How much does your environment matter?

Estimating demand with interdependent preferences

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1 Introduction

2 Consumer choice in markets with environmental labels

This paper focuses on consumer choice among products with and without environmental labels. Discrete choice models, where consumers choose among several products and purchase exactly one product at each such occasion, provide an appropriate analytical framework for such a discussion. These demand models describe products as bundles of characteristics, following Lancaster (1971) and McFadden(1974, 1981) and consumer preferences are defined over these characteristics. The environmental impact of a product, the pollution emitted during production, consumption and disposa, is one of these characteristics.

Environmental impact, however, is not a standard characteristic like color, packaging or size. First of all it is not observable directly for the consumer, because much of the pollution generated throughout the life-cycle of the product is linked to production or disposal. Environmental labels address exactly this problem by signaling the otherwise unobservable environmental impact to consumers. This signal may be noisy, but nonetheless it indicates the firm's effort.

Secondly, even if environmental impact was directly observable, it is unlikely that the consumer's purchase decision would affect her environment directly. The reason for this being that consumption decisions are both geographically and temporally separated from production and transportation that generate large part of the environmental impact of the product, to put it simple the consumer usually lives far away from the factories and makes her choice after the product was already manufactured. Although these two aspects imply that consumers are at best only indirectly affected by these choices it is nevertheless plausible that if everybody would choose products with reduced environmental impact each consumer would be better off. This suggests that environmental impact of consumption goods is best described as a public good (bad).

Indeed, Kotchen (2006) presents a model where consumer choices over products with environmental labels are interpreted as choices over impure public goods, where the public good aspect is the reduced environmental impact signalled by the environmental label. This perspective allows one to treat "green markets" as examples for the private provision of public goods. A long line of research in behavioral economics (summarized for example in Fehr and Fischbacher, 2003) analyzed behavior in public good experiments and provided strong evidence that people are not exclusively motivated by the immediate individual payoffs. Fehr, Fischbacher and Gächter (2001) show that experimental subjects behave as "conditional cooperators" who are willing to contribute in a public good game if they expect others to do so as well. Moreover, Fehr and Gächter (2002) and Rege and Telle (2002) point out the importance punishments and the expression of social disapproval in maintaining such behavior. Theories that explain such behavior cover a wide range including social norms (Bernheim,1994, Brock and Durlauf, 2001 or Brekke, Kverndokk and Nyborg, 2003) and reciprocity (Sugden, 1984 or Fehr and Gächter, 2000).

The following discussion applies the model of Kotchen (2006) to a discrete choice framework and demonstrates how the main behavioral traits identified by public good experiments can be incorporated. The resulting model has two main differences compared to Kotchen (2006). First, it defines consumer choices over a set of products rather then quantities of a pure public good, a pure private good and an impure public good. Second, the present model allows not only for pure altruism as the explanation for the private contributions to the public good, but also takes into account "warm glow" or "unconditional cooperation" and conditional cooperation based on reciprocity or social norms as possible motivations for contributions. The resulting model is similar to Andreoni's (1990) formulation of impure altruism.

2.1 The model of consumer choice

Assume that there are $i = 1...N$ individuals who choose one product out of $j = 1...J$ alternatives. Indicate these choices by the binary variable y_{ij} that takes the value of one if individual i chooses product j and zero otherwise. Products are characterized by a vector of K characteristics, $\mathbf{x}_j = [x_{1j}, x_{2j}, ..., x_{Kj}]$, and an implied public good contribution g_j. Accordingly, the public good contribution of individual i can be expressed as $g_i = \sum_j y_{ij} g_j$.To keep notation simple it is assumed that $\mathbf{x}_j$ includes income of i minus price of product j as well. The public good aspect of the alternatives implies that consumer choices will be influenced not only by the product characteristics $\mathbf{x}_j$ and g_j but also by the total provision of the private good by other consumers, which will be denoted as $G_{-i} = \sum\limits_{n \neq i} g_n$. Besides these deterministic components discrete choice models of consumer behavior account also for factors that are unobservable for the researcher but influence consumer choice by including random utility component by ε_{ij} with joint probability distribution $F(\varepsilon_{i1}, ..., \varepsilon_{iJ})$. Assuming that the random component is additive to the representative utility part the individual i's indirect utility function is usually expressed as:

$$U_{ij} = V_i(\mathbf{x}_j, g_j, G_{-i}) + \varepsilon_{ij}. \tag{1}$$

In such a formulation $V_i(\mathbf{x}_j, g_j, G_{-i})$ depends on other consumers choices (y_{nj}) through $G_{-i} = \sum\limits_{n \neq i} \sum\limits_{j} y_{nj} g_j$ and because choices are probabilistic this implies that $V_i(\mathbf{x}_j, g_j, G_{-i})$ is stochastic as well. Therefore the consumer's decision will be based on the expected representative utility:

$$V_i(\mathbf{x}_j, g_j) = \sum_{j_1}, ... \sum_{j_{i-1}}, \sum_{j_{i+1}}, ..., \sum_{j_N} \prod_{n \neq i} \Pr\left(y_{nj_n} = 1 | \mathbf{x}_j, g_j\right) V_i(\mathbf{x}_j, g_j, G_{-i}). \tag{2}$$

where j_k is the product choice index of individual k and $\Pr\left(y_{kj} = 1 | \mathbf{x}_j, g_j\right)$ is the probability that individual k chooses alternative j given the product characteristics. Then the consumer's utility maximizing choices will be described by the following probabilities:

$$P_{ij} = \Pr(\varepsilon_{ik} - \varepsilon_{ij} < V_i(\mathbf{x}_k, g_k) - V_i(\mathbf{x}_j, g_j), \forall k \neq j). \tag{3}$$

These probabilities form a demand system for the J different alternatives in which only utility differences among alternatives matter for the consumer's decision.

In order to arrive to a fairly general specification of $V_i(\mathbf{x}_j, g_j, G_{-i})$ one has to consider carefully the motivations of the consumer regarding the public good provision. Three cases will be considered:

1. Pure altruism, the classical assumption in the public good literature, which implies that it is aggregate contribution $G_j = g_j + G_{-i}$ that matters for the individual[1] yielding $V_i(\mathbf{x}_j, g_j + G_{-i})$. In this case individual i's contribution and the other consumers' contributions to the public good are perfect substitutes.

2. Warm glow or unconditional cooperation, which imply that only the individual's own contribution g_j matters in her decision, yielding $V_i(\mathbf{x}_j, g_j)$. Warm glow giving

[1]Note that usually total contribution $Y = y_i + y_{-i}$, and does not vary with j. This is so because mostly it is assumed that the consumer optimizes over the quantity of her contribution y_i, implicitly through Y. In the current case, however the consumer can choose among j different type of contributions y_j by choosing one of the products.

is used to describe the case when decisionmakers derive utility from the simple fact of giving (Andreoni, 1990) and do not care about the actions of other decisionmakers.

3. Conditional cooperation, which implies that the utility derived from individual contributions is dependent on other consumers' contributions. One example is the impure altruism concept of Andreoni (1989) that specifies individual utility as $V_i(\mathbf{x}_j, g_j + G_{-i}, g_j)$ and includes both pure altruism and warm glow as special cases. Another formulation based on conformity to social norms or reciprocity cab be expressed as $V_i(\mathbf{x}_j, g_j \frac{G_{-i}}{N-1})$, which implies that other consumers' average contribution and individual i's contribution are complements.

An empirical model of demand for environmentally labelled products should incorporate all these forms of behavior. Before turning to the full specification of the demand model, however, it is worth to discuss the functional form of $V_i(\mathbf{x}_j, g_j, G_{-i})$, because in the discrete choice demand literature a linear specification is assumed most of the time (see for example ABBP, 2007). Although this assumption seems to be innocent, it has serious consequences for the separability of the different behavioral motivations. More specifically, in the pure altruism case the linear formulation implies that the representative utility is:

$$V_i(\mathbf{x}_j, g_j + G_{-i}) = \beta_i \mathbf{x}_j + \theta_i(g_j + G_{-i}), \tag{4}$$

where vector $\boldsymbol{\beta}_i$ and scalar θ_i are individual specific parameters. Because only utility differences ammong alternatives matter for the consumer's decision and $\theta_i G_{-i}$ is constant across alternatives the pure altruism case is equivalent to the warm glow specification $(V_i(\mathbf{x}_j, g_j) = \boldsymbol{\beta}_i \mathbf{x}_j + \theta_i g_j)$. To differentiate between the two cases complementarity of the product characteristics and the public good contributions has to be assumed. An example for such a specification for pure altruism is:

$$V_i(\mathbf{x}_j, g_j + G_{-i}) = \boldsymbol{\beta}_i \theta_i (g_j + G_{-i}) \mathbf{x}_j \tag{5}$$

where $\boldsymbol{\beta}_i \theta_i G_{-i} \mathbf{x}_j$ will differentiate this case from the warm glow case. The conditional cooperation case under the linear utility assumption is:

$$V_i(\mathbf{x}_j, g_j, G_{-i}) = \boldsymbol{\beta}_i \mathbf{x}_j + \theta_i G_{-i} g_j, \tag{6}$$

which can be differentiated from the other two cases.

In order to incorporate the discussion on the different types of behavioral motivation and the possible role of complementarity between private and public product characteristics the following specification is suggested:

$$V_i(\mathbf{x}_j, g_j, G_{-i}) = \boldsymbol{\beta}_i \mathbf{x}_j + \theta_{1i} g_j + \theta_{2i} \frac{G_{-i}}{N-1} g_j + \theta_{3i} g_j \mathbf{x}_j + \theta_{4i} \frac{G_{-i}}{N-1} \mathbf{x}_j. \tag{7}$$

The choice of average contribution by other consumers ($\frac{G_{-i}}{N-1}$) instead of total contributions reflects the assumption that it is rather reciprocity or social norms that steer individual behavior than a classical public good effect. This is plausible since the reduction in environmental impact is difficult to quantify for the consumer.

The discussion so far assumed that the implied contribution of each product to the public good is directly observable, that is consumers have preferences directly over g_j and G_{-i}. As it was pointed out, however, consumers observe only the signal of the environmental label L_j. Throughout the paper I will assume that the environmental label implies a standardized environmental improvement across all products and that the signal it conveys to the consumer is fully credible and without noise, that is:

$$g_j = \delta L_j. \tag{8}$$

Substituting this expression into (7) yields the following utility function:

$$V_i(\mathbf{x}_j, L_j, L_{-i}) = \beta_i \mathbf{x}_j + \theta_{1i} \delta L_j + \theta_{2i} \frac{\delta L_{-i}}{N-1} \delta L_j + \theta_{3i} \delta L_j \mathbf{x}_j + \theta_{4i} \delta L_j \frac{\delta L_{-i}}{N-1} \mathbf{x}_j, \tag{9}$$

where $L_{-i} = \sum\limits_{n \neq i} \sum\limits_{j} y_{nj} L_j$ is the number of environmentally labelled products purchased by consumers other than i. Then taking expectations over other agents' choices the expected representative utility for individual i is:

$$V_i(\mathbf{x}_j, L_j) = \boldsymbol{\beta}_i \mathbf{x}_j + \theta_{1i} \delta L_j + \theta_{2i} \delta^2 P^L L_j + \theta_{3i} \delta \mathbf{x}_j L_j + \theta_{4i} \delta^2 P^L \mathbf{x}_j L_j \tag{10}$$

where $P^L \equiv E\left(\frac{L_{-i}}{N-1}\right) = \frac{1}{N-1} \sum\limits_{k \neq i} \sum\limits_{j} E(y_{kj}) L_j = \sum\limits_{j} P(y_{kj} = 1 | \mathbf{x}_j, L_j, \boldsymbol{\theta}) L_j$ is the probability that a labelled product will be chosen by the consumer given the product characteristics and the taste parameters $\boldsymbol{\theta} = [\boldsymbol{\beta}_i, \theta_{1i}, \theta_{2i}, \theta_{3i}, \theta_{4i}, \delta]$. Because δ cannot be identified it will be normalized to 1 that is the other coefficients will take up its effect.

The final aspect of the utility function specification that is left unresolved is the treatment of individual heterogeneity. So far it was only assumed that individual specific parameters express taste differences across consumers. Nevertheless an estimable empirical specification requires to either assume a theoretical distribution of these parameters or proxy them with observable individual attributes. In this paper the later strategy is used. Denote the vector of individual i's attributes by $\mathbf{z}_i = [z_{1i}, z_{2i}, ..., z_{Ri}]$, then the individual specific parameter θ_{1i} will be modelled as:

$$\theta_{1i} = \sum_{r=1}^{R} \theta_{1r} z_{ri}, \tag{11}$$

and all other individual specific parameters in $\boldsymbol{\theta}$ are modelled this way.

Finally, a relatively simple specification will be assumed for the random part of the utility:

$$\varepsilon_{ij} \sim \text{iid Type I Extreme value}, \tag{12}$$

yielding the following choice probabilities:

$$P_{ij} = \Lambda\left(\beta_i \mathbf{x}_j + \theta_{1i} L_j + \theta_{2i} P^L L_j + \theta_{3i} \mathbf{x}_j L_j + \theta_{4i} P^L \mathbf{x}_j L_j\right), \tag{13}$$

where Λ denotes the logit function.

The main difference between (13) and a usual discrete choice demand system is the presence of the terms involving P^L. To see the implications of this property for identification aggregate choice probabilities across individuals and labelled products:

$$P^L = \sum_j L_j \int \Lambda\left(\beta_i \mathbf{x}_j + \theta_{1i} L_j + \theta_{2i} P^L L_j + \theta_{3i} \mathbf{x}_j L_j + \theta_{4i} P^L \mathbf{x}_j L_j\right) f\left(\mathbf{z}_i | \mathbf{x}_j\right) d\mathbf{z}_i. \tag{14}$$

This expression defines an equilibrium condition for P^L. Therefore individual conditional choice probabilities (13) and the equilibrium condition (14) jointly specify the demand system. The equilibrium beliefs (P^L) about the mean choice probability of environmentally labelled products is endogenously determined in this system and this implies that the interaction terms involving P^L will be endogenous in such models. In effect such a demand system forms a discrete game and the next section discusses the identification conditions of these.

3 Identification of demand systems with interdependent preferences

3.1 Identification of static games

3.2 Assumptions about firm behavior

4 Data

5 Empirical specification and results

6 Conclusion

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