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Are preferences for food quality attributes really normally distributed? An analysis using flexible mixing distributions

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ABSTRACT

We empirically question the commonly invoked assumption of normality of taste distribution in mixed logit models with continuous random parameters. We use a WTP-space random utility discrete choice model with flexible distributions on data from two choice experiments regarding beef with nested set of quality attributes. We specifically focus on distributional features such as asymmetry, multi-modality and range of variation, and find little support for normality. Our results are robust to attribute dimensionality in experimental design. Implications of our results for practitioners in the field are discussed.

1. Introduction

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Product differentiation is a strategic tool for food market operators. Success in this area is heavily reliant on market information derived from reliable methods to analyse differentiated consumer preference. As a consequence, the mixed logit models choice data analysis introduced by Revelt and Train in 1998 were enthusiastically embraced by empirical researchers in food choice (Bonnet and Simioni, 2001; Cicia et al., 2002; Lusk and Schroeder, 2004; Alfnes et al., 2006; Rigby and Burton, 2006) and are still widely used (Ortega et al., 2011; Caputo et al., 2013; Scarpa et al., 2013; van Wezemael et al., 2014; De Marchi et al., 2016; Bazzani et al., 2017). Operationalizing mixed logit models, however, requires assumptions on mixing preference distributions for the sampled population.

The question of what statistical distribution should be selected to model random taste coefficients to avoid unwarrented (and sometimes unintended) impacts in terms of data fit and welfare estimates, still poses serious empirical challenges to analysts. Like others before us, we start by observing that the assumptions on which these models are predicated, despite being often strong and crucial to the conclusions, are most often left unpersuasively justified. The contribution of this article is to explore the effectiveness of recently introduced tools for a robust investigation of common assumptions. Specifically, we offer some significant results on range, asymmetry and multimodality of taste distributions, which we deem as substantive for the future practice of food choice analyses. Our results also have significant implications for conceptual models of consumer demand whose results may be questionable given their reliance on the assumption of uniform preferences (e.g., Crespi and Marette, 2003; Lapan and Moschini, 2007; Giannakas and Yiannaka, 2008).

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The use of various types of preference mixing—finite, continuous or a combination thereof—is by now the presumptive approach in the field of food choice, and it has been in many other areas of application (e.g., environmental, health and transport economics). Yet, most published studies fail to explicitly report investigations on the sensitivity of their results to the sometimes crucial distributional assumptions under which they are derived. Futhermore, such assumptions are often predicated on weak arguments and motivation including operational convenience (e.g., such as mathematical tractability), and comparisons of fit with alternative distributional assumptions. In this context, it is worth highlighting that consistency of maximum likelihood estimates holds only under the correct specification, and applies only probabilistically to the "comparatively" best specification, especially when all the elements in the set of comparison share some shortcomings (e.g., all imply symmetry to the mean).

Almost universally in our review of food choice applications, when the selected model allows for continuous mixing of preferences, it relies on parametric distributions (normal, log-normal, triangular, uniform, etc.). This approach is attractive because it reduces the space of parameters needed for model fit (e.g. from quantiles to only first and second central moments), but it overly simplifies matters, thereby ruling out several behaviourally plausible features of taste distributions, such as limited range, asymmetry, strong skewness and multimodality. This leads to inadequate conclusions, that often fit oddly in the face of common sense or even of mere introspection. Such discomfort has been expressed several times before and traces of it can be found in the concluding remarks of several previous papers approaching the issue from various persectives (Train and Sonnier, 2005; Cherchi and Polak 2005; Burton et al., 2009). Warnings of significant biases due to erroneous distributional assumptions have been issued since the adoption of the mixed logit methodology. Yet, the issue has continued to receive little, if any, attention in empirical analyses of food choice.

To move the field forward, we explore the use of more robust approaches that can enable analysts to openly explore behaviourally realistic distributional structures of food taste. In practice, this requires the adoption of flexible distributional forms, such as mixture of parametric, semi-parametric or non-parametric approaches. There is some obvious resistance to adopting these approaches, as they are bound to be somewhat more complex to implement and tend to deliver the additional features at relatively large sample sizes (Franceschinis et al., 2017). Thus, a successful solution needs to be sufficiently practical to have wide applicability. In moving from a standard parametric description of preference variation to a more flexible one, the analyst faces several unfamiliar challenges linked to taste distributions. In this article, we focus on three important distribution features: the definition of the range of variation, symmetry and multi-modality. These features have obvious and important repercussions for the computation of statistical expectations and quantiles, which are crucial statistics in policy decisions. An example is the well-known so-called "fat-tail" problem (for a recent review see Parsons and Myers, 2016).

Throughout the article, we use a recently proposed semi-parametric choice model: the Logit-Mixed Logit (LML) developed by Train (2016) to explore the sensitivity of our results to the three distributional features mentioned above. This model allows for extremely flexible mixing distributions, that can accommodate asymmetry and multimodality, but it requires setting the range of variation. Hence, we also explore the stability of results in distributional outcomes by varying the range (the empirical support of the distribution). In addition, in response to recent works on the effect of context in food choice (Gao and Schroeder, 2009; and Caputo et al., 2017), we also explore the sensitivity of our distributional results across food attribute types (e.g., cue and independent) when increasing the number of attributes (from three to five) in the discrete choice experiment design and associated utility functions. Finally, to make the article more salient to recent tendencies in food choice, we specify random utility models specified in WTP-space, so as to avoid scale issues and focus on value distributions.

This study contributes to the existing literature of consumer food preference analysis in two important ways. First, we observe that by mostly invoking normality, the great majority of food choice studies[1] using continuous mixing tend to systematically fail to explore the plausibility of distributional assumptions to multimodality, asymmetry and range of variation. All of these features are of potential relevance to policy. Two of these issues (multimodality and asymmetry) were addressed in Scarpa et al. (2008a,b), but they only applied a flexible semi-parametric distribution to one of the various random coefficients in their specification and they specify a model in preference space. The present food choice study is the first to simultaneously address all three of these issues for all random coefficients, using utility in WTP-space by means of a flexible semi-parametric distribution. Our approach moves away from the standard assumptions of normality without excluding them.

Second, to the best of our knowledge, this is the first food choice study exploring the sensitivity of different distributional features across cue and independent attributes when extending the attribute space. As argued by Gao and Schroeder (2009) and Caputo et al. (2017), the way consumers value a 'cue' attribute (described as one whose levels correlate with the levels of other potentially absent attributes) and an independent attribute (relates to the physical aspects of the product whose information stands alone) can depend on the attribute space. Hence, this study adds to this stream of literature by showing that consumers would not only value these attributes differently across design dimensions, but also by suggesting that cue and independent attributes might be systematically characterized by different distributional features and context dependency.

More notably, this study adds to the emerging choice modeling literature by providing a specific exploration of estimates' sensitivity

[1] The food choice literature accounts for over 200 studies using choice experiments on food choice selection. By limiting ourselves to the top 5 journals in the field of agricultural economics, which were selected according to their article influence score (http://www.eigenfactor.org/about.php) and the ISI Web of Knowledge Journal Citations Report, table A1 in the appendix reports the food choice experiment papers published since 2013 in the following peer-reviewed journals: *Food Policy, American Journal of Agricultural Economics, European Review of Agricultural Economics, Journal of Agricultural Economics, and Australian Journal of Agricultural and Resource Economics*. Results clearly demonstrate that most of the published studies on food choice experiments are based on MXL models that assume normal distribution for the non-monetary random taste parameters, and that none of these studies have explored the plausibility of distributional assumptions to multimodality, asymmetry, and range of variation.