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Comment un label « santé » peut-il améliorer l'approvisionnement en biens publics environnementaux ?

Résumé

Bien que les consommateurs soient de plus en plus disposés à payer pour la préservation de l'environnement, la fourniture privée de biens publics par la consommation de biens verts reste limitée. Nous proposons dans cet article d'exploiter un attribut privé supplémentaire de certains biens verts, les bienfaits pour la santé, afin d'accroître la fourniture de biens publics. La santé peut être considérée comme une internalité positive associée à la consommation de certains biens verts. Nous montrons que la correction de cette internalité via un étiquetage informant les consommateurs des bienfaits pour la santé associés à la consommation de ces produits peut accroître l'offre de biens publics. Le niveau du bien public reste insuffisant du point de vue d'un planificateur social, mais, sous certaines conditions, il peut égaler ou dépasser le niveau optimal du bien public du point de vue d'une agence environnementale. Une simulation est réalisée pour illustrer l'impact des préférences des consommateurs sur la fourniture de biens publics à l'équilibre du marché.

Mots-clés : Bien public environnemental, label, modèle théorique

Classification JEL : Q18, D11

How can labeling for health concerns improve environmental public good provisioning?

Abstract

Although consumers are increasingly willing to pay for the environment, the private provision of public goods from the consumption of green goods remains limited. We propose in this paper to exploit an additional private attribute of green goods, the health benefits, in order to increase the provision of public good. Health can be seen as a positive internality associated with the consumption of some green goods. We show that correcting this internality by offering labels describing these health benefits can increase the supply of public goods. The level of public good remains underprovided from the perspective of a social planner, but, under certain conditions, may equalize or exceed the optimal level of the public good from the perspective of an environmental agency. A simulation is performed to illustrate the impact of consumer preferences on the provisioning of public good at market equilibrium.

Keywords: Environmental public good, labeling, theoretical framework

JEL classification: Q18, D11

1. Introduction

With the development of green markets, economic literature shows a strong interest in the private provision of public goods. Although it is not *a priori* an optimal mechanism for financing public goods, because of the non-rivalry property, literature has sought to identify the conditions under which this private provision of public goods, and especially via the green market, could be an effective instrument for preserving the environment.

The literature has shown that, under some conditions, the joint production of a private good and a public good can provide a higher level of public good than voluntary contributions. This is the case when there is a technological advantage in producing both simultaneously. The consumers benefit from these goods at a lower cost than consuming them separately (Kötchen 2006, 2005, 2013). This would increase their consumption of green goods and therefore the provision of public goods. This is also the case if consumers derive additional utility from consuming both goods simultaneously, due to the warm-glow effect, which will encourage them to increase their willingness to pay for green goods (Lusk *et al.* 2007, Frackenpohl *et al.* 2013, Fuller *et al.* 2022). In some very specific market structures, the level of public goods may even equal or exceed its optimal level (Bagnoli et Watts 2003, Heal 2001). Heal (2001) show that a monopolistic firm practicing price discrimination may capture each consumer's willingness to pay for the public good (Heal 2003). In practice, although consumers are increasingly willing to pay for the environment (Aldanondo-Ochoa and Almansa-Sáez 2009, Rousseau and Vranken 2013), the private provision of public goods from the consumption of green goods remains limited (Chan and Kötchen 2014, Besley *et al.* 2017). The literature has even shown that, in very specific situations, the level of public good can even decrease. As green goods are credence goods, the problem of asymmetric information and the misperception of consumers can be counter-productive for improving environmental quality (Munro *et al.* 2016, Baksi *et al.* 2007). One way of restoring trust and information between producers and consumers is to certify green goods with eco-labels recognized by the state or a government agency (Baksi *et al.* 2007).

In line with the literature on impure public goods, we propose in this paper to exploit an additional private attribute of green goods, the health benefits, in order to increase the provision of public good. The literature largely pointed out that consumers' motivations for green products were not purely altruistic and associated with strong environmental sensitivity. If consumers perceive that an environmentally friendly process guarantees food safety, then the perceived benefits from the environmental attributes may also be private (Bougherara and Combris, 2009). In addition, the health factors are often identified as the main motives for consuming organically produced food products (among others, Magnusson *et al.* 2003, Verhoef 2005, Aldanondo-Ochoa and Almansa-Sáez 2009; Brécard *et al.* 2012). Based on these findings, several studies have reinforced the importance of encouraging ecofriendly purchases by promoting their positive effects on health (Dabbert 2006, Rousseau and Vranken 2013).

Recently, health is often considered as a negative internality from the consumption of some foods, such as cigarettes, sugary drinks or red meat (Griffith *et al.* 2018, Funke *et al.* 2022). The long-term health costs of consuming these products are neglected in decision-making, either because consumers are ill-informed about the health consequences of their behavior, or because they make inconsistent choices over time, ignoring or disproportionately reducing their long-term health preferences. In all cases, they misperceive this product attribute. In this paper, we propose to consider health as a positive internality to the consumption of some green products.

Green goods are often produced using low-chemical agricultural practices and/or are associated with superior nutritional qualities (Hornick, 1992). For example, pesticides use can affect both the human health and biodiversity. Another example is the livestock feeding practices : dairy cows fed a higher percentage of grass fodder or extruded linseed produce milk with a higher omega-3 content, which is recommended for a healthy diet (Weill *et al.* 2002) and decreases enteric methane emissions per liter of milk (Weill *et al.* 2009). Consumers generally have little or no information about the farming practices associated with the food products they consume. The benefits associated with consuming green products are therefore overlooked in decision-making, except when green products are certified by labels that is perceived by consumers as being good for health. This is the case, for example, with organic farming or pesticide-free labels.

In this paper, we theoretically show that considering health benefits as a private attribute of some green goods, and correcting this internality of consumption through labels, would increase the provision of the environmental public good. The main condition is the joint provision of private health and environmental public benefits that can occur with food commodities produced using environmentally friendly agricultural practices.

We assume that labelling is certified by a labelling agency, which is a governmental organisation reducing misleading issues (Baksi *et al.* 2007). We compare three market settings for the same green product depending on whether the label informs consumers about environmental and/or health benefits. According to the label, the consumers does not perceive the same information on this good, although this one keeps the same characteristics. These markets are purely theoretical to measure the impact of promoting health benefits. Indeed, in practice, it is difficult to assume that consumers do not perceive the health benefits of an eco-labelled good, and conversely the environmental benefits of a health-labelled good.

The rest of the paper is organized as follows. We start with a description of our theoretical framework, which is inspired by the impure public good model of Kötchen (2005). Then, we will present the optimal conditions that characterize this economy and the equilibrium market conditions. Finally, we compare the different market settings in terms of environmental public good provisioning and distance to social and environmental optimality based on a simulation.

2. The theoretical model

We start from a theoretical framework in which the utility function of consumers depends on the characteristics of the goods. This approach is widely used to model consumer behavior (Gorman, 1980; Lancaster, 1966), particularly in models of impure public goods (Cornes and Sandler, 1994, 1984; Kötchen, 2005). In this analytical framework, green products are impure public goods that generate both a private characteristic and a public characteristic.

2.1. The analysis framework

We consider two food products, a conventional good c and a green good g. These two goods generate the same private characteristic X, which corresponds to the need to feed oneself. The green good g generates the private characteristic X as well as two additional characteristics, a public characteristic Y and another private characteristic H. Since the good g is produced by more environmentally friendly agricultural practices, it is assumed that its production and consumption allow for the improvement of the quality of the environment corresponding to the public good Y. The originality of our approach is that the nutritional qualities of the green good g are superior or less chemical products are required for its production compared with conventional good c. Thus, the consumption of good g improves the health of the consumer, which is another private characteristic H.

The two goods are sold on competitive markets, good c at price p_c and good g at price p_g. For simplicity[1], we consider one representative producer who produces the two goods c and g, subject to technological constraints represented by $T(c, g) = 0$. It is assumed that $p_g > p_c$ to ensure the viability of the conventional good on the market. The marginal cost of producing good g must then be greater than the marginal cost of producing good c to prevent the producer from producing only good g.

We consider $i = 1, \dots, I$ consumers. Each individual's preferences are represented by a strictly increasing and strictly quasi-concave utility function $U^i(X^i, Y, H^i)$, where X^i and H^i are individual i's private consumption of characteristics X (food product) and H (health benefits), and Y (environmental benefits) is the provisioning of the public characteristic such that $Y = \sum_i^I Y^i$, where Y^i is individual i's private contribution. For each individual, the contribution of others to the public characteristic is exogenous, such that $Y = Y^i + \sum_{j \neq i}^I Y^j = Y^i + Y^{-i}$. Each individual can allocate his wealth r^i to purchase a quantity c^i of conventional good c at price p_c and a quantity g^i of impure public good g at price p_g, such that $p_c c^i + p_g g^i \leq r^i$. Buying good c is the most inexpensive method of obtaining private characteristic X. Regarding agricultural technologies, buying one unit of c leads to the provision of one unit of X while buying one unit of g leads to the provision of one unit of X, α units of H and β units of Y, with $\alpha > 0$ and $\beta > 0$. These technological parameters are considered exogenous and known to all consumers when this information is provided on the product label. The relation between the quantities of goods c^i and g^i and the consumption of the characteristics X^i, H^i and Y^i is then defined by $X^i = c^i + g^i$, $H^i = \alpha g^i$ and $Y = \beta g^i + \beta g^{-i}$. Given these relations, the utility function $U^i(X^i, Y, H^i)$, can be rewritten as follows: $U^i(c^i + g^i, \alpha g^i, \beta g^i + \beta g^{-i})$. We therefore consider that each consumer chooses the quantity of good g and c consumed so as to maximize his utility under his budget constraint $p_c c^i + p_g g^i \leq r^i$.

[1] We consider an economy with production to obtain the market equilibria (and not just consumer equilibria). Even if our paper focuses on the analysis of consumer behavior, it is interesting to consider the behavior of producers when discussing the assumptions made about production technologies. In addition, the analytical framework we propose could be used in further research to focus on producer behavior.

2.2. Optimal provision of public good

In this section, we describe the optimal conditions that characterize our economy from the perspective of an environmental agency and a social planner. The environmental agency seeks to optimize the total utility of the consumers only considering the environmental benefits of the products. The social planner seeks a Pareto optimal outcome by considering both the health and environmental characteristics of the food products.

If an environmental agency has the ability to choose the optimal level of public good provision, it would only consider food production X^i and the public good Y jointly produced with g. This is equivalent to assuming that the social regulator thinks that $\alpha = 0$. It would maximize the sum of the individual utility and solve the following problem:

$$\max_{c,g} \ \sum_i U^i\left(c^i + g^i, \beta g^i + \beta g^{-i}\right) \tag{1}$$

subject to: $T(c, g) = 0$

With $\sum_i X^i = c + g$, $Y = \beta g$, $c = \sum_i c^i$ and $g = \sum_i g^i$. At the optimum, the sum of the quantities of goods c and g consumed by all individuals is equal to the quantity of goods produced by the producer according to the production technology $T(c, g)$. The derivation of this program leads to the following first-order conditions:

$$\frac{\partial U^i}{\partial X^i} = \lambda \frac{\partial T(c,g)}{\delta c} \tag{2}$$

$$\frac{\partial U^i}{\partial X^i} + \beta \frac{\sum_i \partial U^i}{\partial \mathrm{Y}} = \lambda \frac{\partial T(c,g)}{\delta g} \tag{3}$$

where λ is the Lagrangian multiplier associated with production technology. Combining these two conditions leads to this optimum condition:

$$\beta \sum_i \frac{\partial U^i / \partial Y_{ea}}{\partial U^i / \partial X_{ea}^i} = \frac{\partial T(c,g)/\delta g}{(\partial T(c,g)/\delta c) - 1}. \tag{4}$$

where $X_{ea}^i$and Y_{ea} correspond to the optimal demand from the environmental agency perspective for private and public characteristics of goods g and c. The sum of the marginal rates of substitution between public and private characteristics must be equal to the marginal rate of transformation. These marginal rates of substitution indicates consumers' willingness to pay according to their preferences. A optimal provision of environmental quality requires that the aggregated willingness to pay be equal to the opportunity costs of environmental quality. We have to consider the sum of the marginal willingness to pay for this public good over all consumers since the quantity of public good consumed is the same for all (Bowen-Lindahl-Samuelson condition) (Samuelson 1954; Samuelson 1969). Note that this condition is also the Pareto optimum condition associated with the model of green consumption defined by Kötchen (2005), which does not consider the private characteristic H^i. The corresponding private consumption H^i is obtained from $\sum_i H^i = \alpha g_{ea}^*$ when g_{ea}^* solves the optimization program of the environmental agency.

In the presence of a private good and a public good, state intervention, such as by an environmental agency, is justified to ensure the provision of the public good. Assuming perfect information from the state, the optimal provision of Y could be achieved by collecting a tax equal to $\sum_i \frac{\partial U^i/\partial Y_{ea}}{\partial U^i/\partial X_{ea}^i}$ on consumers' income to subsidize the production of good g. In this case (and in theory), the provision of public good would be optimal according to the condition defined in Equation (5). In practice, the state has only imperfect information, notably concerning the costs of providing a public good and the willingness of consumers to pay. Then, the real provision of the public good is below its optimal level.

If a social planner had the ability to choose the optimal level of public good provision, he would maximize social welfare considering both the environmental and health benefits associated with the good g. Then he maximizes the sum of the individual utility $U^i\left(c^i + g^i, \beta g^i + \beta g^{-i}, \alpha g^i\right)$ with this additional constraint: $\sum_i H^i = \alpha \sum_i g^i = \alpha g$. The Pareto optimal condition for a social planner corresponds to:

$$\beta \sum_i \frac{\partial U^i/\partial Y_p}{\partial U^i/\partial X_p^i} + \alpha \frac{\partial U^i/\partial H_p^i}{\partial U^i/\partial X_p^i} = \frac{\partial T(c,g)/\delta g}{\partial T(c,g)/\delta c} - 1. \quad (5)$$

Where X_p^i, H_p^i and Y_p correspond to the Pareto optimal demand for private and public characteristics of goods g and c. The Pareto optimum requires that the sum of the marginal rates of substitution between characteristics, weighted by technology parameters α and β, be equal to the marginal rate of transformation. The terms $\frac{\partial U^i/\partial H_p^i}{\partial U^i/\partial X_p^i}$ and $\sum_i \frac{\partial U^i/\partial Y_p}{\partial U^i/\partial X_p^i}$ correspond to the marginal rate of substitution between two characteristics, *i.e.*, the change in the quantity consumed of one characteristic required to keep its utility constant following a change in the quantity consumed of the other characteristic. The difference with the environmental agency is that the optimal level of production of green good g is obtained when the sum of these marginal benefits, for the environment but also for health, is equal to its marginal cost. Public good production is then driven both by consumer demand for environmental quality, and indirectly via the health benefits of the green good.

2.3. Market equilibrium with an eco-label

In this market setting, we consider that the green good g is certified by an ecolabel that informs consumers about environmentally friendly practices. Consumers have no *a priori* information on the health benefits of the product, although they exist. Consumers do not factor the health benefits of green goods into their decisions. This analysis framework also corresponds to a theoretical situation in which consumers have zero preferences for the health. Each consumer i maximizes his utility function under his budget constraint:

$$\max_{c^i,g^i} U^i\left(c^i + g^i, \beta g^i + \beta g^{-i}\right) \tag{6}$$

s.t. $p_c c^i + p_g g^i \leq r^i$.

The first-order conditions are derived only in relation to the product characteristics known by the consumers, *i.e.*, X^i and Y :

$$\frac{\partial U}{\delta X^i} = \lambda p_c \tag{7}$$

$$\frac{\partial U}{\delta X^i} + \beta \frac{\partial U}{\delta Y} = \lambda p_g \tag{8}$$

These conditions, associated with the producer's equilibrium defined by $\frac{p_g}{p_c} = \frac{\partial T(c,g)/\partial g}{\partial T(c,g)/\partial c}$, lead to the following market equilibrium condition:

$$\beta \frac{\partial U^i/\partial Y_e^i}{\partial U^i/\partial X_e^i} = \frac{\partial T(c,g)/\delta g}{(\partial T(c,g)/\delta c) - 1}. \tag{9}$$

where X_e^i and Y_e correspond to the demand for private and public characteristics of goods g and c at equilibrium in a market characterized by an environmental label. These conditions also correspond to the market equilibrium of the green consumption model of Kötchen (2005). Each agent does not consider that the financed public good provision also benefits other agents. Agent i contributes to providing the public good until the marginal cost of the private good is equal to its marginal benefits, without taking into account the marginal benefits of other consumers. Agents also do not consider the health benefits associated with consuming green goods. Consequently, consumers as a whole contribute less to the public good than what would be desirable to achieve Pareto optimality or the environmental agency's optimality.

2.4. Market equilibrium with a health label

In this market setting, we assume that consumers know that good g is better for health than good c but have no information on the environmental impact of the agricultural practices associated with the production process. This analysis framework also corresponds to a theoretical situation in which consumers have zero preferences for the environment. Each consumer i maximizes his utility function $U^i\left(X^i, H^i\right) = U^i\left(c^i + g^i, \alpha g^i\right)$ under his budget constraint. The first-order conditions are derived in relation to the product characteristics known by the consumers, i.e., X^i and H^i. These conditions, which are associated with the producer's equilibrium, lead to the following market equilibrium condition:

$$\alpha \frac{\partial U^i / \partial H_h^i}{\partial U^i / \partial X_h^i} = \frac{\partial T(c,g)/\delta g}{(\partial T(c,g)/\delta c) - 1}. \tag{10}$$

where X_h^i and H_h^i correspond to the demand for private and public characteristics of goods g and c at equilibrium in a market characterized by a health label. Classically, the market equilibrium leads to the optimal provision of private characteristics from the perspective of a health regulator. Even if consumers do not have information on the positive environmental externality associated with their consumption, the public good Y is provided jointly with the production of good g. The quantity of public characteristics Y provided through the consumption of good g is thus equal to the sum of the quantities of private characteristics H^i consumed by all consumers multiplied by the ratio of the technology parameters, such as the following:

$$Y_h = \frac{\beta}{\alpha} \sum_i H_h^i. \tag{11}$$

This equation reflects the jointness of production between environmental and health characteristics, with the ratio β/α corresponding to the intensity of this jointness.

Substituting this last equation into the equilibrium condition (10), we obtain a new condition depending on the level of the public characteristic:

$$\beta\sum_{i}\frac{\partial U^{i}/\partial Y_{h}}{\partial U^{i}/\partial X_{h}^{i}}=\frac{\partial T(c,g)/\delta g}{(\partial T(c,g)/\delta c)-1}. \tag{12}$$

The market equilibrium does not correspond to a Pareto optimal allocation. Nevertheless, recalling the environmental agency optimum (Equation (4)), the market equilibrium of the health label leads to the optimal public good provision from the perspective of an environmental regulator under specific conditions (including the same level of preference for health and the environment). These conditions will be described in Section 3.

2.5. Market equilibrium with an environmental and health label

In this market setting, we consider that green goods g are certified by a label that identifies the environmental and nutritional qualities of product (health and environmental label). This also corresponds to an analytical framework in which we assume that consumer preferences for the environment and health are non-zero. In this case, we consider that the label makes it possible to correct consumption internality. The first-order conditions are derived from the characteristics of the goods X^i, H^i and Y, which are all known by consumers. Each consumer i maximizes his utility function $U^i(X^i, Y, H^i) = U^i(c^i + g^i, \beta g^i + \beta g^{-i}, \alpha g^i)$ under his budget constraint. The market equilibrium conditions are then defined as follows:

$$\alpha\frac{\partial U^{i}/\partial H_{eh}^{i}}{\partial U^{i}/\partial X_{eh}^{i}}+\beta\frac{\partial U^{i}/\partial Y_{eh}}{\partial U^{i}/\partial X_{eh}^{i}}=\frac{\partial T(c,g)/\delta g}{(\partial T(c,g)/\delta c)-1} \tag{13}$$

where X_{eh}^i, H_{eh}^i and Y_{eh} correspond to the demand for private and public characteristics of goods g and c at equilibrium in a market characterized by health and environment label. The willingness to pay for the health and environment labelled product is equal to the sum of the marginal utility of the health characteristic and the marginal utility of the public characteristic. This equilibrium condition do not coincides with the socially optimal condition defined in (5). Classically, the inefficiency of this equilibrium only comes from the absence of considering the externality created by g^i by each consumer on the others, as we can see from the formulation.

Compared to the health label, agents choose their level of g consumption by considering not only the health benefits, but also their environmental benefits. The level of good g, and therefore the provision of public good, is then higher than the optimal level from an environmental agency's point of view, under certain conditions discussed in the next section.

3. Comparison of public good provision

In this section, we assume a functional form of the utility function to compare the level of public good provision from the three types of labels (environmental label, health label, health and environment label) for a same product. We also perform a simulation to observe the evolution of the provision of public goods at the equilibrium of the different market settings according to the consumers' levels of preference for health and environmental benefits.

3.1. Public good demand function

To facilitate the comparison between the different market equilibria derived in the following sections and the optimality conditions, we assume that consumers are homogeneous and the utility function has a functional form as follows:

$$U^i(X^i, Y, H^i) = \theta_X \ln X^i + \theta_Y \ln Y + \theta_H \ln H^i. \tag{14}$$

where θ_X, θ_Y and $\theta_H$correspond to the preference parameters for food, environment and health factors, respectively. This utility function is strictly increasing, twice continuously differentiable and strictly quasi-concave. This type of functional form, such as Cobb–Douglas preferences, considers homothetic preferences, which is classically assumed when consumers wish to derive aggregate consumer demand from the utility maximization behavior of a representative rational consumer (Caselli and Ventura, 2000).

As previously defined, Y_e, Y_h and Y_{eh} correspond to the equilibrium provisioning of a public good with an environment, a health label, and a health and environment label, respectively.

$$Y_e = \beta \left(\frac{\theta_Y/I}{\theta_X + \theta_Y/I}\right)\left(\frac{1}{p_{g,e} - p_{c,e}}\right)\sum_i r^i \tag{15}$$

$$Y_h = \beta \left(\frac{\theta_H}{\theta_X + \theta_H}\right)\left(\frac{1}{p_{g,h} - p_{c,h}}\right)\sum_i r^i \tag{16}$$

$$Y_{eh} = \beta \left(\frac{\theta_Y/I + \theta_H}{\theta_X + \theta_Y/I + \theta_H}\right)\left(\frac{1}{p_{g,eh} - p_{c,eh}}\right)\sum_i r^i \tag{17}$$

The weight of preferences for health and/or environment, which are represented by a ratio depending on θ_X , θ_Y and θ_H, has an important impact on the level of public good provided by the three types of labels. This ratio describes the consumers' willingness to pay for these characteristics. With the environmental label, the market failure is such that the preference for the environment θ_Y is individualized (Equation (15)). Consumers do not consider the willingness of other consumers to pay for this public characteristic. Rather, they only consider their willingness to pay, which is translated in the model as a level of preference divided by the number of consumers (θ_Y/I). In an optimal situation from an environmental agency's perspective, the ratio of preferences would be equal to $\theta_Y/(\theta_X+\theta_Y)$. The level of public good provided with an environmental label is therefore much lower than those provided in optimal situations (all the more so as the size of the market is large). In contrast, in the case where $\theta_Y=\theta_H$ and prices of goods are the same across market settings, the level of public good provided by the health label is optimal in the sense of an environmental agency (Equation (16)). The provision of public good by the health and environment label (Equation (17)) also suffers from an underestimation of the consumers' willingness to pay for Y. Similar to the environmental label, preferences for the environment appear individualized. On the other hand, consumers' willingness to pay for health greatly increases the supply of public goods, and the provision of public good can reach the optimal amount targeted by an environmental agency under certain conditions of relative preferences for health and the environment.

When consumers only have access to information on one of the two complementary characteristics (environmental label or health label), more public goods are provided through the market of a health label in most situations. Assuming identical prices between the environment-labeled and health-labeled good g, an environmental label leads to higher provisioning of the public good only for a case characterized by a very small market associated with a significantly higher preference for environmental characteristics than health characteristics (dividing the expression of Equations (15) and (16) leads to the condition $\theta_Y/\theta_H>I$, in which the environmental label provides more public good). Under perfect information (health and environment label) and when consumers exhibit preferences for the three characteristics ($\theta_X,\theta_Y,\theta_H>0$), the provision of the public good is always higher than the market outcomes of an environmental label or a health label.

Our analysis shows that preference parameters influence market outcomes. This is an expected result because the impact of individual preferences has been highlighted in numerous studies on consumer demand and differentiated market efficiency (Aldanondo-Ochoa and Almansa-Sáez, 2009; Brécard *et al.*, 2012, 2009; Lusk *et al.*, 2007; Moon *et al.*, 2002; Schifferstein and Ophuist, 1998). This literature also emphasizes that consumer preferences are heterogeneous. Moreover, consumers with high preferences for the environment may have different socioeconomic characteristics than those with high preferences for health. Willingness to pay for environmental attributes increases with income, altruism, education and environmental awareness and decreases with age (Aldanondo-Ochoa and Almansa-Sáez, 2009; Brécard *et al.*, 2009; Lusk *et al.*, 2007; Moon *et al.*, 2002), while willingness to pay for health attributes seems decrease with education and increases with age (Brécard *et al.*, 2012; Govindasamy and Italia, 1999; Schifferstein and Ophuist, 1998). Aldanondo-Ochoa and Almansa-Sáez (2009) show that environmental and health attributes are complementary for people who care about the environment. They show a high willingness to pay for health when it is accompanied by an improvement in the environment. In contrast, health-conscious people are not willing to pay more for the environment. In this section, we do not account for this heterogeneity, although we know it exists. We focus on the market outcome considering the behavior of a consumer representative of the average preferences of the population. Adding heterogeneity might introduce additional nuancing elements but would not affect the overall results and conclusions.

We have calculated the quantities of goods g and c at consumer equilibrium, which allows us to derive the demand for public good Y in each market characterized by a specific type of label. We observe that the demand for the public good is higher when consumers have information on the health benefits of consuming good g. However, these public good demands are not directly comparable since the prices of goods g and c are not the same from one market to another. An increase in the demand for good g will lead to an increase in the production of this good g and therefore an increase in its marginal cost, which will be borne by the producer. The selling price of good g will adjust upwards so that it equals its marginal cost. The increase in the price of good g will therefore reduce the initial demand for good g until an equilibrium price, allowing supply and demand to be equalized, is reached. Thus, although the supply of public good will always be higher when the health attribute is valued, the difference in public good Y provided by the different labels will be mitigated by the increase in the price of good g. To compensate for this, the behavior of the producer must be considered, which will be explored in the following section using a simulation.

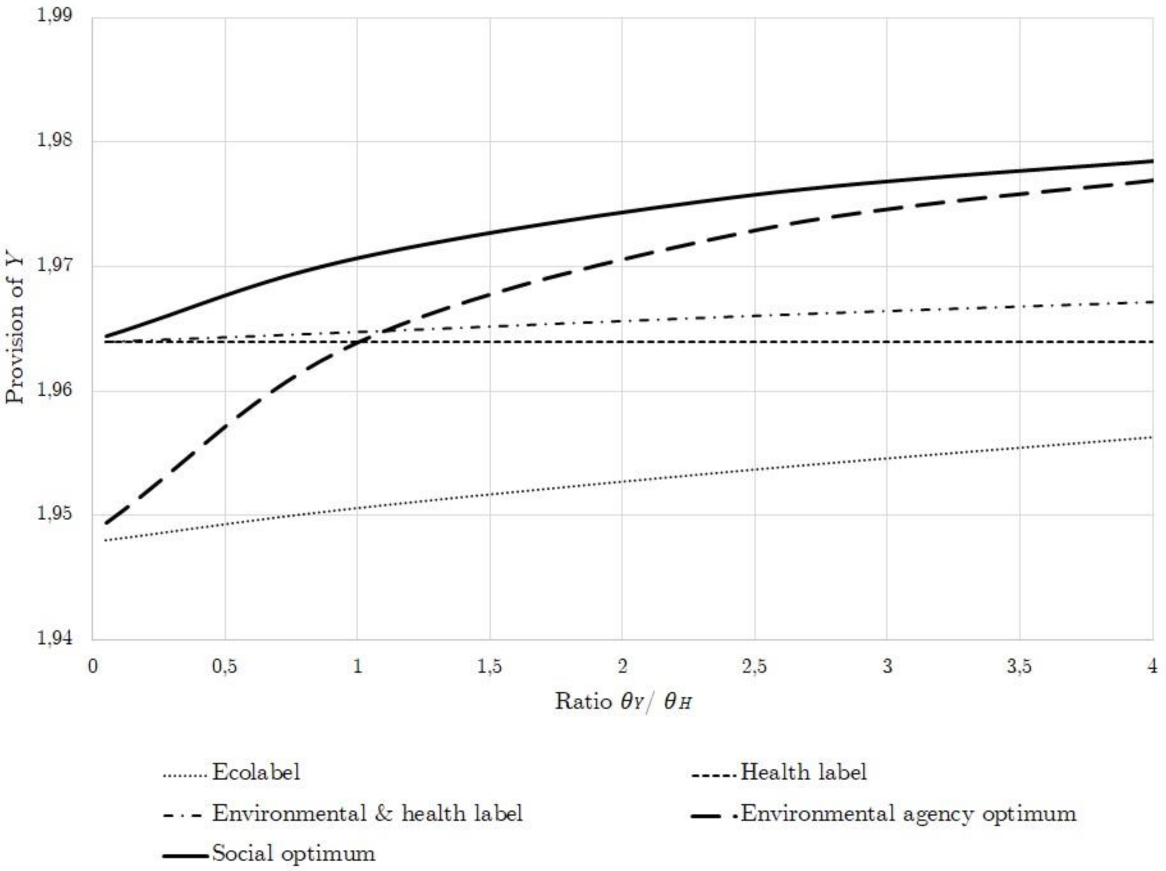
3.2. Simulations of different market equilibria

A simulation is performed to observe the evolution of the provision of Y at the equilibrium of the different markets according to the levels of preference for health and the environment of consumers. In the simulation, we consider a market of 50 consumers who each have an income of 5 to allocate to the purchase of good c and/or good g, which is produced by a single producer. We characterize the production technologies of goods c and g in a simple way, such that several assumptions are met. First, the production of one unit of good g requires less polluting inputs than the production of one unit of good c. Second, the marginal cost of producing good g is higher than the marginal cost of producing good c. If the price of good g was less than or equal to the price of good c, good c would never be consumed. The assumptions made about production technologies are detailed in Appendix A.

We assume that consumers have a preference θ_X for characteristic X equal to 0.8. This preference represents consumers' need for nutrition. The preference for health θ_H is set to 0.2. We vary the value of the preference for the environment θ_Y so that the ratio θ_Y / θ_H varies between 0 and 4. A ratio close to 0 means that the consumer preference for the environment is close to zero or very much lower than the consumer preference for health. A ratio equal to 1 means that the preference for the environment is the same as that for health. The higher the ratio is, the stronger the preference for the environment than for health. For each of the values of this ratio, we calculate the equilibrium prices p_c and p_g, which equalize the supply and demand in different markets and thus the level of public goods supplied. Graph 1 shows the evolution of public good provision at equilibrium in the three economies with labels and at the optimum (social and environmental agency) according to the ratio of preferences for the environment and health and the size of the market.

The environmental label contributes to providing the public good if the price of good g is low. However, even if consumers have high environmental preferences, the strength of environmental labels in stimulating the consumption of good g is lower than that of labels that show the improved nutrition/health benefits for consumers. The performance of health labels compared to the optima depends on the level of consumer preferences for the environment and health. Empirical evidence suggests that in regard to food, consumer preferences for health, a private characteristic, tend to be higher than those for environmental quality (Aldanondo-Ochoa and Almansa-Sáez, 2009; Rudd *et al.*, 2011). This suggests that $\theta_Y < \theta_H$ in most actual market settings; thus, there is a real opportunity for environmental public goods provision to demonstrate and provide information on the complementary health benefits of environmentally friendly food consumption. This case is shown on the left side of the graph, where the ratio θ_Y / θ_H is less than 1. Promoting private attributes, such as health, to stimulate the consumption of environmentally friendly products contributes to the provisioning of more Y than an alternative, such as subsidies driven by the environmental agency. Moreover, in this case, the difference with the Pareto optimal Y is the smallest.

Figure 1: *Evolution of public good provisions.*



We also show that market size does not affect the relative environmental performance of the types of labels. Indeed, with 50 consumers, the environmental label provision will start surpassing the health label provision when preferences for the environment are at least 50 times higher than for health, which is very unlikely in a real life setting. Moreover, the larger the population, the less effective the environmental label and the smaller the difference of provisions between the health and environment label and the health label. This finding suggests that adding information on the joint production of a public characteristic to a label that initially promoted a private characteristic has a negligible environmental impact in a large market.

We can imagine the implementation of an aid to producers to encourage them to have more environmentally friendly practices. In our model, this practice would correspond to a decrease in the marginal cost of production of good g. The equilibrium price of good g would therefore be lower than its price without subsidies. In all labeling scenarios, the provision of public good would be stimulated. Even if the provision of public good is always higher in the case of the health and environment label, the variation of public good provided (with and without subvention) is stronger in the case of the environmental label. An economic incentive for good agricultural practices reduces the gap between the different labels and improves the efficiency of the environmental label compared to other labels.

These results are also dependent on the characteristics of the production technologies used to produce the goods and of the producers, which are in practice very heterogeneous. A producer who is able to adapt to price variations by changing the quantity of inputs used and outputs produced (that correspond to a weaker parameter γ, see Appendix A) will provide more public goods under different labels. On the other hand, a technological improvement that would increase the productivity of the less-polluting input (by further lowering the value of η_g, see Appendix A) would not change the quantity of good g produced but would improve the environmental benefit. This would correspond to an increase in the technological parameter β, which represents the amount of public characteristics provided by the consumption of one unit of good g.

4. Conclusion

In this paper, we investigate the potential of markets for a healthy and environmentally friendly good to contribute to improving environmental public good provisioning. Our model applies when environmentally friendly agricultural practices jointly improve the nutritional quality (or any other intrinsic characteristic) of a food product. That is, when health and environmental characteristics are complementary.

The theoretical analysis provides two main results. First, when consumers only have access to partial information on one of the two complementary characteristics (environment label or health label), only a health label leads to the optimal amount of public good provisioning from the perspective of an environmental agency under certain conditions. Second, providing full information on the public and private characteristics of the food product increases the (i) environmental benefits compared with an ecolabel and (ii) environmental benefits compared with a health label. The extent of this increase depends mainly on the consumers' preferences and market size. Indeed, the difference between a health label and a health and environment label becomes less when consumer preference for health is higher than for the environment.

Our approach relies on several hypotheses. First, we assume no additional cost of labeling on two characteristics rather than one. In practice, the costs of the transaction and the costs of providing, disseminating and processing information in particular are likely to modify market outcomes in many cases. Second, our results are valid under the assumptions of convexity of consumer preferences and the production set. In particular, our assumption of homothetic preferences implies constant income elasticity of demand. For many types of food products, demands for health and environmental quality characteristics are likely to be income elastic (Clements and Si, 2018; Markusen, 2013). In a multiconsumer economy, nonhomothetic utility functions (e.g., with Stone–Geary preferences) could capture income-related effects on the demand for characteristics. One could, for example, assume there is no demand for health and/or environmental quality below a threshold income level. This would result in health labeling having an even stronger positive effect on public goods provision as population income increases. Third, we consider well-defined complementary joint production. Natural processes underlying joint production are complex and often context-dependent. Thus, it might not always be technically feasible to link an agricultural commodity to a measured health and/or environmental attribute.

The combined effects of environmental, nutritional, health and taste characteristics is a topic of many ongoing debates (Bougherara and Combris, 2009). While some complementarities are based on consumers' perceptions without scientific proof, others have been extensively studied and documented. Even if the organic label is initially an environmental label, it can be considered as a health and environment label in our analysis framework since consumers associate a private benefit related to health. Other examples of food labels based on a strict complementarity between health and environmental characteristics do exist. The French quality BBC (Bleu-Blanc-Coeur) branch provides a good illustration. The BBC label was created in the early 2000s to offer consumers differentiated animal products that provide nutritional benefits to human health by enriching the diet of livestock with sources of omega-3 fatty acids (Weill *et al.*, 2002). In parallel to the development of the BBC market, new research has emerged showing that enteric methane emissions decline as ruminant feed is enriched with unsaturated omega-3 fatty (Dong *et al.*, 1997; Grainger and Beauchemin, 2011; Martin *et al.*, 2011, 2008). The availability of new information on the positive environmental impact of the BBC nutritional approach offered new perspectives. In fact, the label now communicates both the nutritional and environmental attributes of dairy products. The nutritional and environmental importance of the BBC approach has by officially recognized by the French government. Our theoretical analysis suggests that a health and environment label such as the BBC label would contribute more to methane emissions abatement than a dairy environmental label to the reduction of enteric methane emissions.

The European Commission recently presented its Farm to Fork strategy as part of the Green Deal with the objective of developing labels promoting both health and environmental benefits. Our results suggest that from an environmental policy perspective, nutritional and health labeling is a relevant tool to increase public goods provisioning and complement agri-environmental subsidies. In addition to supporting the development of labels, policy makers have a role in reducing information asymmetries regarding the reliability and accuracy of the information they carry.

Our findings highlight interesting directions for future research. In a context where consumer preferences for health are strong, knowledge on the impacts of agricultural practices on human health must be strengthened and environmentally friendly agricultural practices that produce healthy food must be encouraged. For example, labeling goods produced without pesticides, for which consumers have a real willingness to pay (Florax *et al.* 2005), seems to be an interesting lever for reducing the use of pesticides. Similarly, it would be interesting to promote research on the evaluation of consumers' willingness to pay for private characteristics (nutrition, health, taste, and social value) for several types of goods produced in an environmentally friendly way. This would allow us to identify the information that should be communicated to consumers via labels.

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Appendix A – Assumptions about the production technology for the simulation

We consider that the producer uses a variable input z (as fertilizer, pesticides) in quantity z_c to produce good c and in quantity z_g to produce good g according to production technologies. We assume that each technology follows a translated quadratic form, which is strictly concave in z (Carpentier and Letort 2012, Femenia and Letort 2016). The price of these inputs is respectively w_c and w_g, and we assume that $w_c < w_g$. The short-term producer's optimization program is written as follows:

$$\max_{z_c, z_g} \Pi = p_c c + p_g g - w_c z_c - w_g z_g$$

$c = \mu_c - \frac{1}{2}\frac{1}{\gamma_c}(\beta_c - z_c)^2$ and $g = \mu_g - \frac{1}{2}\frac{1}{\gamma_g}(\beta_g - z_g)^2$

Solving for the first order condition, we obtained the demand for inputs and the supply of goods g and c at the producer's equilibrium:

$$z_c^* = \beta_c - \gamma_c \frac{w_c}{p_c}$$

$$z_g^* = \beta_g - \gamma_g \frac{w_g}{p_g}$$

$$g_h^* = \mu_g - \frac{1}{2}\gamma_g \left(\frac{w_g}{p_g}\right)^2$$

$$c_h^* = \mu_c - \frac{1}{2}\gamma_c \left(\frac{w_c}{p_c}\right)^2$$

The choice of this form for the production technology allows us to have directly interpretable parameters. Parameters μ_c et μ_g represent the maximum production capacity of the goods c and g. Parameters β_c et $\beta_g$represent the quantity of inputs required to achieve the maximum production of goods. Parameters γ_c et γ_g represent the impact of price ratio on input uses and output supply. The two goods are characterized by different production technologies. To represent the fact that the production of good g is less polluting than the production of good c, we consider that $\mu_g = \mu_c$ and $\beta_g < \beta_c$ which means that less variable inputs considered as polluting are needed to produce good g. We assume that $\gamma_c = \gamma_g = \gamma$. We also assume that the marginal cost of good g is higher than that of good c for a given level of production $\frac{w_g}{(\beta_g - z_g)} > \frac{w_c}{(\beta_c - z_c)}$.

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