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Impure public goods and the comparative statics of environmentally friendly consumption

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Abstract

This paper develops an impure public good model to analyze the comparative statics of environmentally friendly consumption. "Green" products are treated as impure public goods that arise through joint production of a private characteristic and an environmental public characteristic. The model is distinct from existing impure public good models because of the way it considers the availability of substitutes. Specifically, the model accounts for the way that the jointly produced characteristics of a green product may be available separately as well—through a conventional-good substitute, direct donations to improve environmental quality, or both. The analysis provides a theoretical foundation for understanding how demand for green products and demand for environmental quality depend on market prices, green-production technologies, and ambient environmental quality. The comparative static results generate new insights into the important and sometimes counterintuitive relationship between demand for green products and demand for environmental quality.

Keywords: Impure public goods; Green products; Environmental quality

1. Introduction

Consumers are often willing to pay for goods and services that are considered "environmentally friendly" (or "green"), and markets designed to meet this demand are expanding. Market research

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in the United States has found that green products account for 9.5% of all new-product introductions in the economy [15], and analysts have identified the growth and opportunities in green markets as "the next big thing" for small business [13]. The increased availability of green products worldwide has also prompted numerous certification (or "ecolabeling") programs that are designed to verify the environmental claims of thousands of products in more than 31 countries.[1]

Economists have begun to investigate various empirical and theoretical topics related to these green-market trends. The majority of research in this growing literature tends toward one of two categories. The first is empirical research that seeks to determine the factors that influence consumer preferences and willingness to pay for particular green products (e.g., [3,21,22,25]). The second is theoretical research that analyzes the effects of ecolabeling in the context of production decisions, information asymmetries, or international trade (e.g., [7,11,14,20]). While the existing literature addresses many of the important questions surrounding the emergence of green markets, there has been no attempt thus far to develop the general consumer theory that underlies the consumption of all green products. As a result, questions remain about how demand for green products differs from standard theory, and how demand for green products is related to demand for environmental quality.

This paper begins to fill the gap in the literature by developing a general model of environmentally friendly consumption. The model begins with the observation that green products are impure public goods that generate both a private characteristic and an environmental public characteristic. Consider the example of shade-grown coffee, which is coffee grown under the canopy of tropical forests rather than in open, deforested fields. A consequence of this cultivation method, compared to that of conventional coffee, is that shade-grown plantations provide important refuges for tropical biodiversity, including migratory birds. Thus, consumers of shade-grown coffee purchase a joint product that generates coffee consumption (a private characteristic) and conservation of tropical biodiversity (a public characteristic). Other green products—such as green electricity, low-emission vehicles, and sustainably harvested forest products—reveal this same pattern of supplying both a private characteristic and an environmental public characteristic.

The model developed here is distinct from the standard impure public good model (see Cornes and Sandler [4,5]) because of the way it considers the availability of substitutes for the impure public good. Specifically, the model accounts for the way that the jointly produced characteristics of the impure public good may be available separately as well. This possibility is important in the context of green products because consumers often have the opportunity to consume a conventional version of the good and/or make a donation to the associated environmental cause. Consumers of shade-grown coffee, for example, have additional opportunities to consume conventional coffee and to make donations to organizations such as Rainforest Alliance. With other green products, however, such substitute opportunities may be available for the private characteristic only, the public characteristic only, or neither. All of these potential green-market settings are considered in the model developed here, whereas the standard model applies only to settings with no substitute opportunities.

[1] The Global Ecolabeling Network maintains a current list of green-product categories and criteria documents for all ecolabeling programs worldwide. This information is continually updated and is available online at http://www.gen.gr.jp.

The comparative static properties of the model generate the main results. Because utility functions are specified over characteristics of goods rather than over goods themselves, it is possible to distinguish between demand for a green product and demand for environmental quality. With this distinction, it is then possible to examine how changes in the exogenous parameters—including green-production technologies, market prices, and ambient environmental quality—affect not only demand for a green product, but also demand for environmental quality. It turns out, as will be shown, that these two sets of results can differ in important ways.

Several of the general findings are worth summarizing here. First, the comparative static properties of the model are highly dependent on whether substitutes for the green product are available. This implies that, when analyzing environmentally friendly consumption, it is important to consider whether there exist alternative ways to obtain the jointly produced characteristics of a green product—that is, whether there is a conventional-good substitute and/or an opportunity to make a direct donation to the associated environmental cause. Second, the sign of some comparative static results are counterintuitive. For instance, decreasing the price of a green product or improving its technology can actually reduce demand for environmental quality. This surprising result occurs because increased consumption of a green product can crowd out direct donations, with the net effect being a reduction in environmental quality. Finally, many of the comparative static results depend on whether the two characteristics of a green product are complements or substitutes in consumption. These findings demonstrate the importance of clarifying the relationship between preferences for environmental quality and demand for green products.

The remainder of the paper is organized as follows. The next section reviews the setup of Cornes and Sandler's [4,5] impure public good model and shows precisely how and why their model is extended in order to analyze the comparative statics of environmentally friendly consumption. Sections 3–6 use the model to analyze green-market scenarios that differ in terms of whether substitutes for the green product are available. Section 7 discusses general implications and extensions. Section 8 summarizes and concludes.

2. Preliminaries

The standard impure public good model is based on the characteristics approach to consumer behavior, which implies that consumers derive utility from characteristics of goods rather than from goods themselves.[2] Specifically, a representative consumer has preferences over three characteristics—Z, X, and Y—according to a utility function $U(Z,X,Y)$. Characteristics Z and X satisfy properties of a pure private good, while characteristic Y satisfies the non-rival and non-excludable properties of a pure public good. There are two market goods that generate characteristics. One of the goods generates only characteristic Z and is measured in units such that one unit of the good generates one unit of Z; this implies that the notation Z can be used to denote both the good and the characteristic. The other good, denoted g, generates both characteristics X and Y such that one unit of g generates $\alpha > 0$ units of X and $\beta > 0$ units of Y. It follows that the relationship between X and g is given by $X = \alpha g$. The relationship between Y and

[2]See Lancaster [10] and Gorman [8] for the pioneering work on this approach to modeling consumer behavior.

g is a bit more subtle, however. Because Y is a public characteristic, the consumer enjoys her own provision through consumption of g, in addition to the exogenous provision of other consumers and any other sources of Y (such as levels mandated by public policy). Thus, the relationship between Y and g is given by $Y = \beta g + \tilde{Y}$, where $\tilde{Y}$ denotes the exogenously given level of Y.

The good g is referred to as an impure public good because it generates both a private characteristic and a public characteristic. Impure public goods of this type have been interpreted in a variety of ways, with theoretical and empirical applications in the literature ranging from the economics of military alliances to models of philanthropy (e.g., [1,2,4,12,16,19]). Here I interpret g as an environmentally friendly good or service (referred to hereafter as simply a "green product"). As discussed in the introduction, the distinguishing feature of a green product is joint production of a private characteristic (X) and an environmental public characteristic (Y).[3] With this interpretation, the impure public good model provides a framework to begin analyzing demand for green products. In particular, we can analyze how demand for g responds to changes in the green-product technologies (α and β) and exogenous environmental quality ($\tilde{Y}$), in addition to prices and income. Furthermore, by analyzing implicit demand for Y (which is determined by consumption of g), we can see how changes in these same parameters affect demand for environmental quality itself.

There is, however, an important limitation of the standard impure public good model for analyzing environmentally friendly consumption. The model applies only if there are no substitutes for the green product—that is, if consuming g is the only way to obtain characteristic X and augment the level of characteristic Y. Yet this is unlikely to be the case in actual green-market settings. Typically, consumers have opportunities to purchase a conventional version of a green product, or to make a direct donation to the associated environmental cause, or to do both. It was mentioned earlier how consumers of shade-grown coffee have additional opportunities to purchase conventional coffee and to make donations to Rainforest Alliance. In the context of the model, we can now interpret shade-grown coffee as g, and recognize that conventional coffee also generates X, while donations to Rainforest Alliance also provide Y.

In what follows, I extend the comparative static analysis of the impure public good model to include these additional market alternatives. To account for all potential market settings involving consumption of g, I consider three alternative scenarios: one with a conventional-good substitute that generates characteristic X (Section 3), one with the opportunity for donations that directly generate characteristic Y (Section 4), and one with both the conventional-good substitute and the opportunity for donations (Section 6).[4] As part of the analysis, I also compare the results of these

[3]Later in the paper I discuss how all of the results apply equally to green products where the environmental characteristic is not a public good. I also discuss the related notion of "warm-glow" motives for green-product consumption.

[4]Other research has extended the choice setting of the impure public good model in analytically similar ways. Vicary [24] considers the possibility for donations, and Kotchen [9] considers both donations and a private-good substitute. While the latter paper also examines green products, neither paper investigates the comparative static properties of the model in its extended form. The work of Rübbelke [17,18] does consider the comparative static properties of an extended model, yet the setup is different. Rübbelke treats government policies to control greenhouse gas emissions as an impure public good that generates primary (public) benefits and ancillary (private) benefits, while recognizing that alternative policies can also generate the ancillary benefits without the primary benefits. Yet, because the alternative policies are taken as given in his model, the analytical results are more closely aligned with those for the standard impure public good model than with those presented here.

scenarios to those of the standard model (Section 5). It turns out, as we will see, that these different market scenarios have important implications for the consumption of impure public goods in general. And in particular, the results demonstrate how the comparative statics of environmentally friendly consumption depend on whether substitutes for green products are available.

3. Substitute conventional good

This section considers a green-market scenario where, in addition to a green product, consumers have the opportunity to purchase a conventional-good substitute. As a motivating example, consider a green-electricity program in which households can choose to have a portion of their electricity generated with renewable sources of energy. Green electricity is the impure public good (providing electricity consumption and a reduction in pollution emissions) and conventional electricity is the conventional good (providing electricity consumption only). It is assumed in this scenario that consumers do not have the opportunity to make direct donations to reduce emissions, although this possibility will be considered later.[5]

To model this choice setting, we need only modify the setup discussed in the previous section. In addition to the market goods Z and g, there is now a conventional good, denoted c, that generates characteristic X only. To simplify notation, the following assumptions are made about the measured units of characteristics and goods: the units of X and Y are measured such that one unit of g generates one unit of each characteristic (which implies $\alpha = \beta = 1$); the units of the conventional good are measured such that one unit of c generates one unit of X; and Z is a numeraire so that exogenously given prices p_c and p_g are in units of Z.

A representative consumer has exogenous income m and seeks to maximize a strictly increasing and strictly quasiconcave utility function $U(Z, X, Y)$. The consumer's utility maximization problem can be written as

$$\max_{Z,c,g}\{U(Z,X,Y)\,|\,Z + p_c c + p_g g = m, \quad X = c + g, \quad Y = g + \tilde{Y}\}. \tag{1}$$

Examining the Kuhn–Tucker conditions for the solution to this problem reveals that consumption of c will never occur if $p_c \geqslant p_g$; for with this inequality, g provides each unit of X at a weakly lower price than c, and g has the additional benefit of generating a positive amount of Y. In this case, consuming c would never be optimal, and the model would revert back to the standard impure public good model. To rule out this possibility and to maintain the interesting case, it is assumed that $p_c < p_g$. In effect, this assumption identifies a necessary condition for the viability of a conventional good when a green version is available: the conventional good must generate the private characteristic at a strictly lower price, otherwise consumption of the green version would always be preferred.

An alternative and useful way to write the utility maximization problem has the consumer choosing characteristics directly, rather than indirectly through c and g. Using the identities $c = X - g$ and $g = Y - \tilde{Y}$, both c and g can be substituted out of the budget constraint in (1), and

[5]With green electricity, the assumption of no direct donations is reasonable if households are simply unaware that such opportunities exist, or if the public good is local air quality, in which case donation opportunities are exceedingly rare.

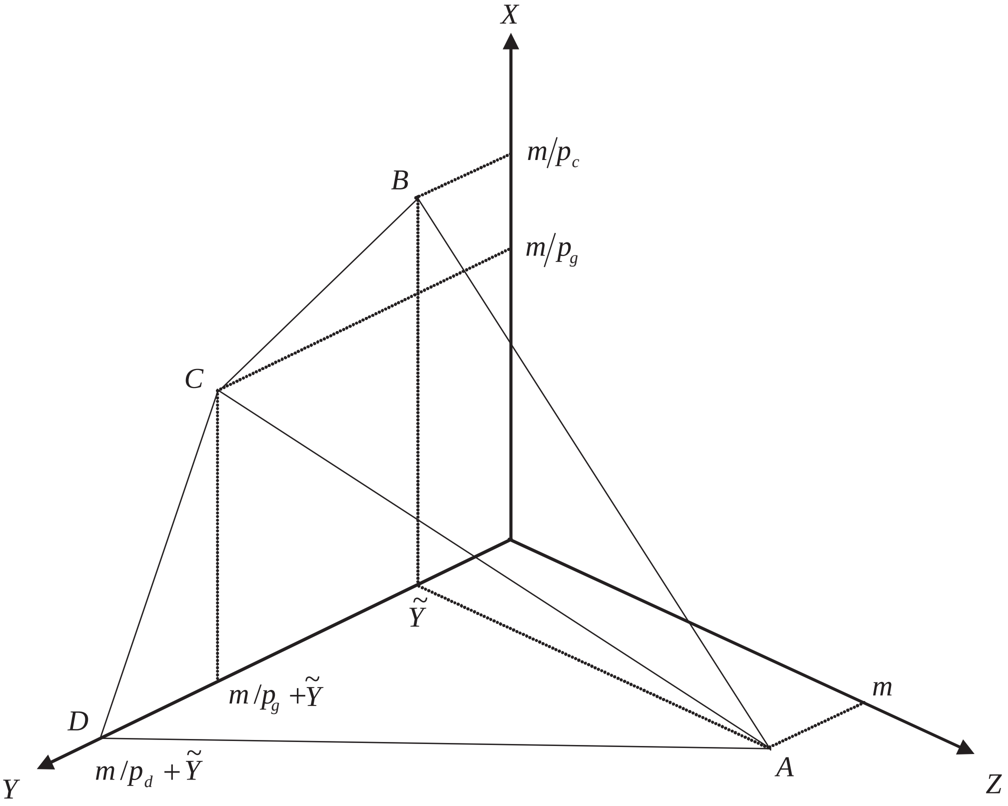

Fig. 1. Budget frontiers in characteristics space.

the consumer's problem can be rewritten as

$$\max_{Z,X,Y} \left\{ U(Z,X,Y) \middle| \begin{array}{l} Z + p_c X + (p_g - p_c)Y = m + (p_g - p_c)\tilde{Y}, \\ 0 \leqslant Y - \tilde{Y} \leqslant X \end{array} \right\}, \tag{2}$$

where p_c and $p_g - p_c$ are the implicit prices of characteristics X and Y, respectively. Note that the implicit price of X is simply the price of the conventional good, and the implicit price of Y is the premium that must be paid for the green version of the good. The budget constraint is written as the "full-income" budget constraint, which includes income plus the value of environmental-quality spillins. The second constraint follows because of the nonnegativity requirements on g and c.[6]

The set of feasible allocations can be seen graphically in Fig. 1 where the plane ABC represents the budget frontier in characteristics space. To see why, consider the following allocations: if all income is spent on Z, the resulting allocation is $(m, 0, \tilde{Y})$ at point A; if all income is spent on c, the resulting allocation is $(0, \frac{m}{p_c}, \tilde{Y})$ at point B; and if all income is spend on g, the resulting allocation is

[6]Because $g \geqslant 0$, the consumer must choose a level of environmental quality Y that is greater than $\tilde{Y}$, which the consumer takes as exogenously given. And because $c \geqslant 0$, augmenting the level of Y above $\tilde{Y}$ requires consuming at least the same amount of X due to the joint production of g.

$(0, \frac{m}{p_g}, \frac{m}{p_g} + \tilde{Y})$ at point C. The frontier ABC, therefore, represents all convex combinations of these points that are feasible and satisfy the full-income budget constraint.[7]

Let us now turn to the analysis of how changes in the exogenous parameters affect demand for environmental quality. Once these results are established, we will then consider how changes in the same parameters affect demand for the green product. Using maximization problem (2), the consumer's demand for environmental quality Y can be written as a function of the implicit prices and full income:

$$\hat{Y}^c = \hat{Y}^c(\pi_y, \pi_x, w), \tag{3}$$

where $\pi_y \equiv p_g - p_c$, $\pi_x \equiv p_c$, $w \equiv m + \pi_y \tilde{Y}$, and the superscript c refers the market scenario that includes a conventional-good substitute. Assuming an interior solution in terms of goods and characteristics (here and throughout), we can differentiate Eq. (3) with respect to any of the exogenous parameters $(m, p_g, p_c, \beta, \alpha, \tilde{Y})$. Letting θ denote any one of these parameters, the comparative static results can be written generally as

$$\frac{\partial \hat{Y}^c}{\partial \theta} = \frac{\partial \hat{Y}^c}{\partial \pi_y} \cdot \frac{\partial \pi_y}{\partial \theta} + \frac{\partial \hat{Y}^c}{\partial \pi_x} \cdot \frac{\partial \pi_x}{\partial \theta} + \frac{\partial \hat{Y}^c}{\partial w} \cdot \frac{\partial w}{\partial \theta},$$

or with more compact notation as

$$\hat{Y}^c_\theta = \hat{Y}^c_{\pi_y} \pi_{y\theta} + \hat{Y}^c_{\pi_x} \pi_{x\theta} + \hat{Y}^c_w w_\theta.$$

Now substituting in the Slutsky decomposition yields

$$\hat{Y}^c_\theta = (\bar{Y}^c_{\pi_y} - \hat{Y}^c \hat{Y}^c_w)\pi_{y\theta} + (\bar{Y}^c_{\pi_x} - \hat{X}^c \hat{Y}^c_w)\pi_{x\theta} + \hat{Y}^c_w w_\theta, \tag{4}$$

where $\bar{Y}^c_{\pi_j}$ for $j = y, x$ denotes the compensated price responses. Expression (4) demonstrates how changes in demand for environmental quality can be understood in terms of familiar substitution and income effects. Changes in any one of the parameters may cause a change in one or both of the implicit prices, giving rise to the substitution and full-income effects in the first two bracketed terms, each of which is multiplied by the change in the corresponding implicit price. The third term captures the fact that a change in any one of the parameters may also cause a change in full income itself, in which case the effect is multiplied by the actual change in full income. In what follows, we will solve (4) explicitly for changes in each of the parameters.

Let's begin with a change in income m, which results in $\hat{Y}^c_m = \hat{Y}^c_w$. This follows because a change in m changes full income by the same amount (since $w \equiv m + \pi_y \tilde{Y}$), but has no effect on either of the implicit prices. In general, the sign of $\hat{Y}^c_w$ will depend on whether environmental quality is a normal or an inferior good. It is assumed here that environmental quality is a normal good; that is, $\hat{Y}^c_m = \hat{Y}^c_w > 0$. Thus, by assumption, demand for environmental quality is increasing in income.[8]

[7]We will return to other parts of Fig. 1 in subsequent sections.

[8]The normality assumption is made in order to focus on the most reasonable case and to sign results in a way that helps build intuition about the main contributions of the analysis. It is, however, straightforward to reinterpret all of the results to the case in which environmental quality is an inferior good.

Now consider changes in the market prices. The effect of a change in p_g can be written as

$$\hat{Y}^c_{p_g} = \bar{Y}^c_{\pi_y} - \hat{g}^c\hat{Y}^c_w < 0.$$

The sign of this expression follows because the substitution effect is always negative and the income effect is assumed to be positive. The implication is that demand for environmental quality is decreasing in the price of the green product. This result is intuitive: an increase in p_g causes an increase in the price of environmental quality (since $\pi_y = p_g - p_c$), which then causes a decrease in the quantity demanded.

The effect of a change in p_c is a bit more subtle:

$$\hat{Y}^c_{p_c} = -\bar{Y}^c_{\pi_y} + \bar{Y}^c_{\pi_x} - \hat{c}^c\hat{Y}^c_w. \tag{5}$$

The sign of this expression is ambiguous. Consider the two substitution effects that arise with an increase in p_c. The first comes from a decrease in π_y (since $\pi_y = p_g - p_c$). The second comes from an increase in π_x (since $\pi_x = p_c$). These two effects are captured in the first and second terms of (5), respectively. The sign of the own-price effect $\bar{Y}^c_{\pi_y}$ is always negative. Yet the sign of the cross-price effect $\bar{Y}^c_{\pi_x}$ depends on whether X and Y are substitutes or complements.[9] In either case, the overall sign of (5) remains ambiguous because $\bar{Y}^c_{\pi_y}$ and $\hat{Y}^c_w$ have opposite signs.

Changes in the technology parameters of the green product can be analyzed in the same way. A change in β changes the amount of Y generated by each unit of g, and this, in turn, changes the implicit price of obtaining Y.[10] As a result, the effect on demand for Y from a change in β can be written in terms of a change in p_g:

$$\hat{Y}^c_\beta = -\pi_y(\bar{Y}^c_{\pi_y} - \hat{g}^c\hat{Y}^c_w) = -\pi_y\hat{Y}^c_{p_g} > 0.$$

Note that this expression has the opposite sign of a change in p_g. This follows because, for example, an increase in β decreases π_y, which is the opposite effect of an increase in p_g. In terms of magnitudes, a change in β differs from a change in p_g by multiplication of π_y, which is the implicit price of the characteristic associated with β. The effect of a change in α follows a similar pattern:

$$\hat{Y}^c_\alpha = -\pi_x(\bar{Y}^c_{\pi_y} + \hat{g}^c\hat{Y}^c_w) = -\pi_x\hat{Y}^c_{p_g} > 0.$$

The only difference is that, relative to a change in p_g, the effect is multiplied by π_x, which is the implicit price of the characteristic associated with α.

Finally, consider a change in exogenous environmental quality $\tilde{Y}$. This result can be written as

$$\hat{Y}^c_{\tilde{Y}} = \pi_y\hat{Y}^c_w = \pi_y\hat{Y}^c_m > 0,$$

which differs from a change in income m by the multiplication of π_y. The reason for this relationship follows from the definition of full income, $w = m + \pi_y\tilde{Y}$, which shows how π_y affects the value of a change in $\tilde{Y}$ but not in m. Although the sign of $\hat{Y}^c_{\tilde{Y}} > 0$, it is worth noting that whether $\hat{Y}^c_{\tilde{Y}}$ is greater than or less than 1 has an important interpretation in terms of the

[9]Throughout the paper, substitutes and complements are defined in terms of the Hicksian (or "Net") definitions of substitutability and complementarity.

[10]To see this effect, it is helpful to recognize that the general expression for the implicit price of Y is $\pi_y = \frac{p_g - \alpha p_c}{\beta}$, for which $\pi_y = p_g - p_c$ is a special case with the normalization $\beta = \alpha = 1$.

Table 1
Summary of qualitative comparative static results

	c and g[a]		d and g		g only	
	Substitutes[b]	Complements	Substitutes	Complements	Substitutes	Complements
$\hat{Y}_m$	+	+	+	+	+	?
$\hat{Y}_{p_g}$	–	–	?	–	–	?
$\hat{Y}_{p_c}$	?	?	na	na	na	na
$\hat{Y}_{p_d}$	na[c]	na	–	?	na	na
$\hat{Y}_\beta$	+	+	?	+	?	?
$\hat{Y}_\alpha$	+	+	?	+	?	?
$\hat{Y}_{\tilde{Y}}$	+	+	+	+	+	?
$\hat{g}_m$	+	+	+	+	+	?
$\hat{g}_{p_g}$	–	–	–	–	–	?
$\hat{g}_{p_c}$	?	?	na	na	na	na
$\hat{g}_{p_d}$	na	na	?	?	na	na
$\hat{g}_\beta$	+	+	+	+	?	?
$\hat{g}_\alpha$	+	+	+	+	?	?
$\hat{g}_{\tilde{Y}}$	?	?	+	+	?	?

[a]This row indicates goods that are available in the market in addition to the numeraire Z.
[b]This row indicates whether the characteristics X and Y are Hicksian substitutes or complements.
[c]na stands for not applicable in the corresponding market scenario.

crowding-out of private provision of environmental quality. $\hat{Y}^c_{\tilde{Y}} < 1$ implies crowding-out of less than one-for-one, and $\hat{Y}^c_{\tilde{Y}} > 1$ implies crowding-in.

Having established the results for $\hat{Y}^c_\theta$, it is now straightforward to derive the comparative statics properties of demand for the green product. Given the relationship $\hat{g}^c = \hat{Y}^c - \tilde{Y}$, we can write these results generally using parallel notation:

$$\hat{g}^c_\theta = \hat{Y}^c_\theta - \tilde{Y}_\theta, \tag{6}$$

where $\tilde{Y}_\theta \equiv d\tilde{Y}/d\theta$ and is equal to zero for changes in all parameters other than $\tilde{Y}$, when it equals 1. Eq. (6) implies that $\hat{g}^c_\theta$ has the same sign as $\hat{Y}^c_\theta$ for all parameters other than $\tilde{Y}$, in which case $\hat{g}^c_{\tilde{Y}} = \hat{Y}^c_\theta - 1$. Note that this latter result demonstrates how the crowding-out or crowding-in of private provision occurs with adjustments in $\hat{g}^c$; the particular case depends on whether $\hat{Y}^c_\theta < 1$ or > 1, respectively. The signs of the results for $\hat{g}^c_\theta$, along with those for $\hat{Y}^c_\theta$, are summarized in the first two columns of Table 1. We will return to these results later as we consider the different market scenarios.

4. Substitute donations

This section analyzes a green-market scenario where a conventional version of the green product is *not* available, but there *is* the opportunity to make a direct donation to the associated environmental cause. Sustainably harvested products from tropical rainforests (such as nuts) provide a motivating example. While there may be no conventional-good substitutes for these products (such as similar nuts not from rainforests), aiding in the conservation of rainforests is possible not just through consumption of the sustainably harvested products, but also through direct donations to organizations such as Rainforest Alliance.

How do the comparative statics differ in this market scenario? We can answer this question by following steps similar to those in the previous section. The standard model must be modified to include the option for a direct donation to Y. Let d denote a donation level that is measured in units of Y, and let p_d denote the price of providing a unit of Y through a direct donation.

The consumer's utility maximization problem for this market scenario can be written as

$$\max_{Z,g,d}\{U(Z,X,Y)\,|\,Z+p_g g+p_d d=m,\quad X=g,\ \ Y=g+d+\tilde{Y}\}. \tag{7}$$

Just as an assumption was necessary in the previous section to maintain viability of c, an assumption is necessary here to maintain viability of d: it is assumed that $p_d<p_g$. This assumption implies that increasing the level of Y through donations d is less costly than through consumption of g. For without this condition, it would never be optimal to make a donation, and maximization problem (7) would be equivalent to that for the standard impure public good model.[11]

We can now substitute g and d out of the budget constraint in (7) using the identities $g=X$ and $d=Y-\tilde{Y}-g$. Then, the utility maximization problem can be written in terms of choices over characteristics:

$$\max_{Z,X,Y}\left\{U(Z,X,Y)\left|\begin{array}{l}Z+(p_g-p_d)X+p_dY=m+p_d\tilde{Y},\\ 0\leqslant X\leqslant Y-\tilde{Y}\end{array}\right.\right\},$$

where the implicit prices of X and Y are now p_g-p_d and p_d, respectively. The first constraint is the full-income budget constraint, and the second constraint follows because of the nonnegativity requirements on g and d.

The budget frontier for this problem is represented by the plane ACD in Fig. 1. As discussed previously, the points A and C correspond to the loci in characteristics space where all income is spent on either Z or g, respectively. But now the frontier also includes the locus where income is spent entirely on d, which is the allocation $(0,0,\frac{m}{p_d}+\tilde{Y})$ at point D. It follows that the plane ACD consists of all convex combinations of these points that satisfy the full-income budget constraint.

Using notation parallel to that in the previous section, demand for environmental quality can be written as a function of the implicit prices and full income:

$$\hat{Y}^d=\hat{Y}^d(\pi_y,\pi_x,w), \tag{8}$$

where, in this market scenario, $\pi_y\equiv p_d$, $\pi_x\equiv p_g-p_d$, and $w\equiv m+\pi_y\tilde{Y}$. With this expression, we can analyze the comparative statics of demand for environmental quality. Then, mirroring the order of the previous section, we can derive similar results for the green product.

[11]The assumption $p_d<p_g$ implicitly assumes after-tax prices for all goods in the model. It is interesting to note, however, that donations can be tax deductible, while expenditures on green products are often subject to sales tax. If we were to make these features explicit in the model, the assumption could be written as $p_d(1-\delta)<p_g(1+\tau)$, where p_d and p_g are the pre-tax prices, δ is the marginal tax deduction, and τ is the marginal sales tax. The effect of both δ and τ is to make the assumption easier to satisfy.

The effect of a change in p_g on demand for environmental quality is

$$\hat{Y}^d_{p_g} = \bar{Y}^d_{\pi_x} - \hat{g}^d \hat{Y}^d_w, \tag{9}$$

which includes a cross-price substitution effect and an income effect. The sign of $\bar{Y}^d_{\pi_x}$ is negative (positive) if X and Y are complements (substitutes), and the sign of $\hat{Y}^d_w (= \hat{Y}^d_m)$ is positive by assumption. It follows that the overall sign of (9) is negative if the two characteristics are complements; otherwise it will depend on the relative magnitudes of the substitution and income effects. Note that the possibility for $\hat{Y}^d_{p_g} > 0$ is somewhat counterintuitive. Intuition might suggest—as we saw earlier—that demand for environmental quality is decreasing in the price of the green product; however, this is not necessarily the case if X and Y are substitutes or the income effect is sufficiently small.[12] The reasoning behind this result is worth emphasizing. Consider a decrease in p_g. This decreases π_x because obtaining X becomes less costly through consumption of g. The decrease in π_x encourages substitution toward X, and because X and Y are Hicksian substitutes, there is also a substitution effect away from Y. Thus, assuming the cross-price substitution effect is larger than the income effect, a decrease in the price of the green product results in a decrease in demand for environmental quality. But what must occur with consumption of g and d to generate this result? It turns out that demand for g increases, but demand for d decreases such that the net effect on environmental quality is negative. This possibility gives rise to an important observation: an increase in demand for a green product does not necessarily improve environmental quality, as increased consumption of the green product can crowd-out direct donations.

Prior intuition can be similarly misleading when it comes to the effect of a change in p_d. A decrease in the price of providing environmental quality through donations is *not* necessarily beneficial for environmental quality. The analytical result of a change in p_d is

$$\hat{Y}^d_{p_d} = \bar{Y}^d_{\pi_y} - \bar{Y}^d_{\pi_x} - \hat{d}^d \hat{Y}^d_w,$$

and the sign of this expression is ambiguous. To see why, consider a decrease in p_d. This has an effect on both implicit prices: a decrease in π_y because providing Y becomes less expensive through d, and an increase in π_x because obtaining X becomes relatively more expensive through g. The first effect unambiguously causes substitution towards environmental quality, but the second does so only if X and Y are substitutes, in which case both substitution effects and the income effect imply that $\hat{Y}^d_{p_d} < 0$. If, however, characteristics X and Y are complements, the net effect on environmental quality is ambiguous, and it is possible for a decrease in the price of a donation to decrease demand for environmental quality.

The effects on demand for Y from changes in the technology parameters of the green product follow a pattern similar to that in the previous section.[13] These results are

$$\hat{Y}^d_{\beta} = -\pi_y(\bar{Y}^d_{\pi_x} - \hat{g}^d \hat{Y}^d_w) = -\pi_y \hat{Y}^d_{p_g}$$

[12]With quasilinear preferences of the form $U(Z, X, Y) = Z + F(X, Y)$, for example, there are no income effects and X and Y being substitutes implies $\hat{Y}^d_{p_g} > 0$.

[13]Here it is helpful to recognize that in general the implicit price of X will be $\pi_x = \frac{p_g - \beta p_d}{\alpha}$, and $\pi_x = p_g - p_d$ is a special case when $\beta = \alpha = 1$.

and

$$\hat{Y}^d_\alpha = -\pi_x(\bar{Y}^d_{\pi_x} - \hat{g}^d \hat{Y}^d_w) = -\pi_x \hat{Y}^d_{p_g}.$$

The sign of both expressions is the opposite of that for a change in p_g, and the magnitudes differ by the multiplication of the implicit price of the characteristic that corresponds to the change in technology. The fact that the sign of both expressions can be negative if X and Y are substitutes results in another important observation: improving either the private- or public-characteristic technology of a green product can result in lower demand for environmental quality.[14] In such cases, demand for the green product increases, but at the expense of a decrease in direct donations that is more than offsetting.

The final parameter to consider is a change in exogenous environmental quality $\tilde{Y}$. The effect of a change in this parameter on demand for environmental quality is $\hat{Y}^d_{\tilde{Y}} = \pi_y \hat{Y}^d_w > 0$, which mirrors the result from the previous market scenario. A change in $\tilde{Y}$ operates like a change in m, but differs according the implicit price π_y. And, once again, whether $\hat{Y}^d_{\tilde{Y}}$ is less than (greater than) 1 determines whether there is crowding-out (crowding-in) of private provision of environmental quality.

We can now turn to the comparative statics of demand for the green product. Unlike the previous scenario, these results do not follow directly from those for demand for Y. This is because, in this scenario, implicit demand for environmental quality depends not only on demand for the green product, but also on donations (recall that $Y = g + d + \tilde{Y}$). Thus, changes in $\hat{g}^d$ cannot be identified from changes in $\hat{Y}^d$ alone, as they also depend on changes in $\hat{d}^d$. It is, however, possible to identify changes in $\hat{g}^d$ from changes in demand for the private characteristic X, which can be written as $\hat{X}^d = \hat{X}^d(\pi_y, \pi_x, w)$. With this demand function, we can use the technological relationship $\hat{g}^d = \hat{X}^d$ to express the comparative statics of demand for the green product as $\hat{g}^d_\theta = \hat{X}^d_\theta$. Because most of these results are symmetric to those in the previous section, they are not derived here; however, the qualitative results for $\hat{g}^d_\theta$ are summarized in Table 1, along with those for $\hat{Y}^d_\theta$.[15]

Compared to the previous market scenario, the only notable difference with respect to demand for the green product occurs with a change in $\tilde{Y}$. It is always the case that $\hat{g}^d_{\tilde{Y}} > 0$, whereas we saw previously how a change in $\tilde{Y}$ can have an ambiguous effect on demand for g. The difference is due to the fact that, in this market scenario, crowding-out will affect donations, but not demand for the green product. Thus, an increase in $\tilde{Y}$ increases full income, which increases demand for X and therefore must increase demand for g (since $\hat{g}^d = \hat{X}^d$).

5. No substitutes

It is possible for the market to offer a green product, but *neither* a conventional-good substitute *nor* an opportunity to make a direct donation to the associated environmental cause. This

[14] This will occur, for example, with quasilinear preferences of the form in footnote 12 or when income effects are sufficiently small.

[15] The qualitative results for $\hat{g}^d_\theta$ are based on the assumption that demand for X satisfies normality, just as the results for $\hat{g}^c_\theta$ are based on the assumption that demand for Y satisfies normality.

green-market scenario is consistent with the setup of the standard impure public good model. Drawing on the work of Cornes and Sandler [5,6], this section summarizes the comparative static results for this market scenario and highlights how they differ from those considered previously.

With choices over the green product and the numeraire only, the consumer's utility maximization problem can be written as

$$\max_{Z,g}\{U(Z,X,Y)\,|\,Z+p_g g=m,\ \ X=g,\ \ Y=g+\tilde{Y}\}. \tag{10}$$

Again, it is useful to transform the maximization problem to consider choices over characteristics. Using the identity $g=X$ to substitute g out of maximization problem (10) yields

$$\max_{Z,X,Y}\{U(Z,X,Y)\,|\,Z+p_g X=m,\quad X=Y-\tilde{Y}\}.$$

The budget frontier for this problem is defined by two linear constraints and is represented by the line segment AC in Fig. 1. As discussed previously, the points A and C correspond to the loci in characteristics space where all income is spent on either Z or g, respectively. In this case, the budget frontier is simply all convex combination of these two allocations that satisfy the two linear constraints. Note that the frontier AC corresponds to the boundary between the budget frontiers of the two previous market scenarios.

The fact that the budget frontier is a line segment in (Z,X,Y) space, rather than a plane, has important implications for the comparative static analysis. Unlike the previous scenarios, we cannot calculate directly the implicit prices of characteristics X and Y or full income. Instead, the analysis must rely on "virtual" prices and income, which together define a hypothetical plane that is tangent to the consumer's indifference surface at the chosen point on segment AC. Cornes and Sandler [5,6] provide a detailed discussion of the method for deriving these virtual magnitudes—which are functions of the exogenous parameters—and for using them to analyze the comparative statics of the model. Here I only summarize their results, and readers interested in the details are referred to the original source. It is, however, helpful to recognized that the results are derived with steps similar to those encountered in the previous sections. In particular, the comparative statics are based on partial differentiation of a demand function for environmental quality: $\hat{Y}^g=\hat{Y}^g(\pi_y,\pi_x,w)$, where the arguments are now the virtual prices and full income, and the superscript g denotes the scenario with no substitutes for the green product.

Using consistent notation, the effect of a change in m on demand for environmental quality can be written as

$$\hat{Y}^g_m=[(\bar{X}^g_{\pi_y}-\bar{X}^g_{\pi_x})\hat{Y}^g_w+(\bar{Y}^g_{\pi_x}-\bar{Y}^g_{\pi_y})\hat{X}^g_w]\,\frac{1}{\Omega}, \tag{11}$$

where $\Omega\equiv\bar{X}^g_{\pi_y}+\bar{Y}^g_{\pi_x}-\bar{X}^g_{\pi_x}-\bar{Y}^g_{\pi_y}>0$.[16] This expression is more complicated than those encountered previously because the choice setting is more restrictive. Demand for X and Y are inextricably linked through consumption of g; that is, changes in demand for both X and Y are restricted by the constraint $\hat{X}^g=\hat{Y}^g-\tilde{Y}$. The important insight that follows from (11), compared to the previous market scenarios, is that the sign is generally ambiguous, even if both

[16]Negative semidefiniteness of the matrix of compensated price responses implies that $\Omega\geqslant 0$, which is assumed to hold strictly.

characteristics are normal goods. For example, it is possible for the sign of (11) to be negative if X and Y are complements.[17] However, if X and Y are substitutes, the sign of (11) is always positive.

The effect of a change in p_g on demand for environmental quality is

$$\hat{Y}^g_{p_g} = (\bar{X}^g_{\pi_y}\bar{Y}^g_{\pi_x} - \bar{X}^g_{\pi_x}\bar{Y}^g_{\pi_y})\frac{1}{\Omega} - \hat{g}^g\hat{Y}^g_m. \tag{12}$$

Here again the result is a bit more complicated, but it follows a familiar pattern. The bracketed term accounts for all of the own- and cross-price substitution effects, and it is always positive.[18] The second term includes the income effect that we have seen already. The overall sign of (12) is positive if X and Y are substitutes (which implies $\hat{Y}^g_m < 0$), yet it is ambiguous if they are complements (which implies that the sign of $\hat{Y}^g_m$ is ambiguous). Thus, for the case of complements, it is once again possible for demand for environmental quality to be increasing in the price of the green product.

Changes in the technology parameters of the green product will affect demand for environmental quality according to

$$\hat{Y}^g_\beta = -\pi_y\hat{Y}^g_{p_g} + \hat{g}^g(\bar{Y}^g_{\pi_y} - \bar{Y}^g_{\pi_x})\frac{1}{\Omega}$$

and

$$\hat{Y}^g_\alpha = -\pi_x\hat{Y}^g_{p_g} + \hat{g}^g(\bar{Y}^g_{\pi_y} - \bar{Y}^g_{\pi_x})\frac{1}{\Omega}.$$

The first term in both expressions is familiar: a change in either the private- or public-characteristic technology of the green product operates like a change in p_g, but has the opposite sign and is weighted by the change in the corresponding implicit price. The second terms are new and arise because of the more restrictive choice setting. The surprising result is that the sign of both expressions is ambiguous, regardless of whether X and Y are compliments or substitutes. Thus, once again, improvements in the technology of a green product need not increase demand for environmental quality.

The final comparative static result with respect to demand for environmental quality is that for change in $\tilde{Y}$:

$$\hat{Y}^g_{\tilde{Y}} = \pi_y\hat{Y}^g_m + (\bar{Y}^g_{\pi_x} - \bar{Y}^g_{\pi_y})\frac{1}{\Omega}. \tag{13}$$

The first term mirrors the results from the previous market scenarios, but an additional term enters once again. It turns out that the sign of (13) is positive if X and Y are substitutes; otherwise it is ambiguous.

The last two columns of Table 1 summarize the qualitative results for $\hat{Y}^g_\theta$. The most striking feature of these result is the fact that many of the signs are ambiguous. As described above, the reason stems from the way that consumers have little flexibility to choose their mix of characteristics. Feasible allocations are restricted to a line segment in (Z, X, Y) space, and the only possible response to a change in an exogenous parameter is a change in consumption of g.

[17] It will be the case that $\hat{Y}^g_m < 0$ if $\bar{Y}^g_{\pi_y} < \bar{Y}^g_{\pi_x} (= \bar{X}^g_{\pi_y}) < \bar{X}^g_{\pi_x} < 0$. See [5,6] for a detailed discussion.

[18] Negative semidefiniteness of the matrix of compensated price responses implies that $\bar{X}^g_{\pi_y}\bar{Y}^g_{\pi_x} - \bar{X}^g_{\pi_x}\bar{Y}^g_{\pi_y} \geqslant 0$, which is assumed to hold strictly.

Accordingly, changes in demand for Y are inseparable from changes in demand for X, and this inseparability introduces more ambiguity than was evident in the previous market scenarios, where there is an additional degree of freedom from which to choose the optimal allocation of X and Y.

The last two columns of Table 1 also summarize the qualitative results for demand for the green product. These follow directly from the identity $\hat{g}^g_\theta = \hat{Y}^g_\theta - \tilde{Y}_\theta$, which is the same as that used in Section 3. It follows that all of the results for $\hat{g}^g_\theta$, with the exception of $\hat{g}^g_{\tilde{Y}}$, have the same sign as the corresponding result for $\hat{Y}^g_\theta$. Changes in $\tilde{Y}$ will be an exception when $0 < \hat{Y}^g_{\tilde{Y}} < 1$, which is the case of incomplete crowding-out. In this case, an increase in $\tilde{Y}$ results in greater demand for environmental quality, but demand increases by less than the exogenous supply. As a result, private provision $(\hat{Y}^g - \tilde{Y})$ decreases, which implies a decrease in demand for the green product.

6. Substitute conventional good and donations

The most general market scenario involving a green product is one that offers both a conventional-good substitute *and* the opportunity to make a direct donation to the associated environmental cause. The example of shade-grown coffee was mentioned earlier, along with the additional opportunities to purchase conventional coffee and to make a donation to Rainforest Alliance. This section examines the comparative statics of environmentally friendly consumption in this general green-market scenario. The analysis, as we will see, relies on the results of the previous sections.

With the complete choice setting—involving Z, c, g, and d—the utility maximization problem can be written as

$$\max_{Z,c,g,d}\left\{ U(Z,X,Y) \,\middle|\, \begin{array}{l} Z + p_c c + p_g g + p_d d = m, \\ X = c + g, \;\; Y = g + d + \tilde{Y} \end{array} \right\}. \tag{14}$$

It is straightforward to show that the assumptions $p_c < p_g$ and $p_d < p_g$ are still necessary to maintain viability of consumption of c and a donation d. In this case, a third assumption is also necessary to maintain the possibility for consumption of g: it is assumed that $p_g < p_c + p_d$. This assumption ensures that the cost of obtaining characteristics X and Y jointly through g is less than the cost of obtaining them separately through c and d.[19] Without the assumption, and thereby viability of g, the model would be equivalent to the standard model of private provision of a *pure* public good.[20]

An important observation about the solution to maximization problem (14)—along with the assumption $p_g < p_c + p_d$—is that a consumer will never consume c *and* make a donation d. This

[19]Referring back to the tax policies mentioned in footnote 11, the assumption that $p_g < p_c + p_d$ could also be modified to take account of sales taxes and tax-deductible donations. This would imply $p_g(1+\tau) < p_c(1+\tau) + p_d(1-\delta)$, which demonstrates how both sales taxes and tax-deductible donations make it more difficult for green products to be viable.

[20]The assumption also ensures a unique solution to maximization problem (14). For if it were the case that $p_g = p_c + p_d$, a unique solution would not be guaranteed, as different bundles of goods could generate the same quantities of characteristics at the same cost.

follows because any combination of X and Y that arises with positive amounts of c and d could be obtained at a lower cost by increasing g and reducing c and d.[21] The fact that the solution to (14) will never include both $c>0$ and $d>0$ implies that we can rewrite the budget constraint as satisfying two inequality constraints: $Z + p_c c + p_g g \leqslant m$ and $Z + p_g g + p_d d \leqslant m$, where the first constraint will bind if $d = 0$, and the second constraint will bind if $c = 0$. Using the identities $X = c + g$ and $Y = g + d + \tilde{Y}$, it is possible to substitute c, g, and d out of the constraints and to rewrite (14) with choices over characteristics:

$$\max_{Z,X,Y}\left\{ U(Z,X,Y) \middle| \begin{matrix} 0Z + p_c X + (p_g - p_c)Y \leqslant m + (p_g - p_c)\tilde{Y}, \\ Z + (p_g - p_d)X + p_d Y \leqslant m + p_d \tilde{Y}, \;\; Y \geqslant \tilde{Y} \end{matrix} \right\}.$$

The budget frontier for this problem is shown in Fig. 1 as both of the planes ABC and ACD. With $\hat{d} = 0$, the first budget constraint will bind, and the chosen point will lie somewhere on the plane ABC. With $\hat{c} = 0$, the second budget constraint will bind, and the chosen point will lie somewhere on the plane ACD. Finally, with $\hat{d} = 0$ and $\hat{c} = 0$, both budget constraints will bind, and the chosen point will lie somewhere on the line segment AC. Note the direct correspondence between these three cases and the more restricted market scenarios that were considered previously.

We can rely on the results from the previous sections to derive the comparative static properties of this more general market scenario. Denote demand for environmental quality as $\hat{Y} = \hat{Y}(p_c, p_g, p_d, \alpha, \beta, \tilde{Y}, m)$, where there is no superscript in this general scenario. Then, for a change in any parameter θ, the comparative statics of demand for environmental quality can be written as follows:[22]

$$\hat{Y}_\theta = \begin{cases} \hat{Y}^c_\theta & \text{if } \hat{c}>0 \text{ and } \hat{d} = 0 \\ \hat{Y}^d_\theta & \text{if } \hat{c} = 0 \text{ and } \hat{d}>0 \\ \hat{Y}^g_\theta & \text{if } \hat{c} = 0 \text{ and } \hat{d} = 0. \end{cases}$$

Furthermore, the comparative statics of demand for the green product can be written as

$$\hat{g}_\theta = \begin{cases} \hat{g}^c_\theta & \text{if } \hat{c}>0 \text{ and } \hat{d} = 0 \\ \hat{g}^d_\theta & \text{if } \hat{c} = 0 \text{ and } \hat{d}>0 \\ \hat{g}^g_\theta & \text{if } \hat{c} = 0 \text{ and } \hat{d} = 0. \end{cases}$$

These expressions demonstrate how the effect of changes in the exogenous parameters will depend on whether the initial consumption bundle includes consumption of the conventional-good substitute, or a direct donation, or neither.

[21]As a result, interior solutions with respect to characteristics will involve consumption of g up to the point where demand for X or Y is satisfied, along with consumption of c, *or* donations d, *or* neither.

[22]An implicit assumption is that changes in the exogenous parameters are small enough so that the consumer's chosen allocation remains on the same section of the budget frontier before and after the change.

7. Discussion

The previous sections demonstrate how the comparative statics of environmentally friendly consumption depend on the availability of substitutes for green products. But why might the jointly produced characteristics of a green product be available separately in some cases, but not in others? One possible explanation—as in the case of rainforest nuts—is that close substitutes are simply nonexistent. Another possible explanation has to do with technological efficiency. Assuming competitive markets, where prices equal marginal costs, the assumptions throughout about relative prices—$p_c < p_g$, $p_d < p_g$, and $p_g < p_c + p_d$—identify technology requirements for market viability of c, d, and g, respectively. If any of these conditions are not satisfied, the corresponding good is technologically inefficient at generating its characteristics, and we would not expect the market to offer such alternatives.

Looking across the rows of Table 1, the effects of price changes on demand for a green product are generally as one would expect. The demand function is downward sloping (except when there are no substitutes for g and X and Y are complements), and changes in the price of other goods can either increase or decrease demand. The effect of changes in the green-product technologies are also intuitive in cases with simultaneous consumption of the conventional-good substitute or direct donations: improvements in either of the technologies of the green product increase demand for it. However, these intuitive results do not necessarily apply in the most restrictive case involving consumption of the green product only.

What do we learn from the comparative statics of demand for environmental quality? An important insight is that intuitive results for green products do not necessarily imply intuitive results for environmental quality. Consider the case where the jointly produced characteristics of the green product are substitutes and there are donations. The results demonstrate that a decrease in the price of the green product or improvements in either of its technologies can actually reduce demand for environmental quality. These counterintuitive results follow because such changes in the exogenous parameters not only increase demand for the green product; they also decrease the implicit price of its private characteristic, which is a substitute for environmental quality. Thus, demand for environmental quality decreases, and this occurs through a reduction in donations that more than offsets the increase in environmental quality from green-product consumption. This possibility highlights the importance—when considering the likely effects of green-product consumption on environmental quality—of taking into account (i) whether the characteristics of green products are substitutes or complements in consumption, and (ii) the interaction between the consumption of green products and direct donations to improve environmental quality.

The last two points for discussion extend the interpretation of the model. The first extension considers an alternative way to interpret the parameter β. Rather than view β as representing a technology, we can think of it as representing the level of awareness that consumers have about the environmental benefits associated with a particular good or service. With no awareness, $\beta = 0$, and consumers perceive green products to be conventional products that are characterized by α only. With greater awareness, β increases, and the comparative static analysis demonstrates the potential effects on product demand and environmental quality. To the extent that green marketing and ecolabeling programs are intended to increase awareness, the model thus provides a framework for understanding the relationship between environmental information about goods and services and environmentally friendly consumption. Developing this perspective is important, as economists and policymakers are coming to view information-based approaches as the third wave of environmental policy, following the first wave of command-and-control regulations and the second wave of market-based instruments [23].

The second extension of the model considers alternative motives for the consumption of green products. Throughout this paper, we have interpreted green products as impure public goods. This implies that green-product consumption is a form of private provision of an environmental public good. But what if the jointly produced characteristics of a green product generate private benefits only? For instance, the relevant characteristics of organic produce may be nutrition and fewer risks to personal health from pesticides—both of which are private benefits. It is also possible that consumers who purchase green products do so because it simply makes them feel good about "doing their part" to protect the environment. In other words, green-product consumption may be motivated by "warm glow," rather than provision of a public good.[23] It turns out that the model is useful for analyzing these cases as well. We need only reinterpret Y as another private characteristic—such as health benefits or warm glow—and set $\tilde{Y} = 0$, since there are no spillins of a private characteristic. With these modifications, all of the comparative static results remain unchanged.

8. Conclusion

This paper develops a general model of environmentally friendly consumption. It begins with the observation that green products can be interpreted generally as impure public goods, with joint production of a private characteristic and an environmental public characteristic. The model is distinct from existing treatments of impure public goods because of the way it considers the availability of substitutes. Specifically, there is consideration of different market scenarios in which the jointly produced characteristics of a green product are available separately as well—through a conventional-good substitute, direct donations to improve environmental quality, or both.

The comparative static properties of the model generate the main results and provide a theoretical foundation for understanding how demand for green products and demand for environmental quality depend on market prices, production technologies, and exogenously given environmental quality. The sign of many of the comparative static results depend on the availability of substitutes for the green product, especially on whether there are opportunities to make a direct donation to the associated environmental cause. Furthermore, the sign of many results depends to a large extent on whether consumer preferences are such that the jointly produced characteristics of a green product are substitutes or complements in consumption. Taken as whole, the analysis considers new choice settings for the consumption of impure public goods, in addition to providing a number of insights into the relationship between demand for green products and demand for environmental quality. Among these results are the surprising findings that increased demand for a green product or improvements in a green product's technology can have detrimental effects on environmental quality.

Future research should consider empirical applications of the model. All of the comparative static results generate testable hypotheses. Indeed, there are an increasing number of

[23]See Andreoni [2] for further discussion of warm-glow motives for private provision of public goods.

opportunities for empirical studies, as markets for green products continue to expand, along with programs and policies designed to increase the awareness of environmental information on goods and services. Combining the theoretical analysis of this paper with empirical evidence would generate insight into the ways in which markets for green products actually affect environmental quality. The combined perspective would also improve the understanding of the potential relationship between environmentally friendly consumption and public policies for environmental protection.

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