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Executive Summary

Using Multidimensional Item Response Theory Models to Explain Multi-Category Purchases

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This paper adds to the literature of multi-category purchase decisions in which one assumes that the choice of one product might impact purchases of other products. Products that are being purchased together by a household are said to form a market basket. Typical examples of market baskets that result from purchases in a supermarket are, e. g., milk and cereals or bread and butter.

To uncover the relationships between various products that can be purchased together, we apply multidimensional item response theory models (MIRT). So far, these models have been applied in, e. g., educational and psychological testing. Based on households' market baskets, MIRT are able to analyse the relationships between purchases of different products. They summarise products, which are typically purchased together, within latent traits. In fact, MIRT can be compared to factor analytic models with the advantage of being able to deal with data that are categorical instead of metric. We estimate various MIRT and compare their performance to another class of models, namely topic models, that have been applied in previous research.

We use an IRI data set that contains 8,531 weekly transactions of 1,237 households across 31 different product categories. We aggregate transactions per households and generate two different data sets (binary and polytomous). The binary data set consists of zeros (when a household has not made a purchase from a certain product category and ones (when a purchase has taken place). In the polytomous data set we incorporate the frequency of purchases.

In total, we estimate four types of models (MIRT and topic models that are each applied to the two data sets). We find that MIRT are superior over topic models for the binary and the polytomous data set. Within MIRT, the model which is applied to the polytomous data set performs slightly better. Based on this model we observe four latent traits that show for each latent trait which product categories are generally purchased together:

latent trait 1: groceries related,
latent trait 2: tissue related,
latent trait 3: drugstore related,
latent trait 4: indulgent food related.

Marketers can use information on latent traits in the following ways: For instant, products that are associated with a latent trait are usually purchased together. If a latent trait does not consist of too many products or product categories these could be offered together, either on the same shelf of a traditional shop or on the same page of an online shop. Regarding latent trait four from our study this would imply that a shop manager could arrange a shelf to the following product categories: beer/ale/alcoholic cider, carbonated beverages, salty snacks, frozen pizza, and dummies of cigarettes (to apply with legal restrictions). As another example, latent

traits can also be used to predict expected purchase frequencies of a product category for households. If a shop manager has more detailed information on households like, e. g., socio-demographic attributes she or he can combine this pool of information with the expected purchase frequencies. Due to this, households can be targeted directly depending their needs and further characteristics.