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Analysis

Ecolabeling, consumers' preferences and taxation

Ingmar Schumacher *

Banque centrale du Luxembourg, 2 boulevard Royal, L-2983, Luxembourg

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ABSTRACT

Ecolabeling is a means of reducing the information gap between consumers and producers. We study the implication of ecolabeling a supposedly green good for a consumer's allocation of income between a dirty and the supposedly green good. In the model, the role of the ecolabel is to help product differentiation, to give reliable information and to reduce informational asymmetries. We show that a conscious consumer (someone with a stronger green attitude or quality concerns) demands more ecolabeled goods; price-oriented consumers demand fewer ecolabeled goods; a subsidy (resp. tax) on the price of the ecolabeled (resp. dirty) good leads to a larger consumption of the ecolabeled (resp. dirty) good whereas it may increase or decrease the demand for the dirty (resp. ecolabeled) good, depending on whether the consumer views both goods as gross substitutes or complements. We then use a cross-individual dataset of 22,568 consumers and show that the demand for ecolabeled goods increases strongly with the consciousness of the consumer but decreases for price-oriented consumers. Ecolabel-oriented consumers feel more informed; more conscious consumers prefer a subsidy on green goods and a tax on dirty goods; price-oriented consumers do not care about the green subsidy but would vote against a tax on the dirty goods.

1. Introduction

An increasing amount of consumers is environmentally-oriented when deciding upon the products that they intend to buy. Yet, consumers searching for environmentally-friendly goods do not have an easy task ahead nowadays. Most products try to attach a somewhat green label to themselves. At a closer look, however, it often seems to be nothing more than cheap talk or a marketing strategy (see e.g. Iyer and Banerjee, 1993). Consumers thus find it difficult to understand which products are actually environmentally-friendly and they do not know where to turn in order to be able to differentiate between dirty and green products.

One means that producers have for making more substantial product information available is by obtaining an ecolabel. An ecolabel is provided by an independent third-party and certifies an environmental standard along the life-cycle of a product. The key problem is that ecolabels have vastly different quality standards and criteria. It, thus, should not come as a surprise that their reliability and informational content have repeatedly been called in question. In a recent study that analyzes ecolabels, Van Amstel et al. (2008) conclude that the "main shortcomings of the ecolabels were found in their ambiguity about environmental themes, their failure to assure the buyer about the product's ecological impact [and] the insufficient information about producers' compliance". While some ecolabels do take the whole product's life-cycle into account, other ecolabels only look at particular and selective aspects that may not capture several important product characteristics. The key question that we thus approach in this article is how ecolabel quality, measured by its means to help product differentiation, to reduce informational asymmetries as well as to provide reliable standards through the labeling procedure itself, affects the consumer's decision between dirty and ecolabeled, green products. Intimately linked to this is, of course, the fact that consumers' characteristics and economic circumstances are important aspects in the decision between ecolabeled and dirty products. We, therefore, complete our study by investigating the effect of green consumerism, income and relative prices on the demand for ecolabeled goods. This will help us to understand when and why ecolabeling helps to protect the environment, and when it is less likely to do so.

Ecolabeled products are not niche products any longer. On the supply side, the number of products that obtained ecolabels has increased during the past years. The EU ecolabel "The Flower" awarded only six licenses in 1996, an additional 128 in 2002, and a further 754 in 2008. There are now approximately 274 of these ecolabels worldwide (www.ecolabelling.org). On the demand side, based upon the recent Flash Eurobarometer 258 study we find that for approximately 50% of European citizens ecolabels play a significant role in their consumption decisions. Hence, ecolabeling is starting to show a significant impact on consumers' behavior. For example, Noblet et al. (2006) conclude that environmental attributes of ecolabeled vehicles are important for the decision to buy those vehicles; Teisl et al. (2002) show that consumers' buying habits

* Tel.: +352 4774 4560.
E-mail address: ingmar.schumacher@bcl.lu.

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respond to Dolphin-safe tuna labels; and others show similar effects in different settings (see Grankvist and Biel, 2007; Cason and Gangadharan, 2002; Arnot et al., 2006; Anderson and Hansen, 2004).

In terms of theoretical investigations, ecolabeled goods are closely related to credence goods. A credence good is a good with some ex post unobservable characteristics, like repair services or homeopathy (Darby and Karni, 1973). Since a consumer is not able to ex post verify the quality of a credence good, a producer may either signal superior quality via a higher price or by attaching a quality label to the product. Most articles that analyze the effect of quality labeling study the producer market. Dosi and Moretto (2001) use a dynamic model of investment decisions to study the firm side of ecolabeling. They investigate whether ecolabeling helps markets in stimulating environmental innovations and whether it reduces the supply of dirty products. They suggest that ecolabeling will improve the trust that consumers have in the company, which might, however, raise the demand for other less environmentally-friendly products of that firm. Amacher et al. (2004) study a duopoly model of vertical product differentiation where firms may ecolabel their products. They find that ecolabeling may increase environmental quality and reduce excessive investment. De and Nabar (1991) look at imperfect third-party certification in a competitive market, while Mason (2006) studies an asymmetric information market where firms decide under which conditions to adopt an ecolabel. Roe and Sheldon (2007) develop a model of vertical product differentiation and analyze how quality communication is achieved when labeling credence goods. Baksi and Bose (2007) study the type of producers that should label their products as well as the method of labeling (self-labeling versus third-party labeling). These articles are also somewhat related to those by Kotchen (2006) and Kotchen and Moore (2007), who analyzes public goods and the introduction of green markets.

In contrast to the existing literature we study the determinants of the demand side for ecolabeled products. We assume that consumers may allocate their income between a dirty, conventional product, and a supposedly green product. The consumer has uncertainty over the underlying characteristics of the green product. For example, many companies use cheap talk to advertise their products without actually showing the environmental advantages. We then study the role of an ecolabel attached to the supposedly green product and the effect on consumer choices. In general, we find that ecolabeling increases the welfare of the consumers; it increases the demand for the ecolabeled good and reduces that of the dirty one; a more conscious consumer (with stronger green preferences or quality considerations) will buy more ecolabeled goods; higher income leads to a larger consumption of both types of goods. We then study the effect of governmental policies. We find that a subsidy on the price of the ecolabeled good leads to a larger consumption of the latter whereas it may increase or decrease the demand for the dirty good (depending on the cross-elasticity of demand). In comparison, a tax on the price of the dirty good reduces the consumption of the dirty good and may or may not increase the demand for the ecolabeled good (depending on the cross-elasticity of demand). A policy successful in reducing pollution through either taxing dirty goods or subsidizing ecolabeled ones then depends on whether the consumer views the goods as substitutes or complements.

We then investigate these results empirically in a cross-individual dataset from the Eurobarometer Flash 258 study. Our empirical analysis confirms the results of the theoretical model and finds a particularly strong role for the conscious consumer hypothesis. We furthermore find that agents who buy ecolabeled goods also feel that they are better informed about the environmental impacts of goods in general, which confirms the projected role of ecolabeling for reducing the information gap. We also study the type of government intervention that consumers would approve of and find that the conscious consumer prefers a subsidy on the green (ecolabeled) goods but also a tax on the dirty goods. We find that price-oriented consumers do not care about a subsidy on the ecolabeled goods (since they are only buying the cheapest goods) but would disapprove of a tax on the dirty goods. Finally, we show that a higher trust in companies, which we associate with better ecolabeling, is positively related to the willingness to incur a tax on the dirty goods and a subsidy on the clean one.

The article is organized as follows. Section 2 presents a short introduction and discussion of the role of ecolabeling, Section 3 the theoretical model, and Section 4 the empirical study. Section 5 concludes.

2. The Role of Ecolabels

The purpose of an ecolabel is "...to raise consumer awareness about the environmental effects of products, to inform consumers about the environmental characteristics of a product and to promote the adoption of more environmentally sound production methods and technologies" (Lehtonen, 1997). We thus suggest to think about ecolabeling as a means of helping to differentiate between products (dirty and green), to provide reliable information and reduce informational asymmetries. We view a *better ecolabel* as one that improves upon a current ecolabel in either of the three points.

2.1. Product Differentiation

One main problem with green goods, like organic food, is that they hold every characteristic of a credence good. Consumers are thus unable to judge the greenness of a product, since they do not possess the knowledge to properly judge the quality of a credence good. Nevertheless, it is also well-known that, nowadays, consumers are willing to pay non-negligible price premia for exactly these unobservable environmental product characteristics (see e.g. Bjørner et al., 2004). Producers, therefore, use marketing strategies as a means of product differentiation to provide consumers with specific information about the environmental advantages that the "green" product is supposed to carry. However, it is obviously in the interest of a profit maximizing firm to disguise its dirty product as a green one in order to reap the price premium attached to green goods while still producing goods with the cheaper, non-ecological methods. Since more and more companies use cheap talk to differentiate their products, consumers have a hard time to truly understand the eco-friendliness of products.[1] They thus require more solid information. This is the role of ecolabeling. Ecolabeling helps consumers to become more aware of the eco-friendly characteristics of a product. The tougher the ecolabel, meaning the more criteria are included in the labeling process, the more characteristics of the ecolabeled good will be known to the consumer. Thus, ecolabeling may be interpreted as helping to differentiate between products based on objective criteria.

2.2. Reliable Labeling

The EU ecolabel "The Flower", the German "Blue Angel", or the Nordic ecolabel "Nordic Swan" certify products to have a good environmental quality and guaranteed technical performance. The more reliable the ecolabel, in other words, the more steps from production to final consumption (cradle-to-grave) are included in the labeling process, the less utility the consumer will lose in case he finds that the product turns out to have some important dirty characteristics nonetheless.

However, the quality and reliability of labeling is in dispute (see e.g. Van Amstel et al., 2008). Especially the recent substantial increase in the number of ecolabels, all with different criteria and stringencies,

[1] In 2008, the CEO of VW, Martin Winterkorn, declared that "VW is now green" due to its BlueMotion series. In effect, the average CO_2 emissions of the VWs that were sold in the five years preceding his statement increased.

makes it difficult for consumers to fully take advantage of ecolabeling as providing a meaningful standard. For discussions and analyses related to the quality and reliability of ecolabels we refer the reader to De and Nabar (1991) and Van Amstel et al. (2008). Thus, though consumers use ecolabels as an aid in differentiating between dirty and potentially green products, they might not fully believe that these ecolabels take the complete life-cycle of the product into account. Therefore, uncertainty remains with respect to potential factors that in the end may compensate (in a negative sense) for the factors that are included in the ecolabeling. Conclusively, more reliable ecolabels provide less utility loss for the consumer in case some dirty product characteristics are found nevertheless.

2.3. Reducing Informational Asymmetries

Reducing informational asymmetries is equivalent to saying that the consumer bears a lower risk of buying a product that turns out to be dirty. Producers of conventional goods will, obviously, attempt to hide potentially dirty and environmentally-harmful product characteristics. The role of ecolabels is to reduce the information gap between producers and consumers.

Ecolabeling can, by properly taking into account the characteristics and life-cycle of a product, induce consumers to attach a higher probability to the fact that the product is actually a green one. For example, a cleaning product could praise itself for being green because one has to use less detergent in order to clean the same amount of dishes as another washing liquid, whereas it may actually end up being more environmentally damaging overall since its concentration is stronger. As shown in Hamilton and Zilberman (2006), ecolabeling may reduce fraud (disguising a dirty product as being green).[2]

The design of ecolabels is crucial for how much probability consumers attach to the fact that the supposedly green product may actually be a dirty one. For an analysis of five Dutch ecolabels see Van Amstel et al. (2008). They conclude that these ecolabels are unable to reduce the information gap between consumers and producers. Thus, not all ecolabels provide the stringent criteria or minimum standards that consumers hope for. Conclusively, although ecolabeling reduces consumers' uncertainties (or change their risks, to be precise), some uncertainty is likely to remain.

3. The Model

A consumer obtains utility from a dirty product, labeled D, and a supposedly green, ecolabeled product, denoted G. His utility function $U(\cdot)$ is increasing in either product with diminishing marginal utility. We define the risk aversion parameter $\theta(x)$, which is equal to $\theta(x) = -xU_{xx}/U_x$, for $x=\{D, G\}$.[3] The role of ecolabeling is then to help the green product to distinguish itself from the dirty one, to help reduce the informational asymmetry between producers and consumers, and to provide reliable information. Nevertheless, since ecolabeling is not perfect, the consumer is uncertain as to how clean good G really is. Thus, the eco-friendliness of a product is unobservable, making the green good a credence good. This uncertainty is characterized by a probability function, where the consumer believes that with probability $q\in(0, 1)$ the product has no (hidden) dirty characteristics, while the consumer believes that with probability $1-q$ the green good holds some dirty characteristics.

We now suggest that the three roles of ecolabeling that we discussed in Section 2, namely reducing informational asymmetries, product differentiation and ecolabel reliability, can be studied within this framework as follows.

Reducing informational asymmetries implies that the consumers bear a lower risk of the supposedly green product to turn out dirty. Thus, whenever we refer to *reductions in informational asymmetries*, we mean an increase in probability q.

We use function $f(\alpha, \gamma)\geq 1$ to measure the additional utility benefit from an eco-friendly product, where $\gamma\geq 0$ denotes the expected eco-friendliness of the green product and $\alpha\geq 0$ the extent of the consumer's green attitude. Thus, γ measures the *product differentiation* due to ecolabeling. A higher γ characterizes a more eco-friendly product and summarizes the expected eco-friendly characteristics of the green product G. These attributes are those that characterize a credence good, e.g. a low amount of pesticides in organic food or the CO_2 which is set free during the product's life-cycle. We assume $f_\alpha>0$ and suggest that f increases convexly in γ. If the dirty and supposedly green goods are virtually indistinguishable then this should add little to utility, while larger differences in those products should increasingly add to utility.

The consumer attaches a probability of $1-q$ to the possibility that the product is dirtier than anticipated and in that case weighs utility by $f(\alpha, \beta\gamma)$, where $\beta\in[0, 1)$. For $\beta\to 1$, the dirty traits of the product are too few to seriously affect the consumer's welfare, whereas for $\beta=0$, the consumer gets to know some important dirty characteristics of the product that make him value the supposedly green product equivalent to the dirty one. An increasing value of β thus measures the *ecolabel reliability*.

Finally, we define a *conscious consumer* to be someone who obtains, for any level where the quantity demanded of the eco-friendly good is equal to that of the dirty good, more marginal utility of the eco-friendly good. Thus, a conscious consumer is someone who has a high value of α, where α denotes a characteristic of the consumer. This may be for two reasons. One, the consumer is more environmentally-friendly oriented, due to for instance intrinsic, moral or social norms (see Nyborg et al., 2006; Schumacher, 2009). Two, the eco-friendly product contains fewer adverse health effects on the consumer. For $\alpha=0$, the consumer is not consciously buying products according to eco-friendliness, whereas for a high α the consumer puts a substantial worth on eco-friendliness.

Our model here is useful under the assumption that consumers neither have the time nor the competence to fully understand the ecological impacts of the products that they buy. The information required to follow the complete life-cycle of a product (cradle-to-grave) is simply too time-consuming to obtain and may contain information about product ingredients or production processes which the consumer cannot relate to. Indeed, this assumption is clearly reasonable, otherwise there would not be a need to attach ecolabels to products.

A consumer's maximization problem is therefore

$$\max_{\{D,G\}} U(D) + qf(\alpha,\gamma)U(G) + (1-q)f(\alpha,\beta\gamma)U(G), \quad (1)$$

subject to $p_dD + p_gG = Y$, where $Y>0$ denotes consumer income and p_x the prices of the dirty and clean good $x=\{d, g\}$. We shall finally assume that the price for ecolabeled goods is larger than that for the dirty good. Mathematically, we therefore have $p_d<p_g$.[4] Practically speaking, a consumer will be faced with such a problem while standing in front of the organic food shelf. If he buys the more expensive organic apples, then he is uncertain as to whether these apples are as organic as advertised or whether the producer nevertheless used pesticides that reduce the difference between the

[2] However, they also show that this depends on the sensitivity of the probability to be detected to increases in monitoring efforts. We are here mainly concerned with third-party labeling.

[3] We denote the first derivative of a function $d(y)$ by d_y and the second derivative by d_{yy}.

[4] This assumption is, for example, supported by Bjørner et al. (2004). They find that Danish consumers are willing to pay a 13% to 18% price premium for ecolabeled toilet papers. A quick through the supermarket will lead to a similar conclusion.

organic and the conventional apples, in which case he might be inclined to spend more on the non-organic apples.

For simplicity we summarize the assumptions of this model again.

- The utility function is $U(x)$, for $x=\{D, G\}$, with $U_x>0$, $U_{xx}<0$. Risk aversion is given by $\theta(x)$, where $\theta(x)=-xU_{xx}/U_x$, for $x=\{D, G\}$.
- The utility weight of a green good is $f(\alpha, \gamma)\geq 1$, $f_\alpha>0$, $f_\gamma>0$, $f_{\gamma\gamma}>0$, $f(0, \gamma)=f(\alpha, 0)=1$. The weight in case it may be dirtier than expected is $f(\alpha, \beta\gamma)\geq 1$, with $\beta\in[0, 1)$.
- Income is $Y=p_dD+p_gG$, with $0<p_d<p_g$.
- A better ecolabel is one with a higher γ, β or q.

3.1. Implications

We now study the implications of ecolabeling in the simple framework introduced above. We derive several propositions that we consider important for understanding the role of ecolabeling and which we also test empirically later. The proofs of these propositions are delegated to the Appendix. All following results are partial equilibrium results and should be understood as such. The results will carry forward into general equilibrium if prices are not very responsive to changes in quantity demanded; the more competitive the production side; and if there is sufficiently little re-distribution from governmental policies.

Proposition 1. *Ecolabeling increases the welfare of the consumers.*

Firstly, by being able to precisely guide the consumer as to which products are actually environmentally-friendly, a consumer learns more about the product which increases his utility if he is a conscious buyer (modeled by increases in γ). At the same time, ecolabels help in providing reliable information for environmentally-friendly products, which gives fewer surprises in the bad state in case the agent finds out about unknown dirty characteristics of the product (modeled by increases in β). Finally, since better ecolabels generally try to take into account as much of a product's life-cycle as possible (called cradle-to-grave approach), this reduces the agents' risk of buying a supposedly eco-friendly product that later may turn out to have dirty characteristics nevertheless (modeled by increases in q).

We now study optimal consumer allocations of income between the dirty and eco-friendly product. The first-order condition of problem (1) gives

$$U_D\frac{p_g}{p_d}\geq qf(\alpha,\gamma)U_G+(1-q)f(\alpha,\beta\gamma)U_G, \tag{2}$$

with equality if $G>0$. The second-order condition is

$$\Psi\equiv U_{DD}\left(p_g/p_d\right)^2+qf(\alpha,\gamma)U_{GG}+(1-q)f(\alpha,\beta\gamma)U_{GG}<0. \tag{3}$$

Based on the second-order conditions we know that any choice of G that satisfies Eq. (2) and the budget constraint induces an optimal allocation of D and G. We re-write Eq. (2) to get

$$\frac{U_D}{qf(\alpha,\gamma)U_G+(1-q)f(\alpha,\beta\gamma)U_G}\geq\frac{p_d}{p_g}. \tag{4}$$

We can already draw several conclusions. Firstly, a consumer who is not a conscious buyer, thus $\alpha=0$, will always spend more money on the dirty good than on the eco-friendly one.[5] Furthermore, if the green good is not viewed as an essential good (meaning that U_G is bounded from above) and if furthermore the consumer is sufficiently income constrained, then there will be a corner solution with $G=0$.

[5] The proof is established as follows. For $\alpha=0$ the first-order condition at an interior solution reduces to $U_D/U_G=p_d/p_g$. Since $p_d<p_g$, this implies $U_D<U_G$. Due to decreasing marginal utility we obtain $D>G$.

Proposition 2. *Ceteris paribus, better ecolabeling increases the demand for the clean good and reduces the demand for the dirty one.*

This result is intimately linked to that in Proposition 1. Since ecolabeling is welfare increasing, better ecolabeling necessarily leads to a higher demand in the ecolabeled products. Given that the consumer spends a certain amount of income on either dirty or ecolabeled products, this implies that the consumption of dirty goods is reduced. This finding is supported in an experimental study by Cason and Gangadharan (2002). They find that cheap talk (e.g. unfounded environmental advertisement) is unable to generate efficient outcomes. Only verifiable quality claims like ecolabeling may help in solving the informational asymmetries and increase the demand for ecolabeled goods.

Proposition 3. *The more conscious the consumer the more ecolabeled goods will he buy. This also reduces his demand for the dirty good.*

The source of changes in consumer consciousness can be manifold. One would believe that most of these changes come from either social pressure, like it would be in the case of changes in moral or social norms, or from increasing health pressures of dirty goods. For example, consumers who are also members of environmental organizations are generally more willing to buy ecolabeled products (see e.g. Wessells et al., 1999). Similarly, increasing environmental pressure may induce a stronger social norm towards environmental behavior (see e.g. Schumacher, 2009). Some consumers also have a stronger moral motivation to act green simply because most people around them act green (Nyborg et al., 2006). Other authors suggest that social networks and political orientation are important drivers of green behavior (Urban, 1986; Olli et al., 2001; Ellis and Thompson, 1997). Whatever the reason behind increases in consumer consciousness, the results are the same — a higher demand for the green, ecolabeled good.

Proposition 4. *The higher the consumer's income the larger the consumption of both the clean and dirty goods. The better the ecolabeling the stronger the impact of changes in income on the dirty good, but the lower the impact of changes in consumer's income on the demand for the ecolabeled good.*

Increases in income, therefore, unambiguously increase the consumption of both goods. Thus, both goods are normal goods (see also Hirshleifer and Riley, 1992). We also notice that a better ecolabeling leads to a stronger impact of income on the demand for the dirty good, but a lower impact of income on the demand for the clean good. This suggests that improvements in ecolabeling have the least impact on the relationship between income and the demand for ecolabeled goods in rich countries, and the strongest impacts in poorer countries.

This result also implies that ecolabeling may, by itself, not be able to induce a kind of Environmental Kuznets Curve relationship (see e.g. Harbaugh et al., 2002) between pollution and income, unless increases in income also induce more and more firms to adopt ecolabeling and therefore greener production.

Proposition 5. *A subsidy on the price of good G leads to an unambiguously larger consumption of good G, whereas* $dD/dp_g<(>)0$ *if* $\theta(G)>(<)1$. *A better ecolabeling accentuates the effect of the subsidy on the ecolabeled good but diminishes (accentuates) the effect of a price change on the dirty good if* $\theta(G)<(>)1$.

A subsidy on the price of the green good G will therefore increase overall pollution through a higher demand of the green good, whereas it may either increase or reduce overall pollution through an increase or decrease in the demand for the dirty good. Which effect dominates in the large depends on the difference in the dirtiness of both goods

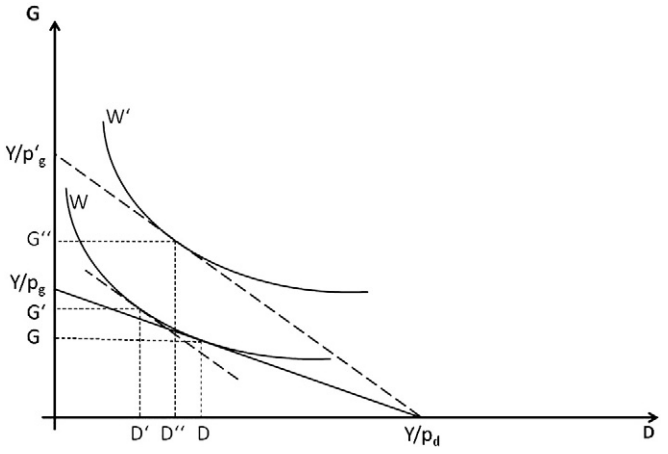

Fig. 1. A subsidy on the price of the green good.

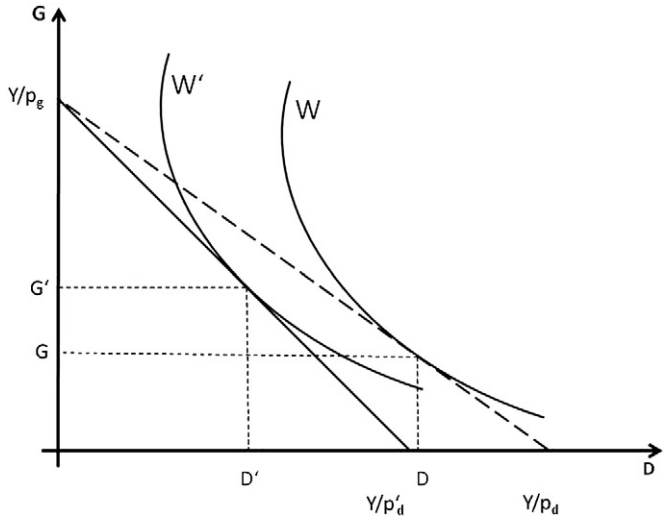

Fig. 2. A tax on the price of the dirty good.

and in the elasticity of demand when the price changes. Fig. 1 shows the case of an increase in the clean good G and a decrease in the dirty good D. We can separate the effect into the substitution and income effect. If the price of the green good decreases from p_g to p_g', then the substitution effect leads to a decrease in the consumption of the dirty good to D', and an increase in the consumption of the clean good to G'. The income effect leads to an increase in the consumption of the green good from G' to G'', and an increase in the consumption of the dirty good from D' to D''. Since we know from Proposition 4 that both goods are normal goods, meaning that their demand increases with increased income, we know that the substitution effect must outweigh the income effect in case the demand of one good declines if the relative prices change. This requires a large cross-elasticity of demand, ϵ_{i,p_j}, where $i=D$, G ($\epsilon_{i,p_j} = \frac{di}{dp_j}\frac{p_j}{i}$). The cross-elasticity of demand ϵ_{D,p_g} has the same sign as dD/dp_g under the same conditions as given in Proposition 5. In case the relative risk aversion $\theta(G)>(<)1$, then $\epsilon_{D,p_g}<(>)0$, implying that the two goods are gross complements (substitutes). If the price of the ecolabeled good decreases, then its quantity demanded increases, and if $\theta(G)>1$ then the low cross-elasticity of demand implies that both goods are complements, such that the demand for the dirty good increases, too.

Thus, a governmental policy that is supposed to reduce overall pollution through subsidizing ecolabeled products must make sure that this good is not a gross complement to a dirty good, since otherwise the demand for the dirty good would increase, too. An example of ecolabeled goods that are likely to be gross substitutes to dirty goods would be ecolabeled food.[6]

A complementary result is that a higher price of the ecolabeled good will lead to a lower consumption of the same good. Clearly, the price effect is important for the trade-off of the consumers. The conclusion that we may draw from this is that, whereas the credence good literature suggests that price increases may increase consumer's demand of a credence good since they signal a good's further hidden attributes, we find that the demand for an ecolabeled credence good may benefit from price decreases. This result is also empirically suggested in the findings by Wessells et al. (1999), who study the determinants for the demand of ecolabeled cod and salmon.

We also conclude that a better ecolabel (i.e. increases in either γ, β or q) makes the ecolabeled good less sensitive to price changes, while it makes the demand for the dirty good less (more) sensitive to changes in the price of the ecolabeled good if the two goods are gross complements (substitutes). This would explain why the demand for some ecolabeled products is insensitive to even high price premia (Bjørner et al., 2004).

Proposition 6. *A tax on the dirty good D increases (reduces) the consumption of the ecolabeled good G for a low (high) cross-elasticity of demand (i.e. if $\theta(D)<(>)1$), whereas the overall consumption of the dirty good decreases. An improved ecolabeling leads to a reduction in (an accentuation of) the price effect on G if $\theta(D)<(>)1$, whereas it increases (reduces) the price effect on the dirty good if $\theta(D)<(>)1$.*

This result is useful since it shows that a tax on the dirty good will lead to a lower environmental impact from consumption in the large. Since a higher tax on the dirty good clearly reduces the demand for the latter, there is more money available for the ecolabeled one. Fig. 2 depicts this scenario (the case under which $\theta(D)<1$). In this case both types of goods are gross substitutes — the reduction in utility from a lower consumption in the dirty good is (partly) compensated for by the increase in demand for the ecolabeled good. However, even if the consumption of the ecolabeled good is subsequently increased, the additional units of the ecolabeled good bought will be less than the amount of dirty goods forgone due to its higher price. Furthermore, since the ecolabeled good is more environmentally-friendly, the overall pollution is reduced.

In terms of short-term environmental policy, a tax on dirty goods is therefore clearly preferred to a subsidy on the ecolabeled good, especially under significant uncertainty over the cross elasticities (or risk aversion parameters).

4. Empirical Analysis

We now study ecolabeling and consumer choices from an empirical perspective. We would like to see whether the empirical evidence supports the points raised in the theoretical part. For this we make use of the Flash Eurobarometer 258 study conducted by The Gallup Organization in 2009 (Flash Eurobarometer 258 The Gallup Organization, 2009). This is a cross-country study of which we use a sample of 22,568 individuals that answered questions related to ecolabeling and consumer choices. The data is qualitative data, which allows us to study the determinants of ecolabeling in consumers' purchasing decisions (not actual choices). Table 2 describes the variables used in the regressions while Table 3 summarizes the variables. Our main dependent variable is *ecolabel*, where consumers state whether ecolabeling plays an important role in their purchasing decisions. We provide several hypotheses which we subsequently investigate. Since our variable is a dichotomous variable we make use

[6] This kind of policy nevertheless requires some care, since various ecolabeled goods might be at the same time substitutes for some dirty goods and complements for other dirty goods. For example, bio fuel is a gross substitute for standard diesel or petrol while cheaper (subsidized) bio fuel would imply a higher demand for cars or tourism.

Table 1
Overview of empirical results.

Hypotheses	Corresponding proposition(s)	Results
Hyp. 1: Demand for ecolabeled goods is higher for conscious consumers	Prop. 3	Being a consumer who buys ecolabeled goods increases by 50% for conscious consumers (Table 4, Regr. 3 and 4)
Hyp. 2: Demand for ecolabeled goods is lower if the relative price of ecolabeled goods is higher (and thus is price-sensitive)	Props. 5 and 6	Price-oriented consumers tend to buy fewer (with a probability decline of 7.6%) ecolabeled products (Table 4, Regr. 2 and 3)
Hyp. 3: The higher the consumer's income the more money will he spend on ecolabeled goods (and this is income-sensitive)	Prop. 4	Proxy for income is significant at 1% level with a positive coefficient (Table 4, Regr. 4)
Hyp. 4: Consumers who choose their products according to ecolabeling also feel that they are better informed		Positive correlation, significant at 1%, between *informed* and *ecolabel* (Table 5)
Hyp. 5: Conscious consumers prefer to have a subsidy on the ecolabeled good or a tax on the dirty one	Props. 5 and 6	*enviro* positive and significant at 1% (Table 6, Regr. 1 and 2)
Hyp. 6: The higher the trust in companies the more the agent wants the ecolabeled good to be subsidized	Prop. 2	*trust* is positive and significant at 1% (Table 6, Regr. 1 and 2)

of the probit model. We use robust (Huber–White) standard errors to account for potential specification errors and cluster for countries to account for country-specific effects. We always present the marginal effects, meaning the change in the probability of obtaining a one in the dependent variable (implying that the respondent views ecolabels as playing an important role for him) for a change in an independent variable.

4.1. Hypotheses

Our hypotheses are the following.

Hypothesis 1. Demand for ecolabeled goods is higher for conscious consumers.

This hypothesis is related to the findings in Proposition 3. To assess the validity of this hypothesis, we use the variable *enviro* as an explanatory variable for *ecolabel*. Variable *ecolabel* has a zero if ecolabels do not play an important role in the consumer's purchasing decisions while a one implies that they do. Variable *enviro* has a zero if a product's environmental impact is not important for the consumer, while it has a one if it is. We suggest that consumers who find a product's impact on the environment important will also tend to buy more ecolabeled goods. Similarly, a conscious consumer is one who knows that dirty goods may have adverse health effects. We use the variable *quality* as a proxy for the health and quality effects of ecolabeled goods. *Quality* has a zero if a product's quality is not important for the respondent, while it has a one if it is. Ecolabeled goods are generally assumed to be healthier (as is the case for clothing or wall paint) and tastier (for food). For example, the EU ecolabel "The Flower" states that its ecolabeled detergents exclude substances that may cause cancer or genetic damage, and that its ecolabeled wall paints use several times less Volatile Organic Compounds than non-certified products. This also suggests than one can say that an ecolabeled good bears a quality premium. To assess this we use the variable *quality*, which determines whether individuals find the quality aspect of goods important for their buying decisions. One would therefore believe that the variable *quality* is positively associated with the buying of ecolabeled goods.

Table 2
Variable description.

Variable	Description
ecolabel	Which statement characterizes you the best? (1 — ecolabeling plays an important part in my purchasing decisions; 2 — ecolabeling does not play an important part in my purchasing decisions; 3 — I never read any labels), recoded as (1 = 1), (2 and 3 = 0)
enviro	How important is the product's impact on the environment when making a decision on what to buy? (1 — not important; 4 — very important), recoded as (1 and 2 = 0) and (3 and 4 = 1)
price	How important is the price of the product when making a decision on what to buy? (1 — not important; 4 — very important), recoded as (1 and 2 = 0) and (3 and 4 = 1)
quality	How important is the quality of the product when making a decision on what to buy? (1 — not important; 4 — very important), recoded as (1 and 2 = 0), (3 and 4 = 1)
informed	How much do you know about the environmental impact of the products you buy and use? (1 — know nothing; 4 — fully aware), recoded as (4 and 3 = 1), (2 and 1 = 0)
trust	How much do you trust producers' claims about the environmental performance of their own products? (1 — not trust; 4 — trust completely); recoded as (4 and 3 = 1), (2 and 1 = 0)
Age	Corresponds to actual age of respondent
Age^2	Age*age
Sex	0 = male, 1 = female
Education	How old were you when you stopped full-time education?
City	Would you say you live in a metropolitan zone?
Town	Would you say you live in a town/urban centre?
taxeco	Should public authorities promote clean products by reducing taxes for clean products? (1 = yes, 0 = no)
taxdamage	Should public authorities promote environmentally-friendly products by increasing taxes for dirty products? (1 = yes, 0 = no)
taxno	Introducing a tax system to promote clean goods is not a good idea (1 = yes, 0 = no)

Hypothesis 2. Demand for ecolabeled goods is lower if the relative price of ecolabeled goods is higher (and thus is price-sensitive).

Proposition 5 and 6 suggest as much. We only have data on the importance of the price of goods in general. We use the variable *price*, where consumers are asked how important the price of a product is for the decision to buy something. A consumer who scores a one in variable *price* is one who perceives the price as important for his consumption decision while a consumer who scores a zero does not find it important. We suggest that a consumer who is very much price-oriented is also someone who has a lower demand for

Table 3
Summary statistics.

Variable	Mean	Std. dev.	*N*
ecolabel	0.511	0.5	22,568
enviro	0.855	0.352	22,568
price	0.894	0.308	22,568
quality	0.981	0.135	22,568
trust	0.518	0.5	22,568
Sex	0.367	0.482	22,568
Age	51.685	15.827	22,568
Age^2	2921.831	1631.46	22,568
Education	19.77	5.957	22,568
City	0.196	0.397	22,568
Town	0.445	0.497	22,568
taxeco	0.922	0.268	8696
taxdamage	0.819	0.385	3753
taxno	0.031	0.173	21,953

ecolabeled goods, since ecolabeled goods generally have a price premium.

Hypothesis 3. The higher the consumer's income the more money will he spend on ecolabeled goods (and this is income-sensitive).

This comes from Proposition 4, where we showed that a larger income will induce consumers to buy more ecolabeled goods. In the dataset we, unfortunately, do not have data on personal income. However, we have a question on the years of education. Since it is well-known that the level of education is generally correlated with personal income[7], we use the variable *education* as a proxy for income. A higher level of education should then be associated with a higher demand for ecolabeled products. Clearly, this proxy is not perfect, since one would believe that consumers with higher education might also know more about the environmental impact of products, care more about its quality or might know more about ecolabels in general. However, we believe that a significant part of this correlation should be captured by the variables *quality*, *price* or *enviro*. Nevertheless, it is likely that the coefficient on *education* overstates the impact of income on ecolabeled goods, which thus requires us to handle the results with some care.

Hypothesis 4. Consumers who choose their products according to ecolabeling also feel that they are better informed.

This hypothesis suggests that the better the ecolabeling, the more serious information the consumer will have on the products. Within the terms of our modeling approach, this suggests that ecolabeling increases γ, which described the informational content of ecolabels.

Our intention is also to investigate the kind of government intervention that is preferred by consumers. For this we look at the preferred tax policy and how this tax policy depends on the consumer's characteristics and attitudes. We formulate the following hypothesis.

Hypothesis 5. Conscious consumers prefer to have a subsidy on the ecolabeled good or a tax on the dirty one.

Obviously, a subsidy on the ecolabeled good implies that this good will be cheaper to buy. Thus, consumers will be able to afford more of it. A preference for a subsidy can be explained both through intrinsic or moral norms to improve the environment, but also through the quality effect of a reduced health hazard. If a consumer, however, prefers a tax on dirty goods, then this may only be explicable through its perceived impact on the environment. A tax on a dirty good will reduce the overall income available to the agent. This will reduce the consumption of the dirty good and may either increase or diminish the amount of ecolabeled goods that he buys. Conclusively, his only motivation for a tax on dirty goods can be explained by resorting to norms (or a public good in the utility function).

Hypothesis 6. The higher the trust in companies the more the agent wants the ecolabeled good to be subsidized.

A higher trust in companies, which can be associated with a better ecolabeling, should increase the demand for ecolabeled goods (according to Proposition 2). Consumers who have a higher demand for ecolabeled goods would also prefer to see a decrease in the price of those goods and would therefore enjoy a subsidy.

[7] Using the World Value Survey, we find a correlation between income classes and educational levels of 0.33, significant at the 1% level.

Table 4
Effects on ecolabeling.

Variables	(1)	(2)	(3)	(4)
	Ecolabel	Ecolabel	Ecolabel	Ecolabel
enviro	0.401***	0.402***	0.399***	0.389***
	(0.0127)	(0.0128)	(0.0130)	(0.0130)
price		−0.0734***	−0.0780***	−0.0763***
		(0.0106)	(0.0103)	(0.0107)
quality			0.127***	0.111***
			(0.0242)	(0.0243)
Sex				−0.0946***
				(0.00984)
Age				0.00746***
				(0.00156)
Age^2				−6.09e-05***
				(1.51e-05)
Education				0.00717***
				(0.000608)
City				0.00402
				(0.0135)
Town				0.0138*
				(0.00763)
Country dummies	Yes	Yes	Yes	Yes
Pseudo-R^2	0.0855	0.0868	0.0876	0.0992
Observations	23,138	23,138	23,138	23,138

Robust standard errors are in parentheses.
***$p<0.01$, *$p<0.1$.

4.2. Results

We present the results of the regressions in the Tables 4 to 6 in the Appendix. Table 1 provides a summary of the hypotheses, the related proposition and the empirical results.

A first result is related to Hypothesis 1. When looking at regressions 3 and 4 in Table 4 we find that both explanatory variables *enviro* and *quality* are highly significant (at the 1% level) determinants of whether consumers buy ecolabeled goods. Not surprisingly, environmental considerations bear the strongest effect upon ecolabeled goods. For a consumer who is concerned about the environmental impact of his consumption, the probability of being a consumer who buys ecolabeled goods increases by roughly 39%, compared to a consumer who does not care about his environmental impact. If the consumer is furthermore quality-oriented, because the ecolabeled goods bear lower health risks for instance, then this probability increases by another 11%. We can therefore expect that most consumers who buy ecolabeled goods buy these for environmental reasons.

Looking at regressions 2 to 4 in Table 4, we see that prices do play a significant role for consumption decisions, but not anywhere near the significance that the environment or quality plays. A price-oriented consumer, meaning someone who buys products mainly due to their relative prices, tends to buy fewer (with a probability decline of roughly 7.6%) ecolabeled products. This effect is somewhat small and suggests that, even though prices do play a role in consumption decisions, they are not able to compensate for either the environmental or the quality impact. This can be easily reconciled with the

Table 5
Ecolabeling and information.

Variables	(1)
	Informed
ecolabel	0.217***
	(0.00769)
Country dummies	Yes
Pseudo-R^2	0.0542
Observations	26,026

Robust standard errors are in parentheses.
***$p<0.01$.

Table 6
Determinants of taxation preferences.

Variables	(1)	(2)	(3)
	taxeco	*taxdamage*	*taxno*
enviro	0.0484***	0.141***	−0.0246***
	(0.00938)	(0.0214)	(0.00426)
price	0.00873	−0.0334*	−0.00135
	(0.0107)	(0.0200)	(0.00411)
quality	0.00904	0.0145	−0.00214
	(0.0246)	(0.0472)	(0.00833)
trust	0.0291***	0.0411***	−0.0110***
	(0.00521)	(0.0124)	(0.00190)
Education	0.000104	0.00224**	−0.000280*
	(0.000421)	(0.00111)	(0.000166)
Sex	−0.0151*	−0.0341**	0.00792***
	(0.00796)	(0.0169)	(0.00307)
Age	−0.000790***	−0.000705	0.000371***
	(0.000206)	(0.000479)	(8.11e-05)
City	−0.0183*	−0.0309	0.00425
	(0.01000)	(0.0220)	(0.00357)
Town	−0.00895	−0.0166	0.00268
	(0.00780)	(0.0177)	(0.00308)
Country dummies	Yes	Yes	Yes
Pseudo-R^2	0.0681	0.0876	0.0616
Observations	8814	3801	22,227

Robust standard errors are in parentheses.
***$p<0.01$, **$p<0.05$, *$p<0.1$.

fact that roughly all ecolabeled goods also have a price premium. For example, Blend and van Ravenswaay, 1999 show that the price responsiveness of demand for ecolabeled apples is low.

A consumer's income is likely to bear a significant positive effect on ecolabeled goods. Our income proxy *education* is significant at the 1% level and positively associated with the buying of ecolabeled goods. Since it is only a proxy for income, we cannot conclude anything from the size of the coefficient. However, the results do confirm Hypothesis 3 and therefore Proposition 4. Nevertheless, as suggested above, variable *education* might capture the effect of other variables, too, wherefore we must handle these results with care.

We also have some further results on control variables. Firstly, men have a highly significant probability of buying fewer ecolabeled products. The size of the marginal effect is between the price effect and the quality effect (at 9.5%). This can be for several reasons. Firstly, a large proportion of the ecolabeled products is food (see ecolabelling.org). Since still a larger proportion of women do the shopping for food (the quality of which directly affects their offspring), and since men are more likely to buy appliances (where cleaner appliances help the environment in general), a standard argument of emphatic distance could at least partly explain the significant difference between the sexes. Furthermore, while the benefits of eco-food directly impact a woman's offspring, the overall environmental impact of buying greener appliances is marginal. Other aspects generally forwarded in the literature are given in Torgler and Garcia-Valinas (2007). We also find that age has an inversely u-shaped relationship with the buying of ecolabeled goods. This could be explained by the fact that advertisement for ecolabeled goods mostly targets the middle age group (Scherlofsky, 2007). Finally, the size of the city one lives in does not bear a significant influence on whether one buys ecolabeled goods or not.[8]

Table 5 shows the relationship between ecolabeling and information. We ask whether someone who buys ecolabeled goods also feels better informed about the environmental impacts of the products. Here we find a significant positive association between ecolabeling and information, where someone who buys ecolabeled goods also feels that he is roughly 22% more likely to feel informed about the environmental impact of the products that he buys. Thus, we can conclude that one of the main targets for which ecolabeling was introduced, namely "...to inform consumers about the environmental characteristics of a product..." (Lehtonen, 1997), is achieved.[9] This result is also confirmed in Teisl et al. (2002), who suggest that the introduction of ecolabels had a positive impact on dolphin-safe tuna consumption. Similarly, Brécard et al. (2009) find that the consumer's knowledge of overfishing is positively associated with the desire to have "green" fish ecolabeled.

We now turn to assess the hypotheses related to the preferred governmental intervention. Results for these are presented in Table 6. Regression 1 looks at what variables might determine whether consumers prefer a subsidy on clean goods; regression 2 studies the variables that explain whether consumers prefer to be taxed on dirty goods; and regression 3 asks whether consumers prefer the lack of a tax system that promotes clean goods. This last regression is a robustness control for regression 1.

In regression 1 we observe that conscious consumers, especially those who consider the environmental impacts of products, prefer to see a subsidy on clean goods. At the same time, these consumers also like to see a tax on dirty goods (regression 2). This result is interesting because a subsidy on the clean (ecolabeled) good might have an adverse effect on total environmental quality (provided $\theta(G)>1$, i.e. dirty and ecolabeled goods are complements). A tax on the dirty good, on the other hand, clearly decreases overall pollution. From the governmental perspective, it is obviously always easier to implement a subsidy rather than a tax, since consumers prefer to see their real income increased rather than diminished. This is supported if we take the mean of variables *taxeco* and *taxdamage*. *taxdamage* has a mean of 0.8 compared to a mean of 0.91 for *taxeco*, where we can clearly reject the hypothesis that means are equal at the 1% level. Though the introduction of a subsidy is on average the preferred policy from the consumer's perspective, in the short run it might be a worse policy since it may increase overall pollution. A subsidy would then only really make sense if it is intended to be a long-run strategy in order "... to promote the adoption of more environmentally sound production methods and technologies." (Lehtonen, 1997)

On the one hand, consumers who buy products solely according to their relative price would not have any specific opinion on whether ecolabeled goods should be subsidized since they only buy the cheapest goods anyway. This is exactly the result found in regression 1. The variable *price* is insignificant. On the other hand, consumers who solely buy according to the relative price would prefer not to find a tax on dirty products since this would raise the price level of the products that they are used to buying. This is confirmed in regression 2, where consumers who choose goods according to their price tend to dislike price increases. In effect, this is a confirmation of the results in Arnot et al., 2006, who studied the revealed purchasing behavior with regard to relative price changes in fair trade and non-fair trade coffee. They found that consumers of fair trade coffee had fewer changes in quantity demanded from a price change than those of other coffee products.

One surprise is the insignificance of the variable *quality*. We would have believed that consumers who choose according to quality should tend to prefer some governmental intervention. In effect, we expected that quality-oriented consumers prefer a subsidy on the ecolabeled good but no policy on the dirty good. However, though this variable turns out to be insignificant in regression (2), we would have expected a significant effect in regression (1). This can be explained by the fact that quality-oriented consumers prefer a price premium as a means of signaling — they prefer a higher price than the one on the

[8] Though the variable *town* is marginally significant.

[9] Clearly, we can only speak of association here, since causality might run the other way, too. For example, our variable *education* is significantly correlated with both the variable *informed* and *ecolabel*.

dirty good in the hope that this higher price is used by the producers as a signal for a quality premium.

Hypothesis 6 suggests that consumers who hold a higher trust in companies, this being a proxy for better ecolabeling, would prefer a subsidy on the clean goods. The variable *trust* is indeed highly significant and positively associated with a preference for a subsidy on the clean good. Since consumers feel that they can trust ecolabeled products more than conventional products, they are open to advocate a subsidy on the ecolabeled products in order to promote these and to obtain these at lower relative market prices. Trust is, however, significantly positively related to a willingness to incur higher taxes on the dirty good. One way in which this could be explained is that consumers want to use higher taxes on dirty goods in order to reduce *relative* prices, which would induce companies to produce more ecolabeled, or trustworthy, products.

5. Conclusion

In this article we studied, both theoretically and empirically, the determinants of a demand for ecolabeled goods from a consumer's perspective. We found that a conscious consumer (one who has environmental preferences and quality considerations) buys significantly more ecolabeled goods and that price-oriented consumers buy significantly fewer products with an ecolabel. Conscious consumers also prefer the promotion of clean goods via a tax and subsidy system to no system at all. Price-oriented consumers do not have an opinion on the subsidy of clean goods since they only buy the cheapest good anyway, whereas they would be unwilling to support a tax on dirty goods in general.

One of the most important results in this study is that consumers generally seem to prefer a subsidy on the ecolabeled good to a tax on the dirty goods. However, as we show theoretically, this subsidy might be a worse policy since it may increase overall pollution. A subsidy would then only really make sense if it ecolabeled products are gross substitutes for dirty products or if the policy is intended to be a long-run strategy in order "...to promote the adoption of more environmentally sound production methods and technologies." (Lehtonen, 1997) Otherwise, overall pollution may increase.

There is still a variety of problems with ecolabeling. For example, if some companies fulfill the ecolabeling criteria but do not possess an ecolabel, then consumers will have a higher uncertainty and buy more dirty products. Equivalently, it could turn out, therefore, that consumers might believe that companies produce dirty products simply because their products are not ecolabeled. This would hold irrespectively of whether companies invest in green technology or not and is more likely to hold the more goods bear ecolabels. This might reduce the companies' incentives to invest in green technology in, for example, very competitive market structures with large costs of adopting green technologies. Thus, with some speculation, one would believe that, after a slower adoption period, more and more companies will turn to ecolabel their products. Given the large diversity in ecolabels that all ask for different environmental standards, this makes it difficult to assess the actual product's quality, which in turn can reduce the consumers' belief in the use of ecolabeling.

Equivalently, ecolabeling might mislead the consumer if the whole product cycle is not taken into account. A step forward would be to introduce a generic standard for ecolabels that provides consumers with a comprehensive and easily recognizable norm or benchmark.

The research here can be extended in several ways. Firstly, one should study this partial equilibrium approach in a general equilibrium perspective. This would also provide some help in assessing the long-term welfare implications of ecolabeling. One could furthermore introduce a public good approach, most likely along the lines of Kotchen (2006) work. This would help in studying the feedback from ecolabeling to environmental quality for example.

Finally, from a policy perspective, it might be useful to raise the general awareness of ecolabeling and to standardize it for easy comparison. For example, one way ahead would be to place the ecolabeling more visibly on products and enforce standardized labeling across sectors. This would help in generating a substantially larger amount of public awareness than is currently the case.

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Appendix A

Proofs

Proof 1. Proof of Proposition 1

The better the ecolabeling the higher the value of β. Since $q \in (0, 1)$ and $\beta \leq 1$, then function $qf(\alpha, \gamma)U(G) + (1-q)f(\alpha, \beta\gamma)U(G)$ is an increasing function of β. For any given choice of G and mphD it attains its maximum at $\beta = 1$. Furthermore, for any $\beta \leq 1$, D and G, function $qf(\alpha, \gamma)U(G) + (1-q)f(\alpha, \beta\gamma)U(G)$ is increasing in q. Similarly, $qf(\alpha, \gamma)U(G) + (1-q)f(\alpha, \beta\gamma)U(G)$ is increasing in γ, which implies that a higher value of γ increases indirect utility at an interior solution for G. □

Proof 2. Proof of Proposition 2

Taking the total derivative of Eq. (2) and re-writing gives

$$\frac{dG}{d\beta} = -\frac{(1-q)\gamma f_{\beta}(\alpha, \beta\gamma)}{\Psi} U_G > 0.$$

Similarly,

$$\frac{dG}{dq} = -\frac{f(\alpha, \gamma) - f(\alpha, \beta\gamma)}{\Psi} U_G > 0,$$

since $f(\alpha, \gamma) > f(\alpha, \beta\gamma)$. Finally, the effect of increases in γ is given by

$$\frac{dG}{d\gamma} = -\frac{qf_{\gamma}(\alpha, \gamma) + (1-q)\beta f_{\gamma}(\alpha, \beta\gamma)}{\Psi} U_G > 0.$$

From the budget constraint we obtain $p_g dG + p_d dD = 0$, which gives

$$\frac{dD}{dG} = -\frac{p_g}{p_d} < 0.$$

Thus, an increase in G is associated with a decrease in D. □

Proof 3. Proof of Proposition 3

Changes in consumer consciousness are represented by changes in α. Total derivative from Eq. (2) gives, with some re-writing,

$$\frac{dG}{d\alpha} = -\frac{qf_{\alpha}(\alpha, \gamma) + (1-q)f_{\alpha}(\alpha, \beta\gamma)}{\Psi} U_G > 0.$$

From the budget constraint we obtain $p_g dG + p_d dD = 0$, which gives

$$\frac{dD}{dG} = -\frac{p_g}{p_d} < 0.$$

Thus, an increase in G is associated with a decrease in D. □

Proof 4. Proof of Proposition 4

We take comparative statics with respect to G and Y in Eq. (2), which gives

$$\frac{dG}{dY} = \frac{p_g}{p_d^2}\frac{U_{DD}}{\Psi} > 0.$$

Comparative statics with respect to D and Y at budget equilibrium give

$$\frac{dD}{dY} = \frac{1}{p_d}(1-p_g\frac{dG}{dY}),$$
$$= \frac{1}{p_d}\frac{qf(\alpha,\gamma)U_{GG} + (1-q)f(\alpha,\beta\gamma)U_{GG}}{\Psi} > 0.$$

Taking total derivatives again gives

$$\frac{d^2G}{dYd\beta} = -\frac{p_g}{p_d^2}\frac{(1-q)\gamma f_\beta(\alpha,\beta\gamma)U_{GG}U_{DD}}{\Psi^2} < 0,$$

and

$$\frac{d^2D}{dYd\beta} = \frac{1}{p_d}\frac{(1-q)\gamma f_\beta(\alpha,\beta\gamma)U_{GG}(p_g/p_d)^2U_{DD}(\Psi-1)}{\Psi^2} > 0.$$

Changes in q affect dG/dY by

$$\frac{d^2G}{dYdq} = -\frac{p_g}{p_d^2}\frac{(f(\alpha,\gamma)-f(\alpha,\beta\gamma))U_{GG}U_{DD}}{\Psi^2} < 0,$$

while

$$\frac{d^2D}{dYdq} = -\frac{p_g}{p_d}\frac{d^2G}{dYdq} > 0.$$

Finally, changes in γ affect dG/dY by

$$\frac{d^2G}{dYd\gamma} = -\frac{p_g}{p_d^2}\frac{(qf_\gamma(\alpha,\gamma) + (1-q)f_\gamma(\alpha,\beta\gamma)\beta)U_{GG}U_{DD}}{\Psi^2} < 0,$$

while

$$\frac{d^2D}{dYd\gamma} = -\frac{p_g}{p_d}\frac{d^2G}{dYd\gamma} > 0.$$

□

Proof 5. Proof of Proposition 5

Take the total derivative of Eq. (2) to get

$$\frac{dG}{dp_g} = \frac{1}{p_d}\frac{u_D - p_g/p_d GU_{DD}}{\Psi} < 0.$$

The total derivative of the budget constraint is $p_d dD + p_g dG + Gdp_g = 0$, which thus leads to a demand for D given by

$$\frac{dD}{dp_g} = -\frac{p_g}{p_d}\frac{dG}{dp_g} - \frac{G}{p_d},$$
$$= -\frac{1}{p_d}\frac{qf(\alpha,\gamma)GU_{GG} + (1-q)f(\alpha,\beta\gamma)GU_{GG} + p_g/p_d U_D}{\Psi}.$$

Substituting from the first-order conditions, we obtain

$$\frac{dD}{dp_g} = -\frac{1}{p_d}\frac{qf(\alpha,\gamma) + (1-q)f(\alpha,\beta\gamma)}{\Psi}(U_G + GU_{GG}).$$

Thus, $\frac{dD}{dp_g} <(>) 0$ if $U_G + GU_{GG} <(>) 0$, which holds if $\theta(G) >(<) 1$. Taking total derivatives again gives

$$\frac{d^2G}{dp_g dq} = -\frac{1}{p_d}\frac{u_D - p_g/p_d GU_{DD}}{\Psi^2}(f(\alpha,\gamma) - f(\alpha,\beta\gamma))U_{GG} > 0,$$

and

$$\frac{d^2D}{dp_g dq} = -\frac{p_g^2}{p_d^3}\frac{f(\alpha,\gamma) - f(\alpha,\beta\gamma)}{\Psi^2}(U_G + GU_{GG})U_{DD}.$$

We find that $\frac{d^2D}{dp_g dq} <(>) 0$ if $\theta(G) >(<) 1$. The effect of changes in β on $\frac{dG}{dp_g}$ is

$$\frac{d^2G}{dp_g d\beta} = -\frac{1}{p_d}\frac{u_D - p_g/p_d GU_{DD}}{\Psi^2}(1-q)f_\beta\gamma U_{GG} > 0,$$

and

$$\frac{d^2D}{dp_g d\beta} = -\frac{p_g^2}{p_d^3}\frac{(1-q)f_\beta\gamma}{\Psi^2}(U_G + GU_{GG})U_{DD}.$$

Thus, $\frac{d^2D}{dp_g d\beta} <(>) 0$ if $\theta(G) >(<) 1$. The effect of changes in γ on $\frac{dG}{dp_g}$ is

$$\frac{d^2G}{dp_g d\gamma} = -\frac{1}{p_d}\frac{u_D - p_g/p_d GU_{DD}}{\Psi^2}(qf_\gamma(\alpha,\gamma) + (1-q)f_\gamma(\alpha,\beta\gamma)\beta)U_{GG} > 0,$$

and

$$\frac{d^2D}{dp_g d\gamma} = -\frac{p_g^2}{p_d^3}\frac{(qf_\gamma(\alpha,\gamma) + (1-q)f_\gamma(\alpha,\beta\gamma)\beta)}{\Psi^2}(U_G + GU_{GG})U_{DD}.$$

Again, $\frac{d^2D}{dp_g d\gamma} <(>) 0$ if $\theta(G) >(<) 1$. □

Proof 6. Proof of Proposition 6

Total derivative of Eq. (2), and making use of the budget constraint, gives

$$\frac{dG}{dp_d} = -\frac{p_g}{p_d^2}\frac{U_D + DU_{DD}}{\Psi},$$

which is positive (negative) if $U_D + DU_{DD} >(<) 0$, or $\theta(D) <(>) 1$. The effect of changes in p_d on D can be obtained as follows. From the budget constraint we get

$$\frac{dD}{dp_d} = -\frac{D + p_g dG/dp_d}{p_d}.$$

Substituting the solution for dG/dp_d, we find that

$$\frac{dD}{dp_d} = -\frac{1}{p_d}\frac{(qf(\alpha,\gamma) + (1-q)f(\alpha,\beta\gamma))DU_{GG} - (p_g/p_d)^2U_D}{\Psi} < 0.$$

We calculate the effect of better ecolabeling through q, γ and β. Taking the total derivative again leads to

$$\frac{d^2G}{dp_d dq} = \frac{p_g}{p_d^2}\frac{u_D + Du_{DD}}{\Omega^2}(f(\alpha,\gamma) - f(\alpha,\beta\gamma))u_{GG},$$

$$\frac{d^2G}{dp_d d\beta} = \frac{p_g}{p_d^2}\frac{u_D + Du_{DD}}{\Omega^2}(1-q)\gamma f_\beta(\alpha,\beta\gamma)u_{GG},$$

$$\frac{d^2G}{dp_d d\gamma} = \frac{p_g}{p_d^2}\frac{u_D + Du_{DD}}{\Omega^2}(qf_\gamma(\alpha,\gamma) + (1-q)\beta f_\gamma(\alpha,\beta\gamma))u_{GG}.$$

where $d^2G/dp_d dq < (>) 0$ if $\theta(D) < (>) 1$, with an equivalent result for changes in β and γ. We also obtain

$$\frac{d^2D}{dp_d dq} = -p_g^2 / p_d^3 (f(\alpha,\gamma) - f(\alpha,\beta\gamma)) U_{GG} \frac{DU_{DD} + U_D}{\Psi^2},$$

$$\frac{d^2D}{dp_d d\beta} = -p_g^2 / p_d^3 \frac{\gamma(1-q) f_\beta(\alpha,\beta\gamma)}{\Psi^2} (DU_{DD} + U_D) U_{GG},$$

$$\frac{d^2D}{dp_d d\gamma} = -p_g^2 / p_d^3 \frac{q f_\gamma(\alpha,,\gamma) + (1-q) f_\gamma(\alpha,\beta\gamma)\beta}{\Psi^2} (DU_{DD} + U_D) U_{GG}.$$

We find that $d^2D/(dp_d dq) > (<) 0$ if $\theta(D) < (>) 1$. The same result obtains for changes in β and γ. □

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