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A Literature Review on Demand Models in Retail Assortment Planning

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Abstract

A retailer assortment is defined as the mix of products carried by a retail store. Assortment planning (AP) is a process of selecting types and number of product to be kept from a given product line and also to determine the optimal level of inventory of these products. The assortment optimization problem in the literature varies because of the type of demand models considered by the authors or because of the context of the problem considered. Various authors have developed models in past that cater to various objectives associated with shelf-space allocation and assortment decisions. It has been observed that the demand estimation in any assortment planning problem mostly considered shelf-space and substitution parameters. In the current work, the assortment planning problem dealt by various researchers primarily with shelf-space and substitution effect consideration will be reviewed.

Keyword: Assortment Planning, Demand Models, Shelf-space, Substitution

Introduction

A retailer assortment is defined as the mix of products carried by a retail store. The purpose of selecting a subset of products from the available products is to maximize the retailer's objective e.g. profit, under consideration of constraints like limited space available for display, defined budget for the number of products and their SKUs, inventory to be carried to meet a desired service level, and last but not the least to fulfil the ever changing needs of the consumers. As stated by Quelch and Kenny (1994), the number of products in the market for sale are increasing at a faster rate than the realized sales of the products. It is understood that the assortment selected by any retailer has a greater impact on its gross margin or sales and hence the assortment planning decisions play an important role in retail management.

Assortment planning (AP) is a process of selecting types and number of product to be kept from a given product line and also to determine the optimal level of inventory of these products. The critical issue faced by the retailer in the process of AP is to estimate the demand for each product. Further by using these demand estimates, developing a profit function and choosing the best array of products to maximize profit under various constraints (Rajaram, 2001). Assortment planning is relatively a new field for both the academicians as well as practitioners in terms of specialized models for optimizing assortment. Though assortment planning always remained a point of concern for the retailer, the development of scientific methods is limited in this field.

Assortment planning has been the focus of numerous industry studies. Taylor (1970) was among the first few who stressed upon the importance of assortment planning in retail sector. It is very important for any retailer to efficiently manage the process of assortment planning. Poor assortment planning may lead to markdown costs due to excessive inventory of un-demanded products and lost sales due to rapid sell-outs of popular products. In the perspective of retailer, category management allows them to establish good category assortment plans as well as to make better decisions on shelf space allocation and prices and promotion in order to improve sales and profits (Arkader and Ferreira, 2004).

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In a retail business, the products being offered are classified in categories, sub-categories and further the decision is taken on the number of SKU's to be kept in different sub-categories. Sometimes the decision is also taken on the number of brands to be kept in a given sub-category. For example, in a FMCG store, biscuits and namkins are called the categories whereas different types of biscuits like butter/cream/cashew etc. are called sub-categories and further how many SKU's of the subcategories is to be carried on the shelf are the decision variables. The numbers of categories is also referred as width of the assortment while the number of sub-categories is called depth of the assortment. The assortment optimization problem in the literature varies because of the type of demand models considered by the authors or because of the context of the problem considered. Literature/ studies also vary in terms of the time span of study and the products under consideration.

Literature Review

In a typical supermarket, the customers buy product without help of any sales personal i.e. the products displayed has to sell itself (Hansen and Heinsbroek, 1979). The shelf-space utilization and assortment carried by the retailer, hence become an important factor in new business scenario. It has become important for the retailers to carry the products that minimizes the lost sales due to stock-outs and maximizes its profit. Consumer reaction towards assortment carried by retailer has always remained a puzzle. In some research it has been concluded that increasing the varieties in any store increases the probability of purchase. However, in recent research (Kök, Fisher, and Vaidyanathan, 2009), it has been reasoned that the product variety has reached to its saturation and now, decrease in assortment has led to increase in profits. The idea is that more number of products in the assortment led to confusion in the minds of consumers, increased searching cost and hence sometimes leading to no purchase incidence.

Models have been developed in the past 40 years to address the various objectives associated with retail shelf allocation and assortment planning. It has been observed that the demand estimation in any assortment planning problem mostly considered shelf-space and substitution parameters. In this section, the assortment problem dealt by various researchers primarily with shelf-space and substitution consideration will be reviewed.

Assortment Planning with Space Elastic Demand Model

It has been posited in the literature that sale of a product in a self-service types of atmosphere, is influenced by the shelf-space provided to the product. As in any superstore the space is limited, there is always a problem of shelf-space distribution among different brands and products. In a very early work Lee (1961) investigated the variables affecting the shelf- space allocation decision in agricultural based products. Many important issues which are interrelated with each other like the merchandising effect, frequency of replenishment, lot size of replenishment and cost associated in terms of labour were considered in the model. Brown and Tucker (1961) examined the effect of shelf-space on sales of three categories of products. The products were classified as unresponsive products like salt, general use products like breakfast food and occasional buy products like canned nuts. The study found mixed results among the categories and there was no definite results concluded between the sales and the space allocated.

Cairns (1963) used a graphical solution to allocate shelf-space among two products to maximize profits while taking space elasticity into account. Direct shelf elasticity/ Cross space elasticity is defined as the ratio of relative change in unit sales of the considered product to the relative change in shelf-space of that product/ competing products (Chen, Chen, and Tung, 2006). The model considered by Cairns does not takes into account the limited shelf-space as well as integral facing restrictions.

Kotzan and Evanson (1969) examined the effect of shelf-space alteration on the sales of the four products in drug category. Though the study didn't explore the cause of this relationship, but it was observed that the increase in the shelf-space increased the sales for some products. However, some of the products attained their maximum profit even at lower space than the space assigned earlier. The model by Hansen and Heinsbroek (1979) took into account space elasticity and considered a minimum shelf allocation for each product as a constraint. An integer constraint was also incorporated in the model. Cross-space effects were factored in, as were out-of-stock and replenishment costs. Using a Lagrange multiplier approach, near-optimal solutions were obtained.

Marcel Corstjens and Doyle (1981) developed a geometric programming model where both product and cross- space elasticity were considered and the objective was profit maximization. The model highlights sales-space elasticity that gauges the sales response of a given product to the space allocated to another. It is the first space allocation model to incorporate such interdependencies. Costs were modelled as functions of inventory investment and handling expenses. Other constraints included store size, upper and lower bounds on space of each category as well as availability/minimum service level of products. A geometric programming approach was used to solve the problem. It was reported that the optimal space allocation is dependent on product profitability, direct space elasticity of the product and products cross-space elasticity. The model developed by C-D has been the base of many studies incorporating space elastic demand.

Corstjens and Doyle (1983) extended the static model to a dynamic one that allows for the anticipation of changing customer tastes and changing product growth and life cycles that could motivate retailers to allocate more space to new products and to divest from declining ones. Zufryden (1986) proposed a model that takes into account space elasticity, cost of sales, and demand-related marketing variables, but neglected cross space elasticity between products while fixing non-space marketing variables. A dynamic programming approach to the model was used to solve the problem.

Bultez and Naert (1988b) also used the model developed by C-D and used it in product category management models. They developed a model called SHARP and optimized space allocation within a product category, taking into account interdependencies within product groups and across groups using marginal analysis approach. In the model by Bultez and Naert (1988b) space elasticity was estimated using a symmetric attraction model and later an asymmetric attraction model (Bultez, Naert, Gijsbrechts, and Abelle, 1989). The model however is limited for linear cases as the marginal analysis approach used in the model is not suitable for nonlinear models.

An empirical work was done by Desmet and Renaudin (1998) using the C-D model. They studied the response of changing the space given on the product category sales. Interestingly, they observed that the space elasticity increase with the impulse- buying rate of the product category. In a large-scale experimental study on shelf management, Drèze, Hoch, and Purk (1994) concluded that the position of a product on the shelf is far more important to determining sales than the number of facings allocated to the product, as long as a minimum threshold to avoid out of stocks was maintained. The problem modelled the effect of shelf-space on sales of product as a Gompertz growth model, which is S-shape curve but non-symmetric about the point of inflection.

A integrated model considering inventory, product assortment and shelf space was developed by Urban (1998). A suitable algorithm heuristics was used for solving the problem. However, no empirical testing of the model was done. The impact of location factors in space allocation decision were studied by Campo, Gijsbrechts, Goossens, and Verhetsel (2000). It was concluded that the space allocation rules differ for different product based on their location in the store. Bookbinder and Zarour (2001) integrated Direct Product Profit into shelf-space allocation optimization problem. The (C-D) framework was used with an addition of the DPP method. Various numerical examples for the case of two products were solved by the methods of nonlinear programming and then by geometric programming. The results were compared with other heuristics like simulated annealing. The effects of change in any of the cost element i.e. the logistical cost or the inventory holding cost on the allocation of shelf-space under optimization were examined in the paper.

Yang (2001) developed a model based on the nonlinear model of (C-D). This non-linear model is difficult to get implemented in real life problems. Hence, the model was converted to a linear multi-knapsack integer programming problem with some assumptions. The other constraints put on the model were the minimum and maximum amount of shelf-space given to various products. Maximum profit per unit of displayed length was made criteria for the heuristics. However, few constraints incorporated for optimization is the limitation of this study.

A study on shelf-space allocation at product level was done by Irion, Al-Khayyal, and Lu (2004).They also considered the basic modelling of C-D. Similar to C-D model, it was assumed that the product demand is a function of its own and complimentary/ supplementary product space elasticity. While modelling the problem, the cost of including any product in the assortment consisted of linear purchasing costs, inventory costs from an economic order quantity model, and a fixed cost. Putting a cap on the upper and lower limits of the shelf-space, the maximized the profits with integer facings restrictions. Using stepwise linearization of the problem, they converted the problem as a mixed integer program (MIP) with linear constraints. The linearization framework is general enough to accommodate several extensions. The limitation of the study however, is that, no empirical testing of the model was done considering shelf-space allocation at product level. Bai and Kendall (2005b) solved the shelf-space problem using hyper heuristics based on simulated annealing. Though the data considered were hypothetical, but the procedure was found more satisfactory and produced quality solutions.

Hariga, Al-Ahmari, and Mohamed (2007) developed an integrated model that optimizes the retailer's profit under shelf-space and backroom storage constraints. Various choices to be made using the model includes the product variety to be carried by the retailers, the location decision i.e. which product to be placed where in the store, the space allocated to various SKU's and quantity to be ordered for each products. The problem was solved using LINGO software.

Abbott and Palekar (2008) developed an algorithm for single as well as multi-item inventory system for optimal replenishment timings. The diminishing shelf-space as a criterion for assortment planning was considered. Gajjar and Adil (2010) developed an alternate formulation of Shelf-Space Allocation Problem considering Space Elasticity using piecewise linearization technique. A two phase heuristic that worked satisfactorily for sufficiently large problems was developed.

Assortment Planning with Substitution Demand Model

In a retail chain, when a customer arrives and does not find the appropriate products, he can either buy another product from the same category that is present in the store or he will not buy any of the products or he will wait for the desired product to arrive at the store and shop later. Hence if the customers are brand loyal, there will not be any substitution effect in the sales of any product. However, marketing research shows that that most of the purchase decisions are taken at the point of purchase and a large number of customer substitute for their favourite product during shopping (Europe, 1998). Hence, substitution and demand generated due to substitution is an important aspect of modelling assortment in any retail chain. In an early work, Lancaster (1966) used concept of utility and substitution. The process of substitution with the concept of utility was explained and concluded that a person will substitute if the utility gained from the alternative purchase in better than the utility achieved by having desired product options.

Anderson and Amato (1974a) developed an optimization model maximizing the retailer profit that considered optimal brand selection and further display area allocated to these brands. The study considered only short run scenario. The aggregate market demand was decomposed in different categories based on the consumer preferences. An algorithm similar to fixed charge problem was used for estimation of optimal brand mix and display area allocation. The problem studied was an un-constrained.

Borin, Farris, and Freeland (1994) formulated a problem which incorporated both, the product assortment and space allocation where there is limited space. However due to non-linear objective and constraints and presence of binary variables in the objective function, it was difficult to get a closed form solution of the problem. The total demand was divided as unmodified, modified, stock-out, and acquired demand. It was concluded that the solution may be sub optimal if the condition of out of stock is not considered. Simulated annealing heuristic solution approach was used to solve the problem and results were compared with the results of other common heuristic approach. A problem of using these models is that the estimation of parameters used for the model is not error free. Borin and Farris (1995) analyzed the deviation in parameter estimation which will yield almost same assortments and shelf allocations as compared to the actual results. It was concluded that even 50% error in parameter estimation will lead to actual results.

Van Ryzin and Mahajan (1999) studied the assortment problem for a single period using MNL model for demand estimation. The process is assumed to be stochastic in nature. The inherent assumption was that consumers can substitute only once if their favourite product is not available. The substitution is assortment based only. This type of substitution is also called as static choice assumption. Closed form expression for equilibrium prices and optimized assortment were developed. It was concluded that the optimal assortment is always a set of products which are in the most popular set. Because of the assumption like constant price and cost, the model cannot be generalized.

Smith and Agrawal (2000b) estimated demand using exogenous demand model to study the assortment planning problem. The substitution effect was jointly incorporated with multi-period inventory replenishment. It was concluded that substitution has significant effect on both assortment as well as inventory policy. The optimum base stocking level was estimated when subjected by constraint of basic service level to be maintained for those items. Some common form of substitution matrix was also developed depending on the type of substitution among products. The basic substitution assumes that the demand is evenly distributed among the competing products; however demand based substitution ratio was considered in some complex models.

Chong, Ho, and Tang (2001) introduced three brand-width measures to characterize the brand-level assortment and explained how consumer preferences for different assortments can be captured. A hierarchical modelling framework was developed and estimated for purchase incidence and brand choice using an extensive panel-level data set spanning eight food categories. It was concluded that the model developed was better fit and predicts better than the benchmark modelling framework that combines the standard purchase-incidence model with Guadagni and Little (1983) brand share model. The modelling framework was integrated with a local improvement heuristic to form a tool for reconfiguring category assortment. It was found that category profit increased as much as 25.1% as a result of assortment reconfiguration.

Mahajan and van Ryzin (2001b) developed a stochastic sample path optimization model for assortment planning. In the model both type of substitution effect i.e. static as well as dynamic substitution was considered. MNL model was used in the study. Substitution based on the principle of utility maximization was explained. Though the testing of the model was on not on real data but it showed that the retailer should carry more popular brands than unpopular brands as indicated by traditional newsboy analysis. Rajaram (2001) developed a non linear programming for assortment planning and solved it with efficient heuristics. Budgetary constraints were incorporated and also a lower and upper bound for the products to be stored was incorporated in the model. The methodology was applied in a large fashion retailer store and studied on 27 brands. It was reported that use of this method increased the retailer's profit almost by 40% and also reduced the markdown costs.

Agrawal, Smith, and Tsay (2002a) described a methodology for managing capacity, inventory and shipments for an assortment of retail products by multiple vendors. It was found that all the vendors have different lead time, cost, and flexibility in product lines. The demand was considered stochastic and fluctuates over time. An optimization model was developed to choose the production commitments that maximize the retailer's expected gross profit when the demand, vendor's capacity and flexibility constraints were given. In collaboration with a global retailer, the model was incorporated in decision support system and it was also tested by two retailers. (Cachon, Terwiesch, and Xu, 2005) developed an assortment model using consumer search as an important factor in the model. The demand was assumed to follow the MNL model. A no-search option was introduced where consumer has a predefined choice. They compared the same with two other types of search i.e. limited and infinite search options.

Gaur and Honhon (2005) solved a single-period assortment planning and inventory management problem considering locational choice. The optimal variety, product location, and inventory decisions were determined under static substitution and then the same model was extended to dynamic substitution model using the bounds generated in static model as well as retailer imposed upper bound. It was concluded that the optimal assortment consists of products equally spaced out and there is no substitution among them. Using two heuristics the assortment problem was solved and it was found that using static substitution as a base in very close to approximation.

Cachon and Kök (2007) studied the assortment planning problem with multiple merchandise categories and basket shopping consumers. A game theory based model was developed in which retailers choose prices and variety level in each category and consumers make their store choice between retail stores and a no-purchase alternative based on their utilities. It was concluded that category management (CM) never finds the optimal solution and provides both less variety and higher prices than optimal. It was further concluded that introduction of more products may strain the relationship between retailers and manufacturers regarding assortments.

Kok and Fisher (2007) developed methods for demand estimation and parameter estimation. An iterative optimization heuristic was proposed for solving the assortment planning problem. A new structural property was established that related the products included in the assortment and their inventory levels to product characteristics such as gross margin, case-pack sizes, and demand variability. Li (2007b) studied assortment planning problem using MNL demand model considering continuous as well as discrete in-store traffic, developed a profit rate heuristics for solving the assortment problem. Shah and Avittathur (2007) developed a heuristics to solve a multi-item inventory and assortment problem simultaneously. Demand cannibalization effect as well as substitution effect was incorporated in their retail portfolio planning model.

Aydin and Hausman (2009) investigated the role played by slotting fees in coordinating the assortment decisions in a supply chain. A model with single-retailer, single-manufacturer supply chain was analyzed, where the retailer decides what assortment to offer to end customers. It was found that double marginalization resulted in a discrepancy between the retailer's optimal assortment and the assortment that maximizes total supply chain profits. A payment scheme that is analogous to slotting fees was considered i.e. the manufacturer pays the retailer a per-product fee for every product offered by the retailer in excess of a certain target level. It was concluded that if the wholesale price is below some threshold level, this payment scheme induces the retailer to offer the supply chain optimal assortment and makes both parties better off.

Goyal, Levi, and Segev (2009) showed that even a simple assortment planning problem is NP hard. They developed a polynomial time approximation scheme heuristics to solve these problems that too with desired accuracy. Yücel, Karaesmen, Salman, and Türkay (2009) developed a model for the multi-product inventory, product assortment and supplier selection problem with multi level demand substitution. The analysis was performed to examine the effects of three parameters, substitution cost, supplier selection cost, and shelf-space limitations, separately.

Miller, Smith, McIntyre, and Achabal (2010) developed a methodology for choosing optimal retail assortments for infrequently purchased products which has typical characteristic that there is no historical record of most of these consumers. The wide variety of consumers and their preferences makes decision making complex for these types of products. They used multiple integer linear programming approach for determining the optimal retail assortments. The generalization of the model was checked using alternative consumer choice assumptions and ranges of parameter values.

Descriptions of Demand Models

Space Elastic Demand Model

Under the space elastic demand, the demand of the product is measured in terms of the space allocated to the given products as well as the space allocated to its competitive products. In a supermarket scenario, a category of products are kept at same place. Hence, it is rational to assume that the space allocated to competing products has an influence on the sales/ demand of the products. Lee (1961) in his paper mentioned the space as an important variable in agricultural based product selection. Since then, many authors have used space and cross space elasticity as a measure for demand.

The demand function under this model is written as

$$D = \alpha_i * f(S_i, S_{ji}), \quad (1)$$

where α_i = Latent demand for product i, and

S_i = Space allocated to product i, and

S_{ji} = Space allocated to product j.

The same expression has been used by many researchers in the context of retail demand estimation. However, many authors have extended this model by incorporating some more variables in the model, which were important in the context studied. The structure of the equation, however, remained unchanged in all these extension.

Multinomial Logic Model

It is safe to assume that every customer tries to maximize the utility obtained from shopping. This particular behaviour of consumers is reflected in the Multinomial Logic model. The model computes the probability of choosing an alternative as a function of the attributes

Table 1: Type of Demand Models and Variables Considered

(Author, Year)	*Demand Model Used*		*Variables Considered*
	Space Elastic	*Substitution*	
(Gajjar and Adil, 2010)	X		Space available, Upper and lower limits on space
(Yücel, et al., 2009)		X	Cost of Substitution, Cost of supplier selection, shelf-space limitations
(Goyal, et al., 2009)		X	Static and Dynamic Substitution, Utility
(Aydın and Hausman, 2009)		X	Utility , Slotting fee, Substitution
(Abbott and Palekar, 2008)	X		Direct and cross space elasticity, Inventory, profit, cost
(Hariga, et al., 2007)	X		Direct and cross space elasticity, Locational effect, Inventory level
(Shah and Avittathur, 2007)		X	Substitution, Space, Multi-item inventory level, Cannibalization
(Li, 2007a)		X	Substitution, Continuous and discrete in-store traffic, Product profit, Cost
(Kök and Fisher, 2007)		X	Utility, Substitution rate, Cost, Price, facings
(Cachon and Kök, 2007)		X	Utility, Profit, Cost, Basket Shopping consumers, Game theory
(Hariga, et al., 2007)	X		Direct and cross space elasticity, Locational effect, Inventory level
(Gaur and Honhon, 2006)		X	Static and dynamic substitution, Space, Location, inventory, profit
(Cachon, et al., 2005)		X	Consumer search, Utility, Profit
(Bai and Kendall, 2005a)	X		Shelf-Space, Upper and lower bound on space, Cost, Price
(Irion, et al., 2004)	X		Facing, Direct and cross space elasticity, lower and upper bound of facing allocation, holding cost, restocking cost
(Agrawal, Smith, and Tsay, 2002b)		X	Revenue, Cost, Marketing variables, Seasonality
(Yang, 2001)	X		Revenue, Space, Lower and upper cap on space
(Rajaram, 2001)		X	Selling and cost price, Set up cost, Budget, Salvage price, Shelf-Space
(Mahajan and van Ryzin, 2001a)			Inventory cost, Price, Utility, Space, Substitution
(Chong, et al., 2001)		X	Utility, Substitution, Margin, Brand loyalty, Brand Configuration,
(Bookbinder and Zarour, 2001)	X		Direct/Cross Space Elasticity, Direct Product Profit, Profit Margin, Inventory Cost
(Smith and Agrawal, 2000a)		X	Substitution, Service level, Overstocking and Shortage cost, Margin, Space
(Ryzin and Mahajan, 1999)		X	Inventory cost, Price, Utility, Space, Substitution
(Urban, 1998)	X		Shelf-space, Inventory level
(Desmet and Renaudin, 1998)	X		Shelf-space, Month of purchase, Store rating
(Borin and Farris, 1995)		X	Substitution , Space elasticity, Lot size, Margin
(Dreze, Hoch, and Purk, 1995)	X		Shelf-Space, Location, price, heterogeneity across brand and stores
(Borin, et al., 1994)		X	Substitution , Space elasticity, Lot size, Margin
(Bultez and Naert, 1988a)	X		Direct and cross space elasticity, cost of sales, profit margins
(Zufryden, 1986)	X		Direct and cross space elasticity, Selling cost, Marketing variables like advertisement
(M. Corstjens and Doyle, 1983)	X		Margins, sales, direct and cross space elasticity, product growth rates, relative growth rates and the discount rate.
(Marcel Corstjens and Doyle, 1981)	X		Direct and cross space elasticity, Price of products and Handling costs
(Hansen and Heinsbroek, 1979)	X		Direct and cross space elasticity, Integer facings, Service level
(Anderson and Amato, 1974b)		X	Brand preference
(Frank and Massy, 1970)	X		Shelf-Space, Shelf Positioning, Brand effect, Stores effect
(K. K. Cox, 1970)	X		Insignificant relation between shelf-space and sales for staples

(*Contd.*)

(Author, Year)	*Demand Model Used*		*Variables Considered*
	Space Elastic	*Substitution*	
(Kotzan and Evanson, 1969)	X		Examined the effect of shelf-space alteration on sales, Reason was not found for the same.
(K. Cox, 1964)	X		Proposed a graphical solution for allocating space
(Cairns, 1963)	X		Proposed a graphical solution for allocating space
(Brown and Tucker, 1961)	X		Examined the effect of shelf-space on sales of three categories of product, found mixed results
(Lee, 1961)	X		Study of space implication in retail and variables affecting this allocation
(Baumol and Ide, 1956)	X		Examined the trade-off between carrying large assortment with various cost associated

of all the alternatives available (McFadden, University of California, Research and Development, 1973). The model even being stochastic in nature captures decision variables. An extension of MNL model is the locational choice model. It is also a utility-based model.

The use of MNL model is common in various management streams like marketing and economics literature (Guadagni and Little, 1983). In this model, a no purchase option is given a utility of 0. The customers arriving in the store rate the utility of different products in different way. Hence, the utility is decomposed in two parts, i.e.

$$U_j = u_j + \varepsilon_j \qquad (2)$$

where

u_j = Deterministic component of Utility and

ε_j = Random component of Utility

The first component of the utility is considered same for all the consumers, while the second component depends on individual consumer. The random component is assumed to follow Gumbel[1] distribution which is also called a double exponential distribution. The function can be written as

$$\Pr(X \le \varepsilon) = e^{-e^{-\left(\frac{\varepsilon}{\mu+\gamma}\right)}} \qquad (3)$$

where,

γ= Euler's constant = 0.5772, and

μ represents the heterogenity of customers

This expression suggests that though the different consumers have same expected utility for a given product, the realized utility will be different. This may be due to the type of consumer base under study or it may be some other unobservable factors.

The Gumbel distribution is closed under maximization. Hence, probability that a customer chooses product j from is given by

$$p_j(s) = \frac{e^{\frac{u_j}{\mu}}}{\sum k \in S \cup \{0\} \frac{e^{u_k}}{\mu}} \qquad (4)$$

This closed form solution makes MNL model an efficient method for modelling customer choice in analytical studies

Exogenous Demand Model

In Exogenous Demand models, the demand is measured directly using data from individual consumers. The consumer will purchase another product or will not buy any of the product within the category of her desired product is not available in the store. In this type of model, a given consumer selects a product from a set of items, and if his preferred product is not available, may be because of out of stock (OOS) or out of assortment (OOA), he will substitute the product with some other comparable product with a define substitution probability The substitution probability matrix for multiple items can be written as

[1] The ε are independently distributed random variables with a double exponential distribution given by . The mean and variance of this distribution is 0.575 and 1.622 respectively.

$$\mu_{ji} = \begin{pmatrix} 0 & \mu_{12} & \cdots \\ \mu_{21} & 0 & \cdots \\ . & \cdots & \cdots \end{pmatrix} \quad (5)$$

The substitution probability depends on the type substitution considered. Sometimes the substitution probability is equally distributed among the competing products while at time the probability is considered as weighted ratio of the demand of the competing products. Also, in some cases, the substitution is possible among neighbouring products only and not among all the products in the category.

Conclusion

The purpose of assortment planning is to select a subset of products from the available products is to maximize the retailers objective which can be profit or revenue etc. under consideration of constraints like limited display space available, budget for the number of products and their SKU's, inventory to be carried to meet a desired service level and last but not the least to fulfil the ever changing needs of the consumers. Assortment planning is relatively a new field for both the academicians as well as practitioners in terms of specialized models for optimizing assortment. Though assortment planning always remained a point of concern for the retailer, the development of scientific methods is limited in this field. The present work highlighted the demand models that are mostly used in estimation of demand in retail and hence further used for better assortment planning. The study of the demand models gives readers a clear idea about the demand estimation process and other nuances of these models.

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