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Green consumption: The impact of trust and pessimism

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Abstract

This paper proposes a green consumption model under uncertainty, where we consider green goods as impure public goods and analyze the comparative statics of green consumption. We consider that the environmental efficacity of green goods is uncertain, and we model uncertainty with risk perceptions, specifically with trust (defined as a belief about the veracity of the available information) and pessimism/optimism (which represents the consumer's probability estimation of the realization of the worst possible outcome when consuming green goods). We study their respective impact on green consumption and consider individuals with heterogeneous beliefs. Pessimism has a negative impact on green demand; meanwhile, an increase in trust does not always imply an increase in green demand. We determine the impact of uncertainty on the equilibrium and the socially optimal level of private voluntary provision and show that green consumption decreases with pessimism at the equilibrium. Meanwhile, at the optimum, an increase in pessimism will decrease the individual's contributions, for both the pessimist and optimist consumers. Moreover, we also find that the sub-optimality of the Nash equilibrium, in presence of an impure public good, is not straightforward under uncertainty.

JEL classification: D83, D9, H41, Q5.

Keywords: Green consumption, trust, pessimism, uncertainty, impure public goods.

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1 Introduction

For the last few years, there has been an increase in environmental awareness. For example, in 2018, 16% of Europeans thought that environmental degradation and climate change were among their major concerns, compared to 2017, where they were only 12% (Eurobarometer, 2018). These concerns are partly due to the negative effects that some conventional goods may have on their production or use on health and the environment. For example, cosmetics might contain microplastics that can finish in the ocean, impacting marine wildlife. These elements have led to the emergence of a green goods market. Over 2002-2015, the importance of environmentally related products in trade increased in more than 20 countries[1]. A green good is a product (tangible or intangible) that minimizes its environmental impact (direct and indirect) during its whole life-cycle, subject to the present technological and scientific status (Sdrolia and Zarotiadis, 2019). For example, these goods may be more recyclable, consume fewer resources, or have reduced packaging. Green goods can be organic fruits and vegetables, green energy, recycled products, or green fashion: the particularity of green products is that their consumption contributes to environmental quality. Moreover, individuals are increasingly willing to pay more for an environmentally-friendly product compared to their conventional substitute. For example, only 30% of the respondents of the survey "Greening Household Behavior: The Role of Public Policy" (OECD, 2011) are unwilling to pay any premium price for organic foods.

To implement incitative public policies to achieve a socially optimal green good consumption it is necessary to understand which are the variables having an impact on environmentally-friendly consumption. Recently, there have been multiple studies about the different determinants of green consumption. Joshi and Rahman (2015) reviewed the literature on green purchase behavior, and they identified some barriers to green consumption despite a positive attitude towards green products, such as high price, lack of consumer trust, or low availability.

Different studies found that sociodemographic and socioeconomic variables are important determinants in green consumption, such as age, income, or education (Brouhle and Khanna, 2012; Brécard et al., 2009). We can consider environmental and health concerns to be the main drivers for environmental consumption (Young et al., 2010; Tsakiridou et al., 2008; Joshi and Rahman, 2019). Also, availability (Brouhle and Khanna, 2012), or perceived availability (Vermeir and Verbeke, 2008)

[1] OECD (2017), Green Growth Indicators 2017, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264268586-en

have a positive impact for eco-labeled goods consumption. Many empirical and theoretical articles focalised in social norms as having an important role in green consumption (Nyborg, Howarth and Brekke, 2006; Thøgersen, 2011; Farrow, Grolleau and Ibanez, 2017; Welsch and Kühling, 2009).

These are a few examples of the numerous determinants studied in green consumption. This paper will focus on an additional, and not yet explored, potential determinant on green consumption: the uncertainty on its impact on health and environmental quality. Some of these goods' benefits are easily identifiable, such as taste for organic products; nevertheless environmental and health benefits are more complex to observe. We consider uncertainty as influencing green consumption since there is a lack of information concerning the effect that conventional and green goods have on the environment and health. These effects are difficult to quantify, and they are only visible in the long term. Moreover, some industries take advantage and market themselves as "green" while their products are not really environmentally-friendly, worsening consumers' trust.

Hence, consumers face global uncertainty that will only be lifted in the future through sufficient scientific research. Consumers do not have the capacity to tell with confidence to which extent the consumption of green products results in environmental and health benefits. For instance, there could be a subjective trade-off between consuming an organic fruit that has travelled long distances and a conventional non-organic, grown with pesticides, local fruit. Considering every aspect of consumption and its unexpected consequences is difficult for the consumer due to the complexity (or almost impossibility) of verifying their efficacity. Information is difficult to obtain, so individuals may not have enough knowledge to realize the negative impact of their consumption choices on the environment. The existing studies about the effects on the environment are not precise enough to allow a thorough comparison of the consequences between the different available products; consequently it becomes more difficult for the consumer to make a choice. For these reasons, the objective environmental benefits of green goods are partially unknown.

Knowledge of the environment has been widely studied: higher knowledge in environmental issues positively impacts green consumption (Joshi and Rahman, 2015; Young et al., 2010; Pieniak, Aertsens and Verbeke, 2010). However, the consumer usually has not enough information about environmental issues since they are complex and require research. Therefore, individuals have to make their choices under uncertainty: they do not know exactly the consequences of consuming or not a green good. Uncertainty about the efficacity of green goods might be a significant barrier to consuming them; hence, it is necessary to consider it in green consumption models. Some articles have considered this dimension of uncertainty, such as Etner, Jeleva and Jouvet (2007, 2009) where the authors introduce uncertainty in the future environmental quality and heterogeneity in individuals' risk perceptions. In Tamai (2018), the author introduces uncertainty in the private provision of public goods using a general dynamic equilibrium model with stochastic disturbances.

The uncertainty is global, none of the agents (producers or public authorities) have enough information to determine the efficacity of green goods over the environment. The state of knowledge nowadays does not allow to estimate with certainty the green goods' efficacity. Despite this lack of information, there is still available information that all the agents possess, although it is partial. Thanks to this partial knowledge, the agents are able to determine some estimates about the efficacity and communicate them to the consumers. However, consumers do not always trust these estimates. The neo-additive capacity model (Chateauneuf, Eichberger and Grant, 2007) allows the characterization of uncertainty and represents the lack of trust in the probability estimates among the consumers given by trustful authorities, moreover, it allows the individuals to have different beliefs about the efficacity of green goods.

Our model represents preferences thanks to the neo-additive capacity model where we will characterize uncertainty through two types of beliefs: pessimism/optimism and trust. We consider pessimism as one essential barrier to green consumption. It represents the consumer's probability estimate of the realization of the worst outcome possible when consuming green goods, it can be interpreted as the impact of her consumption on the environment. Pessimists overestimate the probability of realization of worst states of nature, on the contrary, optimists overestimate the probability of realization of the best state of nature.

We now turn to trust, it represents a belief about the veracity of the available information. Some studies found that a lack of trust is an important barrier to green consumption (Tsakiridou et al., 2008; Young et al., 2010). The study by (OECD, 2014) tells us that "Some respondents believe that there may be potential environmental benefits associated with purchasing the good, they may not "trust" that these benefits will occur". This study shows that some individuals, despite that they are willing to pay a premium price for an environmentally-friendly good and their environmental concerns, they do not trust that there are environmental or health benefits: for example, 60% of Australian respondents do not think that organic fruits and vegetables have environmental and health benefits, this percentage increases to 85% for Koreans. Furthermore, the level of trust that the respondents of the OECD (2014) survey have in scientific experts is a determinant in believing that climate change is caused by human activity. The study also shows that the source of information about the products' environmental impacts is also important. There is globally a low level of trust in information given by the government about the environmental effect of goods. For example, in France, only 30% of the respondents trust the government concerning the environment, meanwhile they are 75% to trust researchers, scientists, and experts.

In the literature on green consumption, green goods are considered as impure public goods (Kotchen, 2005; Wichman, 2016). The impure public goods model was first introduced by Cornes and Sandler (1984, 1994), where the authors developed the standard model: consumers acquire utility from the characteristics of the goods. An impure public good is a good that generates utility to the consumer through the joint production of a private characteristic and a public characteristic. Indeed, green products produce a private characteristic (for example, nutrition for organic fruits and vegetables) and an environmental (public) characteristic.

Coupling the public good with private benefits has the advantage that it mitigates under-provision of the public good (Cornes and Sandler, 1984). Impure public goods, therefore, act as an incentive for increasing private provision of the public good. Impure public goods as a bundle of public and private characteristics suggest that people should be at least as altruistic as when impure alternatives are not available (Cornes and Sandler, 1984, 1994; Kotchen, 2006).

However, Engelmann, Munro and Valente (2017) found that impure public goods may hamper contributions because it is a cheap way to buy positive self-image. Mazar and Zhong (2010) show that exposure to green products can have a positive societal effect by inducing pro-social and ethical acts, nevertheless, purchasing green products may license indulgence in self-interested and unethical behaviors. It has been demonstrated that the availability of an impure public good may have a negative effect on charitable behavior, it provides a justification to give only little without a bad conscience. Furthermore, the results from Munro and Valente (2016) suggest that green goods may decrease pro-environmental behaviors.

In this paper, we will develop a green goods model, characterized by an impure public good, where we introduce uncertainty through trust and pessimism. We are going to study the theoretical implications of the introduction of uncertainty and the comparative statics of the model. The purpose of this paper is to analyze the impact of uncertainty and risk perceptions on the private voluntary provision of impure public goods. We find that a lack of trust in information given by official sources may be an important barrier to green consumption: an increase in trust does not necessarily lead to an increase in green consumption. It depends on the individual's level of pessimism. We also show that pessimism has a negative impact on green consumption. Comparing the Nash equilibrium to the social optimum, we show that the sub-optimality of the Nash equilibrium when in presence of an impure public good is not always true under uncertainty. Furthermore, assuming that individuals have heterogeneous preferences and beliefs, either in pessimism or in trust, we find that green consumption decreases with pessimism at the equilibrium. Meanwhile, at the optimum, an increase in pessimism will decrease the individual's contributions, for either pessimists and optimists. We show that increasing trust might be counter-productive since it decreases green consumption for optimistic individuals.

This paper is structured as follows. In section 2, we present the impure public goods model, verifying the effect of a change in income, price, environmental quality, and green good's quality on green consumption. In section 3, we introduce uncertainty in the model and we study the effect of trust and pessimism in an environmentally friendly consumption. Finally, section 4 concludes.

2 Green good demand: the basic determinants

2.1 The individual consumption of a green good

We base our model on the one developed by Kotchen (2005) that is built on the characteristics approach to consumer behavior (Lancaster, 1966). Consumers derive utility from the characteristics of the goods rather than from goods themselves. In their setting, individuals derive utility from two characteristics, X, and Y. The characteristic X gives private utility to the consumer, it represents the shared characteristic (for instance, nutrition if we consider a fruit), and Y satisfies properties of a pure public good, it represents the common environmental characteristic. There are two market goods: a conventional good (c), that only generates the characteristic X; and there is a green good (g), that generates characteristics X and Y, it is an impure public good. We assume that these goods are substitutes. For example, if we consider electricity, the conventional good would be electricity generated from fossil fuels and the green good, electricity generated from renewable energies; in this case, X represents energy, and Y represents the environmental quality. The model in Kotchen (2005) is in line with the model developed by Cornes and Sandler (1994) of impure public goods, with the particularity that it allows the substitutability of goods.

In our model, the preferences of a representative consumer are represented by a utility function $U(X, Y)$. We assume that this utility function is additively separable: $u(X) + v(Y)$ with $u(X)$ and $v(Y)$ increasing and concave. The assumption of separability allows us to have independent preferences over the characteristics: the marginal utility of the private characteristic does not depend on the public characteristic and vice-versa. The function $u(X)$ represents the agent's preferences over the primary functionality of the good itself, and $v(Y)$ represents the agent's preferences towards the environmental characteristic. The consumer has an income m, she will devote her income to the consumption of conventional and green goods. Each unit of the conventional good (c) generates a unit of X. Each unit of the green good (g) generates one unit of X and $\varepsilon_0 > 0$ units of Y, where ε_0 represents the exogenous impact that the consumption of the green good has on the environmental quality. The relationship between the private characteristic X, the conventional good c and the green good g is given by $X = c + g$. The relationship between Y and g is given by $Y = \varepsilon_0 g + Y_0$, note that Y being a public characteristic, its level will depend on the consumption of green goods of all the individuals in the economy as we will see in section 3. P_g represents the exogenous green good's price and P_c the conventional good's price, that we normalize to 1, in accordance with the markets $P_g > P_c$ [2].

The individual consumption is solution of the following problem:

$$\begin{aligned} \max_{X,Y} \; U(X, Y) &= u(X) + v(Y) \\ s.t. \quad P_g g + c &= m \\ X &= c + g \\ Y &= \varepsilon_0 g + Y_0 \\ c \geq 0, g &\geq 0 \end{aligned} \tag{1}$$

We rewrite the program as a function of the quantity of the green good:

$$\max_{g \geq 0} \; U(g) = u\big(m - g(P_g - 1)\big) + v(\varepsilon_0 g + Y_0) \tag{2}$$

[2] If this inequality is not verified ($P_g \leq P_c$) the consumer's problem becomes trivial and the consumer will only consume green goods.

Since we assume the concavity of the utility functions u et v, the second-order condition is satisfied:

$$U''_{gg}(g) = (-P_g + 1)u''\big(m - g(P_g - 1)\big) + \varepsilon_0 v''(\varepsilon_0 g + Y_0) < 0 \tag{3}$$

The condition for an interior solution $g \in]0; \frac{m}{p_g}[$ is $U'_g(g) = 0$[3]:

$$U'_g(g) = (-P_g + 1)u'\big(m - g(P_g - 1)\big) + \varepsilon_0 v'(\varepsilon_0 g + Y_0) = 0 \tag{4}$$

The demand for green good g^* is thus implicitly given by equation 4. The interpretation of this equation is straightforward, g^* equalizes the marginal cost to the marginal benefit, as it appears in the following equation.

$$u'\big(m - g(P_g - 1)\big) + \varepsilon_0 v'(\varepsilon_0 g + Y_0) = (-P_g)u'\big(m - g(P_g - 1)\big)$$

The first part of the marginal benefit comes from the consumption of the good itself, its functionality, meanwhile, the second part of the marginal benefit comes from the environmental preferences of the consumer.

If all the income is spent on the conventional good c, we obtain the following allocation: $U\big(m, Y_0\big)$. On the contrary, if all the income is spent on the green good g, the resulting allocation is $U(\frac{m}{p_g}, \varepsilon_0 \frac{m}{p_g} + Y_0)$.

2.2 Comparative statics

We are going to analyze the impact of the changes in exogenous parameters on green consumption. The sign of the impact of a given parameter $\theta \in \{P_g, P_c, m, \varepsilon_0, Y_0\}$ on green good consumption is given by:

$$\frac{dg^*}{d\theta} = \frac{-U''_{g\theta}(g^*, \theta)}{U''_{gg}(g^*)}$$

From equation (3), $U''_{gg}(g)$ is negative. Consequently, the effect of a variation in any of the parameters will depend on the sign of $U''_{g\theta}(g, \theta)$.

The results from the comparative statics are standard in the literature, the following proposition summarizes them and confirms in our framework some of the

[3]From now on we will note $\frac{\partial f(x,y)}{\partial x} = f'_x(x,y)$ and $\frac{\partial f(x,y)}{\partial x \partial y} = f''_{xy}(x,y)$.

results in (Kotchen, 2005):

Proposition 1 *The exogenous market and the individual characteristics have the following impact on green good consumption :*

- *If the income of the consumer increases, she will increase her green consumption.*
- *An increase in green goods' price will decrease green consumption.*
- *An increase in green good's quality increases utility if* $\frac{1}{\varepsilon_0 g} > \frac{-v''(\varepsilon_0 g + Y_0)}{v'(\varepsilon_0 g + Y_0)}$.
- *An increase in the initial environmental quality will decrease green consumption.*

PROOF See Appendix A. □

If the income of the consumer increases, she will increase her green consumption. Therefore, a wealthier individual will consume more green goods, we are in the presence of a normal good.

We find conventional results, the green good is an ordinary good. An increase in the green good's price will diminish green consumption, the substitution and the income effect go on the same direction. On the contrary, an increase in the conventional good's price has an unknown effect on green consumption, this ambiguous result comes from the substitution effect and the income effect [4].

The sign of the expression (25) is ambiguous. An increase in quality will not necessarily imply an increase in green consumption. We recognize a saturation threshold that depends on a concavity index (right side of the inequality). When the utility function is strongly concave, an increase in the green good's quality will decrease green goods consumption. This threshold depends directly on the concavity of the individual's utility function. The more the utility function is concave, the more the marginal utility will rapidly decrease, therefore the more the individual will attain rapidly the saturation threshold. The consumer will value less an additional unit of the green good, not being enough to induce the individual to increase its consumption after an efficiency increase.

An increase in Y_0 will induce a diminution in green consumption. If the environmental quality is good, the less the individual will want to improve the environmental quality by increasing green consumption. From this result, we can also

[4] This result has already been identified by Kotchen (2005).

deduce a crowding-out effect: if there is an exogenous variation in the environmental quality, through an increase in public spendings relative to environmental protection for instance, individuals will contribute less to the public good.

2.3 Green good consumption in an economy with heterogeneous individuals

In this section we consider an economy composed by N individuals that may differ in their utility functions. Suppose that environmental quality depends on the consumption of green goods of each individual $\sum_{i=1}^{N} g_i$, the green good's quality ε_0, and on the exogenous level of environmental quality Y_0. Each individual chooses a quantity of the green good in a non cooperative way, considering the other's green consumption as given. G represents green consumption: $G = \sum_{i=1}^{N} g_i$. We will note $G_{-i} = \sum_{j \neq i}^{N} g_j$, such as G_{-i} represents the green consumption of all the individuals except the one of the consumer i[5].

Now we will consider the following equation:

$$\max_{g_i} U_i(g_i, G_{-i}) = u_i\big(m_i - g_i(P_g - 1)\big) + v_i\big(\varepsilon_0(g_i + G_{-i}) + Y_0\big) \tag{5}$$

2.3.1 Crowding out

Let us now study the effect of a variation in the exogenous consumer's green consumption (G_{-i}) to environmental quality. We assume here that the consumption of the other consumers is given. We study how green consumption changes after a variation of the other's voluntary contributions to the public good.

Proposition 2 *The best response of the consumer i when there is an increase in the other's consumer's green consumption is to decrease her voluntary individual contribution.*

Proof

$$\frac{dg_i}{dG_{-i}} = -\frac{U''_{igG_{-i}}}{U''_{igg}} < 0$$

Because:

$$U''_{ig_iG_{-i}} = \varepsilon_0^2 v_i''(\varepsilon_0(g_i + G_{-i}) + Y_0) < 0 \tag{6}$$

An increase in G_{-i} generates a crowding-out effect. The increase in the other's green consumption diminishes the individual's consumption of the green good and

[5]Note that in sections 2.1 and 2.2 we assume that $G_{-i} = 0$.

thus the individual contribution to the public good. We find a crowding-out effect generated by the consumers' behavior and not by public interventions. The best response of the consumer i is to play the opposite strategy than the other consumers.

2.3.2 Equilibrium

Now we will consider the equilibrium. For an interior solution, the contribution, $\hat{g}_i$, $i = 1, ..., N$, at the Nash equilibrium verifies the following first-order condition:

$$U'_{ig_i}(g_i) = (-P_g + 1)u'_i\big(m_i - g_i(P_g - 1)\big) + \varepsilon_0 v'_i\big(\varepsilon_0(g_i + G_{-i}) + Y_0\big) = 0 \quad (7)$$

We obtain the equilibrium by solving the system of N equations corresponding to $i = 1, ..., N$. This result will be useful for the following sections.

2.3.3 Socially optimal green good consumptions

We assume a utilitarian social central planner whose welfare function is expressed by the sum of individual utilities: $W = \sum_{i=1}^{N} U_i(X_i, Y)$, his program takes the following form:

$$\begin{aligned} \max_{X_1,...,X_N,Y} \; W = & \sum_{i=1}^{N} u_i(X_i) + \sum_{i=1}^{N} v_i(Y) \\ s.t \;\; & m_i = c_i + P_g g_i, \;\; i = 1, ..., N \\ & X_i = c_i + g_i, \;\; i = 1, ..., N \\ & Y = \varepsilon_0(G) + Y_0 \end{aligned} \quad (8)$$

Substituting the constraints into the program, we rewrite the program as a function of the quantity of the green good:

$$\max_{g_1,...,g_N} W(g_1, ..., g_N) = \sum_{i=1}^{N} u_i\big(m_i - g_i(P_g - 1)\big) + \sum_{i=1}^{N} v_i(\varepsilon_0 \sum_{i=1}^{N} g_i + Y_0)$$

The socially optimal contribution of individual i, g_i^*, $i = 1, ..., N$, verifies the following first-order condition:

$$W'_{g_i}(g_1, ..., g_N) = (-P_g + 1)u'_i\big(m_i - g_i(P_g - 1)\big) + \varepsilon_0 \sum_{i=1}^{N} v'_i(\varepsilon_0 \sum_{i=1}^{N} g_i + Y_0) = 0 \quad (9)$$

Note that, at the optimum, if we assume that all the individuals have the same private preferences ($u_1 = ... = u_N$), but they differ in the preferences over environmental quality ($v_1 \neq ... \neq v_N$), then the quantity of green goods consumed by each individual will be the same for the N individuals in the economy. Such as $g_i^* = g_j^* = ... = g_N^* = g^*$, since all the individuals have the same social marginal benefit and the same marginal cost, then the quantity consumed will be the same.

2.3.4 Comparison between equilibrium and optimum

Let us now compare the Nash equilibrium to the social optimum in the case where the individuals differ both in $u_i(X_i)$ and $v_i(Y)$.

Proposition 3 *The optimal quantity of green consumption is larger than the one in the Nash equilibrium obtained in the decentralized setting.*

PROOF

$$\varepsilon_0 \sum_{i=1}^{N} v'_i(\varepsilon_0(g_i + G_{-i}) + Y_0) > \varepsilon_0 v'_i\big(\varepsilon_0(g_i + G_{-i}) + Y_0\big)$$

Since $v'_i(\varepsilon_0(g_i + G_{-i}) + Y_0) > 0$.

□

When we compare the first-order conditions (7) and (9), the marginal benefit at the optimum is larger than at the Nash equilibrium, and the marginal cost stays the same. We obtain that the optimal level of green consumption is larger than the Nash equilibrium level for any individual: $g^* > \hat{g}_i$, $\forall i = 1, ..., N$.

We have a known result of the literature of public goods: the suboptimality of the Nash equilibrium. This result comes from the equalization of the marginal cost of each individual to the social marginal benefit (SMB) that is composed by the individual marginal benefit (MB_i) of consumption of consumer i, and the sum of the individual marginal benefits of all the consumers in the economy ($SMB = MB_i + \sum_{j \neq i}^{N} MB_j$). This Nash suboptimality comes from the internalization of the externality present in the model generated by the impure public good. Therefore, knowing that $\hat{G} = \sum_{i=1}^{N} \hat{g}_i$ and that $G^* = \sum_{i=1}^{N} g_i^*$, we can prove that $\hat{G} < G^*$.

3 Uncertainty, trust and the consumption of green goods

3.1 Introducing trust in the consumer's decisions: a neo-additive capacity model

As explained in section 1, we introduce uncertainty on the characteristics of green goods.We now assume that the impact of green good consumption on environmental quality is uncertain. Authorities provide probabilistic information on this impact, but this information is not considered as perfectly reliable by consumers. For some goods, this is because it is based on partial scientific knowledge (data are in limited quantity). For others, this is because of a more general lack of trust in official sources.

This uncertainty will not be lifted until extensive research about the subject allows the individuals to compare the real impact of the goods between them.

More precisely, ε_0 that measures the impact of a unit of green good on environmental quality is not perfectly known and can take all the values in the interval $[\underline{\varepsilon}, \overline{\varepsilon}]$ with $\underline{\varepsilon} < \overline{\varepsilon}$. $\overline{\varepsilon} \geq 0$ is the best possible outcome (the best impact that green goods can have on environmental quality). On the contrary, $\underline{\varepsilon} \leq 0$ represents the worst possible outcome, the worst impact that green goods can have on environmental quality. We allow $\tilde{\varepsilon}$ to take negative values in order to take into account situations in which green goods can have a negative impact on the environment. For example, biofuels are considered a green substitute for petrol: they may reduce greenhouse gas emissions, and it is a renewable energy. However, agricultural production has unintended negative impacts on water, land or biodiversity. Depending on the methods and the crops, used to produce the biofuels, it can cause more greenhouse gas emissions than fossil fuels, for example, by the use of nitrogen fertilizers[6]. In this section, we will also consider goods that are perceived as green by the consumer.

We assume that public authorities provide consumers with a probability distribution of the random variable $\tilde{\varepsilon}$ with a density fonction $f(.)$, and we assume that $\mathbb{E}(\tilde{\varepsilon}) > 0$. To take into account the potential lack of trust in this probabilistic information, as well as consumers' ambiguity attitudes and risk attitudes, we assume that their preferences are represented by the model of Chateauneuf, Eichberger and Grant (2007). This model generalizes a subjective expected utility model and allows

[6]Food and Agriculture Organization of the United Nations (FAO). 2008. Biofuels: prospects, risks and opportunities. In The State of Food and Agriculture 2008. FAO. Rome.

the separation between risk attitude and non-probabilised uncertainty attitudes.

With this preferences representation model, the consumers' problem in (2) writes:

$$\max_g U(g)$$

with

$$\begin{aligned} U(g) = \; & u\big(m - g(P_g - 1)\big) + (1-\delta)\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} v\big(\varepsilon g + Y_0\big) f(\varepsilon)\,\mathrm{d}\varepsilon \\ & + \delta\Big[\alpha v\big(\underline{\varepsilon} g + Y_0\big) + (1-\alpha) v\big(\overline{\varepsilon} g + Y_0\big)\Big] \end{aligned}$$

where

$\delta \in [0,1]$ measures the level of distrust in the distribution P;

$\alpha \in [0,1]$ measures the level of pessimism (or ambiguity aversion);

$U(.)$ is a Von Neumann–Morgenstern utility function;

These parameters allow us to model psychological phenomena. The first one represents the degree of confidence $(1-\delta)$ in the probabilistic assessment from official sources of the uncertain event (the efficacity of green consumption in environmental quality). This trust parameter may differ between the consumers because it may depend on past experience and other people's beliefs. Moreover, a mistrustful individual will react differently to new information, and she will over-weight the best (worst) outcome, considering essentially the extreme outcomes without differentiating the different degrees of likelihood. The second parameter (α) represents the degree of pessimism where the individual over-weights the worst outcome. It can also be considered as a measure of ambiguity aversion since it comes from the expectation of negative outcomes.

In this model, we assume that when a decision-maker does not trust the probability distribution of reference, she is in total uncertainty (complete ignorance) and applies the Hurwicz Max-Min criterion: the individual evaluates her decision by a weighted sum of the best and the worst outcomes. On the contrary, when he completely trusts the probability distribution of reference she takes her decisions under risk using expected utility.

The condition for an interior solution $g \in]0, \frac{m}{P_g}[$ is $U'_g(g) = 0$. We only consider individuals consuming green goods.

$$U'_g(g) = (-P_g + 1)u'\big(m - g(P_g - 1)\big) + (1 - \delta)\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} \Big[\varepsilon v'(\varepsilon g + Y_0)\Big] f(\varepsilon)\,\mathrm{d}\varepsilon + \delta\Big[\alpha\underline{\varepsilon}v'(\underline{\varepsilon}g + Y_0) + (1-\alpha)\overline{\varepsilon}v'(\overline{\varepsilon}g + Y_0)\Big] = 0 \tag{10}$$

The second-order condition is satisfied due to the assumption of concavity of the function $U(g)$:

$$U''_{gg}(g) = (-P_g + 1)^2u''\big(m - g(P_g - 1)\big) + (1 - \delta)\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} \Big[\varepsilon^2 v''(\varepsilon g + Y_0)\Big] f(\varepsilon)\,\mathrm{d}\varepsilon + \delta\big[\alpha\underline{\varepsilon}^2v''(\underline{\varepsilon}g + Y_0) + (1-\alpha)\overline{\varepsilon}^2v''(\overline{\varepsilon}g + Y_0)\big] < 0 \tag{11}$$

When we compare the first-order condition of the model without uncertainty (equation 4), to the model's first-order condition with uncertainty (equation 10), the marginal cost stays the same. However, the marginal benefit (MB) takes the following different form, and depends on δ, α, and the reference distribution $f(\varepsilon)$:

$$MB = u'\big(m-g(P_g-1)\big)+(1-\delta)\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} \Big[\varepsilon v'(\varepsilon g+Y_0)\Big] f(\varepsilon)\,\mathrm{d}\varepsilon+\delta\Big[\alpha\underline{\varepsilon}v'(\underline{\varepsilon}g+Y_0)+(1-\alpha)\overline{\varepsilon}v'(\overline{\varepsilon}g+Y_0)\Big]$$

In this setting, if $\delta = 0$, the individual entirely trusts the available information and makes decisions based on this information. On the contrary, if $\delta = 1$, the individual does not trust at all the available information, and α will be the only parameter having an impact on green consumption. If $\alpha = 1$, the only outcome that is taken into account is the worst possible. On the contrary, if $\alpha = 0$, the best possible outcome is the only one that is considered.

In the following sections we are going to study the impact of trust and pessimism on green consumption.

3.2 The impact of pessimism

We seek to study the impact of an increase in pessimism on green consumption.

Proposition 4 *Pessimism has a negative impact on green consumption.*

Proof Changes in an individual's pessimism over the impact of green goods on the environment is given by: $\frac{dg^*}{d\alpha} = -\frac{U''_{g\alpha}(g^*, \alpha)}{U''_{gg}(g^*)}$ (equation (11) shows that $U''_{gg}(g) < 0$). The sign of this expression is hence determined by:

$$U''_{g\alpha}(g^*, \alpha) = \delta \underline{\varepsilon} v'(\underline{\varepsilon} g^* + Y_0) - \delta \overline{\varepsilon} v'(\overline{\varepsilon} g^* + Y_0) < 0 \tag{12}$$

We can conclude that $U''_{g\alpha}$ is negative since $v'(Y) > 0$ and $\underline{\varepsilon} < 0$.

□

Consequently, $\frac{dg^*}{d\alpha}$ is also negative: a higher level of pessimism induces a decrease in green goods consumption. The more the individual is pessimistic, the less she will consume green goods. If an individual thinks that her green consumption will have a negative or no impact on environmental quality, she will consume less of these goods, since the consumer will not want to pay the premium price. Optimistic consumers have a higher marginal benefit from consuming the green good: they value more an additional unit of the public good than pessimists. If the individual completely trusts the available information (when $\delta = 0$), the decision will not depend on pessimism. On the contrary, if $\delta \neq 0$, regardless of the level of trust, if pessimism (α) increases, the decision-maker will consume less green goods.

3.3 The impact of trust

Let us determine the impact of an increase in the level of mistrust (δ) in available information on green goods consumption.

Proposition 5 *The impact of trust on green consumption will depend on the level of pessimism. There is a threshold $\hat{\alpha}$ such as if $\alpha > \hat{\alpha}$, green consumption decreases with mistrust (δ). If $\alpha < \hat{\alpha}$, green consumption will increase.*

Proof See Appendix B. □

α must be greater than $\hat{\alpha}$, so that trust induces a negative impact on green goods consumption. Consequently, the more an individual is mistrustful, the less she will consume green goods, if and only if the individual is pessimistic such that we have $\alpha > \hat{\alpha}$. A mistrustful individual will consume more green goods if the individual is sufficiently optimistic: $\alpha < \hat{\alpha}$

Since we are studying the effect of a variation in the level of the individual's mistrust (δ), and that the level of trust corresponds to $(1 - \delta)$, we can say that : In order to increase green goods consumption of pessimists, one way is to increase its trust in the available information.

This result implies that in order to increase green goods consumption it is necessary to target different types of individuals. Generally, a mistrustful optimistic individual will consume more green goods than a trustful consumer, since the trustful consumer's decision will only depend on the available information and not on risk perceptions (pessimism or optimism). The effects of trust and pessimism show that social opinion and risk perceptions can have an impact over green consumption. Increasing optimism among the consumers is a way to increase green consumption, however, the level of optimism is difficult to increase for public authorities. It is easier to modify the levels of mistrust among the individuals by reassuring pessimistic individuals about the true probability of the different events, and therefore transforming their beliefs. Therefore, information is an important parameter that can have significant consequences on environmental quality.

3.4 Equilibrium

In this section, we seek to determine the Nash equilibrium. Consider a population of size N where each consumer chooses her public contribution, $\hat{g}_i$, considering the consumption of the green goods of the other individuals in the economy:

$$\begin{aligned}\max_{X,Y} U_i(X,Y) = u_i(X) + (1-\delta)\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} v_i\big(Y(\varepsilon)\big) f(\varepsilon)\,\mathrm{d}\varepsilon + \delta\big[\alpha v_i\big(Y(\underline{\varepsilon})\big) + (1-\alpha)v_i\big(Y(\overline{\varepsilon})\big)\big] \\ s.t.\ m_i = c_i + P_g g_i \\ X = c_i + g_i \\ Y = \tilde{\varepsilon}G + Y_0\end{aligned} \tag{13}$$

We can rewrite the program in function of the quantity of green goods by substituting the constraints into the program, and in function of the green good's quantity:

$$\begin{aligned}\max_{g_i} U_i(g_i) =& u_i\big(m_i - g_i(P_g - 1)\big) + (1-\delta)\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} v_i\Big(\varepsilon\sum_{i=1}^{N} g_i + Y_0\Big) f(\varepsilon)\,\mathrm{d}\varepsilon \\ &+\delta\Big[\alpha v_i\Big(\underline{\varepsilon}\sum_{i=1}^{N} g_i + Y_0\Big) + (1-\alpha)v_i\Big(\overline{\varepsilon}\sum_{i=1}^{N} g_i + Y_0\Big)\Big]\end{aligned}$$

The contribution, the interior solution $\hat{g}_i$, at the Nash equilibrium verifies the following first-order condition:

$$U'_{ig_i}(g_i) = (-P_g + 1)u'_i\big(m_i - g_i(P_g - 1)\big) + (1-\delta)\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} \Big[\varepsilon v'_i(\varepsilon \sum_{i=1}^{N} g_i + Y_0)\Big] f(\varepsilon)\,\mathrm{d}\varepsilon$$
$$+ \delta\Big[\alpha\underline{\varepsilon}v'_i(\underline{\varepsilon}\sum_{i=1}^{N} g_i + Y_0) + (1-\alpha)\overline{\varepsilon}v'_i(\overline{\varepsilon}\sum_{i=1}^{N} g_i + Y_0)\Big] = 0 \tag{14}$$

To determine the Nash equilibrium, it is necessary to solve the equation system composed of N equations. Each equation being the first-order condition of each individual in the economy. We have $\hat{G} = \sum_i^N \hat{g}_i$, it is the level of private voluntary contributions to the public good at the Nash equilibrium.

3.4.1 Heterogeneous levels of pessimism

Let us now suppose that the economy is composed by only two individuals. They are identical in their utilities, $u_1 = u_2$, $v_1 = v_2$, and in their trust level, however, they differ in pessimism. We assume that the individual 1 is less pessimistic than the individual 2 ($\alpha_1 < \alpha_2$), and we assume that they both have the same level of mistrust $\delta_1 = \delta_2 = \delta$.

Proposition 6 *At the equilibrium, the more pessimistic the individual is, the less she will consume green goods.*

Proof The marginal benefit relative to the environment of the individual 1 is larger than the individual's 2 marginal benefit relative to the environment (knowing that $\underline{\varepsilon}$ is negative).

$$\delta\Big[\alpha_1\underline{\varepsilon}v'_1(\underline{\varepsilon}G+Y_0)+(1-\alpha_1)\overline{\varepsilon}v'_1(\overline{\varepsilon}G+Y_0)\Big] > \delta\Big[\alpha_2\underline{\varepsilon}v'_2(\underline{\varepsilon}G+Y_0)+(1-\alpha_2)\overline{\varepsilon}v'_2(\overline{\varepsilon}G+Y_0)\Big]$$

□

We find that different risk perceptions induce a modification in green consumption and therefore modify voluntary contributions to the public good. The less pessimistic individual will contribute more to the environmental quality than the more pessimistic individual: $\hat{g}_1 > \hat{g}_2$. The reason is that the less pessimistic individual believes that the consumption of the green good will have a greater impact on the environmental quality than the more pessimistic individual, therefore, she feels able to improve the environment with her consumption. Pessimists give more weight to the worst possible outcome, overestimating the likelihood of the worst possible outcome: they misjudge the green good's efficacity. Thinking that consumption can improve environmental quality may incentivize the individual to consume green goods.

3.5 Optimum

In this section we seek to determine the optimal level of the private voluntary contribution. The utilitarian central planner maximizes the social welfare, which is the sum of the individuals' utilities $W = \sum_{i=1}^{N} U_i(X_i, Y)$. We assume that the individuals have heterogeneous preferences over the goods and environmental quality. The maximization program of the social planner takes this form:

$$\begin{aligned}
\max_{X_i,\dots,X_N,Y} W = & \sum_{i=1}^{N} u_i(X_i) + (1-\delta)\sum_{i=1}^{N}\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} v_i\big(Y(\varepsilon)\big) f(\varepsilon)\,\mathrm{d}\varepsilon \\
& + \sum_{i=1}^{N} \delta\big[\alpha v\big(Y(\underline{\varepsilon})\big) + (1-\alpha) v\big(Y(\overline{\varepsilon})\big)\big] \\
s.t.\ & m_i = c_i + P_g g_i,\ i = 1, \dots, N \\
& X_i = c_i + g_i,\ i = 1, \dots, N \\
& Y = \tilde{\varepsilon} G + Y_0
\end{aligned} \tag{15}$$

We rewrite the consumer's problem in function of the green good consumption:

$$\begin{aligned}
\max_{g_1,\dots,g_N} W = & \sum_{i=1}^{N} u_i\big(m_i - g_i(P_g - 1)\big) + (1-\delta)\sum_{i=1}^{N}\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} v_i\Big(\varepsilon\sum_{i=1}^{N} g_i + Y_0\Big) f(\varepsilon)\,\mathrm{d}\varepsilon \\
& + \sum_{i=1}^{N} \delta\Big[\alpha v_i\Big(\underline{\varepsilon}\sum_{i=1}^{N} g_i + Y_0\Big) + (1-\alpha) v_i\Big(\overline{\varepsilon}\sum_{i=1}^{N} g_i + Y_0\Big)\Big]
\end{aligned}$$

To determine the optimum, it is necessary to solve the equation system composed of N equations. At the optimum, an interior solution g_i^*, represents the quantity consumed of green goods and verifies the following first-order condition by the individual i:

$$
\begin{aligned}
W'_{g_i}(g_1,...,g_N) =&(-P_g+1)u'_i\big(m_i - g_i(P_g-1)\big) + (1-\delta_i)\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} \Big[\varepsilon v'_i(\varepsilon \sum_{i=1}^{N} g_i + Y_0)\Big] f(\varepsilon)\,\mathrm{d}\varepsilon \\
&+ \delta_i\Big[\alpha_i \underline{\varepsilon} v'_i(\underline{\varepsilon}\sum_{i=1}^{N} g_i + Y_0) + (1-\alpha_i)\overline{\varepsilon} v'_i(\overline{\varepsilon}\sum_{i=1}^{N} g_i + Y_0)\Big] \\
&+ \sum_{j\neq i}^{N}\Big[(1-\delta_j)\int_{\underline{\varepsilon}}^{\overline{\varepsilon}}\Big[\varepsilon v'_j(\varepsilon\sum_{i=1}^{N} g_i + Y_0) f(\varepsilon)\,\mathrm{d}\varepsilon\Big] \\
&+ \sum_{j\neq i}^{N}\Big[\delta_j\Big(\alpha_j \underline{\varepsilon} v'_j(\underline{\varepsilon}\sum_{i=1}^{N} g_i + Y_0) + (1-\alpha_j)\overline{\varepsilon} v'_j(\overline{\varepsilon}\sum_{i=1}^{N} g_i + Y_0)\Big)\Big] = 0
\end{aligned}
\tag{16}
$$

The quantity at the optimum for each individual is obtained by equalizing the individual marginal cost from consuming green goods to the social marginal benefit. The social marginal benefit represents the sum of all the marginal benefits of all the individuals.

3.5.1 Comparison between equilibrium and optimum under uncertainty

In this section we seek to compare the green consumption level at the Nash equilibrium to the social optimum, under uncertainty.

Proposition 7 *Under uncertainty, there exists a threshold, ε^*, such as if $\underline{\varepsilon} < \varepsilon^*$, the optimal level of green consumption is smaller than the level at the Nash equilibrium.*

Proof If we compare the green consumption at the social optimum (equation 16) to the Nash equilibrium (equation 14), we can find a threshold ε^* such as the optimal level of green consumption is equal to the level at the Nash equilibrium:

$$
\underline{\varepsilon} = \frac{-(1-\delta_j)\int_{\underline{\varepsilon}}^{\overline{\varepsilon}}\Big[\varepsilon v'_j(\varepsilon\sum_{i=1}^{N} g_i + Y_0)\Big] f(\varepsilon)\,\mathrm{d}\varepsilon - \delta_j(1-\alpha_j)\overline{\varepsilon} v'_j(\overline{\varepsilon}\sum_{i=1}^{N} g_i + Y_0)}{\delta_j\alpha_j v'_j(\underline{\varepsilon}\sum_{i=1}^{N} g_i + Y_0)} \equiv \varepsilon^* < 0
\tag{17}
$$

□

Consequently, comparing this social optimum (equation 16) to the Nash equilibrium (equation 14) we do not find the standard result of the Nash equilibrium sub-optimality when introducing uncertainty. When $\underline{\varepsilon} = \varepsilon^*$, we find that the level of green consumption at the Nash equilibrium is equal to the level at the optimum $g_i^* = \hat{g}_i$. When $\underline{\varepsilon} < \varepsilon^*$, we find that $g_i^* < \hat{g}_i$, therefore it might be possible that when in presence of a positive externality, at the Nash equilibrium, individuals consume more green goods than at the social optimum, since the efficacity of the green goods over the environment might be worse than the one of the conventional good. Therefore, this result comes from the assumption that $\underline{\varepsilon} < 0$.

At the equilibrium, the individual only takes into account her marginal benefit, meanwhile, at the optimum, she takes into account the social marginal benefit, however, since we assume that green consumption may have a negative impact over the environment ($\underline{\varepsilon} < 0$) this social marginal benefit may be negative. The individual internalizes the external benefits that result from the consumption of the green good of all the individuals (i.e. the contribution of all the individuals excepted for the individual i to the public good). On the contrary, if we assume that $\underline{\varepsilon} \geq 0$, so that $\underline{\varepsilon} > \varepsilon^*$, we find the standard result of the sub-optimality of the Nash equilibrium since the social marginal benefit taken into account at the optimum is positive.

This result shows us that when consumers have to make decisions under uncertainty it isn't straightforward that, in presence of an impure public good, the optimal level will be greater than the quantity at the equilibrium. This result goes in the opposite direction to that found in the literature relative to public goods, the sub-optimality of the Nash equilibrium.

3.5.2 The consequences of heterogeneous risk perceptions

Let us now study the consequences of heterogeneous risk perceptions. Suppose an economy composed of N individuals. Welfare depends on the level of environmental quality and the consumption of conventional goods. In consequence, it also depends on the consumption of green goods of all the individuals. We assume that the individuals have all the same preferences, but only differ in pessimism: $\alpha_i \neq \alpha_j \neq ... \neq \alpha_N$. They all consume the same quantity of green goods due to the optimality condition.

Proposition 8 *At the optimum, an increase in pessimism diminish the individual's contributions, for pessimists and optimists.*

PROOF

$$\frac{dg^*}{d\alpha_i} = -\frac{W''_{g\alpha_i}(g^*, \alpha_i)}{W''_{gg}(g^*)}$$

$$W''_{g\alpha_i}(g^*, \alpha_i) = N\delta\Big[N\underline{\varepsilon}v'\Big(\underline{\varepsilon}(Ng) + Y_0\Big) - N\overline{\varepsilon}v'\Big(\overline{\varepsilon}(Ng) + Y_0\Big)\Big] < 0 \qquad (18)$$

□

An increase in pessimism in the economy will diminish green consumption since it has an impact on the social marginal benefit, modifying the quantity at the optimum of green good consumption. If an individual becomes more pessimistic, she is giving more weight to the worst possible outcome. It will induce a reduction in the social marginal benefit, causing a decrease in the optimal quantity of green goods consumption, for all the individuals, even for optimistic consumers. On the contrary, if there is an increase in optimism in the economy, the optimal level of green consumption will also increase, for optimists, but also for pessimists.

3.5.3 The effect of an increase in the proportion of pessimists in the economy

We assume an economy composed by N individuals, where there are two types of consumers: optimists and pessimists. Optimists are characterized by α_{op}, and pessimists are characterized by α_{pe}. The proportion of pessimists in the economy is represented by π, consequently, the number of pessimists in the economy corresponds to $N\pi$. Also, the proportion of optimists is equal to $(1-\pi)$ and the number of optimists is represented by $N(1-\pi)$.

Suppose a utilitarian social planner who seeks to maximize the welfare:

$$\begin{aligned}\max_g W =& Nu\big(m - g(P_g - 1)\big) + (1-\delta)N\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} v\Big(\varepsilon(Ng) + Y_0\Big) f(\varepsilon)\,\mathrm{d}\varepsilon \\ &+ N\pi\delta\Big[\alpha_{pe} v\Big(\underline{\varepsilon}(Ng) + Y_0\Big) + (1-\alpha_{pe}) v\Big(\overline{\varepsilon}(Ng) + Y_0\Big)\Big] \\ &+ N(1-\pi)\delta\Big[\alpha_{op} v\Big(\underline{\varepsilon}(Ng) + Y_0\Big) + (1-\alpha_{op}) v\Big(\overline{\varepsilon}(Ng) + Y_0\Big)\Big]\end{aligned} \tag{19}$$

The social optimal contribution, g^*, verifies the following first-order condition for an interior solution:

$$\begin{aligned}W'_g(g) =& N(-P_g + 1)u'\big(m - g(P_g - 1)\big) + N(1-\delta)\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} \Big[\varepsilon v'(\varepsilon(Ng) + Y_0)\Big] f(\varepsilon)\,\mathrm{d}\varepsilon \\ &+ N\pi\delta\Big[\alpha_{pe}\underline{\varepsilon} v'(\underline{\varepsilon}(Ng) + Y_0) + (1-\alpha_{pe})\overline{\varepsilon} v'(\overline{\varepsilon}(Ng) + Y_0)\Big] \\ &+ N(1-\pi)\delta\Big[\alpha_{op}\underline{\varepsilon} v'(\underline{\varepsilon}(Ng) + Y_0) + (1-\alpha_{op})\overline{\varepsilon} v'(\overline{\varepsilon}(Ng) + Y_0)\Big] = 0\end{aligned} \tag{20}$$

Let us now study the impact of an increase in the share of pessimists, directly meaning a decrease in the number of optimists in the population, on green consumption.

Proposition 9 *An increase in the share of pessimists will decrease the level of the social optimal contribution.*

Proof We seek to determine the sign of:

$$\frac{dg^*}{d\pi} = -\frac{W''_{g\pi}(g^*, \pi)}{W''_{gg}(g^*)}$$

$$\begin{aligned} W''_{g\pi}(g^*, \pi) =& N\delta\Big[\alpha_{pe}\underline{\varepsilon}v'(\underline{\varepsilon}(Ng^*) + Y_0) + (1-\alpha_{pe})\overline{\varepsilon}v(\overline{\varepsilon}(Ng^*) + Y_0)\Big] \\ & - N\delta\Big[\alpha_{op}\underline{\varepsilon}v'(\underline{\varepsilon}(Ng^*) + Y_0) + (1-\alpha_{op})\overline{\varepsilon}v'(\overline{\varepsilon}(Ng^*) + Y_0)\Big] < 0 \end{aligned} \tag{21}$$

We can see that the sign of the equation above is negative, therefore we obtain:

$$\frac{dg^*}{d\pi} < 0$$

□

When the pessimists' share in the population increases, the social marginal benefit decreases because pessimists value less an additional unit of the green good. Therefore, if there are more pessimists in the economy, every individual, even optimists, will consume less green goods, and the level of public good contributions will also decrease.

4 Conclusion

This paper proposes a green consumption model where we consider green goods as impure public goods. The aim is to define the different determinants of private voluntary contributions to the environmental public good and their impact to green demand. The comparative statics of the model shows that an increase in green good's quality does not necessarily imply an increase in green consumption, as it essentially depends on the consumer's preferences. We also show that an increase in environmental quality decreases green consumption. Furthermore, we consider that the green goods' environmental efficacity is partially unknown so individuals have to make a choice under uncertainty regarding their consumption decisions. In order to introduce this determinant, we base our model on Chateauneuf, Eichberger and Grant (2007) as a way to represent consumers' preferences. Hence, this paper's particularity is that we introduce uncertainty into an impure public good model to analyze its impact on green consumption. The presence of uncertainty is modelled with the beliefs of the consumers: trust and pessimism/optimism. Moreover, we study how those beliefs impact the private voluntary provision of public goods. We show that a lack of trust in information given by official sources may be an important barrier to green consumption. Though, an increase in trust does not necessarily lead to an increase in green consumption: it depends on the level of the individual's level of pessimism. We also find that pessimism has a negative impact on green consumption. Furthermore, under uncertainty, we find that it is possible for green consumption at the Nash equilibrium to be greater or equal to the one at the optimum when the efficacity of green goods on environmental quality is negative. This result tells us that when an individual makes a decision under uncertainty, the sub-optimality of the Nash equilibrium when in presence of an impure public good is not always true. Moreover, we study the case where individuals have heterogeneous preferences and beliefs, either in pessimism or in trust, and its impact over voluntary green consumption. We find that at the equilibrium, green consumption decreases with pessimism. Meanwhile, at the optimum, an increase in pessimism will decrease the individual's contributions, for either pessimists and optimists. These results are helpful in order to introduce non-monetary incentives, through reassuring individuals about the probability of the possible efficacity of green goods, since the increase of the levels of optimism in the economy, and modifying trust's levels allows to attain the socially optimal level relative to green consumption. Indeed, public policies may consider the possibility of influencing consumers' beliefs, such as trust and/or pessimism. If it is socially optimal to increase green demand, increasing optimism represents a way to attain this objective, however, it might be easier for the government to influence trust in information than optimism. The results show that increasing trust might be counter-productive since it will diminish green consumption for optimistic individuals. Thus, it is necessary to target different types of individuals before implementing public policies looking for an increase in the level of trust: it is useful to increase trust only for pessimistic individuals if the result seeked is to increase green consumption. One of the limitations of the model is that we assume that the government, or the experts, possess and communicate their probability estimation over the green good's efficacity, we assume that based on that information the consumer will decide her level of trust. However, they do not necessarily estimate (and communicate) these probabilities. In the section 2.3.1, we study a crowding-out effect from a positive exogenous variation of the other consumers' voluntary contributions, where the consumer i decreases her green consumption. However, since social norms are not included in the model, it may be possible that an increase in the others' green consumption increases the individual i's green consumption, as shown by Nyborg, Howarth and Brekke (2006) or Thøgersen (2011). Future research should consider testing experimentally the impact of the different determinants of green consumption, including trust and pessimism.

Appendix A: Proof of proposition 1

Proof

- An increase in income:

  Since $P_g > 1$:

$$U''_{gm}(g,m) = (-P_g + 1)u''\big(m - g(P_g - 1)\big) > 0 \tag{22}$$

- An increase in price:

$$U''_{gP_g}(g,P_g) = -u'\big(m - g(P_g - 1)\big) + (1 - P_g)(-g)u''\big(m - g(P_g - 1)\big) < 0 \tag{23}$$

$$U''_{gP_c}(g,P_c) = P_g u'\big(m - g(P_g - 1)\big) + (1 - P_g)(-m + P_g g))u''\big(m - g(P_g - 1)\big) \tag{24}$$

- An increase in ε_0:

$$U''_{g\varepsilon_0}(g,\varepsilon_0) = v'(\varepsilon_0 g + Y_0) + \varepsilon_0 g v''(\varepsilon_0 g + Y_0) \tag{25}$$

  An increase in ε_0 will have a positive impact in green goods consumption if and only if:

$$\frac{1}{\varepsilon_0 g} > \frac{-v''(\varepsilon_0 g + Y_0)}{v'(\varepsilon_0 g + Y_0)}$$

- An increase in the exogenous level of environmental quality:

$$U''_{gY_0}(g, Y_0) = \varepsilon_0 v''(\varepsilon_0 g + Y_0) < 0 \tag{26}$$

□

Appendix B: proof of proposition 5

Proof We want to determine the effect of a variation in the individual's trust over green consumption, it can be determined by: $\frac{dg^*}{d\delta} = -\frac{U''_{g\delta}(g^*, \delta)}{U''_{gg}(g^*)}$.

Thanks to the concavity assumption of the function (equation (11): $U''_{gg}(g^*) < 0$), we only need to determine the sign of $U''_{g\delta}(g^*, \delta)$:

$$U''_{g\delta}(g^*, \delta) = -\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} \Big[\varepsilon v'(\varepsilon g^* + Y_0)\Big] f(\varepsilon)\,\mathrm{d}\varepsilon + \Big[\alpha \underline{\varepsilon} v'(\underline{\varepsilon} g^* + Y_0) + (1-\alpha)\overline{\varepsilon} v'(\overline{\varepsilon} g^* + Y_0)\Big] \tag{27}$$

The sign of this expression is ambiguous. If $U''_{g^*\delta}$ is negative, $\frac{dg^*}{d\delta}$ will be negative aswell. It will be the case if:

$$\alpha > \frac{\overline{\varepsilon} v'(\overline{\varepsilon} g^* + Y_0) - \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} \big[\varepsilon v'(\varepsilon g^* + Y_0)\big] f(\varepsilon)\,\mathrm{d}\varepsilon}{\overline{\varepsilon} v'(\overline{\varepsilon} g^* + Y_0) - \underline{\varepsilon} v'(\underline{\varepsilon} g^* + Y_0)} \equiv \hat{\alpha}; \hat{\alpha} \in [0, 1] \tag{28}$$

α must be greater than $\hat{\alpha}$, so that trust induces a negative impact on green goods consumption. Consequently, the more an individual is mistrustful, the less she will consume green goods, if and only if the individual is pessimistic such that we have $\alpha > \hat{\alpha}$. In order to allow α to be greater or smaller than $\hat{\alpha}$, it is necessary that $0 \leq \hat{\alpha} \leq 1$. The inequality is verified if and only if:

$$\overline{\varepsilon} v'(\overline{\varepsilon} g^* + Y_0) > \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} \varepsilon v'(\varepsilon g^* + Y_0) f(\varepsilon)\,\mathrm{d}\varepsilon > \underline{\varepsilon} v'(\underline{\varepsilon} g^* + Y_0)$$

This inequality is verified since the expected value of a random variable is comprised between its extreme values. On the contrary, if $U''_{g\delta}$ is positive, $\frac{dg^*}{d\delta}$ will be positive. A mistrustful individual will consume more green goods if the individual is sufficiently optimistic:

$$\alpha < \hat{\alpha}$$

□

References

Brécard, Dorothée, Boubaker Hlaimi, Sterenn Lucas, Yves Perraudeau, and Frédéric Salladarré. 2009. "Determinants of demand for green products: An application to eco-label demand for fish in Europe." *Ecological Economics*, 69(1): 115–125.

Brouhle, Keith, and Madhu Khanna. 2012. "Determinants of participation versus consumption in the Nordic Swan eco-labeled market." *Ecological Economics*, 73: 142–151.

Chateauneuf, Alain, Jürgen Eichberger, and Simon Grant. 2007. "Choice under uncertainty with the best and worst in mind: Neo-additive capacities." *Journal of Economic Theory*, 137(1): 538–567.

Cornes, Richard, and Todd Sandler. 1984. "Easy Riders, Joint Production, and Public Goods." *The Economic Journal*, 94(375): 580.

Cornes, Richard, and Todd Sandler. 1994. "The comparative static properties of the impure public good model." *Journal of Public Economics*, 54(3): 403–421.

Engelmann, Dirk, Alistair Munro, and Marieta Valente. 2017. "On the behavioural relevance of optional and mandatory impure public goods." *Journal of Economic Psychology*, 61: 134–144.

Etner, Johanna, Meglena Jeleva, and Pierre-Andre Jouvet. 2007. "Risk perceptions, voluntary contributions and environmental policy." *Research in Economics*, 61(3): 130–139. Publisher: Elsevier.

Etner, Johanna, Meglena Jeleva, and Pierre-Andre Jouvet. 2009. "Pessimism or Optimism: A Justification to Voluntary Contributions Toward Environmental Quality*." *Australian Economic Papers*, 48(4): 308–319. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1467-8454.2009.00378.x.

Farrow, Katherine, Gilles Grolleau, and Lisette Ibanez. 2017. "Social Norms and Pro-environmental Behavior: A Review of the Evidence." *Ecological Economics*, 140: 1 – 13.

Joshi, Yatish, and Zillur Rahman. 2015. "Factors Affecting Green Purchase Behaviour and Future Research Directions." *International Strategic Management Review*, 3(1): 128 – 143.

Joshi, Yatish, and Zillur Rahman. 2019. "Consumers' Sustainable Purchase Behaviour: Modeling the Impact of Psychological Factors." *Ecological Economics*, 159: 235–243.

Kotchen, Matthew J. 2005. "Impure public goods and the comparative statics of environmentally friendly consumption." *Journal of Environmental Economics and Management*, 49(2): 281–300.

Kotchen, Matthew J. 2006. "Green Markets and Private Provision of Public Goods." *Journal of Political Economy*, 114(4): 816–834.

Lancaster, Kelvin J. 1966. "A New Approach to Consumer Theory." *Journal of Political Economy*, 74(2): 132–157. Publisher: University of Chicago Press.

Mazar, Nina, and Chen-Bo Zhong. 2010. "Do Green Products Make Us Better People?" *Psychological Science*, 21(4): 494–498.

Munro, Alistair, and Marieta Valente. 2016. "Green Goods: Are They Good or Bad News for the Environment? Evidence from a Laboratory Experiment on Impure Public Goods." *Environmental and Resource Economics*, 65(2): 317–335.

Nyborg, Karine, Richard B. Howarth, and Kjell Arne Brekke. 2006. "Green consumers and public policy: On socially contingent moral motivation." *Resource and Energy Economics*, 28(4): 351 – 366.

OECD. 2011. "Greening Household Behaviour: The Role of Public Policy." *OECD Publishing.*

OECD. 2014. *Greening Household Behaviour: Overview from the 2011 Survey - Revised edition. OECD Studies on Environmental Policy and Household Behaviour*, OECD.

Pieniak, Zuzanna, Joris Aertsens, and Wim Verbeke. 2010. "Subjective and objective knowledge as determinants of organic vegetables consumption." *Food Quality and Preference*, 21(6): 581–588.

Sdrolia, Evangelia, and Grigoris Zarotiadis. 2019. "A Comprehensive Review for Green Product Term: From Definition to Evaluation." *Journal of Economic Surveys*, 33(1): 150–178.

Tamai, Toshiki. 2018. “Dynamic provision of public goods under uncertainty.” *Economic Modelling*, 68: 409–415.

Thøgersen, John. 2011. “Green Shopping: For Selfish Reasons or the Common Good?” *American Behavioral Scientist*, 55(8): 1052–1076.

Tsakiridou, Efthimia, Kostantinos Mattas, Christina Boutsouki, and Yorgos Zotos. 2008. “Attitudes and behaviour towards organic products: an exploratory study.” *Intl J of Retail & Distrib Mgt*, 36(2): 158–175.

Vermeir, Iris, and Wim Verbeke. 2008. “Sustainable food consumption among young adults in Belgium: Theory of planned behaviour and the role of confidence and values.” *Ecological Economics*, 64(3): 542–553.

Welsch, Heinz, and Jan Kühling. 2009. “Determinants of pro-environmental consumption: The role of reference groups and routine behavior.” *Ecological Economics*, 69(1): 166 – 176.

Wichman, Casey J. 2016. “Incentives, green preferences, and private provision of impure public goods.” *Journal of Environmental Economics and Management*, 79: 208–220.

Young, William, Kumju Hwang, Seonaidh McDonald, and Caroline J. Oates. 2010. “Sustainable consumption: green consumer behaviour when purchasing products.” *Sustainable Development*, 18(1): 20–31.