LUXURY BOUTIQUE LAYOUT DESIGN

REPORT ON OPTIMIZING PRODUCT PLACEMENT

MCGILL MMA
GROUP 2

Xinran Yu
Yichen Yu
Xiaorong Tian
Tian Xu

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I. Introduction

In the dynamic world of retail, the key to success lies in the strategic placement of products. The project embraces this challenge, utilizing decision analytics to optimize product arrangement in a newly opened luxury boutique. Such initiative aims to attract new customers, maximize store revenue, and enhance the experiences of VIP clients, fundamentally supporting the boutique's growth and market expansion.

What makes this project particularly interesting is its application of advanced analytics in a traditional retail context. By blending data-driven insights with a comprehensive understanding of luxury retail, the team aims to revolutionize how products are presented in boutique spaces.

With the primary goal in view, the team choose to employ a detailed 2019 dataset from a luxury brand, capturing customer purchases and product data. As the team found that the information from the dataset uncovers purchasing patterns, informing tailored product displays that engage both new and VIP customers, thereby maximizing revenue.

Therefore, the project's objectives focus on three core areas: increasing number of new customers, boosting annual store revenue, and optimizing purchases frequency by VIP clients. These targets are pursued with a discerning understanding of the inherent constraints, such as the boutique's spatial layout and the imperative for a diverse and inclusive product assortment. With a carefully crafted product placement strategy that not only innovatively caters to diverse customer preferences, but also encompasses various genders and clothing categories, fulfilling the primary objectives effectively.

II. Problem Description and Formulation

2.1. Data selection and scenario description

The dataset presents Fiscal Year 2019 sales data for a leading global luxury brand, detailing consumer behavior and product popularity.Sensitive data within the dataset has already been anonymized, and enhanced metrics for each SK*(SKU: Single stock keeping unit)* have been instituted. The focus of the analysis rests on the top 5,845 SKUs, selected based on metrics that include product category, launch season, and targeted gender demographics. Data excerpts in the appendix illustrate the metrics used, which track new customer acquisitions, VIP customer engagements *(Note: customers with over $3000 in purchases in the past year will be defined as VIP customers)*, and total fiscal revenue for each product. With the dataset encompassing 29 stores, the objective values are averaged to estimate each store's contribution to the overall metrics (*Sample rows and data dictionary could be found in appendix*).

On November 9th, the team conducted a detailed review of luxury retail environments in Montreal and captured photos for reference. Using these insights, the team created a luxury store layout with 88 designated product display positions *(detailed in the appendix)*.

2.2. Objective function reasoning

With the mindful of specific operational objectives and constraints, the team has developed three pivotal objectives for the strategic model:

- **New_customer**: Historical total number of new customers buying the product as their first purchase. This is to elevate the inflow of new clientele, thereby expanding the market reach.
- **Revenue**: Historical total revenue generated by the product in the fiscal year. This is to

amplify annual revenue across the retail locations, ensuring sustained financial growth.

- **Vip_customer**: Historical total number of VIP members purchasing the product. This is to enhance the purchase frequency of VIP clientele, reinforcing brand loyalty and consumer engagement.

The store's objectives are to enhance revenue by optimizing product placement to increase sales from new and VIP customers. The store layout is designed to balance product displays to achieve these goals effectively. In addition, the model incorporates assumptions to assess the impact of window displays on purchasing behavior, aligning with findings by Sen et al. (2002) that such displays significantly inform consumer perceptions of a store's quality and brand image. A provisional 10% bonus multiplier is integrated to capture the effect of window displays, subject to refinement with ongoing research and validation in practice. As for VIP customers, their high-frequency, high-volume purchases are attributed to strong brand attachment, as described by Shukla et al. (2016), thus not necessitating an additional multiplier within the model's framework.

2.3. Constraints Reasoning

The merchandising strategy of the store is informed by critical constraints designed to optimize product visibility, uphold exclusivity, and improve the overall customer experience. Below is a detailed outline of these key constraints:

One SKU Per Shelf Constraint: Limiting each shelf to a single SKU ensures each product gets ample visibility. This approach is designed to attract customer attention and highlight the exclusivity of each item, a key aspect in luxury retail. Also, it will force the model to avoid populating hundreds of SKUs in a single shelf.

Unique SKU Appearance: Restricting each SKU to appear only once throughout the store prevents product repetition, thus maintaining a sense of uniqueness and exclusivity. This approach is critical in a luxury setting where distinctiveness is highly valued.

Showcase Windows for Current Season's New Arrivals: Prioritizing the display of new arrivals in showcase windows capitalizes customer interest in the latest trends. This strategy is intended to draw in both regular customers and passersby, keeping the brand's offerings fresh and exciting.

Showcase Windows Only Contain One Pair of Shoes and One Bag: This constraint ensures a balanced and appealing display of popular categories. Shoes and bags are often high-visibility items in luxury boutiques, serving as flagship products that attract a wide range of customers.

Majority Category Representation in Each Area: Ensuring that each area of the store primarily displays preassigned types of products allows for a more organized and focused shopping experience. This approach helps customers easily find what they are looking for and enhances the perception of specialized offerings.

Separating Men's and Women's Clothing Areas: Segregating clothing by gender caters to specific customer preferences and shopping behaviors. This separation facilitates a more personalized shopping experience and makes it easier for customers to navigate the store. Also, it is a common practice based on the team’s visit to local luxury boutiques.

Accessories Near the Cash Register: Placing small accessories like jewelry, wallets, and belts near the checkout area capitalizes on impulse purchases. These items, often seen as add-ons, can significantly boost sales, especially when strategically positioned at the point of sale.

Maintaining a High Proportion of Latest Models (≥ 70%): It is essential to ensure that at least 70% of the products on display are from the latest season to keep the store's offerings modern and in sync with the current fashion trends. This strategy also leaves room for classic and popular products from past seasons.

Female Product Proportion (≥ 50%): Given the significant market share and purchasing power of female customers in the luxury sector (E. Stokburger-Sauer & Teichmann, 2011), maintaining at least 50% of the store's products targeted at women is strategic for catering to this crucial demographic.

III. Numerical Implements and Results

3.1. Data preprocessing

The team applies data preprocessing techniques in Python, encoding categorical attributes such as gender, birth season, and product category into a structured format. This is achieved through the creation of dummy variables, which convert these categories into a binary representation: a variable is marked as '1' to denote the presence of a category within a product's attributes, and '0' to indicate its absence. Such transformation is a critical step in formulating the constraints that will underpin the operational framework of the model.

3.2. Objective function implementation

In the boutique store placement optimization model, the primary decision variables are defined as follows: $\boldsymbol{X}[\boldsymbol{i},\boldsymbol{j}]$ is a binary matrix that plays a crucial role in determining the assortment of product types at various placement. Each element of this matrix represents the choice of a particular type at a specific place. If $\boldsymbol{X}[\boldsymbol{i},\boldsymbol{j}]$ is set to 1, it implies the selection of the

j-th product at the i-th location. Conversely, a value of 0 indicates that the j-th style is not chosen for the i-th location.

The objective function of the model is multifaceted, integrating various business aspects to optimize store placement. The team adjusted the priority of each function to see which can generate the overall best result (*Explain further in 3.4 Result Interpretation*).

- **New Customer Attraction**: This part of the objective function focuses on maximizing the power of attracting new customers. For locations 4 to 87, it calculates the historical new customer purchases of each product from the dataset $New[j]$ *(See Section 2.1 for detail)*, multiplied by the presence of the j-th product at the i-th location. For the first three locations (0 to 3), an adjustment factor of 1.1 is applied, highlighting the special customer attraction capability of shopwindows in these prime locations. The focus here is on the effectiveness of product placement in attracting new customers.

$$\text{New customers:} \quad 1.1 \times \sum_{i=0}^{3} \sum_{j=0}^{5844} \text{New}[j] \times X[i,j] + \sum_{i=4}^{87} \sum_{j=0}^{5844} \text{New}[j] \times X[i,j]$$

- **Revenue Generation**: This component addresses the revenue generation potential from product placements. For locations 4 to 87, it involves summing the products of historical revenue generated of each product $revenue[j]$ and the corresponding X values. For the first three locations (0 to 3), a factor of 1.1 is included, under the assumption that shopwindow products will generate a higher sales benefit. This assesses how product placement contributes to the boutique's revenue.

$$\text{Revenue:} \quad 1.1 \times \sum_{i=0}^{3} \sum_{j=0}^{5844} \text{revenue}[j] \times X[i,j] + \sum_{i=4}^{87} \sum_{j=0}^{5844} \text{revenue}[j] \times X[i,j]$$

- **VIP Influence:** The objective function quantifies the influence of VIP customers across all locations, summing up the products' historical VIP clients purchasing amount and the corresponding X values. Despite its reduced priority, it remains important due to the luxury industry's focus on catering to high-value clients, who can significantly impact the boutique's success and brand image.

$$\text{VIP:} \quad \sum_{i=0}^{87} \sum_{j=0}^{5844} \text{vip}[j] \times X[i,j]$$

3.3. Constraints implementation

One SKU Per Shelf: There are 88 shelves, from positions 0 to 87. For each shelf, the sum of all potential SKUs that could be placed on that shelf must equal exactly 1. This ensures that each shelf features precisely one product.

$$For\ i\ \in\ \{0,\dots,87\}, \quad 1 = \sum_{j=0}^{5844} X[i,j]$$

Unique SKU Appearance: For each SKU, the sum of its presence across all 88 shelves must be less than or equal to 1. This means an SKU can appear at most once in the entire store, ensuring exclusivity in display.

$$\text{For } j\ \in\ \{0,\dots,5844\}, \quad 1 = \sum_{i=0}^{87} X[i,j]$$

Display Cases Next to Cash Registers: For specific categories like belts, jewelry, and SLGs *(other accessories)*, the constraint ensures that a fixed number of units are displayed near the cash register. For example, if there are 'n' belt positions, each position in this section must feature exactly one SKU belongs to the belt category.

$$\text{For example: For } i \in \text{jewelry, } \sum_{j=0}^{5844} X[i,j] \times \text{Category}[j][2] = 1$$

* Category is the dataset contains the product name and its dummified category.

* Category[j][2] is a binary if the product j falls in jewel category

Showcase Window Constraints:

- New Seasonal Products: For each showcase position, the constraint requires that the sum of the products multiplied by a binary indicator of whether it is a new seasonal item (1 for new season, 0 otherwise) must equal 1. This ensures only new seasonal items are displayed in the showcase.

$$\text{For } i \in \text{shopwindow: } \sum_{j=0}^{5844} X[i,j] \cdot \text{birthseason}[j] = 1$$

*birthseason[j] is a binary indicating if the product is released in the latest season (Spring/Summer 2019)

- Minimum Proportion of New Seasonal Products: The total count of new seasonal items across all 88 shelves must be at least 70% of the total number of positions. This can be formulated as the sum of the new seasonal items across all shelves being greater than or equal to 0.7 times 88.

$$\sum_{i=0}^{87} \sum_{j=0}^{5844} X[i,j] \times \text{birthseason}[j] \geq 0.7 \times 88$$

Female Product Rate (≥ 50%): The ratio of female-targeted products in the store must be at least 50% of the total product offering. This is calculated as the sum of female products (multiplied by a binary gender indicator, 1 for female and 0 otherwise) being at least 50% of the sum of all products across the 88 shelves.

$$\sum_{i=0}^{87}\sum_{j=0}^{5844} X[i,j] \times \text{Gender}[j][1] \geq 0.5 \times \sum_{i=0}^{87}\sum_{j=0}^{5844} X[i,j]$$

*Gender[j][1] is a binary if product j is for female

3.4. Result interpretation

	Revenue	# Of New Customers	# Of VIP
Prior Target: VIP	760,543.87	395	32
Prior Target: New Customers (Base Model)	770,999.51	478	27
Prior Target: Revenue	855,308.69	426	29

Upon analyzing the results, the team found that the overall outcome aligns well with the preconceptions about luxury store layouts. The placement of products adheres to a traditional luxury store format, with all items neatly organized within their designated sections. Moreover, the model's objective values will adjust based on the priority changes set for each objective, demonstrating the methodology's applicability. This allows boutique stores to prioritize objectives, thus maximizing the specific KPIs targeted for that period. For the final results, the base model prioritizes number of new customers over VIP purchases and revenue, resulted in a portfolio of products that had historically attracted 478 new (non-distinct) customers in the 2019 Fiscal Year, a revenue generation of $770,999, and 27 VIP purchases. Detailed results will be presented in the appendix.

The model's output indicates a pronounced selection bias towards products featuring monochromatic schemes, with a particular emphasis on black and white within the ready-to-wear segment. While this trend aligns with the brand's current product range, it presents a deviation from the traditional luxury retail practice of offering an eclectic color array to captivate a varied clientele. This inclination towards minimalist coloration implies that, for this brand, understated tones may have a more pronounced impact on customer acquisition and revenue enhancement.

The initial model tended to favor products from previous seasons, likely due to their longer market presence and related revenue generation. The team corrected this by incorporating new-season products in the constraints, highlighting a limitation of the approach. Instead of relying on a full year's data, using seasonal sales data, and updating the product layout each season would enhance the model's operational applicability. This adjustment not only improves the current model but also suggests a direction for future enhancements.

IV. Problem Extension

Indeed, the base model for the new luxury boutique specifically targets the placement of new seasonal products. Its focused approach aims to attract new customers and enhance VIP experiences by strategically situating these items across various store locations. However, while the base model is robust in strategizing product placement for a luxury boutique, it exhibits limitations, particularly in its handling of discounted items. This oversight potentially impacts the boutique's ability to fully leverage pricing strategies to diversify the clientele and stimulate sales. Discounted products, a key aspect for attracting cost-conscious new customers and retaining VIPs who appreciate exclusive offers. Thus, refining the model to incorporate discounts is crucial for tapping into a wider customer base in the competitive luxury market.

In the advanced iteration of the optimization model for the luxury boutique, the team introduced discounting strategies to refine the product placement and pricing approach. The addition of the binary variable $Z[i, j]$ in conjunction with $Y[i]$ facilitates the management of discounts, ensuring that they are applied in a sophisticated manner that aligns with the boutique’s luxury positioning.

To be specific, Constraint 8 limits the number of discounted items to less than 15% of the total non-seasonal products, ensuring that the store maintains an image of exclusivity while still offering selective incentives. Constraints 10 and 11 prohibit discounts on new seasonal products and in shop window displays, reinforcing the premium nature of the latest collections and maximizing the appeal of the boutique's most visible products. These parameters are carefully calibrated to entice price-sensitive shoppers with attractive offers, without diluting the boutique's high-end brand image.

The data from the extended model indicates a substantial increase in new customer acquisition, which is the target of the extension. Despite this, the number of VIP customers remains constant, implying that the discount initiatives have little effect on VIP customer behavior. Additionally, there is a decrease in total revenue attributed to the reduced pricing strategy.

	Revenue	**# Of New Customers**	**# Of VIP**
Base Model	770,999.51	478	27
Model With Extension	743,993.04	511	27

In conclusion, the extended model's impact on the understanding of product placement strategy is profound. It demonstrates that discounts, if executed judiciously, can be a powerful tool to attract both new customers, who might be drawn by the exclusivity of time-sensitive deals. This strategic application of discounts can enhance the allure of new seasonal products, as well as staples, potentially leading to improved store performance. The model’s results underscore the importance of maintaining a balance between the boutique's luxury positioning and the dynamic use of discounts to remain competitive and profitable.

V. Recommendation and Conclusion

To elevate the sophistication and utility of the boutique store placement optimization model, it is essential to incorporate comprehensive historical promotion and inventory data. The integration of historical promotion data will shed light on the effectiveness of previous marketing endeavors, guiding the formulation of enhanced promotional strategies based on empirical evidence rather than conjecture. Additionally, incorporating inventory data will provide pivotal insights into stock availability and turnover rates, ensuring product availability is optimized.

Moreover, the current model's scope could be expanded by including category data, such as the various styles of tops and trousers. This detail would enable more strategic product positioning, potentially increasing customer engagement and sales by capitalizing on cross-selling opportunities and curating visually compelling merchandise displays. Further augmenting the model with pricing and sales data would significantly refine its predictive precision and operational effectiveness. Such integration would afford a more intricate understanding of consumer purchasing behaviors and overall store performance.

To extend the model's utility beyond boutique stores, it can be reconfigured to suit various specialty retailers. The flexibility to adapt to changing market conditions and consumer preferences is vital. With appropriate adjustments to its constraints and objectives, the model could serve department stores, sports stores, or other retail sectors.

Reflecting on the project, a more extensive initial data collection phase, encompassing a broader range of product types and deeper customer insights, would have been beneficial. Addressing the model's scalability and adaptability to different retail instances in future iterations will enhance its applicability and utility across various retail scenarios, making it a more versatile tool for retail strategy optimization.

VI. Reference

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Shukla, P., Banerjee, M., & Singh, J. (2016). Customer commitment to luxury brands: Antecedents and consequences. *Journal of Business Research*, *69*(1), 323–331. https://doi.org/10.1016/j.jbusres.2015.08.004

VII. Appendix

Style-Fabric-Color	Gender	Birth Season	Comm. Category Subgroup	New	VIP	Revenue
Small Pouch Calf Leather-Black Warm Gold	Male	Fall / Winter 2015-2016	SLG	1315	27	1503941.21
Portatutto Vitello-Black Warm Gold	Male	Fall / Winter 2015-2016	SLG	804	9	790309.192
T-Shirt-Black	Male	Fall / Winter 2018-2019	RTW	763	97	2723679.93
T-Shirts Cotton Jersey-Black	Male	Fall / Winter 2017-2018	RTW	693	28	940473.359

Table 1: Sample Data Rows

Style-Fabric-Color	The style, fabric, and color of the SKU.
Gender	Gender the SKU is targeting for (Male, Female, Unisex).
Birth Season	Birth Season of the product, latest season is referring to Spring/Summer 2019
Comm.Category	Category the product belongs to, including but not limited to RTW, BELT, and JEWLERY.
new	The number of new customers who have purchased this product in their first order in Fiscal year 2019.
VIP	The number of VIP purchases (customers who have purchased over $3000 in the past 12 months) for this product in Fiscal year 2019.
revenue	The total revenue generated by this product in Fiscal Year 2019.

Table 2: Data Dictionary

Women Clothing+Unisex: 10 units x35~x44		Men Clothing+Unisex: 10 units, x55~x64
	Cash registery， Belt-10 UNITS x65~x74, Fashion Jewery-4 units x75~x78, SLG-10 UNITS x79~x88	
Women Clothing+Unisex: 10 units,x25~x34		Men Clothing+Unisex: 10 units, x45~x54
Bags and Accessories: 5 counts x15~x19		Bags and Accessories: 5 counts x20~x24
Bags and Accessories: 5 counts x5~x9		Bags and Accessories : 5 counts x10~x14
Window shopping: x1~x2	**Entrence**	Window Shopping, x3~x4

Figure 1: Default Boutique Layout Design for the Model

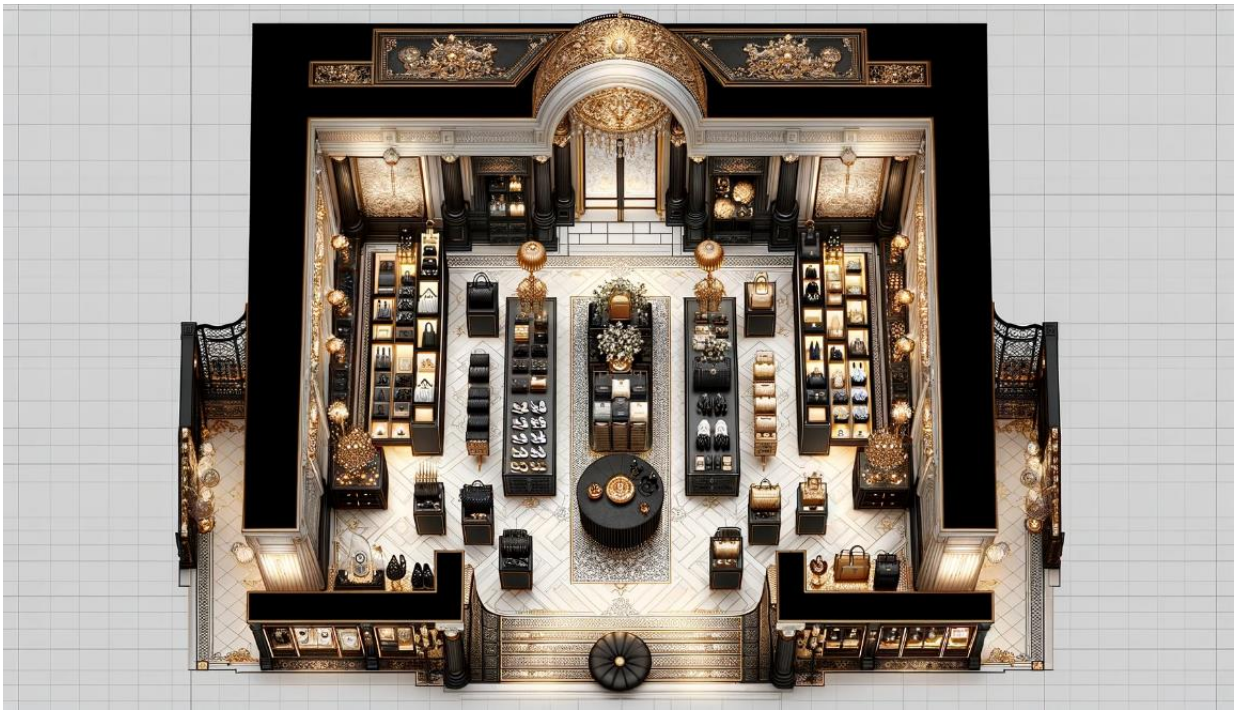

Figure 2: Final Design Visualization based on the predicted results

Figure 3: Picture taken from the local luxury store

Figure 4: Picture taken from the local luxury store

Figure 5: Picture taken from the local luxury store