An Analytical Approach to Greenwashing: Certification Versus Noncertification

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ABSTRACT

"Greenwashing" – labeling products as environmentally sound while actually not – occurs when a firm eschews sustainable business practices but still wishes to enter environment-friendly markets. In response, environmentally conscious firms resort to eco-label certification to signal the authenticity of their products. Assuming that some consumers in the market are informed about product labeling while others are not, we study the problem of whether to certify one's products using both a game-theoretic model and a profit-maximizing pricing model. In the game between a producer and multiple consumers, we find that the equilibrium solution is for the producer to pursue a segmentation strategy. We also find the optimal production policies in a demand setting and analyze the certification decision as a function of several parameters. Certification is superior in low price sensitive markets; when the informed-consumers market size is sufficiently large; and when the ratio of certification cost to production cost is not excessive.

Key Words: *Greenwashing, Corporate Social Responsibility, Sustainable Development.*
JEL Classification: *M21, M31, M14*

"Yeşile Boyama" Kavramının Analitik İncelenmesi: Sertifikalı Etiketlerin Sertifikasızlarla Karşılaştırılması

ÖZET

"Yeşile Boyama"- ürünleri gerçekte olmadığı halde çevre dostuymuş gibi göstererek etiketlendirme- bir firmanın sürdürülebilir işletme politikalarını uygulamaktan kaçındığı ancak yine de çevre dostu ürün pazarına girmek istediği durumlarda görülür. Buna karşılık, çevresel bilince sahip şirketler kendi ürünlerinin gerçekliğine işaret etmek amacıyla eko-etiket sertifikasyonu yoluna başvurur. Pazardaki bir takım tüketicilerin ürün etiketleri hakkında bilgili olduğu ve diğer tüketicilerin olmadığı farzedilirse, bir firmanın ürünlerini sertifikalı yapıp yapmama problemini hem oyun teorisi hem de kar maksimizasyonu açısından fiyatlandırma modelleri yoluyla inceledik. Bir üretici ve birden çok tüketici arasındaki oyunda, denge çözümünü üreticinin bölümlendirme stratejisi izlemesi olarak bulduk. Ayrıca optimum üretim politikalarını talep açısından bulduk ve sertifikasyon kararını ilgili bir takım parametreler açısından analiz ettik. Sertifikasyon tercihinin düşük fiyat duyarlılığı olan pazarlarda, bilgili tüketici pazar büyüklüğünün yeterli büyüklükte olduğunda, ve sertifikasyon maliyetinin üretim maliyetine oranının çok büyük olmadığı durumlarda daha üstün olduğunu gördük.

Anahtar Kelimeler: *Yeşile Boyama, Kurumsal Sosyal Sorumluluk, Sürdürülebilir Kalkınma.*
JEL Sınıflaması: *M21, M31, M14*

I. INTRODUCTION

More than ever before, consumers seek "green" products for their families and their planet. They want goods and services that are more sustainable and more specifically environmentally friendly. A study by the U.S. Environmental

Protection Agency (EPA) shows that the environmental aspects of a product are becoming more valuable to consumers (EPA, 1994:6). Imkamp (2000: 194) replicated a study done in 1989 on the preference of environmental friendly products where one of the questions sought consumers' preferences for quality versus ecological labels and found that preferences for eco-labels had risen from 19% in 1989 to 46% in 1998. Correspondingly, many firms meet that consumer demand by offering environmentally friendly products. Based on recent studies by TerraChoice, an environmental marketing agency, the total number of environmentally friendly products has increased by an average of 79% in both 2007 and 2008 (TerraChoice, 2009) and 73% since 2009 (TerraChoice, 2010:5). However, as van Doorn and Verhoef (2011:170) find, consumers are not always willing to pay more, for example, for products such as organic foods. Their results indicate that for vice goods, the perception of lower quality decreases consumers' willingness to pay.

Although the number of firms that are entering the green market is increasing, there are still other firms that only operate in the traditional, non-environmental friendly products market. Therefore, the first decision of a firm is whether to enter the green market or not. In this paper, however, we do not study the decision of whether to enter this market or not. Instead, we study the firms that have already decided to enter the green market and their next decision of whether to adopt environmental standards to produce environmental products as they are supposed to be produced, or else to "greenwash," meaning to claim that their products are environmentally friendly while actually they may not be.

The environmental aspect of a product makes it as a credence good (Darby and Karni, 1973:70), which means that consumers cannot verify the quality of the product even after consumption. This situation creates information asymmetry between the producer and the consumer, where the producer has more or better information than the consumer. Information asymmetry generates strong incentives for opportunistic producer behavior. For example, the producer might offer products with inaccurate, incomplete, or ambiguous labels, a practice that is commonly referred to as "greenwashing" (Beder, 1997:16, Laufer, 2003:258, Sullivan, 2009:4). In these situations, however, consumers' trust towards the firm may be weakened, resulting in negative attitudes toward the brand and lower purchase intentions (Newell, Goldsmith and Banzhaf, 1998:52). This damage, and compromised firm reputation, can reduce its market value (Fombrun, 1996:9). To combat such undesirable reputation effects, some firms that have followed the required processes for producing environmentally friendly products, have turned to a credible way to inform consumers of their green products in order to differentiate themselves from the firms that have not followed the required processes, and simply greenwash. The credible way is obtaining certified "eco-labels" which are indicators of overall high environmental quality of a product (Scammon and Mayer, 1993:340). By having the certification, firms will be able to ensure their consumers that they have taken the proper initiatives to produce environmentally friendly products. The idea, in part, is to avoid being associated

with greenwashing and its unfavorable consequences by adopting costly certification systems in order to credibly signal the environmental quality of their products as verified by an independent third party organization.

However, some other firms make environmental claims on their products without any third party certification. This is to avoid the additional production cost of complying with the certification criteria as well as the actual certification processing fees. It is essential to note that, whenever we mention certification cost in this paper, we refer not only to the certification fee, but also to the cost of complying with the environmental criteria. Although the main decision that this paper focuses on is whether to certify or not, the decision of whether to adopt environmentally friendly practices is also embedded in this decision. Since the cost of adopting environmental standards to production is generally much higher than the cost of certification itself, firms that already conform to the desired standards will most likely seek third party certification. In other words, if any firm has already adopted required specific environmental standards to produce environmental products, they would not make general claims which may, in turn, create a greenwashing image.

We need to point out that while we do not condone greenwashing practices, such strategies are generally legal and are certainly widespread. In the United States and Europe, for example, a trip to any supermarket will turn up products that are labeled "natural" but are not organically produced. Companies that emphasize profits over all else will continue to adopt such practices, which of course are not limited to food production but do occur across the spectrum of consumer products, including even pharmaceutical products. A much more comprehensive study of these ethical issues was undertaken by Bowen (1953).

Greenwashing, while frequently examined in terms of policy making, is an understudied area in the organization literature. In this paper we will study this phenomenon from a firm strategy point of view. The certification decision can be a dilemma for firms. On one hand, producers face a cost premium both in following sustainable practices and obtaining certification; on the other hand, failing to certify may carry with it the loss of reputation and associated loss of customers. In studying this problem, the contribution of this paper is twofold. After the literature review in Section 2, in Section 3 we first model the producer's decision process as a game of incomplete information between the producer and its customers and determine the conditions that make certification more advantageous from the firm's perspective. In the initial model, we find that if a sufficiently high proportion of consumers are informed, then the producer should certify its product. We proceed to introduce a price signal into the model, which provides a separating equilibrium, in which both certified and greenwashed goods are produced, and consumers are differentiated according to their preferences.

In Section 4 we address the firm's decision within a profit maximizing model, thus studying the impact of the certification decision on the firm's profitability as a function of several parameters. Our primary findings are that the price sensitivity of the market has a huge impact on the certification decision. In

particular, in highly price sensitive markets, the informed customers' market size/the uninformed customers' market size ratio should be larger than (0.7) in order for certification to become more profitable than greenwashing, as compared to low price sensitive markets (where the ratio was 0.3). In the low price sensitive markets, if the informed customers' market size is below 30% of the uninformed customers' market size, then regardless of certification cost and alpha, the percentage of informed customers lost in the event of greenwashing, greenwashing always dominates certification. When the informed customers' market size is between 30% and 50% of the uninformed customers, the decision depends both on the cost of certification/cost of production ratio and alpha. As expected, a relative increase in certification cost makes the certification option less desirable. After 50%, whether certification is the more profitable option depends only on alpha. Whereas, in the high price sensitive markets, when the informed customers' market size is below 70% of the uninformed customers' market size, then regardless of certification cost and alpha, greenwashing always dominates certification. Between 70% and 100%, whether certification is more profitable depends on both the cost of certification/cost of production ratio and alpha. In the low price sensitivity case, quite high levels of certification cost can be borne; however, in the high price sensitivity case, beyond the point where certification cost equals 30% of the production cost, certification is no longer more profitable and thus greenwashing becomes the better strategy. In other words, given the same market size ratio, if demand is relatively elastic, certification dominates when certification cost is less than 30% of the production cost. In Section 5 we provide some directions for future work in this area.

II. LITERATURE REVIEW

A. Characteristics of Green Consumers

Traditional economic theory assumes that people are only willing to pay for private goods from which they obtain a direct benefit. However, as is well-known, people spend their money on intangible goods such as charity; they also devote much of their limited time on activities with little measurable personal return, like recycling.

Green consumers are found to be opinion leaders as well as careful shoppers. They are skeptical of eco-friendly product advertising (Shrum *et al*., 1995:75). That means they actively seek information on products before making purchase decisions and are sensitive to misleading information such as greenwashing. For example, in an *Advertising Age Poll*, most of the respondents stated that they found that environmental claims are not very believable (Chase and Smith, 1992:35). Moreover, Shrum *et al*. (1995:76) state that there is lack of loyalty among green consumers and they are active information searchers. This implies that a green consumer can easily stop buying a brand and switch to another one when they feel they are deceived. Moreover, research indicates that consumers respond negatively when companies do not act responsibly (Trudel and Cotte, 2008:3). In such cases a backlash is likely to occur, leading to current, and potentially future, customer loss.

B. Greenwashing and Certification

Darby and Karni (1973:71) added a new class, credence goods, to Nelson's (1970) classification of ordinary, search, and experience goods. Examples of this would be many types of services, and kosher foods. Likewise, goods with an environmentally friendly claim (e.g., organic foods) are also credence goods, since the attribute is not evident for the consumers during their purchase or after consumption (which creates an information asymmetry between the producer and consumers).

As proposed by Spence (1973:358), in situations with asymmetric information, one of the parties may send a signal that conveys relevant information to the other party. Accordingly, the other party interprets the signal and adjusts his/her behavior. In our setting, this signal is an eco-label attached to the product, which provides information about its credence attributes (Howard and Allen, 2006:442). In the absence of other information, eco-labeling can be credible or not; to solve this informational asymmetry, however, third-party agencies have stepped in. Such governmental or private agencies (or international organizations), for a fee, monitor the production process and determine if the producer has indeed adhered to standards. If so, they bestow their own label (e.g., "USDA organic", the "EU Ecolabel"), thus certifying the product. However, if the eco-label is not verified by a third party organization, then it becomes just a cheap talk. Thus, the presence of certified eco-labels reduces information asymmetry between a producer and consumers by signaling credible information about the environmental quality of the product and to indicate that the product is superior in this regard to an unlabeled similar product (Crespi and Marette, 2005:96).

In the absence of certification, the fraud that may be caused by uncertified eco-labeling is called *greenwashing*. The term "greenwashing" dates to 1986 and is attributed to biologist and environmentalist Jay Westerveld (Sullivan, 2009:4). According to TerraChoice, it is "the act of misleading consumers regarding the environmental practices of a company or the environmental benefits of a product or service" (TerraChoice, 2009:5). According to their 2010 report there are may be different causes or "sins" of greenwashing such as irrelevance, vagueness, false, fake label (TerraChoice, 2010:5). For example, in the case of irrelevance, an environmental claim may be truthful but is unimportant or unhelpful for consumers seeking environmentally preferable products. In particular, a producer claim that it is environmentally friendly because it is 'CFC-free' is greenwashing, since CFCs are banned by law so its products are not providing extra benefit compares to all other products. On the other hand, one of the most important aspects of environmentally friendly products is adopted "cradle-to-grave" approach which means minimizing the impact on environment in every stage of the process. Under this approach, it addresses a range of questions from where the raw materials going into products come from to what happens to products post-use. Therefore, production of environmentally friendly products requires a detailed understanding of the socio-environmental impacts of the entire supplier

system. In some other cases, a claim suggesting that a product is environmentally friendly based on a narrow set of attributes without attention to other important environmental issues may be an example of greenwashing. Paper, for example, is not necessarily environmentally-preferable just because it comes from a sustainably-harvested forest. Other important environmental issues in the paper-making process, such as greenhouse gas emissions, or chlorine use in bleaching may be equally important.

Studies in this stream of literature usually focus on policy development and implementation and conclude that third-party certification is a necessary condition for the green market (Laufer, 2003:258, McKluskey, 2000:4, Ramus and Montie, 2005:383). Although greenwashing is not yet very well-studied in the marketing and organization literature, it is prevalent in the marketplace. In the US and Canada, TerraChoice found that of the 2,219 North American non-food products surveyed, over 98% committed greenwashing (TerraChoice, 2010:6).[1]

There are detrimental consequences of greenwashing both for consumers and the firm. First, consumers who are sensitive about the environment are deceived and their trust is misplaced, since they are misled into purchases that do not hold their environmental commitment. Moreover, companies that take advantage of consumers' environmental concerns to increase sales are usually exposed to negative customer reactions when it becomes apparent. For example, Procter and Gamble has been criticized for making misleading environmental claims on paper towels (Cairncross, 1992:12). Eventually, such behavior may create an unfavorable reputation of the company, resulting in lost customers (Newell *et al*., 2001:52).

In the model that we develop, while we rely on third party certification to eliminate some of the informational asymmetry, some uncertainty remains in two respects. We assume that producers using uncertified labels (i.e. "natural", "earth-friendly") are most likely greenwashing because the uncertified label may be either fake or too broad so that does not have a meaning. Regarding the consumers, we partition them into two categories, "informed" and "uninformed." Informed consumers know exactly what the certified labeling means and they are mostly familiar with the certified labels and logos so that they can differentiate them with the uncertified ones easily, while uninformed consumers do not. Therefore, in the greenwashing case, while uninformed consumers are fooled by the uncertified claims made by the producer, in fact they do not get real benefit from buying green products as it is supposed to provide. As for the producer, when they distribute the product, they do not know whether a particular consumer is informed. It is very reasonable to assume a producer has consumers from both types.

In this study, we model the dilemma that firms face in the decision to become certified using both a game theoretic approach and a market demand

[1] This statistic is surprising; even if it can be challenged, it illustrates that greenwashing is very pervasive.

approach. There are many factors that affect that decision, such as the size of the informed and uninformed consumer markets, price sensitivity of the consumers, production cost and certification process cost. In the next two sections, we will model these factors and their effects on firm's profitability and resolution of the certification dilemma.

III. THE CERTIFICATION PROBLEM AS AN EXTENSIVE FORM GAME

A. The Structure of the Game

To model the decision process, we assume that there is a single producer that will choose between two actions: to certify or not to certify. Again, certification means that the producer not only has employed environmentally sound or sustainable practices, but has also paid a fee for an independent agency to monitor their practices and deem them acceptable. For a producer that does not certify, we assume that they engage in ordinary, non-sustainable practices, but employs greenwashing, i.e., uses some sort of unofficial labeling to make their product more competitive in the market.

We assume for now that there is a single consumer in the market. There are two possible *types* of consumer: one is called *informed*, meaning that they understand that a certified product has undergone rigorous environmental production while an unofficially labeled product has not; the other type is called *uninformed*, meaning that they do not understand (or recognize the difference) between the two different labels. Equivalently for our analysis, the uninformed type can also represent a consumer who understands the difference between the labels but does not care whether the product has been produced sustainably or not, provided that the product still appears to be "natural." Either type of player has two actions: to purchase or not.

This decision setting can be modeled as a game of *incomplete information* (Fudenberg and Tirole, 1991: 12) because the producer does not know what type of player the consumer is. To model this type of game, we will follow Harsanyi (1967:163) and Kreps and Wilson (1982:870) by transforming it into a game of *imperfect* information where a randomization on the part of "nature" provides either an informed or uninformed consumer. First, we assume that the selling price in the market is the same, regardless of whether the product is certified or not, and further, we assume that the uninformed consumer is indifferent to the purchase of a certified or uncertified product.

We need to make a number of assumptions, which are listed below.

Let p = probability that the consumer is informed ($0 \le p \le 1$)

c = cost to produce and certify a sustainable product

m = cost to produce an uncertified product

r = selling price

b_i = benefit to informed consumer when purchasing a certified product

b_u = benefit to uninformed consumer when purchasing either product

$-d$ = disutility to informed consumer if purchasing an uncertified product.

We further assume that b_i, $b_u > 0$; $c > m$ (i.e., the cost to produce and certify the certified product exceeds the cost to produce and label the uncertified product); $r > c$; and that $d > 0$ (the payoff in the game will be written as $-d$).

In Figure 1 below we represent the game, which we call the *certification game*, in extensive form.

(Figure 1 about here.)

In Figure 1, there are two possible actions by the consumer: to buy or not to buy. Also note that two of the consumer action nodes are shaded; this is to denote they are in the same information set, i.e., that these two positions in the game are indistinguishable to that player. However, this point is of no consequence in the game, since the uninformed consumer will always buy.

The structure of the certification game is similar to the credence good and monitoring games in McCluskey (2000:4) but there are important differences. In our model, a monitoring system is an integral part of the certification action, whereas McCluskey's monitoring model treats the monitoring process as one that will occur a (random) percentage of the time. Furthermore, in our model, the costs to produce are incurred by the producer whether the consumer buys or not, while in McCluskey's models the producer incurs a production cost when the product is purchased but does not incur this cost when the product is not purchased. The presence of these costs makes a significant difference in the analysis.

First notice that when the producer certifies the product, the subgame perfect equilibrium is (certify, purchase) regardless of the type of consumer; since $b_u > 0$, uninformed consumers always buy, and since $b_i > 0$, informed consumers buy if the product is certified. If the producer does not certify, uninformed consumers still buy, but since $0 > -d$, informed consumers do not. We then observe that for the producer, the maximin, or baseline, strategy in general is to always certify: here, both types of consumer will purchase the product, and the expected value to the producer is $(r - c)$.

B. Analysis

To analyze further, we treat the imperfect information aspect where the consumer is informed with probability p and uninformed with probability $(1 - p)$. In this model, the expected value for the producer to certify its product is

$$E[\text{certify}] = p(r - c) + (1 - p)(r - c) = (r - c),$$

while the expected value not to certify the product is

$$E[\text{do not certify}] = p(-m) + (1 - p)(r - m).$$

The value of p that equilibrates these two expectations is given when

$$r - c = p(-m) + (1 - p)(r - m)$$

$$\Rightarrow \quad p = \frac{c-m}{r} . \qquad (1)$$

Result (1) implies that if $p \geq \frac{c-m}{r}$, then the producer should certify; otherwise, the producer should not certify. (Note that $0 < \frac{c-m}{r} \leq 1$.) As contrasted to a repeated game model, or a market strategy game with many players, we will refer to the present, single-play certification game as a *one-shot* game. In this one-shot game, when p is uniformly distributed on [0,1], the expected value to the producer is

$$E[\text{one-shot}] = \int_{p=0}^{p=\frac{c-m}{r}} [(1-p)(r-m)+p(-m)]dp + \int_{p=\frac{c-m}{r}}^{p=1}(r-c)dp$$

$$= \int_0^{\frac{c-m}{r}}(r-m)dp - \int_0^{\frac{c-m}{r}} rp\,dp + \int_{\frac{c-m}{r}}^{1}(r-c)dp$$

$$\Rightarrow E[\text{one-shot}] = (r-c)\left(1-\frac{c-m}{r}\right) + (r-m)\left(\frac{c-m}{r}\right) - \left(\quad\right)^2 \qquad (2)$$

Now, compare E[one-shot] to the baseline (maximin) outcome (r – c): we claim

$$E[\text{one-shot}] = (r-c)\left(1-\frac{c-m}{r}\right) + (r-m)\left(\frac{c-m}{r}\right) - \left(\quad\right)^2 > (r-c)$$

$$\Leftrightarrow \quad (r-m)\left(\frac{c-m}{r}\right) - \left(\quad\right)^2 > (r-c) - (r-c)\left(1-\frac{c-m}{r}\right)$$

$$\Leftrightarrow \quad (r-m) - \left(\quad\right) > (r-c)$$

$$\Leftrightarrow \quad r - \quad c - \quad m > (r-c), \text{ (which is true since } c > m),$$

and shows that the one-shot mixed strategy dominates the baseline strategy to always certify.

However, since the producer ultimately produces its products for a market, it is natural to consider the producer/consumer interaction as a repeated game. However, doing so does nothing to change the situation. In repeated one-shot games with the same structure, the producer will follow the same equilibrium strategy and the consumers will not deviate from their actions either. Of course, in actual repeated play, the producer would develop an estimate $\hat{p}$ for p, through observing the history of the process or from other analysis and input.

However, in actuality, producers and consumers do not play such sequences of one-shot games. Rather, producers manufacture a lot size of items, delivered all at once, and consumers are present in large numbers. We determine whether it makes sense for the producer, faced with the type of market we describe, to pursue a segmentation strategy in order to better match supply with demand.

C. Playing the Market versus One-Shot Games

Instead of a serially repeated game with n plays, we consider a production situation where the producer "plays" the game simultaneously with n>1 independent consumers. Each consumer purchases one item. Instead of a probability p that a consumer is informed, we now have an expected number np of informed consumers, and similarly an expected number n (1 – p) of uninformed consumers. As is the case for the one-shot game, a producer in this situation would face the problem of how to generate an estimate $\hat{p}$ for p, but for now we will assume that the producer knows the true proportion p of informed consumers. In the literature the expected value derived from knowing the consumers' types, minus the expected value without this information, is known as the *expected value of perfect information* (Hirshleifer, 1971:565).

First we assume that each informed consumer will purchase a certified product, while each uninformed consumer will purchase an uncertified product. When c > m, the segmentation strategy that is perfectly adapted to the market is to produce np certified products and n (1 – p) uncertified products. Let $0 \leq p \leq 1$. The expected value to the producer under this market strategy is

$$E[\text{market strategy} \mid p] = [np(r-c) + n(1-p)(r-m)] = (r-m) - p(c-m) \quad (3)$$

Now let $f_P(p)$ be a density function for p. From (3) we obtain the following:

$$E[\text{market strategy}] = \int_{p=0}^{p=1} [(r-m) - p(c-m)]\, f_P(p)dp \,. \quad (4)$$

If, for example, we assume that p is uniformly distributed over [0,1], then (4) becomes

$$E[\text{market strategy}] = \int_{p=0}^{p=1} [(r-m) - p(c-m)]\, dp$$

$$= \int_0^1 (r-m)dp + (c-m)\int_0^1 p\, dp$$

$$= (r - m) - \qquad (c - m) . \qquad (5)$$

In deriving (5), we assumed that the producer knows the true value of p, and therefore, (5) is the expected value with perfect information. The market segmentation strategy indeed yields a higher return than the one-shot strategy (for this particular distribution), as shown in (6) below.

$$(r - c)\left(1 - \frac{c - m}{r}\right) + (r - m)\left(\frac{c - m}{r}\right) - \qquad)^2 < (r - m) -$$

$$(c - m) . \qquad (6)$$

Confirmation of (6) is done in the Appendix.

Note that quantity (5) – (2) is the expected value of perfect information, i.e., the additional benefit a decision maker would obtain if they knew every consumer's type.

There is a problem with implementing this approach, however, which is that uninformed consumers may purchase certified products. This would reduce the producer's profit, since there would remain informed consumers in a market with no more certified products to purchase. One way to overcome this problem is to provide a price signal where the certified products sell at price $r_1 > r_2$, while uncertified products sell at price $r_2 = r$. For $0 \leq p \leq 1$, the expected value to the producer in this price-differentiated case is equal to $p(r_1 - c) + (1 - p)(r_2 - m)$; it is easy to check that this expected value exceeds the expected value for the market strategy in (3).

To implement the market strategy as described, the producer would have to

(1.) Develop a product line (i.e., produce both certified and uncertified products); and

(2.) Differentiate the two products with a price signal that will sort the two types of consumers accordingly.

As long as $(r_1 - r_2) < b_i$, i.e., the premium that informed consumers would pay for the certified good does not eliminate the benefit they derive from the purchase, informed consumers will all purchase the certified good, uninformed consumers will all purchase the uncertified product (because $r_2 < r_1$), and the market segmentation strategy will have achieved a *separating equilibrium* in which the consumers are sorted perfectly, according to their preferences. It is possible that a company that already produces products in a sustainable fashion

may be reluctant to alienate loyal customers by introducing a greenwashed product. One suggestion that might ease implementation is to develop the greenwashed product under a different brand name.

Thus far, we have considered the producer/consumer interaction as a game in which the product, regardless of quality, is offered either at a single price, or, in the market segmentation case, with a price signal. In these instances we have prescribed the producer's actions as a function of the proportion of informed consumers that exist in the market. In Section 4 below we will treat the certification problem from a pricing point of view.

IV. THE DEMAND MODEL FOR THE CERTIFICATION PROBLEM

A. Demand Characteristics

Now we treat the certification problem using a demand model. First, as in Section 3, we will partition the consumer population into two categories: informed and uninformed, with the same characteristics as before. We need to make some further assumptions with respect to demand characteristics, market share and percentage of customer loss.

We assume demand to be linear and downward sloping. The downward sloping characteristic implies that as the price increases, the quantity demanded decreases. We assume that demand is a function of market size and sensitivity to price. Price sensitivity is the change in the quantity demanded in response to a unit change in price. In other words, it is the importance that customers place on price, relative to other dimensions of the product such as brand name, functionality, ease of use etc. in their purchase decisions. In our model, demand is linear in the form of:

$$Q(P_X) = a - bP_X$$

where a captures the size of the market; b captures the sensitivity to price; and P_X is the market price, where the subscript X will take on the symbol C when the product is certified and N when not certified..

Since the producer has two types of consumers, it faces two different demand functions. This difference stems from the variation in the size of the market and the sensitivity to price between consumer types. Informed and uninformed consumer types comprise different markets which have different sizes, a_I and a_U. Although people are increasingly more aware of the environmental quality for the products that they buy and the certified eco-labels attached to the products, we assume that most consumers in the market are still uninformed; in other words, we assume that the market size for uninformed customers is greater than or equal to that for informed customers, i.e., $a_U \geq a_I$. Moreover, the price sensitivity varies based on consumer and product type. Thus, we assume different price sensitivity parameters for the two types of consumers, informed and uninformed, b_I and b_U . Since informed customers are more knowledgeable about the environmental quality and labeling, they may give relatively more importance to environmental quality as compared to price, and

that means they are less price sensitive compared to uninformed customers, i.e., $b_U \geq b_I$. Thus, we define $Q_I(P_N)$ as the demand function for informed consumers:

$$Q_I(P_N) = a_I - b_I P_N$$

where the subscrip t *I* refers to the informed consumer type, and similarly, we define $Q_U(P_N)$ as the demand function for uninformed consumers:

$$Q_U(P_N) = a_U - b_U P_N$$

where the subscript *U* refers to the uninformed consumer type.

Parameter *α,* the *percentage of customer loss*, refers to a proportion of informed consumers that will stop buying the product due to the realization of greenwashing. As mentioned before, several studies show that consumers would actually punish firms when they realize the presence of unethical firm practices such as greenwashing. We assume the firm faces competition in the conventional (non-environmentally-friendly) products market. Therefore, in the case of greenwashing, consumers who realize greenwashing practices of a firm can switch to conventional substitutes. By definition only informed consumers have the sufficient knowledge to detect greenwashing, so they are the only group of consumers whose total demand is affected by this loss. Therefore, we assume that a percentage, *α*, of the informed consumers only, will be lost in case of greenwashing, with $0 \leq \alpha \leq 1$.

Accordingly, we define $Q_C(P_C)$ as the total demand function in the case of product certification as follows:

$$Q_C(P_C) = Q_I(P_C) + Q_U(P_C)$$

On the other hand, we define $Q_N(P_N)$ to be the total demand function when the producer chooses not to certify:

$$Q_N(P_N) = (1 - \alpha)Q_I(P_N) + Q_U(P_N) .$$

B. The Profit Maximizing Solution

Under the assumptions mentioned above, the producer wants to maximize its profits. Therefore, we develop the profit maximization problem as follows. As before, we let *m* represent the cost to produce one unit of the uncertified good (i.e., without employing any sustainable production processes), while *c, c* ≥ *m,* is the cost to produce one unit of the certified good (i.e., *c* includes the additional cost required to produce a unit of the sustainable good, as well as the certification fee). Note that both *m* and *c* are variable costs. For simplicity, we assume there are no fixed costs. We define profit for the producer as unit profit margin (price minus cost) times the quantity demanded. Then, the profit for the certification condition is:

$$\pi_C = (P_C - c)Q_C(P_C) .$$

Since $Q_C(P_C)$ as previously defined is equal to $Q_I(P_C) + Q_U(P_C)$, then

$$\pi_C = (P_C - c)(a_I - b_I P_C + a_U - b_U P_C) \quad . \tag{7}$$

We now solve the following profit maximizing problem for the certification condition:

$Max\ \pi_C$.

If we take the first derivative of π_C with respect to P_C and set it equal to 0, then we obtain the equilibrium price as

$$P_C^* = \frac{[(a]_I + a_U) + c(b_I + b_U)}{2\,(b_I + b_U)}$$

(8)

Substituting P^*_C into (7), we will obtain $\pi_C^* = \frac{[[(a]_I + a_U) - c(b_I + b_U)]^2}{4(b_I + b_U)}$ (See the Appendix for details.) Also, note that the second derivative, $-2b_I - 2b_U < 0$, so P^*_C is a local maximum.

Similarly, the profit equation for the non-certification (c = 0) condition is:

$\pi_N = (P_N - m)Q_N(P_N)$.

As described before, $Q_N(P_N) = (1 - \alpha)Q_I(P_N) + Q_U(P_N)$. Hence,

$$\pi_N = (P_N - m)\big((1 - \alpha)(a_I - b_I P_N) + a_U - b_U P_N\big).$$

(9)

As we did with the certification condition, in the non-certification condition we solve the problem max π_N and find the optimal value P^*_C. Taking the first derivative of π_N with respect to P_N and setting it equal to 0, we obtain (see the Appendix for details):

$$P_N^* = \frac{[(a]_I - \alpha a_I + a_U) + m(b_I - \alpha b_I + b_U)}{2(b_I - \alpha b_I + b_U)}.$$

(10)

Then we plug (9) into the profit equation, and find:

$$\pi_N^* = \frac{[(a_I \quad \alpha a_I \blacksquare + a_U) - m(b_I \quad \alpha b_I \mid b_U)]^2}{4(b_I - \alpha b_I + b_U)}.$$

In order for certification to become best for the firm, the following condition must be met:

$\pi_C^* > \pi_N^*$, i.e.,

(11)

V. RESULTS

In this section we describe the results of several numerical studies that were carried out to explore the relationships among the parameters employed in our model. In each study, we employed a sensitivity analysis to determine whether greenwashing or certifying is the better strategy for a given pair of conditions. The numbers in the tables are the alpha values beyond which certification becomes more profitable than greenwashing (where alpha is the

percentage of informed customers lost in the event of greenwashing). One important ratio we utilize repeatedly is the ratio of the additional cost to "upgrade" from an uncertified product to a certified product. This ratio is expressed by $\Delta c/m$, where the additional cost is represented by $\Delta c = c - m$. Here we assume that $\Delta c \leq m$ because it is reasonable to assume the actual production cost (which includes all the raw material cost or any other variable cost to produce an uncertified product) is larger than the additional cost to produce a certified product. In the explanations below, whenever we use certification cost, we mean Δc. In Table 1 below we study the relationship between the $\Delta c/m$ ratio (the ratio of certification cost to ordinary production cost) and price sensitivity.

[Table 1 about here.]

In Table 1 we assume that $\Delta c \leq m$ as before, and use a grid on this axis from 0.1 to 1.0 for the $\Delta c/m$ ratio. The variable on the horizontal axis is the price sensitivity with two categories: low ($b_U = 0.2$ and $b_I = 0.1$) and high ($b_U = 0.9$ and $b_I = 0.8$). These values were chosen in order to reflect high and low price sensitivity cases while keeping the relationship between b_I and b_U the same ($b_U > b_I$). In this analysis, the control variables are market sizes for informed (a_I) and uninformed (a_U) customers. We fixed the a_I/a_U ratio as 0.9 which means market size for informed customers is 90 % of the market size of the uninformed customers.

We found that profits for both the certification and greenwashing conditions tend to decrease in markets where customers are more price sensitive compared to markets with less price sensitivity. In the low price sensitivity case, quite high levels of certification cost (Δc) can be borne; however, in the high price sensitivity case, beyond the point where certification cost equals 30% of the production cost, certification is no longer more profitable and thus greenwashing becomes the better strategy. In other words, if demand is relatively elastic, certification is dominated, unless certification cost is less than 30% of the production cost.

We then studied the relationship between the a_I/a_U ratio and price sensitivity. The results appear in Table 2.

[Table 2 about here.]

In Table 2, we study market size effects, assuming that $a_I > 0$ and $a_I \leq a_U$, meaning there is at least one informed customer in the market and the market size for informed customers is less than or equal to the market size for uninformed customers. Therefore, we take values from 0.1 to 1 for the a_I/a_U ratio. The variable on the horizontal axis is the price sensitivity with two categories: low ($b_U = 0.2$ and $b_I = 0.1$) and high ($b_U = 0.9$ and $b_I = 0.8$). In this analysis, the control variable is the $\Delta c/m$ ratio which we fixed it at 0.1, meaning that the certification cost is 10% of the ordinary production cost.

In case of the low price sensitive markets, the point where certification starts to dominate greenwashing is when $a_I/a_U = 0.3$ (if $\alpha \geq 0.27$). That means if the informed customers' market size is above 30% of the uninformed customers' market size, then certification becomes more profitable as compared to

greenwashing, depending on the value of alpha. For larger values of the a_I/a_U ratio, smaller values of alpha will be sufficient in order for certification to become the more profitable option.

In highly price sensitive markets, the threshold where certification dominates greenwashing is $a_I/a_U = 0.7$ (if $\alpha \geq 0.89$). That means if informed customers' market size is above 70% of the uninformed customers' market size, then certification becomes more profitable as compared to greenwashing. As before, for larger values of the a_I/a_U ratio, under smaller values of alpha, certification becomes the most profitable option.

Therefore, in highly price sensitive markets, the a_I/a_U ratio should be at least 0.7 in order for certification to become more profitable than greenwashing, as compared to low price sensitive markets where it is 0.3.

Table 3 presents results for the relationship between the $\Delta c/m$ ratio and the a_I/a_U ratio, with low price sensitivity.

[Table 3 about here.]

As before, the $\Delta c/m$ ratio is measured in units from 0.1 to 1.0 on the vertical axis. The variable on the horizontal axis is the a_I/a_U ratio, which also ranges from 0.1 to 1. In this analysis, the control variable is the price sensitivity, which is fixed with $b_I = 0.1$ and $b_U = 0.2$ in the low price sensitivity setting.

If the informed customers' market size is below 30% of the uninformed customers' market size, then regardless of certification cost and alpha, greenwashing always dominates certification. When the informed customers' market size is between 30% and 50% of the uninformed customers, the decision depends both on the $\Delta c/m$ ratio and alpha. As expected, an increase in the $\Delta c/m$ ratio leads to more greenwashing, i.e., a relative increase in certification cost makes the certification option less desirable. After 50%, whether certification is the more profitable option depends only on alpha. For example, if $\Delta c = 0.5m$ and the informed customers' market is half of the uninformed customers' market, alpha needs to exceed 63% in order for certification to dominate greenwashing. Otherwise, greenwashing dominates certification.

Table 4 reports the results when we study the relationship between the $\Delta c/m$ ratio and the a_I/a_U ratio, in the high price sensitivity case.

[Table 4 about here.]

This analysis mirrors the above study in Table 3 except that now the price sensitivity is high, with $b_I = 0.8$ and $b_U = 0.9$. Consistent with the previous explanations, greenwashing generally dominates certification in highly price sensitive markets. When the informed customers' market size is below 70% of the uninformed customers' market size, then regardless of certification cost and α, greenwashing always dominates certification. Between 70% and 100%, whether certification is more profitable depends on both the $\Delta c/m$ ratio and alpha. As in the low price sensitivity case, an increase in the $\Delta c/m$ ratio has a direct relationship with greenwashing being more profitable for a particular a_I/a_U ratio. Conversely, for higher values of alpha, certification becomes more attractive; as the a_I/a_U ratio increases, certification dominates greenwashing at smaller alpha

values for a particular $\Delta c/m$ ratio. For example, when $\Delta c/m = 0.1$ and the a_I/a_U ratio is 0.7, when α exceeds 0.9, certification will dominate greenwashing. On the other hand, when the a_I/a_U ratio is 0.8, for alpha values beyond 0.47, certification dominates greenwashing. That is, for higher a_I/a_U ratios (e.g. 0.9 or 1), even if a smaller percentage of informed customers stop buying the product, certification still becomes more profitable compared to greenwashing.

VI. DISCUSSION AND CONCLUSIONS

For a firm that is considering the production and sale of eco-friendly products, certification is a critical decision. On the one hand, the firm will take on the extra costs of the certification process, but on the other hand, there is the threat of customer loss because of greenwashing. If consumers are not sensitive to greenwashing, then the firm will enjoy lower costs and higher profit margins; however, if sufficiently many consumers detect greenwashing and do not purchase the product, then it is worthwhile to proceed with the certification process. The study by Newell, Goldsmith, and Banzhaf (1998) shows that the "perception of deception" creates negative feelings among potential customers. As we detail below, our model further refines this possible backlash against greenwashing firms by quantifying the environments in which greenwashing will and will not be successful.

In this paper we have studied the certification decision through the use of two models. In treating the decision as embedded in a game between the producer and consumer, we assumed that informed consumers can detect greenwashing but that the producer does not know what type of player the consumer is. In this game of incomplete information, we provide the equilibrium solution. In this solution, if the probability that the consumer is informed is sufficiently high, then it pays for the producer to certify.

Additionally, we treated the game as one between a producer and multiple consumers, a proportion of which are informed. In this case, the best option for the producer is to pursue a segmentation strategy, whereby they produce both certified and non-certified goods. The addition of a price premium for the certified goods leads to a separating equilibrium where all consumers are able to purchase the good they want. Ultimately, the game model illustrates not only the relationship between strategy and market composition, but also provides insight into the value of information and the value-added that results from a segmentation strategy.

To complement the game model, we employed a demand model where the consumer market is again divided into those who are either informed or uninformed. In this more nuanced model, given that some known proportion of informed consumers will disdain a greenwashed, or non-certified, good, the producer aims to find the optimal price point for both certified and non-certified goods.

After determining the optimal pricing, we analyzed the sensitivity of certification as a function of several parameters; the general conclusion is that the price sensitivity of a market is key when making a certification decision. In

particular, in highly price sensitive markets, the informed customers' market size/the uninformed customers' market size ratio should be larger (0.7) in order for certification to become more profitable than greenwashing, as compared to low price sensitive markets (where the ratio was 0.3). In the low price sensitive markets, if the informed customers' market size is below 30% of the uninformed customers' market size, then regardless of certification cost and the percentage of informed customers lost in the event of greenwashing (α), greenwashing always dominates certification. When the informed customers' market size is between 30% and 50% of the uninformed customers, the decision depends both on the cost of certification/cost of production ratio and α where, a relative increase in certification cost makes the certification option less desirable. After 50%, whether certification is the more profitable option depends only on α. Whereas, in the high price sensitive markets, when the informed customers' market size is below 70% of the uninformed customers' market size, then regardless of certification cost and α, greenwashing always dominates certification. Between 70% and 100%, whether certification is more profitable depends on both the cost of certification/cost of production ratio and α. In the low price sensitivity case, quite high levels of certification cost can be borne; however, in the high price sensitivity case, beyond the point where certification cost equals 30% of the production cost, certification is no longer more profitable and thus greenwashing becomes the better strategy. While the separating equilibrium in the game model shows that the price signal can serve to sort the two different consumer groups by different purchasing behavior, our demand model allows us to further pinpoint the certification decision as a function of price sensitivity.

In this paper, we pursue an analytical approach toward the decision to pursue eco-label certification. To the best of our knowledge, the study of this environmental product decision using either a game theoretic or other economic analysis has been studied very little in the literature. McCluskey (2000) is one of the few studies but as we pointed out earlier, we believe that our model fits the managerial decision problem more closely.

While we have explored the demand model from a number of different perspectives in terms of sensitivity to its parameters, we should mention some limitations of the model. Specifically, in the demand model (as well as in the extensive form game), we divide consumers into two groups: informed and uninformed, where uninformed consumers always buy (regardless of their level of understanding about the products), while informed consumers purchase only sustainable goods. Of course, in real-world markets, there are likely additional purchasing behaviors that take place; for example, consumers might exhibit "semi-informed" behavior where they purchase some sustainable and some ordinary products, depending on their budgets and the brand appeal of the products. In addition, we made some assumptions to simplify the analysis regarding the demand characteristics, markets sizes and price sensitivities of the consumer groups which creates additional limitations to this paper. Relaxing these assumptions can be a good avenue for future research. Furthermore, for future

research, one may want to test if the parameters suggested in the model can actually explain the variation in the certification decision with empirical data. In order to test this model, one could look at the firms that operate in various product categories with different price sensitivities such as environmentally friendly milk versus environmentally friendly bathroom tissue or environmentally friendly house cleaning products. (Such decisions are not limited to business-to-consumer markets, but are found in industrial applications, such as the decision to produce and market HVAC air handling systems.) One could frame the problem as studying the likelihood of certification. With this interpretation, a logit or probit model can be used in an empirical analysis.

To sum up, environmentally friendly, or green, products are increasing in both availability and demand. As a result, more producers than ever are exploring the viability of offering such products. At the same time, the extra costs required to produce and certify environmentally friendly products, plus the fact that such goods are credence goods, incentivizes many firms to engage in greenwashing. This study gives insights about which decision parameters managers should acquaint themselves with and their impact on the certification decision. Furthermore, the results suggest specific critical points beyond which certification may become a more profitable option, given a price sensitivity of a market (low versus high). Managers can get valuable insights from our study by comparing their numbers that are specific to the market they are operating in, with the thresholds provided in this study for each parameter in order to decide whether certification would a better option for their firm.

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Appendix

(1.) Confirmation of (6):

Let $K = \frac{c - m}{r}$ and substitute into (6). We obtain

$$(r - c)(1 - K) + (r - m)K - \frac{r}{2} K^2 < (r - m) - \frac{r}{2} K$$

$$\Leftrightarrow \quad (r - c) + (c - m)K - \frac{r}{2} K^2 < (r - m) - \frac{r}{2} K$$

$$\Leftrightarrow \quad (c - m)K - \frac{r}{2} K^2 < (c - m) - \frac{r}{2} K$$

$$\Leftrightarrow \quad -\frac{r}{2} K^2 < (c - m)(1 - K) - \frac{r}{2} K$$

$\Leftrightarrow \quad \frac{r}{2} K - \frac{r}{2} K^2 < (c - m)(1 - K)$

$\Leftrightarrow \quad \frac{r}{2} K(1 - K) < (c - m)(1 - K)$

$\Leftrightarrow \quad \frac{r}{2} \left(\frac{c - m}{r}\right) < (c - m)$

$\Leftrightarrow \quad \frac{c - m}{2} < c - m.$ □

Therefore, the market segmentation strategy in Section 3 has a higher expected value than the one-shot strategy.

(2.) Deriving π^*_C for the certification condition:

Once we have obtained P^*_C, we then substitute as follows: let a = $[(a]_I + a_U)$ and b = $(b_I + b_U)$. Then

$$P_C^* = \frac{a + c\,b}{2b}.$$

Replace this in the profit function

$$\pi_C^* = (P_C^* - c)(a_I - b_I P_C^* + a_U - b_U P_C^*)$$

$$\Leftrightarrow$$

$$\pi_I C^\uparrow * = (P_I C^\uparrow * - c)(a_I I + a_I U - P_I C^\uparrow * (b_I I + b_I U)$$

$$\pi_C^* = (P_C^* - c)(a - P_C^* b)$$

$$\pi_C^* = \left(\frac{a + c\,b}{2\,b} - c\right)\left(a - \frac{a + c\,b}{2\,b} b\right)$$

$$\pi_C^* = \left(\frac{a + c\,b - 2\,cb}{2\,b}\right)\left(\frac{2a - a - c\,b}{2}\right)$$

$$\pi_C^* = \left(\frac{a - c\,b}{2\,b}\right)\left(\frac{a - c\,b}{2}\right)$$

$$\pi_C^* = \frac{(a - c\,b)^2}{4\,b}.$$

Therefore, we obtain $\pi_C^* = \frac{[[(a]_I + a_U) - c(b_I + b_U)]^2}{4(b_I + b_U)}$.

(3.) Deriving π^*_N for the non-certification condition:

$$\pi_I N^\uparrow * = (P_I N^\uparrow * - m)((1 - \alpha)(a_I I - b_I I\, P_I N^\uparrow *)) + a_I U - b_\downarrow U\, P_I N^\top *)$$

$$\Leftrightarrow$$

$$\pi_N^* = (P_N^* - m)(a_L - b_L P_N^* - \alpha a_L + \alpha b_L P_N^* + a_U - b_U P_N^*)$$

$$\pi_N^* = P_N^* a_L - P_N^{*2} b_L - P_N^* \alpha a_L + P_N^{*2} \alpha b_L + P_N^* a_U - P_N^{*2} b_U - m a_L + P_N^* m b_L + m \alpha a_L - P_N^* \alpha m b_L - m a_U + P_N^* m b_U.$$

Now take the derivative of π_N^* with respect to P_N^* and set equal to 0.

$$\frac{d\pi_N^*}{dP_N^*} = a_L - 2P_N^* b_L - \alpha a_L + 2P_N^* \alpha b_L + a_U - 2P_N^* b_U + m b_L - \alpha m b_L + m b_U = 0$$

$$2P_N^* (b_L - \alpha b_L + b_U) = [(a]_L - \alpha a_L + a_U) + m(b_L - \alpha b_L + b_U)$$

$$P_N^* = \frac{[(a]_L - \alpha a_L + a_U) + m(b_L - \alpha b_L + b_U)}{2(b_L - \alpha b_L + b_U)}.$$

Now substitute as follows: let a = $[(a]_L - \alpha a_L + a_U)$ and b = $(b_L - \alpha b_L + b_U)$. Then,

$$P_N^* = \frac{a + m\,b}{2\,b}.$$

Replace this in the profit function

$$\pi_N^* = (P_N^* - m)(a_L - b_L P_N^* - \alpha a_L + \alpha b_L P_N^* + a_U - b_U P_N^*)$$

Rearrange terms:

$$\pi_N^* = (P_N^* - m)(a_L - \alpha a_L + a_U - P_N^* (b_L - \alpha b_L + b_U))$$

$$\pi_N^* = (P_N^* - m)(a - P_N^* b)$$

$$\pi_N^* = \left(\frac{a + m\,b}{2\,b} - m\right)\left(a - \frac{a + m\,b}{2\,b} b\right)$$

$$\pi_N^* = \left(\frac{a + m\,b - 2\,m\,b}{2\,b}\right)\left(\frac{2a - a - m\,b}{2}\right)$$

$$\pi_N^* = \left(\frac{a - m\,b}{2\,b}\right)\left(\frac{a - m\,b}{2}\right)$$

$$\pi_N^* = \frac{(a - m\ b)^2}{4\ b}$$

$$\pi_N^* = \frac{[(a_I - \alpha\ a_I + a_U) - m\ (b_I - \alpha\ b_I + b_U)]^2}{4(b_I - \alpha\ b_I + b_U)}$$

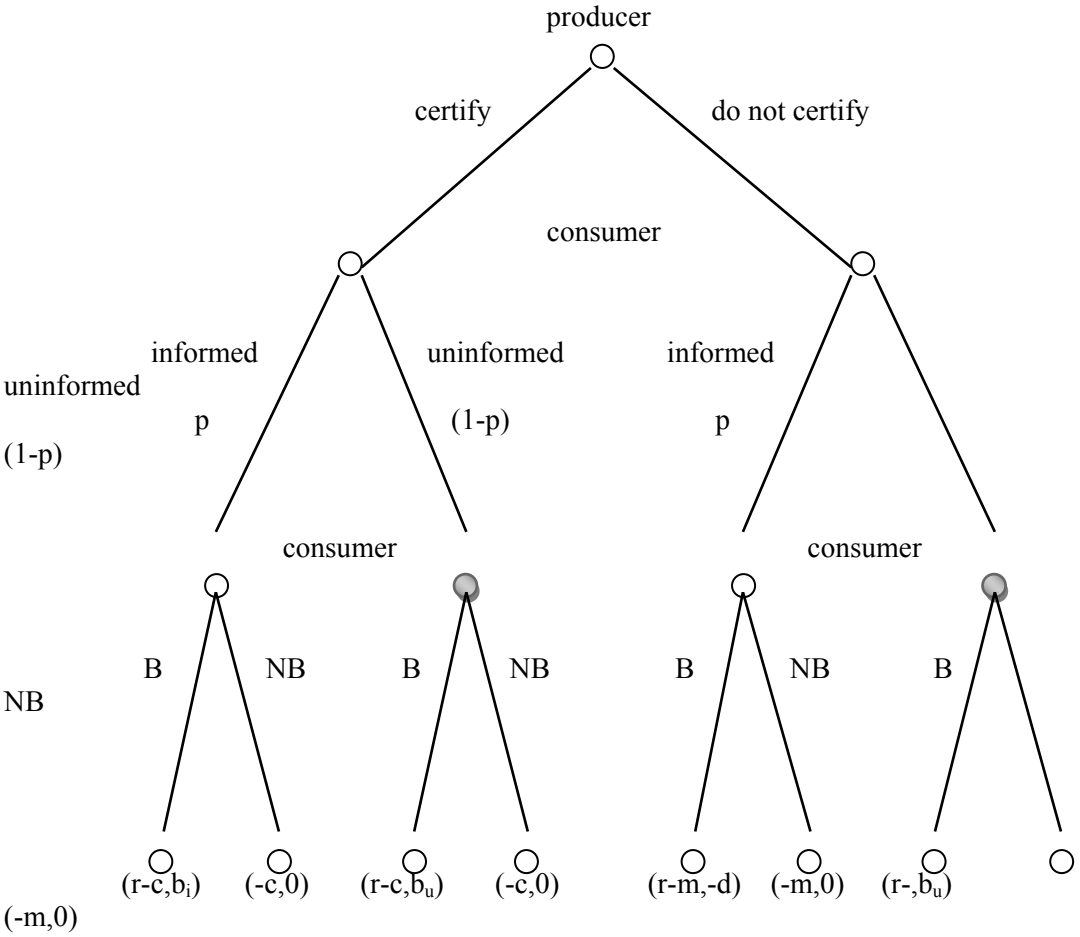

Figure 1: certification game in extensive form
B denotes buy; NB denotes do not buy.
Payoffs are given with the producer's payoff listed first.

Tables

Table 1: Sensitivity Analysis between Δc/m ratio and price sensitivity

	Price Sensitivity		
		Low (b_U=0.2, b_I=0.1)	High (b_U=0.9, b_I=0.8)
Δc/m ratio	0.1	0.03	0.33
	0.2	0.06	0.62
	0.3	0.08	0.89
	0.4	0.11	GW
	0.5	0.14	GW
	0.6	0.16	GW
	0.7	0.19	GW
	0.8	0.21	GW
	0.9	0.24	GW
	1	0.26	GW

GW denotes greenwashing. Numbers in the table show the alpha values when the two profit function intersect. Beyond these values of alpha, certification becomes more profitable than greenwashing. Δc/m ratio is the proportion of unit cost of being certified to unit production cost.

Table 2: Sensitivity Analysis between a_I/ a_U ratio and price sensitivity

	Price Sensitivity		
		Low (b_U=0.2, b_I=0.1)	High (b_U=0.9, b_I=0.8)
a_I/a_U ratio	0.1	GW	GW
	0.2	GW	GW
	0.3	0.27	GW
	0.4	0.11	GW
	0.5	0.07	GW
	0.6	0.05	GW
	0.7	0.04	0.89
	0.8	0.04	0.47
	0.9	0.03	0.33
	1	0.03	0.25

GW denotes greenwashing. Numbers in the table show the alpha values when the two profit functions intersect. Beyond these values of alpha, certification becomes more profitable than greenwashing. a_I / a_U ratio is the proportion of informed consumers' market size to uninformed consumers' market size.

Table 3 - Sensitivity Analysis between Δc/m and a_I/ a_U ratio (Low price sensitivity)

	a_I/a_U ratio									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**	**1**
0.1	GW	GW	0.27	0.11	0.07	0.05	0.04	0.04	0.03	0.03
0.2	GW	GW	GW	0.21	0.14	0.1	0.08	0.07	0.06	0.05
0.3	GW	GW	GW	0.32	0.2	0.15	0.13	0.1	0.08	0.07
0.4	GW	GW	GW	0.42	0.27	0.2	0.16	0.13	0.11	0.1
0.5	GW	GW	GW	0.52	0.33	0.24	0.19	0.16	0.14	0.12
0.6	GW	GW	GW	0.62	0.39	0.29	0.23	0.19	0.16	0.14
0.7	GW	GW	GW	0.72	0.45	0.33	0.27	0.22	0.19	0.17
0.8	GW	GW	GW	0.82	0.51	0.38	0.3	0.25	0.21	0.19
0.9	GW	GW	GW	0.92	0.57	0.42	0.34	0.28	0.24	0.21
1	GW	GW	GW	GW	0.63	0.47	0.37	0.31	0.26	0.23

Δc/m ratio

GW denotes greenwashing. Numbers in the table show the alpha values when the two profit functions intersect. Beyond these values of alpha, certification becomes more profitable than greenwashing. a_I / a_U ratio is the proportion of informed consumers' market size to uninformed consumers' market size. Δc/m ratio is the proportion of unit cost of being certified to unit production cost.

Table 4 - Sensitivity Analysis between c/m and a_I/ a_U ratio (High price sensitivity)

	a_I/a_U ratio									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**	**1**
0.1	GW	GW	GW	GW	GW	GW	0.9	0.47	0.33	0.24
0.2	GW	GW	GW	GW	GW	GW	GW	0.89	0.62	0.48
0.3	GW	GW	GW	GW	GW	GW	GW	GW	0.89	0.79
0.4	GW	GW	GW	GW	GW	GW	GW	GW	GW	0.89
0.5	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
0.6	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
0.7	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
0.8	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
0.9	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW
1	GW	GW	GW	GW	GW	GW	GW	GW	GW	GW

c/m ratio

GW denotes greenwashing. GW denotes greenwashing. Numbers in the table show the alpha values when the two profit functions intersect. Beyond these values of alpha, certification becomes more profitable than greenwashing. a_I / a_U ratio is the proportion of informed consumers' market size to uninformed consumers' market size. Δc/m ratio is the proportion of unit cost of being certified to unit production cost.