Conjunctive Screening in Models of Multiple Discreteness

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Consumer demand for products often result in the purchase of multiple goods at the same time. Corner solutions, or the non-purchase of items, occur when consumers have strong preference for some goods that do not satiate and weak preference for other goods. However, if non-purchase arises because a consumer finds particular brands and attributes unacceptable, leading to the formation of consideration sets, then estimates of preference will be too extreme and biased. In this paper, we extend the work on consideration sets and discrete choices to a wider class of models, and develop a model of multiple discreteness with conjunctive screening of the alternatives that remove offerings from consideration. We propose a simple method for consideration set formation that does not require one to specify a partitioned space of the augmented variable, and that can be adapted into any model specification to remove an outcome variable from the model likelihood function.

The consumer's set of considered brands is comprised of up to J goods and an outside good, z. We assume decreasing marginal utility for all goods, implying that consumers satiate in their preferences, and that utility is additively separable. Screening in the model is reflected in the indicator function Ij, which is equal to one if alternative j is included in the consideration set and is equal to zero otherwise. Consumers maximize their utility subject to constraints and consideration:

$$\text{Max } u(x,z) = \sum_{j=1}^{J} \frac{\psi_j}{\gamma} \ln(\gamma x_j + 1) I_j + \ln(z) \quad \text{subject to} \quad \sum\nolimits_{j=1}^{J} p_j x_j I_j + z \leq E$$

where

$$I_j = \prod_{d=1}^{D} [1 - \tau_d \times I(A_{j,d} = 1)] \times I(p_j < \tau_p)$$

where the indicator function Ij accounts for screening behavior and enters both the utility function and budget constraint. In this formulation, x_j is the purchase quantity of good j, ψ_j captures the baseline preference for good, γ is a satiation parameter, and p_j is a price. We define ψ_{jt} as follows:

$$\psi_{jt} = \exp(a_j\beta + \varepsilon_{jt})$$

where β is the vector of `part-worths', a_j is the design vector for alternative j. The matrix A specifies the presence of attributes for the products, with $A_{jd} = 1$ indicating that good j has attribute d. The parameter $\tau_d \in \{0,1\}$ indicates whether the attribute d is used to screen alternatives.

In the estimation, the heterogeneity in the model parameters are captured as follow:

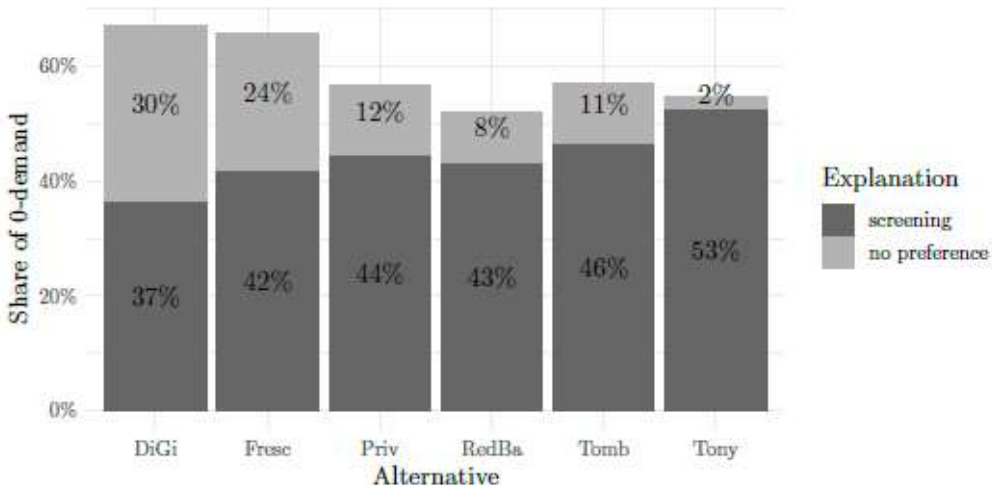
$$\tau_{dh} \sim \text{Bernoulli}(\delta_d)$$
$$\ln\tau_p \sim N(\delta_p, \sigma_p)$$
$$\theta_h \sim N(\bar{\theta}, V_\theta)$$

where δ_d captures the aggregate propensity of attribute d being used in the screening process, δ_p is the log-price threshold, and $\theta_h = (\beta_h, ln\sigma_h, ln\gamma_h, lnE_h)$

We apply the proposed model to two conjoint datasets that were collected from national panels, ice cream and frozen pizza purchases.

First, in the ice cream data, responses are both discrete and volumetric. This allows us to compare differences in how screening affect purchase incidence versus volumetric demand per incidence. The models with screening fit to the purchase data better than do models without screening in both discrete and volumetric demand.

Secondly, in the frozen pizza data, we find that conjunctive screening accounts for many of the observed corner solutions and leads to estimates of preference and satiation that differs from traditional models of multiple-discreteness without screening. We explore implications for disentangling non-purchase due to consideration set formation. The proposed model allows for calculation of an inclusion probability due to the presence of specific attributes, distinguishing zero demand driven by non-consideration versus lack of preference. The figure below provides the summary for the two sources of zero demand for each alternative.



where {DiGi, Fresc, Priv, RedBa, Tomb, Tony} are the brand names used in the study, i.e., {DiGiorno, Frescetta, Prialte Label, Red Baron, Tombstone, Tony's}. The share of corners based on screening varies between 37% for DiGiorno and 53% for Tony's pizza. Thus, a large proportion of observed zero demand is due to consumer screening and general lack of interest in the offering.

The presence of consideration sets in choice has implications for product formulation and optimization, particularly when consumers are unresponsive to attribute levels within the region needed for consideration set inclusion. When this occurs, specific respondents will tend to be accepting of small changes in the formulation of an offering, so long as they retain the alternative in their consideration set. Product optimization then shifts from the search for

attribute levels that maximize the likelihood of purchase, to the levels that maximize the likelihood of consideration. We show that the presence of a consideration set in consumer choices results in different implications for expected demand calculation and product formulation. Our method to incorporate screening mechanism can be incorporated into any model likelihood for discrete and continuous demand.

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