in an experiment. If you read the following instructions carefully, you can, depending on your and other participants' decisions, earn a significant amount of money. It is therefore important that you take your time to understand the instructions. Please do not communicate with the other participants during the experiment. Should you have any questions, ask us.

You will be called to make one or more decisions. You will have to make your decisions without knowing other participants' decisions. Other participants will not know your decisions either.

You should take your time to make your decision. All the information you provide will be anonymous.

Your earnings will be paid to you in cash at the end of the experiment. Earnings will be confidential.

Below is presented the general functioning of the experiment. You will also find some questions to allow you to check that you have understood the mechanisms correctly.

The Experiment simulates the functioning of a Market. You and the other participants in the room will be randomly divided between Sellers and Buyers. The computer will randomly determine your role (Buyer or Seller) and you will keep that role until the end of the experiment. There will be 6 Buyers and 6 Sellers. There is only one product sold and bought. However, the product can

	$1st$	$2nd$	$3rd$	$4th$
H	7	8	9	10
S	5	6	7	8

be Standard Quality or High Quality. The experiment consists of 10 consecutive trading periods.

Below you will find a thorough description of the Seller and Buyer's roles and of the functioning of the market.

SELLERS

Sellers will be randomly divided into 2 groups: one will produce High quality products (that are also more costly to produce), while the other group will produce Standard quality products. For brevity, we will call H-Seller the one selling High Quality products and S-Seller the ones selling Standard quality goods. Sellers need to decide what price they will charge for their products. Price has to be an integer (1;2;3... not 2.8; 7.5 etc...)

Sellers spend money to produce goods (seller's costs) and receive revenue from the sales of the goods. Their final monetary payoff depends on their profit (revenue minus costs). In other words, the higher your profit in each single trading period, the higher you monetary reward of the experiment!

Take a moment to consider the table below. It represents the cost to Sellers of producing each unit. 'H' is the row of unit costs for the H-Sellers and 'S' for the S-Seller. Costs of production for each unit of product increase with quantity. Therefore, the first unit will be cheaper than the second, and so on.

If a H-Seller sells 2 products at a price of 12, then his total profit is going to be:

Revenue=12*2=24

Cost=7+8=15

Profit=24-15=9

If a S-Seller sells 3 products at a price of 10, then his profit is:

Revenue=10*3=30

Cost=5+6+7=18

Profit=30-18=12

In the experiment, you can produce up to 4 units for each trading period. The only condition is that you must cover your production cost. Going back to the previous table, if you are a S-Seller and you decide to charge a price of 20, then you will produce 4 units. However, if you decide to charge a price of 6, then you will be able to produce only 2 units (as, if you were producing a third unit, the cost of production would be higher than your revenue!!). In the experiment the computer will check this for you and will determine the amount you will produce in each period accordingly.

However, you may not be always able to sell all the products brought to the Market. In this case, you will pay only for the costs of production of the sold goods.

So, if a H-Seller produces 4 goods but sells only 3 at a price of 14, then the profit will be:

Revenue: 14*3=42

Costs: 7+8+9=24

Profit: 42-24=18

After you have made the decision about the price, H-Sellers (not S-Sellers) will be offered the possibility to advertise. Advertisement is costly (it will cost 4, for every period you advertise, but regardless of the units of products you sell). However, you signal that your products are High Quality.

So, for example, if a H-Seller sells 3 units at 11 and decides to advertise, then his profit will be:

Revenue: 11*3=33

Cost of Production: 7+8+9=24

Profit: 33-24-4=5

	$1st$	$2nd$	$3rd$
$HQ/SQ\ product$	$12-p$	$11-p$	$10-p$

BUYERS

Buyers are divided into two groups as well: some do not care about the quality of the product (High or Standard), while others prefer High quality. For brevity we will call the former SQ Buyers and the latter HQ Buyers.

Buyers' final monetary payoff depends on the satisfaction they get from consuming the items purchased. In other words, the higher satisfaction at the end of each single trading period, the higher your monetary reward at the end of the experiment!

A HQ Buyer will get higher satisfaction buying higher quality products; on the other hand, a SQ Buyer will get the same satisfaction from a High quality and a Standard quality product. Total satisfaction is given by the sum of the satisfaction obtained consuming each unit of product minus the cost of purchasing the products. Consuming the first unit gives higher satisfaction than consuming the second and so on. Each Buyer can purchase a maximum of 3 units.

Below you can find a table representing the satisfaction of the Buyers consuming products of the two different qualities and p denotes the price the consumer paid for each unit bought.

Satisfaction is higher for the consumption of the first product and it decreases for each extra unit consumed:

If a SQ-Buyer buys 2 units of High Quality products at a price of 7, then his satisfaction is going to be:

Satisfaction: (12-7)+(11-7)=5+4=9

Looking at the table, it is easy to see how the same satisfaction is obtained by buying 2 products of Standard Quality as the numbers are the same..

Again, if a SQ Buyer buys 1 unit of High Quality products at a price of 10 and 2 of Standard Quality products, at a price of 11 the total satisfaction is:

Satisfaction= (12-10)+(11-11)+(10-11) =2+0-1=1

It is important to notice how purchasing the 3rd unit of the product is actually decreasing the total satisfaction. If the Buyer had bought only 2 products at the same price, his satisfaction would have been actually higher; in fact:

Satisfaction= (12-10)+(11-11)=2+0=2

HQ-Buyers, though, do get more satisfaction if they buy High Quality products. In particular, for each unit of High Quality product they buy they have an extra 2 of satisfaction.

If a HQ-Buyer buys 1 High Quality product at a price of 8, his satisfaction is going to be:

Satisfaction: (12-8)+2=6

It is easy to see that if he buys 1 Standard Quality product at the same price his satisfaction (12-8=4) is actually lower.

If, again, he buys 2 units of High Quality products at a price of 8 and 1 unit of Standard Quality product at a price of 7, then his satisfaction is:

Satisfaction: (12-8)+(11-8)+(10-7)+(2*2)=4+3+3+4=14

One more thing. Some Seller will invest in Advertisement. This is a costly activity for them to let you know their products are SURELY High Quality.

However, you should be aware that a H-Seller may decide not to advertise.

Market functioning

At the beginning of the experiment the computer will randomly assign you and the other participants in the room one of the four possible roles: S-Sellers, H-Sellers, HQ-Buyers and SQ-Buyers. Following that, the sellers will decide what price they want to charge for their own goods. Given the chosen prices,

the computer determines the production of each seller as already explained above. Sellers also decide if in this particular period they wish to advertise.

Then, the products are presented to the Buyers. A table will present the quantity available for each price and it will also highlight which of the Sellers have decided to advertise or not. Buyers are ordered randomly and, one by one, they will choose how many products they want to buy. So each Buyer in the list will only be able to choose among the products that are left after the previous Buyer has bought what he wants. Once all the Buyers have made their choices, profits and satisfactions are calculated.

The same procedure is repeated 10 times. Every new trading period, producers will be able to change their prices and Buyers will be able to buy up to 3 units. At the end of the 10th trading period the experiment will finish, the computer will calculate your earnings and the experimenter will come to your desk and pay your earnings in cash. You will be paid the earnings of ALL trading periods.

Before starting the experiment, please answer the following Questionnaire to check that the experiment has been explained clearly. You are asked to use the tables presented before.

*A H-Seller produces and sells 4 products at a price of 15 and decides to advertise.

His profit is.....

* What is the maximum amount of units a Seller can sell?.....

* What is the maximum amount of units a Buyer can buy?.....

*Can a S-Seller advertise?

*A S-Seller produces 4 products but only sells 2 at a price of 12.

His profit is.....

*A HQ Buyer buys 2 High Quality products at 13 and 1 Standard Quality at a price of 10.

His satisfaction is.....

*Can a High Quality product bear no advertisement?.....

*A SQ Buyer buys 1 High Quality product at 12, and 2 Standard Quality at a price of 9.

His satisfaction is.....

B.4 Both Certification Treatment

You are about to take part in an experiment. If you read the following instructions carefully, you can, depending on your and other participants' decisions, earn a significant amount of money. It is therefore important that you take your time to understand the instructions. Please do not communicate with the other participants during the experiment. Should you have any questions, ask us.

You will be called to make one or more decisions. You will have to make your decisions without knowing other participants' decisions. Other participants will not know your decisions either.

You should take your time to make your decision. All the information you provide will be anonymous.

Your earnings will be paid to you in cash at the end of the experiment. Earnings will be confidential.

Below is presented the general functioning of the experiment. You will also find some questions to allow you to check that you have understood the mechanisms correctly.

The Experiment simulates the functioning of a Market. You and the other participants in the room will be randomly divided between Sellers and Buyers. The computer will randomly determine your role (Buyer or Seller) and you will keep that role until the end of the experiment. There will be 6 Buyers and 6 Sellers. There is only one product sold and bought. However, the good can be Standard Quality or High Quality. The experiment consists of 10 consecutive trading periods.

	$1st$	$2nd$	$3rd$	$4th$
H	7	8	9	10
S	5	6	7	8

Below you will find a thorough description of the Seller and Buyer's roles and of the functioning of the market.

SELLERS

Sellers will be randomly divided into 2 groups: one will produce High quality products (that are also more costly to produce), while the other group will produce Standard quality products. For brevity, we will call H-Seller the one selling High Quality products and S-Seller the ones selling Standard quality goods. Sellers need to take two decisions:

1.Decide what price they will charge for their products. Price has to be an integer (1;2;3... not 2.8; 7.5 etc...)

2.Decide whether to advertise or not.

1. Choice of Price.

Sellers spend money to produce goods (seller's costs) and receive revenue from the sales of the goods. Their final monetary payoff depends on their profit (revenue minus costs). In other words, the higher your profit in each single trading period, the higher you monetary reward of the experiment!

Take a moment to consider the table below. It represents the cost of Sellers of producing each unit. 'H' is the row of unit costs for the H-Sellers and 'S' for the S-Seller. Costs of production of each unit of product increase with quantity. Therefore, the first unit will be cheaper than the second, and so on.

If a H-Seller sells 2 products at a price of 12, then his total profit is going to be:

Revenue=12*2=24

Cost=7+8=15

Profit=24-15=9

If a S-Seller sells 3 products at a price of 10, then his profit is:

Revenue=10*3=30

Cost=5+6+7=18

Profit=30-18=12

In the experiment, you can produce up to 4 units for each trading period. The only condition is that you must cover your production cost. Going back to the previous table, if you are a S-Seller and you decide to charge a price of 20, then you will produce 4 units. However, if you decide to charge a price of 6, then you will be able to produce only 2 units (as, if you were producing a third unit, the cost of production would be higher than your revenue!!). In the experiment the computer will check this for you and will accordingly choose the amount you will produce in each period.

However, you may not always be able to sell all the products brought to the Market. In this case, you will pay only for the costs of production of the sold goods.

So, if a H-Seller produces 4 goods but sells only 3 at a price of 14, then the profit will be:

Revenue: 14*3=42

Costs: 7+8+9=24

Profit: 42-24=18

2. Advertisement

After you have made the decision about the price, you will be asked whether you want to advertise. Advertisement is costly. In this way, however, you signal yourself to be selling High Quality products. There are two kinds of advertisement:

*For all Sellers: A cheap advertisement (Ad1, that costs 2, for every period you advertise, but regardless of the units of products you sell). You market your good as being High Quality. This does not need to be necessarily the case

(so you can use Ad1 even if your products are Standard Quality). So whether you are a H-Seller or S-Seller, you can still decide to advertise.

*For H-Sellers: A more expensive advertisement (Ad2, that costs 4, for every period you advertise, but regardless of the units of products you sell); Ad2 will indicate to buyers that your goods are surely High Quality.

H-Sellers can choose either kinds of advertisement but cannot use both at the same time. S-Sellers can only opt for the cheap advertisement, should they wish to advertise at all.

So if a H-Seller decides to go for Ad2 and sells 3 units at 13, then his profit is:

Revenue= 12*3=36

Cost of Production=7+8+9=24

Profit=36-24-4=8

Remember that you can still decide not to advertise.

BUYERS

Buyers are divided into two groups as well: some do not care about the quality of the product (High or Standard), while others prefer High quality. For brevity we will call the former SQ Buyers and the latter HQ Buyers.

Buyers' final monetary payoff depends on the satisfaction they get from consuming the items purchased. In other words, the higher satisfaction at the end of each single trading period, the higher your monetary reward at the end of the experiment!

A HQ Buyer will get higher satisfaction buying higher quality products; on the other hand, a SQ Buyer will get the same satisfaction from a High quality and a Standard quality product. Total satisfaction is given by the sum of the satisfaction obtained consuming each unit of product minus the cost of purchasing the products. Consuming the first unit gives higher satisfaction than consuming the second and so on. Each Buyer can purchase a maximum of 3 units.

	$1st$	$2nd$	$3rd$
$HQ/SQ\ product$	$12-p$	$11-p$	$10-p$

Below you can find a table representing the satisfaction of the Buyers consuming products of the two different qualities and p denotes the price the consumer paid for each unit bought.

Satisfaction is higher for the consumption of the first product and it decreases for each extra unit consumed:

If a SQ-Buyer buys 2 units of High Quality products at a price of 7, then his satisfaction is going to be:

Satisfaction: (12-7)+(11-7)=5+4=9

Looking at the table, it is easy to see how the same satisfaction is obtained by buying 2 products of Standard Quality as the numbers are the same.

Again, if a SQ Buyer buys 1 unit of High Quality products at a price of 10 and 2 of Standard Quality products, at a price of 11 the total satisfaction is:

Satisfaction= (12-10)+(11-11)+(10-11) =2+0-1=1

It is important to notice how purchasing the 3rd unit of the product is actually decreasing the total satisfaction. If the Buyer had bought only 2 products at the same price, his satisfaction would have been actually higher; in fact:

Satisfaction= (12-10)+(11-11)=2+0=2

HQ-Buyers, though, do get more satisfaction if they buy High Quality products. In particular, for each unit of High Quality product they buy they have an extra 2 of satisfaction.

If a HQ-Buyer buys 1 High Quality product at a price of 8, his satisfaction is going to be:

Satisfaction: (12-8)+2=6

It is easy to see that if he buys 1 Standard Quality product at the same price his satisfaction (12-8=4) is actually lower.

If, again, he buys 2 units of High Quality products at a price of 8 and 1 unit of Standard Quality product at a price of 7, then his satisfaction is:

Satisfaction: (12-8)+(11-8)+(10-7)+(2*2)=4+3+3+4=14

One more thing. Some Sellers will invest in Advertisement. This is a costly activity for them to make their products stand out. You will find this information in the table with prices and quantity.

Ad2 tells you that the products are surely High Quality.

Ad1 tells you that the product may be High Quality (but maybe not).

However, a product does not need to be advertised to be High Quality.

Market functioning

At the beginning of the experiment the computer will randomly assign you and the other participants in the room one of the four possible roles: S-Sellers, H-Sellers, HQ-Buyers and SQ-Buyers. Following that, the sellers will decide what price they want to charge for their own goods. Given the chosen prices, the computer determines the production of each seller as already explained above. Sellers also decide if in this particular period they wish to advertise.

Then, the products are presented to the Buyers. A table will present the quantity available for each price and it will also highlight which of the Sellers have decided to advertise or not. Buyers are ordered randomly and, one by one, they will choose how many products they want to buy. So each Buyer in the list will only be able to choose among the products that are left after the previous Buyer has bought what he wants. Once all the Buyers have made their choices, profits and satisfactions are calculated.

The same procedure is repeated 10 times. Every new trading period, producers will be able to change their prices and Buyers will be able to buy up to 3 units. At the end of the 10th trading period the experiment will finish, the computer will calculate your earnings and the experimenter will come to

your desk and pay your earnings in cash. You will be paid the earnings of ALL trading periods.

Before starting the experiment, please answer the following Questionnaire to check that the experiment has been explained clearly. You are asked to use the tables presented before.

*A H-Seller produces and sells 4 products at a price of 15 and decides to use Ad1.

His profit is.....

* What is the maximum amount of units a Seller can sell?.....

* What is the maximum amount of units a Buyer can buy?.....

*How much does an Ad2 cost?.....

*Who can choose to use Ad1?.....

*A S-Seller produces 4 products but only sells 2 at a price of 12.

His profit is.....

*A H-Seller sells 2 products at 10 and chooses Ad2.

His profit is.....

*Can a High quality product be without advertisement?.....

*Can a Standard quality product be advertised with Ad1?.....

*A HQ Buyer buys 2 High Quality products at 13 and 1 Standard Quality at a price of 10.

His satisfaction is.....

*A SQ Buyer buys 1 High Quality product at 12, and 2 Standard Quality at a price of 9.

His satisfaction is.....

Appendix C

Demonstrations - Chapter 3

Eq. 3.24:

$$p_3 = P(unb \mid a_2 = 1) = \frac{P(a_2 = 1 \mid unb)P(unb)}{P(a_2 = 1)}$$

$$P(a_2 = 1 \mid unb) = \tfrac{1}{2}$$

$$P(unb) = p_2$$

$$P(a_2 = 1) = \tfrac{1}{2}p_2 + (1 - p_2)g_2$$

$$p_3 = \frac{\frac{1}{2}p_2}{\frac{1}{2}p_2 + (1 - p_2)g_2}$$

Eq. 3.26

$$\begin{aligned} p^{**} &= P(w_2 = 1 \mid a_2 = 1) = \frac{P(a_2 = 1 \mid w_2 = 1)P(w_2 = 1)}{P(a_2 = 1)} \\ P(a_2 &= 1 \mid w_2 = 1) = p_3 + (1 - p_3) = 1 \\ P(w_2 &= 1) = \frac{1}{2} \\ P(a_2 &= 1) = \frac{1}{2}p_3 + (1 - p_3) = 1 - \frac{1}{2}p_3 \\ p^{**} &= \frac{1\frac{1}{2}}{1 - \frac{1}{2}p_3} = \frac{\frac{1}{2}}{\frac{2-p_3}{2}} = \frac{1}{2}\frac{2}{2 - p_3} = \frac{1}{2 - p_3} \end{aligned}$$

Eq. 3.30:

$$p_1 = P(unb \mid a_1 = 0) = \frac{P(a_1 = 0 \mid unb)P(unb)}{P(a_1 = 0)}$$

$$P(unb) = p_0$$

$$P(a_1 = 0 \mid unb) = \tfrac{1}{2}$$

$$P(a_1 = 0) = \tfrac{1}{2}p_0 + (1 - p_0)\tfrac{1}{2}\alpha + (1 - p_0)(1 - \tfrac{1}{2})(1 - \alpha) = \tfrac{1}{2}$$

$$p_1 = P(unb \mid a_1 = 0) = \frac{\frac{1}{2}p_0}{\frac{1}{2}} = p_0$$

Eq. 3.31:

$$p_1 = P(unb \mid a_1 = 1) = \frac{P(a_1 = 1 \mid unb)P(unb)}{P(a_1 = 1)}$$

$$P(unb) = p_0$$

$P(a_1 = 1 \mid unb) = \frac{1}{2}$

$P(a_1 = 1) = \frac{1}{2}p_0 + (1 - p_0)\frac{1}{2}(1 - \alpha) + (1 - p_0)(1 - \frac{1}{2})\alpha = \frac{1}{2}$

$p_1 = P(unb \mid a_1 = 1) = \frac{\frac{1}{2}p_0}{\frac{1}{2}} = p_0$

Eq. 3.32:

$$P(green \mid a_1 = 0) = \frac{P(a_1 = 0 \mid green)P(green)}{P(a_1 = 0)}$$

$P(green) = \frac{1}{2}$

$P(a_1 = 0 \mid green) = \alpha$

$P(a_1 = 0) = \frac{1}{2}p_0 + (1 - p_0)\frac{1}{2}\alpha + (1 - p_0)(1 - \frac{1}{2})(1 - \alpha) = \frac{1}{2}$

$P(green \mid a_1 = 0) = \frac{\alpha\frac{1}{2}}{\frac{1}{2}} = \alpha$

Eq. 3.33:

$$P(green \mid a_1 = 1) = \frac{P(a_1 = 1 \mid green)P(green)}{P(a_1 = 1)}$$

$P(green) = \frac{1}{2}$

$P(a_1 = 1 \mid green) = 1 - \alpha$

$P(a_1 = 1) = \frac{1}{2}p_0 + (1 - p_0)\frac{1}{2}(1 - \alpha) + (1 - p_0)(1 - \frac{1}{2})\alpha = \frac{1}{2}$

$P(green \mid a_1 = 1) = \frac{(1-\alpha)\frac{1}{2}}{\frac{1}{2}} = 1 - \alpha$

Eq. 3.36:

$$\begin{aligned}
P(w_1 &= 0 \mid a_1 = 0) = \frac{P(a_1 = 0 \mid w_1 = 0)P(w_1 = 0)}{P(a_1 = 0)} \\
P(a_1 &= 0 \mid w_1 = 0) = p_1 + (1 - p_1)g_1\frac{\alpha}{\frac{1}{2}} + (1 - p_1)(1 - g_1) \\
&= 2\alpha g_1 - 2\alpha g_1 p_1 + 1 - g_1 + g_1 p_1 \\
&= p_1 + (1 - p_1)\alpha\frac{\alpha}{\frac{1}{2}} + (1 - p_1)(1 - \alpha) = p_1 + (1 - p_1)(2\alpha^2 + 1 - \alpha) \\
P(w_1 &= 0) = \frac{1}{2} \\
P(a_1 &= 0) = \frac{1}{2}p_1 + (1 - p_1)g_1\alpha + (1 - p_1)(1 - g_1)(1 - \alpha) \\
&= \frac{1}{2}p_1 + (1 - p_1)(2\alpha^2 + 1 - 2\alpha) \\
P(w_1 &= 0 \mid a_1 = 0) = \frac{1}{2}\frac{p_1 + (1 - p_1)(2\alpha^2 + 1 - \alpha)}{\frac{1}{2}p_1 + (1 - p_1)(2\alpha^2 + 1 - 2\alpha)}
\end{aligned}$$

Eq. 3.41

$$
\begin{aligned}
p'^{*} &= P(w_1 = 1 \mid a_1 = 1) = \frac{P(a_1 = 1 \mid w_1 = 1)P(w_1 = 1)}{P(a_1 = 1)} \\
P(a_1 &= 1 \mid w_1 = 1) = p_1 + (1 - p_1)g_1 + (1 - p_1)(1 - g_1)\frac{1 - \alpha}{\frac{1}{2}} \\
&= 2\alpha g_1 - 2\alpha g_1 p_1 + 1 - g_1 + g_1 p_1 \\
&= p_1 + (1 - p_1)\alpha\frac{\alpha}{\frac{1}{2}} + (1 - p_1)(1 - \alpha) = p_1 + (1 - p_1)(2\alpha^2 + 1 - \alpha) \\
P(w_1 &= 1) = \frac{1}{2} \\
P(a_1 &= 1) = \frac{1}{2}p_1 + (1 - p_1)g_1(1 - \alpha) + (1 - p_1)(1 - g_1)\alpha \\
&= \frac{1}{2}p_1 + (1 - p_1)(2\alpha^2 + 1 - 2\alpha) \\
p'^{*} &= \frac{1}{2}\frac{p_1 + (1 - p_1)(2\alpha^2 + 1 - \alpha)}{\frac{1}{2}p_1 + (1 - p_1)(2\alpha^2 + 1 - 2\alpha)} = p^*
\end{aligned}
$$

$$
\begin{aligned}
p'_2 &= P(unb \mid a_1 = 0 \neq w_1) = 0 \\
p_2 &= P(unb \mid a_1 = 0 = w_1) = \frac{p_0}{p_0 + (1 - p_0)(2\alpha^2 - \alpha + 1)} \\
g'_2 &= P(green \mid a_1 = 0 \neq w_1) = 0 \\
g_2 &= P(green \mid a_1 = 0 = w_1) = \frac{\alpha^2}{p_0 + (1 - p_0)(2\alpha^2 - \alpha + 1)}
\end{aligned}
$$

Eq. 3.43:

$$p'_2 = P(unb \mid a_1 = 0 \neq w_1) = \frac{P(a_1 = 0 \neq w_1 \mid unb)P(unb)}{P(a_1 = 0 \neq w_1)}$$

$$P(a_1 = 0 \neq w_1 \mid unb) = 0 \rightarrow p'_2 = 0$$

Eq. 3.44:

$$p_2 = P(unb \mid a_1 = 0 \wedge w_1 = 0) = \frac{P(a_1 = 0 \wedge w_1 = 0 \mid unb)P(unb)}{P(a_1 = 0 \wedge w_1 = 0)}$$

$$P(a_1 = 0 \wedge w_1 = 0 \mid unb) = \tfrac{1}{2}$$

$$P(unb) = p_1$$

$$P(a_1 = 0 \wedge w_1 = 0) = p_1\tfrac{1}{2} + (1 - p_1)g_1\alpha + (1 - p_1)(1 - g_1)\tfrac{1}{2}$$

$$= \alpha\alpha - \tfrac{1}{2}\alpha + \tfrac{1}{2}\alpha p_1 - \alpha\alpha p_1 + \tfrac{1}{2}$$

$$= \alpha(\alpha - \tfrac{1}{2}) + \tfrac{1}{2} - \alpha^2 p_1(\alpha - \tfrac{1}{2}) = \alpha(\alpha - \tfrac{1}{2})(1 - \alpha p_0) + \tfrac{1}{2}$$

$$p_2 = \frac{\frac{1}{2}p_1}{\alpha g_1 - \frac{1}{2}g_1 + \frac{1}{2}g_1 p_1 - \alpha g_1 p_1 + \frac{1}{2}} = \frac{\frac{1}{2}p_0}{\alpha^2 - \frac{1}{2}\alpha + \frac{1}{2}\alpha p_0 - \alpha^2 p_0 + \frac{1}{2}}$$

$$= \frac{p_0}{\alpha(2\alpha-1)(1-\alpha p_0)+1}$$

Eq. 3.45:

$$g_2' = P(green \mid a_1 = 0 \neq w_1) = \frac{P(a_1 = 0 \neq w_1 \mid green)P(green)}{P(a_1 = 0 \neq w_1)}$$

$$P(a_1 = 0 \neq w_1 \mid green) = 0 \rightarrow g_2' = 0$$

Eq. 3.46:

$$g_2 = P(green \mid a_1 = 0 = w_1) = \frac{P(a_1 = 0 = w_1 \mid green)P(green)}{P(a_1 = 0 = w_1)}$$

$$P(green) = \alpha$$

$$P(a_1 = 0 = w_1 \mid green) = \alpha$$

$$P(a_1 = 0 \wedge w_1 = 0) = p_1\tfrac{1}{2} + (1-p_1)g_1\alpha + (1-p_1)(1-g_1)\tfrac{1}{2}$$

$$= \alpha\alpha - \tfrac{1}{2}\alpha + \tfrac{1}{2}\alpha p_1 - \alpha\alpha p_1 + \tfrac{1}{2}$$

$$= \alpha(\alpha - \tfrac{1}{2}) + \tfrac{1}{2} - \alpha^2 p_1(\alpha - \tfrac{1}{2}) = \alpha(\alpha - \tfrac{1}{2})(1-\alpha p_0) + \tfrac{1}{2}$$

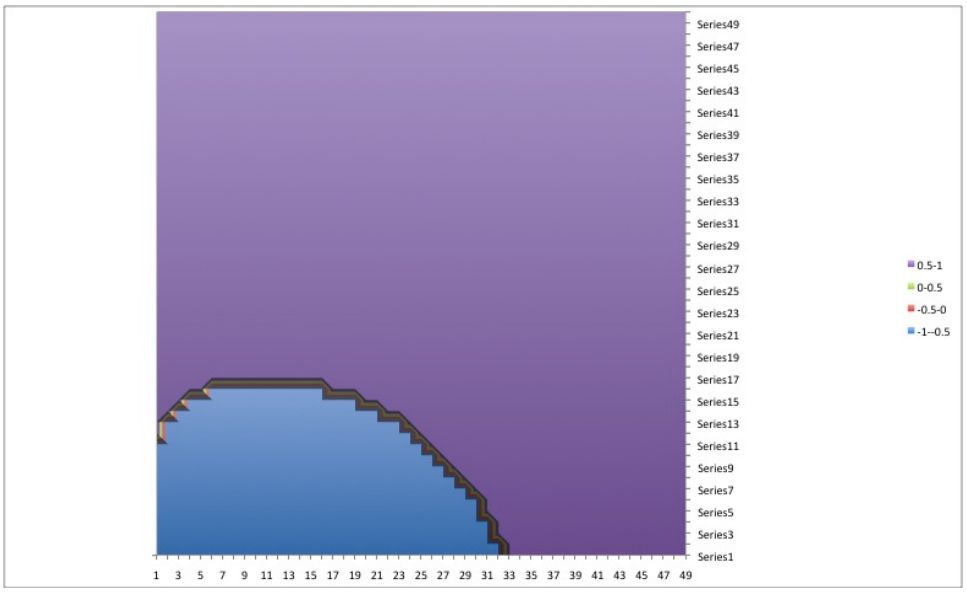
$$g_2 = \frac{\alpha^2}{\alpha(\alpha - \frac{1}{2})(1-\alpha p_0) + \frac{1}{2}}$$

Eq. 3.82:

$$\begin{aligned}
-[w_1 - d_1(0)]^2 - \beta[w_2 - d_2(1)]^2 &> -[w_1 - d_1(1)]^2 - \beta\frac{1}{4} \\
-d_1(0)^2 - \beta[w_2 - d_2(1)]^2 &> -d_1(1)^2 - \beta\frac{1}{4} \\
\beta(\frac{1}{4} - [w_2 - d_2(1)]^2) &> d_1(0)^2 - d_1(1)^2 \\
\beta &> \frac{d_1(0)^2 - d_1(1)^2}{\frac{1}{4} - \frac{1}{2}(-d_2(1))^2 - \frac{1}{2}(1-d_2(1))^2} \\
\beta &> \frac{(d_1(0) - d_1(1))(d_1(0) + d_1(1))}{\frac{1}{4} - \frac{1}{2}d_2^2(1) - \frac{1}{2}d_2^2 + d_2 - \frac{1}{2}} \\
\beta &> \frac{2d_1(0) - 1}{\frac{1}{4} - \frac{1}{2}{d_2}^2 - \frac{1}{2}d_2^2 + d_2 - \frac{1}{2}} \\
\beta &> \frac{2d_1(0) - 1}{-(d_2^2 - d_2 + \frac{1}{4})} \\
\beta &> \frac{1 - 2d_1(0)}{(d_2(1) - \frac{1}{4})^2}
\end{aligned}$$

Figures C.1, C.2 and C.3 show (for a given value of β) the critical values of alpha (vertical axis) for the different values of p_0.

Figure C.1: Alpha, when Beta<2



Some care is required interpreting this set of figures. Let us consider figure C.1 for instance. This shows that if β is lower than 2[1] (in the graph $\beta = 1$), under a certain value $\overline{p}$ (in the graph $\overline{p} = 0.70$), values of α are included within the feasible range; this means that, considering the intertemporal weighting β and her initial reputation p_0, the adviser will be indifferent to the two strategies. Once her initial reputation goes above the threshold $\overline{p}$ (0.7 in the graph), then we can see how α would have to become negative[2]. This means that the adviser will find more convenient not to disclose her information in period 1 and face punishment in the following period. So, if period 2 is less than twice as

[1]The condition of $\beta < 2$ has been found by extrapolation. It is in fact satisfied for $\beta = 1.99$ but not for $\beta = 2$.

[2]In passing, let us draw the attention on how to interpret critical values of α outside the specified range $\left[0; \frac{1}{2}\right]$. α is:

$\alpha = P(a_1 = 0 \mid green)$

that is the probability that a green adviser would disclose that the state of the world in period 1 is zero. Negative probability then means "never" and it should be considered (for our purposes) as $\alpha = 0$. If $\alpha > \frac{1}{2}$, this means that whenever $w_1 = 0$ she will disclose her information and therefore it should be considered $\alpha = \frac{1}{2}$.

important than period 1, the brown adviser will be indifferent as to whether to tell the truth or not up to a certain level of reputation. After that, she decides to bank on her reputation in period 1 and be recognised as biased in period 2.

Figure C.2: Alpha, when Beta=2

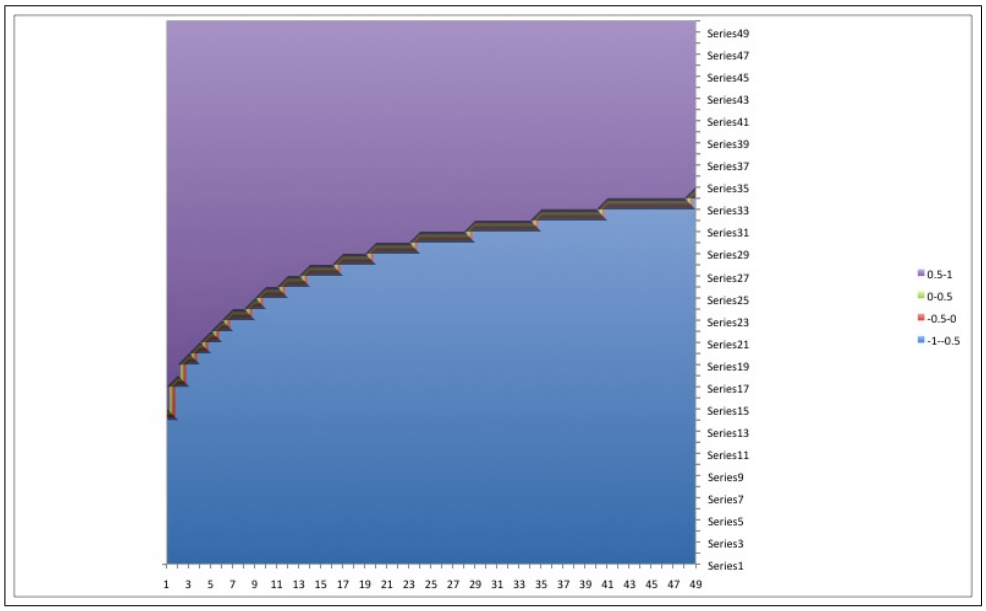
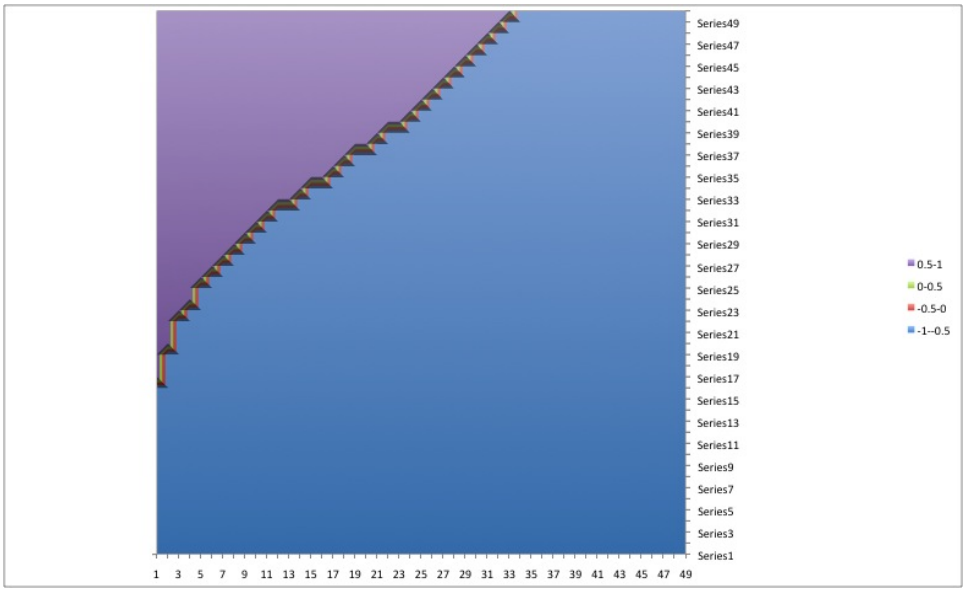


Figure C.2 shows that for $\beta = 2$, the adviser is always indifferent to the two strategies, for any value of p_0.

Figure C.3: Alpha, when Beta=3



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