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Optimization Strategy to Minimize the Allocated Space for Placing MaximumNumber of Products in Retail Stores

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Abstract: This paper explores the topic of shelf space optimization in supermarkets or retail stores, delving into the importance of shelf space allocation for cosmetic products in a highly competitive industry with low profit margins. Cosmetic items in retail stores generate worldwide revenue of 571 billion USD. One of the most significant benefits of optimized shelf space allocation for cosmetics is improved customer satisfaction. This strategy can lead to more efficient inventory management, resulting in reduced lost sales, increased revenue, and improved product availability. It also helps retailers identify and prioritize their most profitable products. Customers are more attracted to cosmetic items arranged in a strategic and visually appealing way. Furthermore, they are influenced by various in-store factors such as flavors, pricing, sizes, colors, or brands. Effective allocation of shelf space helps customers navigate the store easily, find the items they need, and enhances their shopping experience, leading to increased sales growth for the store. The main objective of this work is to arrange cosmetic products in a way that minimizes lost sales while maximizing profits, considering constraints such as available space, expiration dates, and seasonal demand changes. The paper explores different methods for product placements, including binary integer programming, various optimization methods, and basic decision making. The literature review examines the work of other researchers in this field and explores consumer psychology to understand the reasoning behind product placement. The paper also highlights its underlying logic and explains the basic decision-making processes involved. Ultimately, this work aims to contribute to the development of the "next generation" of shelf space planning systems.

Keywords: Shelf Space Optimization, Inventory Management, Product Placement, Binary Integer Programming, Simplex, Consumer Psychology

I. INTRODUCTION

Retail stores utilize strategic product placement to increase profits. The way the product items are placed in the stores is carefully orchestrated to maximize profits, taking into account various factors such as optimal product placement, customer behavior, product popularity, inventory levels, market trends and historical sales data. This ensures that the customers navigate through a deliberate maze of products, ultimately leading to increased revenue for the store. Operations research plays a very important role in determining these profits made by the store. Even the placement of a bottle of sunscreen can have significant consequences for the stores bottom-line.

The importance of shelf spaceoptimization cannot be overstated. In a highly competitive environment, every inch of shelf pace is valuable real estate to increase sales. The retail stores use strategic shelf arrangements to encourage customers to purchase more than they need, often without realizing it. The ways the products are arranged in the shelves catch the customers' attention often persuading them to buying more items thanthey actually need. In addition, the retailers can make buying products easier by organizing them in a logical and intuitive manner, so that it becomes easier for customers to find the items they are looking for. Optimization of shelf space is an ongoing challenge for retail stores. This paper explores solutions for efficiently optimizing shelf space using operations research techniques such as binary integer programming, optimization literature review. Binary integer programming is particularly helpful as it simplifies the decision-making process by using a simple "yes or no" decision variable. A literature review involves an analysis of the works done in the field by other researchers in the past. Literature review may examine research on the factors that influence consumers' purchasing decisions, including product placement and store layout. Retailers strategically place certain products in high-traffic areas, such as near the entrance or checkout, to increase visibility and impulse purchases. Other products might be placed at eye-level. Ultimately all these techniques help the stores to achieve their objective of profit maximization which are discussed in [13].

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II. LITERATURE REVIEW

We are describing the background of our planning in this section. We will analyze related literature and try to identify the research gap and define the contribution of this paper. A detailed understanding of the actual scopeof the planning problem is required in order to make the difference. To maximize the profit of a category, the shelf planner must decide how to place a given set of products in the limited area of shelf space containing several shelf segments so that lost sales is minimized and the retailer get maximum profit.

We can describe a solution for proper and efficient optimization of shelfspace in stores by using the OR techniques as discussed in [1]. The retail shelves should be adjusted by varying the number of shelf boards as well as the height and depth of each shelf board as described in [2] & [5]. Practical method that is to be used in shelf space allocation planning and to maximize the profit is discussed in [12]. Shelf space allocation decision is sensitive to demand behaviour of individual brands as well as the retail store specific demographic characteristics. The system dynamics model aims to provide a pragmatic and manager friendly platform for evaluating various shelf space allocation scenarios as describes in [3].

By analysing the other research papers, we came to know that other papers mostly focus on FMCG and retail marketing but we are working on cosmetic items. Already a lot of products are available in the cosmetics category, and every year many morebrands and products are being added in this category. As per by the reports from 2010 to 2022 around 40% newcosmetic brands came into the market adding a wide range of products and brands in this section so it becomes hard for a retail store or a Mart to display all the items on their shelves so there should be a proper strategy to optimise that available space and get good sales from that as mentioned in [6].

III. METHODOLOGY

For the production and operation management in stores and marts we have used the non-liner method of allocating the shelf-space as mentioned in [4] & [7]. We have used binary integer programming to place products in the shelves of retail store, as the role of suppliers and retailers is important as discussed in [14]. Here we have taken the example of sunscreen. As we all know that many brands are available in the market. Here we are taking 3brands for example (Brand A, Brand B and Brand C) having different profit margins. Each sunscreen of BrandA gives a profit of 100, Brand B of 70 and Brand C of 50. Now coming to the shelves, generally they are categorized on the basis of their reach from the customers. In malls, different racks have different rents like the rack which is easily accessible and close to the reach of customers have high rent, whereas the bottom racks havelowest rent. The rent also varies from product to product depending upon the profit margin to be earned by the seller. Here we are taking example of four different racks. 50 is charged as the rent of Product A, 30 for Product B, 20 for Product C placed in Rack 1, 2,3 respectively. Now forming the equations:

Rack 1: $50x + 30y + 20z \leq 5000$
Rack 2: $35x + 25y + 20z \leq 3500$
Rack 3: $20x + 15y + 10z \leq 4000$
Rack 4: $15x + 10y + 5z \leq 2500$

In the above equations, x is the maximum number of products of Brand A that can be placed, y for Brand B and z is for Brand C. Seller has a maximum budget of 15000 to place all the sunscreens in the different racks. 5000 for Rack 1 (i.e., the Sum Product of rent and number of units of product), 3500 for Rack 2, 4000 for Rack 3 and 2500 for Rack 4. As Brand A has the highest margin so to maximize the profit one can think of filling all the rackswith that single product. This may create problem as customers will not have different choices and there will be amonopoly of single sunscreen. Hence a restriction is applied that number of products cannot exceed more than 40units of Brand A, 45 units of Brand B and 50 units of Brand C in any shelf. And just to avoid the mistake we hadkept one more condition that total number of products should be greater than zero. Now forming the equations:

$1x + 0y + 0z \leq 41$
$0x + 1y + 0z \leq 45$
$0x + 0y + 1z \leq 50$
& $1x + 1y + 1z \geq 0$

Putting these conditions in MS-Excel we had got the following data:

We have put all the equations in the Excel and maximum limit as RHS.

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We kept the profit per product so that we can calculate the maximum profit that can be earned.

Now doing the SumProduct of the (number of products) and (different rents charged) as LHS we will getthe solution.
Solver is used to set objective as maximum profit, and keep the "To:" section at "max", and in objectiveselect the cells of the equations and also select (<= & >=) from add constraints section. Lastly selectingthe solving method as "Simplex LP" we got the solution in 0 and 1 as in [8].

All the solution will be displayed in the maximum profit and profit per rack (LHS) section.

Shelf Space Optimization Methodology

	Product 1	**Product 2**	**Product 3**			
No. of product	40	45	23.75			
Profit	100	70	50	8337.5		
	Product 1	Product 2	Product 3	LHS		RHS
Rack 1	50	30	20	3825	≤	5000
Rack 2	35	25	20	3000	≤	3000
Rack 3	20	15	10	1712.5	≤	4000
Rack 4	15	10	5	1168.75	≤	2500
max product	1	0	0	40	≤	40
max product	0	1	0	45	≤	45
max product 3	0	0	1	23.75	≤	50
ratio 1	1	1	1	0	≤	0

Fig. 1 Final Matrix

For the data which we used, we got maximum profit as 8384 and in the LHS section, profit from Rack 1 is 3825, Rack 2 is 3000, Rack 3 is 1713, as profit and Rack 4 has 1169. We can obtain this profit by putting 40 units fromBrand 1, 45 units from Brand 2 and 23.8(=24) units from Brand 3.

IV. LIMITATIONS

a) Some products are left out as there is limited space, and it is not possible to fit all items in a given space.
b) Space requires changes in physical layout of a store which is expensive and time consuming.
c) Products which are not sold within their expiration dates (shelf life) result in wastage and loss in sales.
d) Introduction of a new item and adjusting their inventory is difficult due to lack of flexibility.
e) Prioritizing the items which are more saleable results in narrower selection of overall items.

V. REAL LIFE APPLICATIONS

1. Libraries can benefit from shelf space optimization to ensure efficient organization and accessibility of books and other resources. Arranging books according to genres, subjects make it easier for visitors to locate books and borrow them.
2. Warehouses and Distribution centers strategically arrange the items shelves, using vertical spaceeffectively to maximize storage and streamline inventory management.
3. Exhibition and Trade Show Booths can apply shelf space optimization principles to maximize the impactof booth displays. Careful arrangement of brochures, products, samples or promotional materialsexhibitors can attract attention of people.
4. Shelf space optimization is essential in hospitals, clinics and pharmacies. By categorizing items based on usage frequency and criticality, healthcare providers can minimize the time spent in searching for necessary items and enhance patient care.
5. This is also applicable in kitchen and pantries cabinets to maximize storage capacity and facilitate betterorganization of food items, utensils and other household supplies.

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VI. CONCLUSION

The findings of this study demonstrate the value of shelf space optimization in our daily lives. We have exploredthe advantages and numerous implementation strategies to achieve optimal effectiveness. Retail establishments generally seek to take advantage of customer attention points to boost sales and profits as described in [9]. In addition to helping customers get the best bargain possible, shelf space optimization can also help retailers, sell the most lucrative products. We have used binary integer programming for the optimal locations for a range of products, which helped to maximize revenue and maintain consumer satisfaction as discussed in [10] & [11]. This strategy lowers thepossibility of ambiguity and mistakes, establishing a solid foundation for choosing the best options. Thus, we can conclude that use of simple methods such as binary integer programming can help businesses develop to a great extent.

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