A MANAGERIAL PERSPECTIVE OF RETAIL ASSORTMENTS: DECIDING WHAT TO CARRY

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ABSTRACT

This research addresses the problem faced by a category buyer who must decide which subset of SKU's available from manufacturers to carry. The buyer's problem can be viewed as consisting of three interrelated parts: (1) assessing the preferences of customers for the competing SKU's, (2) given these preferences, representing the customer's purchase process among offered SKU's, and (3) given the preferences and customer purchase process, selecting the subset to carry that will maximize the buyer's goals for the category (e.g., profit, revenue, market share, etc.). Customer preferences are collected via conjoint analysis administered over the web. We represent the customer's decision process as including the concept of "satisficing". Optimal assortments are established using a 0,1 mathematical programming formulation. To address the uncertainty of the customer's purchase when the retailer carries two or more satisfactory products, we consider boundary formulations that compare the best case and the worst case purchases from the point of view of the retailer. Empirical results and insights for each of the three interrelated parts are presented.

INTRODUCTION

One of the key decisions for retail buyers is to determine which products should be stocked so as to best obtain the retailer's category goals (Levy and Weitz, 1995). This is particularly true for categories such as the ones we consider which involve seasonal buying as opposed to basic categories with continuous replenishment (for instance, supermarkets). Typically the limited amount of retail display space and the large number of products offered by manufacturers limits the assortment to a small subset of the products available in the entire market. For example, for DVD players there were 117 products offered by manufacturers in May 2001, each offering some combination of features and price. A consumer electronics retailer, such as Best Buy, may choose to carry no more than 20 of these DVD players. Therefore, the buyer must decide which of the 1.7×10^{22} possible assortments would best achieve the goals for the category.

When making the assortment decision, in-store historical data seems relevant, but actually only provide information on sales of the existing assortment and not what the potential might have been from any different assortment. Furthermore, market sales data may contain endogeneity because items broadly stocked by retailers will have greater sales than less broadly stocked items. Field tests are infeasible given the long lead-times in placing orders with manufacturers to say nothing of the vast number of possible assortments to test.

Despite its importance, there has been limited research directly examining the managerial decision of what to carry. In this paper, two streams of research that add insight into identifying the key issues for retail assortment are examined – research on retail shelf space management and research on manufacturer product line development. The issues arising from these two streams are then integrated into the three stages of the assortment selection process – customer preference assessment, customer purchase process and, given these, the selection of retail assortments. Empirical examinations of the core issues are presented for each stage in order to advance the understanding of the selection of retail assortments.

BACKGROUND

There has been a long tradition of research in marketing examining retail shelf space management (Anderson and Amato, 1974; Hansen and Heinsbroek, 1979; Corstjens and Doyle, 1981; Corstjens and Doyle, 1983; Bultez and Naert, 1988; Dreze, Hoch and Purk, 1994). The focus has been on developing models that allocate limited shelf space across items carried by the retailer to maximize the retailer's category goals. Because this stream of literature is predominately focused on space allocation, the treatment of the assortment selection decision has been scant. Specifically, assortment selection is limited to removing products from an existing assortment when the allocated shelf space drops to near zero. A key insight arises from this literature: that customers may "compromise at the shelf". If a retailer does not stock the product that is most preferred, the customer may switch to a stocked product rather switch to another retailer. In the shelf space management literature, this possibility is typically represented by assuming a portion of the preferred product's sales being "recaptured" while the rest is lost to the retailer. However, this representation does not directly consider each customer's preference differences between the stocked and the most preferred product.

The second stream of literature that adds insights to the retail assortment decision is research on manufacturer product line development (Zufryden, 1982; Green and Kreiger, 1985; McBride and Zufryden, 1988; Kohli and Sukumar, 1990; Chen and Hausman, 2001). In this research the problem is which set of products a manufacturer should offer, where each potential product is viewed as a collection of product attributes and price. This creates a combinatorially explosive number of potential products that might be offered, leading many researchers to focus on solution heuristics (Kohli and Sukumar, 1990), or advocating clustering of customer preferences to reduce the problem size (Green and Kreiger, 1985).

Although this research stream initially appears highly similar to the retail assortment decision, key differences exist. In the retailer's problem, the number of potential products are only those produced by manufacturers. Additionally, price is rarely a decision variable at the time of assortment selection since pricing is typically a tactical in-season decision after the assortment has already been selected. Together, these considerations limit the size of the retailer's decision on the potential product dimension.

Additionally, due to small differences in product utility and the cost of continuing to shop, the customer may be willing to satisfice and purchase a stocked product if it is within a threshold of the maximum utility in the market. Thus, the manufacturer's problem formulation has used a threshold to determine if the customer will purchase from the manufacturer and then utility maximization to determine which acceptable product will be purchased. In contrast, the retailer's problem formulation focuses on the highest utility product available in the market, and the threshold is used to determine if a retailer's product is "close enough" to that preferred product to induce the customer to compromise at the shelf.

Despite these differences, two key insights for the retail assortment decision arise from the literature. First is that model formulations should fully maintain the idiosyncratic values and preferences of individual customers. Aggregating individual preferences (as opposed to choices) to market level preferences would require an interpersonal utility comparison that may not be meaningful (Green and Kreiger, 1985). Additionally, using aggregated preferences may result in incorrect results when some products are highly similar and/or individual preference functions are highly dissimiliar (McIntyre and Miller 1999, Chen and Hausman, 2001). The second insight is that the assortment should be selected simultaneously rather than by incrementally adding/deleting products (Green and Kreiger, 1985; McBride and Zufryden, 1988; Kohli and Sukumar, 1990).

ASSESSING CUSTOMER PRODUCT PREFERENCES

Similar to Green and Kreiger (1985), customer product preferences are assessed by an adaptive conjoint approach administered through the Active Decisions' Active Buyers Guide. Visitors to Ask Jeeves, Yahoo and other e-commerce sites completed the adaptive conjoint task to obtain recommendations for themselves as to what products they would find most attractive. As separate data, the set of all available products in the market and the attributes for each were obtained via web crawlers (including price). The data consist of 2,213 respondent's attribute part-worth profiles and all 117 DVD SKU's available at that point in time.

From the conjoint part-worth data, a matrix was developed that specifies each customer's utility for each product. To obtain consistent normalization and avoid interpersonal utility comparisons, the utilities in each row were then divided by that customer's maximum utility across the products available in the market. The data indicates a high degree of heterogeneity in the value that customers place on the products available. Sixty-six of the 117 products had at least one customer who valued it the highest of all products in the market.

CUSTOMER PURCHASE DECISION AND SELECTING THE OPTIMAL ASSORTMENT

The customer's purchase decision is represented using the notion of satisficing. Operationally, we assume that if a customer finds a product that achieves at least a threshold percentage of her highest utility product in the market, then the customer is "satisfied." Clearly, the potential market for a given assortment is a function of the threshold, and consequently the optimal assortment will depend on it as well. Since the relationship between the customer's search cost and the appropriate threshold is difficult to determine, we assess instead the sensitivity of assortment results to the choice of threshold. We use this to replace the utility matrix with a 0, 1 matrix $\mathbf{X}$.

For a given $\mathbf{X}$ matrix created by customer preferences and threshold, we determine the optimal assortment by integer programming. Because of the uncertainty regarding which product a customer will purchase when two or more satisfactory products are offered, we develop two boundary formulations based on the customer always choosing the largest unit revenue product (MaxiMax) as well as based on the customer always choosing the least unit revenue product (MaxiMin). The difference in assortment outcome under the two formulations is then compared.

The Optimistic or MaxiMax Profit Formulation

$$Max\sum_{i,j} Y_{ij} v_{ij}(w)$$

subject to: $Y_{ij} \leq X_{ij} y_j$, for all i,j

$$\sum_j Y_{ij} \leq 1, \text{ for all } i$$

$$\sum_j y_j \leq K$$

The Pessimistic or MaxiMin Formulation

$$\text{Max } \sum_i V_i(w) \text{ subject to: } V_i(w) \leq \sum_j y_j X_{ij} v_{ij}(w), \text{ for all } i$$

$$V_i(w) \leq X_{ij} y_j v_{ij}(w) + (1 - X_{ij} y_j)B, \text{ for all } i,j$$

$$\sum_j y_j \leq K$$

Intuitively, it is apparent that the impact of the issues and alternative formulations may vary across assortment sizes (e.g., k = 1 to n). We compared the total potential revenue generated by the optimal assortments corresponding to these two formulations for two satisficing thresholds. When the satisficing threshold is set to 1.0, customers only purchase the highest utility product and the MaxiMax and MaxiMin formulations yield the same solutions for all assortment sizes. This is because there is a one-to-one mapping between each product and the group of customers who will only purchase that product. Note that in this situation, the integer programming is not necessary because the optimal k product assortment is simply the k products with respectively the largest customer bases.

Potential revenue increases with assortment size in a strictly concave manner until the maximum is reached at an assortment size of 66. At this point, all shoppers are offered what to them is the highest utility product and no further revenue gains are possible. Note that a retailer with non-zero stocking costs would not increase the assortment size beyond approximately 40 products because of the flatness of the potential revenue curve beyond this point. We term the assortment sizes between approximately 40 and the maximum the "saturation assortment" sizes. Note that 50% of the potential revenue from the category can be obtained from an assortment size of only 7 products, which we term the "core assortment." Assortment sizes between 7 and approximately 40 we term the "build out assortment" sizes.

When the satisficing threshold is set to .90 the customer will find acceptable any product yielding utility greater than 90% of the maximum utility product. The MaxiMax and MaxiMin formulations yield similar potential revenue for the core assortment sizes. The potential revenue is on average 58% higher than when the threshold was set at 1.0 because customers are willing to compromise to the core assortment products. Above the core assortment sizes, the MaxiMax and MaxiMin formulations indicate very different revenue potentials. MaxiMin solutions indicate that a maximum revenue of $420,000 occurs at an assortment size of only 50 products because stocking additional products allows customers to switch to lower revenue SKU's. MaxiMax solutions indicate a much higher revenue potential ($590,000) and a saturation at 80 products because stocking incremental products results in customers switching to higher revenue SKU's. Note that the MaxiMin formulation suggests a much "shorter" build out range as exhibited by a sharp knee in the potential revenue curve.

With such a divergence in potential revenue from the Maximax and MaxiMin formulations beyond the core assortment range, we examined the sources of the difference. The difference could be due to two factors, different items in the respective assortments and the different assumption regarding the customer's decision process. An examination of the SKU's in each formulation's assortments revealed that in the core assortment range (1 – 7 SKU's) the two formulations selected the same SKU's for each assortment size. These SKU's are also the same as those selected by both methods when the satisficing threshold was set to 1.0, indicating that the core assortment products are stable across formulations for the threshold levels examined. This implies that the core assortment is relatively robust to the issues and methods examined, as well as, obtains a relatively large portion of the potential revenue from the category.

Beyond the core assortment range, a fairly consistent 75% of the products were the same from the two formulations at each assortment size. The consistency of the overlap indicates that the two assortments are not diverging in their contents as the assortment size increases.

To evaluate the revenue differences in the assortments developed by the MaxiMax and MaxiMin formulations without the confounding influence of the assumed customer's decision process, we cross evaluated the assortments. In other words, we evaluated the assortments developed by the MaxiMax formulation using the MaxiMin assumed decision process and vice versa. Results indicate that the assortments developed from MaxiMax and the assortments developed from MaxiMin yield virtually identical revenue potentials when evaluated using the same assumption. In other words, although the two methods yielded assortments containing 75% the same items and 25% different items, the items that are different are nearly equivalent in their revenue potential.

The final stage of the empirical examination was to assess the relative performance of the assortments developed using alternative methods. The methods chosen were: (1) assuming a homogeneous market and developing assortments based on an MNL representation using the aggregated customer product utilities (Avg Util), (2) accounting for the market heterogeneity but developing the assortment based on rank ordered product preferences rather than optimization (Most Preferred), and (3) developing assortments based on market heterogeneity and optimization but not accounting for any customer satisficing that may exist (Max Utility). In this way the relative contribution to performance due to the three steps in the assortment decision can be assessed. To insure comparable evaluations, we evaluated all assortments using MaxiMin.

When the satisficing threshold is set to 1.0 so that the customer would only purchase the maximum utility product, all the methods selected the same assortments except the average utility method. This method yielded assortments that had 40% less revenue than all the other methods, indicating that when customers do not satisfice any method that accounts for market heterogeneity will be equivalent.

When the satisficing threshold is set to .90, each method yields different assortments. When evaluated using the MaxiMax or MaxiMin assumptions, the relative performance is equivalent so only the MaxiMin evaluations are presented. The assortment developed from assuming a homogeneous market is substantially inferior across assortment sizes. The assortments developed from accounting for heterogeneity (but not optimized) performed well for core assortment sizes, but yielded only 70% of the maximum potential revenue during the build-out assortment sizes. Assortments developed by ignoring the satisficing of customers, but accounting for market heterogeneity and optimization yielded assortments that were 91% of the maximum potential revenue. These results imply that accounting for market heterogeneity is the most important factor in developing retail assortments regardless of satisficing thresholds. Optimization and accounting for satisficing further improve the assortments for the build-out and saturation assortment sizes when customers satisfice and do not harm assortment performance if customers do not satisfice. Additionally, the results imply that correctly identifying the core assortment has the most significant impact on category sales.

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