Hospitality Industry - Profit Maximization under Loyal Customer Prioritization Model

May 13, 2024

Course: ORIE 5132, Pricing Analytics and Revenue Management

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1 Introduction

The hospitality industry traditionally generates revenue through the sale of room nights and ancillary services such as dining, spa treatments, and event hosting. Historically, Revenue Management (RM) in this sector focused on maximizing room revenues, employing strategies based on historical data and demand forecasting to optimize pricing and inventory. This approach predominantly targeted short-term financial gains through tactical adjustments in occupancy rates and room pricing, often overlooking the potential of other revenue streams.

The works from the papers provided emphasize the need for a holistic view of RM encompassing all hotel revenue streams, integrating advanced technologies and Customer Relationship Management (CRM). Such integration enhances strategic planning and employs sophisticated data analytics to improve decision-making and customer loyalty, thereby fostering long-term profitability. In this report, we will dive deeper into the strategic and operational decisions that underscore this paradigm shift, focusing on how hotels can optimize both their primary and ancillary services.

2 Critical Piece: Main Revenue Management Decisions

Effective revenue management is paramount in the hotel industry, necessitating a careful balance between immediate financial returns and sustained customer relationships. This balance is achieved through a strategic amalgamation of high-level strategic decisions, which set the overarching business goals and service offerings, and detailed operational decisions, which handle daily pricing and promotional activities. This paper lays the foundation for an in-depth analysis of dynamic pricing, the importance of long-term customer value, and innovative approaches to enhancing revenue via ancillary services. These discussions are supported by comprehensive data analysis aimed at optimizing both revenue generation and customer satisfaction.

2.1 Strategic Revenue Management

Strategic revenue management decisions in the hotel sector typically involve choices regarding service offerings, hotel layout structuring, or the formulation of long-term room pricing strategies based on seasonal demands. These decisions, which are made infrequently, necessitate a broad market perspective and a clear understanding of the hotel's strategic objectives.

2.2 Operational Revenue Management

Conversely, operational revenue management decisions are more frequent and involve dynamic adjustments in room pricing, promotional strategies for ancillary services, and modifications to hotel staffing contingent on occupancy levels. For instance, decisions to offer last-minute room discounts or to alter the pricing of spa services aim to optimize revenue during periods of decreased occupancy.

2.3 Dynamic Pricing

The application of dynamic pricing in the hotel industry requires cautious handling due to the potential trade-offs it presents. While it can maximize revenue through real-time adjustments in room rates based on demand fluctuations, it might also provoke customer dissatisfaction if perceived as unfair, especially by loyal customers who value consistent pricing. Thus, maintaining equilibrium between dynamic pricing strategies and predictable pricing models is crucial.

2.4 Long-term Customer Value (LTV)

Recognizing the importance of Long-term Customer Value (LTV) is crucial for hotels, as it underscores the need to cultivate enduring customer relationships. This may involve loyalty programs that offer benefits such as availability guarantees or discounted rates for frequent guests, highlighting the hotel's recognition of their long-term contribution over mere immediate profits.

2.5 Ancillary Services

The interaction between ancillary and primary services is another vital facet of revenue management. Effective pricing strategies for ancillary services not only bolster overall revenue but also enhance the customer experience, potentially increasing on-site spending. For example, bundling room accommodations with spa access and breakfast, or providing complimentary shuttle services to the airport, can augment attractiveness and boost demand.

The decisions highlighted herein depend extensively on data analysis. Essential data points include historical occupancy rates, seasonal demand, competitive pricing, and customer spending patterns on-site, typically extracted from the hotel's property management systems and booking engines. Additionally, external market data from tourism forecasts can offer valuable insights into broader market trends that significantly influence revenue management strategies.

3 Mathematical Model:

MATHEMATICAL MODEL SETUP:

$C \rightarrow$ Total # of rooms available.

$D_1 \rightarrow$ Demand for regular customers.
$D_2 \rightarrow$ Demand for loyal (True Friends) customers.

$b \rightarrow$ Booking limit for regular customers.

$f_1 \rightarrow$ revenue for regular customers.
$f_2 \rightarrow$ revenue for loyal customers.

* $\alpha \rightarrow$ fraction of revenue refunded to regular customers on cancellation
(* Note: $\alpha = 1$ for loyal customers, i.e., NO cancellation fee)

$r \rightarrow$ cost of room maintenance for each customer who shows.

$\theta \rightarrow$ cost of rejecting a regular customer, i.e., if demand D_1 exceeds booking limit.

$p \rightarrow$ probability of a customer showing (not cancelling) independently.

$\cdot\times\cdot$ $Z(n) \rightarrow$ random variable representing no. of shows given that we have 'n' reservations over booking horizon.

($\cdot\times\cdot$ Note: $Z(n)$ is a binomial random variable and can be represented as the sum of 'n' bernoulli random vars, with probability of success $= p$.

$$\therefore Z(n) = \beta_1 + \beta_2 + \cdots \beta_n \quad \text{where } \beta_i \sim \mathrm{Bern}(p) \;\; \forall\, i = 1, \ldots n.$$
)

Our model maximizes over the total expected profit function $\pi(b, D_1, D_2)$ to find the optimal solution for b.

Our profit function is modeled as follows:

$=$ $\boxed{\text{revenue from regular customer} - \text{fraction of revenue refunded to regular customers who cancel}}$

$+$ $\boxed{\text{revenue from loyal customer} - \text{fraction of revenue refunded to loyal customers who cancel}}$

$-$ $\boxed{\text{cost of maintenance of room for each regular \& loyal customer who shows (does not cancel).}}$

$-$ $\boxed{\text{cost of rejection for each regular customer we are unable to service.}}$

MATHEMATICAL MODEL SOLUTION:

$$\pi(b, D_1, D_2) = f_1 \cdot \min(b, D_1) - \alpha \cdot f_1 [\min(b, D_1) - Z(\min(b, D_1))]$$

$$+ f_2 \cdot \min(C - \min(b, D_1), D_2)$$

$$- f_2 \cdot [\min(C - \min(b, D_1), D_2) - Z(\min(C - \min(b, D_1), D_2))]$$

$$- r [Z(\min(b, D_1)) + Z(\min(C - \min(b, D_1), D_2))]$$

$$- \theta [\max(Z(\min(b, D_1)) - b, 0)]$$

Note: using min / max transformations, the term with θ as the coefficient can be re-written as:

$$= + \theta [\min(b - Z(\min(b, D_1)), 0)]$$

$$= + \theta [\min(b, Z(\min(b, D_1))) - Z(\min(b, D_1))]$$

$$\therefore \pi(b, D_1, D_2) = (1 - \alpha) f_1 \cdot \min(b, D_1) + \alpha \cdot f_1 \cdot Z(\min(b, D_1))$$

$$+ f_2 \cdot Z(\min(C - \min(b, D_1), D_2))$$

$$- r [Z(\min(b, D_1)) + Z(\min(C - \min(b, D_1), D_2))]$$

$$+ \theta [\min(b, Z(\min(b, D_1))) - Z(\min(b, D_1))]$$

$$\therefore \pi(b, D_1, D_2) = (1-\alpha) f_1 \cdot \min(b, D_1) + (\alpha f_1 - r - \theta) \cdot z(\min(b, D_1))$$
$$+ (f_2 - r) \cdot Z(\min(c - \min(b, D_1), D_2))$$
$$+ \theta \cdot \min(b, z(\min(b, D_1)))$$

Now, let: ① $\min(b, D_1) = \pi_1(b, D_1)$

② $z(\min(b, D_1)) = \pi_2(b, D_1)$

③ $Z(\min(c - \min(b, D_1), D_2)) = \pi_3(c - \min(b, D_1), D_2)$

④ $\min(b, z(\min(b, D_1))) = \pi_4(b, z(\min(b, D_1)))$

$\therefore$ we now have:

$$\pi(b, D_1, D_2) = (1-\alpha) f_1 \cdot \pi_1(b, D_1) + (\alpha f_1 - r) \cdot \pi_2(b, D_1)$$
$$+ (f_2 - r) \cdot + \pi_3(c - \min(b, D_1), D_2)$$

we want to solve for: $\max\limits_{b \in \mathbb{Z}+} \mathbb{E}\{\pi(b, D_1, D_2)\}$

$\therefore$ we need to find the first b such that:

$$\mathbb{E}\{\pi(b+1, D_1, D_2)\} - \mathbb{E}\{\pi(b, D_1, D_2)\} \leq 0$$

① First computing: $\pi_1(b+1, D_1) - \pi_1(b, D_1)$

$$= \min(b+1, D_1) - \min(b) D$$

$$= \begin{cases} D_1 - D_1 = 0 & \text{if } D_1 \leq b \\ b+1-b = 1 & \text{if } D_1 \geq b+1 > b \quad \text{(integrality)} \end{cases}$$

$$\therefore \mathbb{E}\{\pi_1(b+1, D_1) - \pi_1(b, D_1)\} = 1 \cdot \mathbb{P}(D_1 \geq b+1)$$

② Second computing: $\pi_2(b+1, D_1) - \pi_2(b, D_1)$

$$= z(\min(b+1, D_1)) - z(\min(b, D_1))$$

$$= \begin{cases} z(D_1) - z(D_1) = 0 & \text{if} \quad D_1 \leq b \\ z(b+1) - z(b) & \text{if} \quad D_1 \geq b+1 > b \ \text{(integrality)} \end{cases}$$

$$= \begin{cases} 0 & \text{if} \quad D_1 \leq b \\ \beta_{b+1} & \text{if} \quad D_1 \geq b+1 > b \ \text{(integrality)} \end{cases}$$

$$= \begin{cases} 0 & \text{if} \quad D_1 \leq b \\ 1 & \text{if} \quad D_1 \geq b+1 > b, \ \beta_{b+1} = 1 \\ 0 & \text{if} \quad D_1 \geq b+1 > b \quad \beta_{b+1} = 0 \end{cases}$$

$$\therefore \mathbb{E}\{\pi_2(b+1, D_1) - \pi_2(b, D_1)\} = 1 \cdot \mathbb{P}(D_1 \geq b+1) \cdot \mathbb{P}(\beta_{b+1} = 1)$$

$$= \mathbb{P}(D_1 \geq b+1) \cdot \mathbb{P}(\beta_{b+1} = 1) = \mathbb{P}(D_1 \geq b+1) \cdot p$$

③ Third computing: $\pi_3(c - \min(b+1, D_1), D_2)$

$$- \pi_3(c - \min(b, D_1), D_2)$$

$$= z(\min(c - \min(b+1, D_1), D_2)) - z(\min(c - \min(b, D_1), D_2))$$

$$= \begin{cases} 0 & \text{if} \quad D_1 \leq b \\ z(\min(c-(b+1), D_2)) - z(\min(c-b, D_2)) & \text{if} \quad D_1 \geq b+1 \end{cases}$$

$$= \begin{cases} 0 & \text{if} \quad D_1 \leq b \\ 0 & \text{if} \quad D_1 \geq b+1, \quad D_2 \leq c-b-1 \\ z(c-b-1) - z(c-b) & \text{if} \quad D_1 \geq b+1, \quad D_2 \geq c-b \end{cases}$$

$$= \begin{cases} 0 & \text{if} \quad D_1 \leq b \\ 0 & \text{if} \quad D_1 \geq b+1, \quad D_2 \leq c-b-1 \\ -\beta_{c-b} & \text{if} \quad D_1 \geq b+1, \quad D_2 \geq c-b \end{cases}$$

$$= \begin{cases} 0 & \text{if} \quad D_1 \le b \\ 0 & \text{if} \quad D_1 \ge b+1, \quad D_2 \le c-b-1 \\ -1 & \text{if} \quad D_1 \ge b+1, \quad D_2 \ge c-b, \quad \beta_{c-b} = 1 \\ 0 & \text{if} \quad D_1 \ge b+1, \quad D_2 \ge c-b, \quad \beta_{c-b} = 0 \end{cases}$$

$$\therefore \mathbb{E}\left\{\Pi_3(c-\min(b+1, D_1), D_2) - \Pi_3(c-\min(b, D_1), D_2)\right\}$$

$$= -1 \cdot \mathbb{P}(D_1 \ge b+1, D_2 \ge c-b, \beta_{c-b} = 1)$$

$$= -1 \cdot \mathbb{P}(D_1 \ge b+1) \cdot \mathbb{P}(D_2 \ge c-b) \cdot p$$

④ Fourth computing : $\Pi_4(b+1, z(\min(b+1, D_1)))$

$$- \Pi_4(b, z(\min(b, D_1)))$$

$$= \min(b+1, z(\min(b+1, D_1))) - \min(b, z(\min(b, D_1)))$$

$$= \begin{cases} \min(b+1, z(D_1)) - \min(b, z(D_1)) & D_1 \le b \\ \min(b+1, z(b+1)) - \min(b, z(b)) & D_1 \ge b+1 \end{cases}$$

$$= \begin{cases} 0. & D_1 \le b \\ z(b+1) - z(b) & D_1 \ge b+1 \end{cases}$$

$$= \begin{cases} 0 & \text{o/w} \\ 1 & D_1 \ge b+1, \quad \beta_{b+1} = 1 \end{cases}$$

$$= \mathbb{P}(D_1 \ge b+1) \cdot p$$

$\therefore$ **Summing up:**

$$\Rightarrow (1-\alpha f_1)\cdot \mathbb{P}(D_1 \geq b+1)$$
$$+ (\alpha f_1 - \gamma - \theta)\cdot \rho \cdot \mathbb{P}(D_1 \geq b+1)$$
$$-(f_2-\gamma)\cdot \rho \cdot \mathbb{P}(D_1 \geq b+1)\cdot \mathbb{P}(D_2 \geq c-b)$$
$$+ \theta \cdot \rho \cdot \mathbb{P}(D_1 \geq b+1) \leqq 0$$

$$\Rightarrow (1-\alpha f_1)\cdot(1-\mathbb{P}(D_1 < b+1)) + (\alpha f_1 - \gamma)\cdot \rho \cdot (1-\mathbb{P}(D_1 < b+1))$$
$$-(f_2-\gamma)\cdot \rho \cdot (1-\mathbb{P}(D_1 < b+1))(1-\mathbb{P}(D_2 < c-b)) \leq 0$$

$$\Rightarrow (1-\alpha f_1)\cdot(1-F_1(b+1)) + (\alpha f_1 - \gamma)\cdot \rho \cdot (1-F_1(b+1))$$
$$-(f_2-\gamma)\cdot \rho \cdot (1-F_1(b+1))(1-F_2(c-b)) \leqq 0$$

$$\Rightarrow (1-\alpha f_1)\cdot(1-\cancel{F_1(b+1)}) + (\alpha f_1 - \gamma)\cdot \rho \cdot (1-\cancel{F_1(b+1)})$$
$$\leqq (f_2-\gamma)\cdot \rho \cdot (1-\cancel{F_1(b+1)})(1-F_2(c-b))$$

$$\therefore \quad (1-\alpha f_1) + (\alpha f_1 - \gamma)\cdot \rho \leqq (f_2-\gamma)\cdot \rho \cdot (1-F_2(c-b))$$

$$\therefore \quad F_2(c-b) \geq \frac{(1-\alpha f_1) + (\alpha f_1 - \gamma)\cdot \rho}{(f_2-\gamma)\cdot \rho}$$

$$\boxed{\therefore \quad b \leqq c - F_2^{-1}\left(\frac{(1-\alpha f_1) + (\alpha f_1 - \gamma)\cdot \rho}{(f_2-\gamma)\cdot \rho}\right)}$$

3.1 Interpretation of the Equation

3.1.1 Expected Revenue Calculation:

- The term $(1-\alpha)f_1$ calculates the adjusted revenue from regular customers, accounting for potential refunds from cancellations.
- The term $(\alpha f_1 - \gamma) \cdot \rho$ reflects the actual revenue after subtracting maintenance costs, adjusted for the probability of the customer showing up.

3.1.2 Ratio of Revenues:

- The revenue expected from regular customers is compared to the revenue expected from loyal customers, calculated as $(f_2 - \gamma) \cdot \rho$.
- This comparison helps in determining how much revenue each room allocated to regular customers generates in comparison to rooms allocated to loyal customers.

3.1.3 Setting the Booking Limit b:

- F_2^{-1} is the inverse function of F_2, which could represent the cumulative distribution function (CDF) for demand or room utilization for loyal customers.
- The equation sets b such that after accounting for the expected demand for loyal customers, the remaining rooms can be allocated to regular customers.

4 Conclusion

The derived formula is a strategic approach to room allocation that ensures a balance between maximizing revenue and maintaining loyalty programs. This methodology prioritizes high-value loyal customers while ensuring that occupancy and revenue generation from regular customers are optimized.

This comprehensive approach ensures that hotels not only meet the current needs of their customers but are also well-positioned to adapt to future challenges and opportunities in the hospitality industry. By integrating advanced data analytics, customer-focused strategies, and technology-driven solutions, hotels can achieve a competitive edge and foster sustainable growth.