

Master Thesis Proposal

How costly is sustainability for a company with configurable products? Analytical results from assortment optimization.

Global warming is one of the most important challenges in the current century. Not only citizens, but governments and companies must contribute to ensure a sustainable future and to avoid negative effects like extreme weather events. Currently, ~14 % of greenhouse gas emission come from transportation (Umpfenbach, 2017). Many industries emit carbon dioxide in both, production and in the supply chain. The car manufacturing industry is a prime example where not only the location of production but also the configuration of the product can have major impact on the environmental footprint. Car manufactures shift production capacity between different locations as capabilities are globally redundant. The emissions can be further decreased as more and more sustainable alternatives are available (like an electric engine). A decrease in emissions results in many cases in profit loss. How costly is sustainability for a company with configurable products?

The optimal offer of configurable products is a strongly researched academic area. Two streams regard the same problem from different angles. First, product line design decides on the number of products while designing each product in one step. Second, assortment optimization (AO) only decides which product among a predefined set should be offered to maximize e.g., profit. A discrete demand model is in many cases assumed. The multinomial logit model is, due to its mathematical properties and its good empirical results, one of the most famous discrete demand models. The importance of each attribute can be reflected with a customer utility function. Additional cost structures (e.g., for R&D or logistics) or interdependencies between variables caused by attribute decisions are not reflected in most research papers. Most works in the AO field focus on methods for solving variants of the basic AO problem formulation but the models typically neglect the implications that specific attributes like sustainability have beyond the customer utility function, e.g. on supply chain design and related cost (Kök, Fisher, & Vaidyanathan, 2008). Exemplary, the work from Şen et al. (2018) presents a solution method for assortment optimization models under mixed logit demand using a conic formulation. While little to no work has been done on incorporating sustainability considerations into assortment optimization models, one exception is Umpfenbach (2017) who analyses the impact of emission reduction on a car company's assortment and supply chain decisions as well as on the resulting profitability.

The objectives of this thesis are to:

- review discrete choice models and the impact of sustainable attributes on customers demand behavior,
- position the paper of Umpfenbach (2017) in the stream of assortment optimization incorporating discrete choice models. Further review additional literature which considers sustainability attributes in optimization models and discuss limits as well as challenges,
- in addition, analyze the paper of Umpfenbach (2017) and discuss the contribution,

- implement the model from Umpfenbach (2017) in AMPL with McCormick inequalities and either extend the model or adopt it to a different configurable product industry (like computer or household appliances),
- conduct a sensitivity analysis to analyze the research question and outline limits of the model,
- and provide open research gaps and future trends together with model improvements.

Recommended basic literature:

Umpfenbach, E. et al. (2017). Promoting sustainability of automotive products through strategic assortment planning, *European Journal of Operational Research*.
<http://dx.doi.org/10.1016/j.ejor.2017.08.031>

Kök, A. G., Fisher, M. L., & Vaidyanathan, R. (2008). Assortment planning: Review of literature and industry practice. *In Retail supply chain management (pp. 99–153)*. Springer.

Şen, Alper; Atamtürk, Alper; Kaminsky, Philip. (2018). Technical Note—A Conic Integer Optimization Approach to the Constrained Assortment Problem Under the Mixed Multinomial Logit Model. *In Operations Research* 66 (4), pp. 994–1003. DOI: 10.1287/opre.2017.1703.