Optimized Revenue: Strategic Overbooking & Dynamic Pricing

1. General Overview

The project is centered on establishing the most advantageous pricing and overbooking strategies for an airline's coach and first-class tickets. It aims to boost profit from ticket sales while managing the costs of overbooking. For the sake of customer relations, the airline prefers to restrict overbooking to coach seats. Ticket pricing, which varies and influences the independent demand for each class, plays a pivotal role in sales probability, with coach sales likelihood increasing when first-class is fully booked.

Utilizing dynamic programming, the project explores various overbooking scenarios and pricing strategies to pinpoint the one that yields the highest expected discounted profits, thus proposing an overbooking policy that strikes a balance between maximizing revenue and reducing overbooking-related financial risks. The analysis is thorough, taking into account fixed costs, fluctuating demands, and the dynamics between the two classes of service, all to inform the airline's strategic decisions effectively.

2. Initial Revenue and Cost Analysis (2 possible choices)

5-Seats Overbooking Strategy:

For analytical purposes, a set of assumptions and conditions has been established as foundation for revenue and overbooking cost management strategy. In real-world scenarios, these parameters may shift according to market conditions:

- Sales Opportunities & Pricing Strategy: The airline can sell tickets over 365 days leading up to the flight, offering 100 coach and 20 first-class seats. Tickets are priced at two levels: $300 or $350 for coach and $425 or $500 for first-class. The probability of selling a ticket varies with its price; coach tickets have a 65% (at $300) or 30% (at $350) chance of being sold, while first-class tickets have an 8% (at $425) or 4% (at $500) chance.
- Passenger Show-up Rates: The expected passenger show-up rates are 95% for coach and 97% for first-class. In light of the airline's strategy to overbook coach by 5 seats, a comprehensive analysis of revenue against costs is essential, considering the costs of $50 for moving a passenger to first-class and $425 for denied boarding.
- Discounted Profit Calculation: The annual discount rate is set at 17%, translating into a daily discount factor of 1/(1+0.17/365), which is used to derive the net present value of projected revenues and overbooking penalties.

A numerical framework has been developed to simulate and assess the profitability of diverse pricing and overbooking strategies in the period preceding flight departure. Central to this framework is a value function designed to forecast expected profits from ticket sales and costs related to possible overbooking. The dimensions of the function array are as follows: 106 for coach seats plus overbooking options, 21 for first-class seats, and 366 for the total days until departure plus one. The value function accommodates the total number of coach and first-class seats along with the respective overbooking allowance and pricing decisions, which are indexed for various combinations of low and high prices in both classes. The value function is defined as:

$$V(c,f,t) \;=\; max_{p\in\{p_c,p_f\}}(R(c,f,p) + \delta \cdot E[V(c', f, t+1)])$$

Where:

- p_c and p_f are the pricing decisions for coach and first-class seats, respectively.
- $R(c,f,p)$ represents the immediate revenue from selling a ticket at prices.
- δ is the daily discount factor derived from the annual rate, here applied to transition the value of future profits back to present-day valuation.

- $E[V(c', f, t+1)]$ is the expected value of the system in the next state, considering the probabilities of ticket sales and passenger showups.

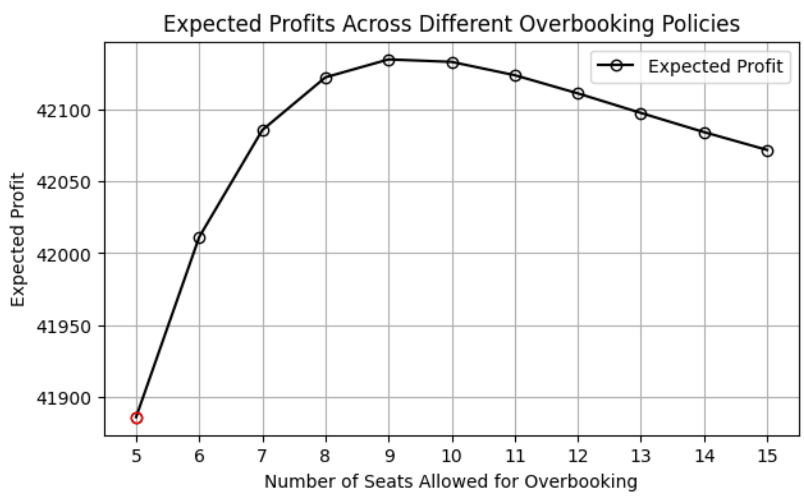
The model's mechanics take into account a range of scenarios, from having seats available to sell to reaching full capacity, adjusting revenue calculations as needed. When both seat classes are open for sale, revenue is computed based on all possible sales outcomes for that day and anticipated future sales, which are discounted to their current value. Once first-class seats are sold out, the chance of selling a coach seat marginally rises, mirroring an actual shift in consumer behavior when higher-tier options are exhausted.

This method enables the prediction of revenues influenced by various pricing and seat availability combinations, including cases where first-class is fully booked, slightly lifting the likelihood of coach seat sales. The model adapts to focus solely on the remaining class for revenue projections if one class is completely reserved. If both classes reach full occupancy, the model progresses by carrying the system's value forward without accruing additional revenue.

The iterative application of the value function over a 365-day sales window allows the dynamic pricing model to simulate outcomes under various pricing and overbooking policies. The analysis identifies an optimal strategy (high price for coach tickets and a low price for first-class) that enhances the expected discounted profit ($41,886.16). This profit represents the maximum potential profitability considering all future scenarios.

6-15 Seats Overbooking Strategy:

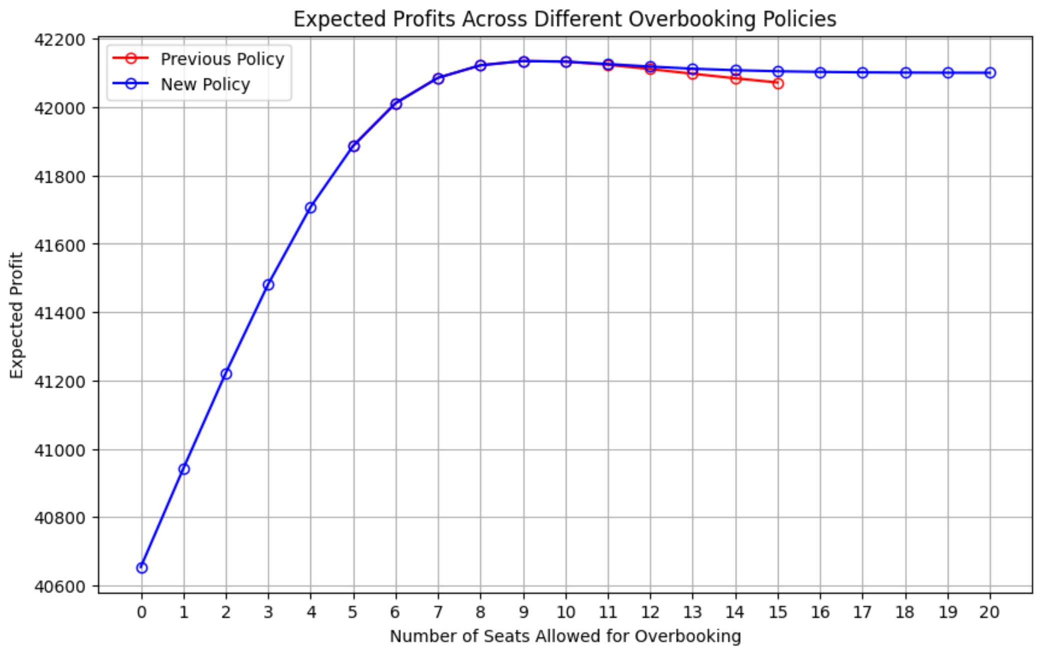
Expanding overbooking from 5 to 15 seats affects expected profits, with a sharp increase in gains as overbooking grows from 5 to 9 seats, peaking at $42,135. This suggests early revenue from additional ticket sales surpasses the costs of denied boardings. Profits then plateau and dip as overbooking exceeds 9 seats (see graph below), indicating risks begin to eclipse the extra revenue. This turning point is key for assessing the risk-reward ratio of overbooking, aiding in determining the best overbooking cap. Notably, profits are lowest at a 5-seat level, underscoring the advantage of a moderate overbooking approach.



3. **New Policy (3 possible choices)**

The pricing model has been expanded to include a no-sale option for coach class, enhancing daily pricing flexibility. This revised strategy contrasts with the previous fixed-seat cap approach by employing a dynamic method that allows for the suppression of coach sales entirely when advantageous. Introducing this third pricing choice grants leverage to manipulate demand more precisely. This innovation aligns with a commitment not to exceed a ceiling of 120 coach seats sold, while also enabling mitigation of potential overbooking based on real-time sales data and time remaining. The refined model now calibrates the daily sales approach, offering a more tailored and responsive overbooking management tactic.

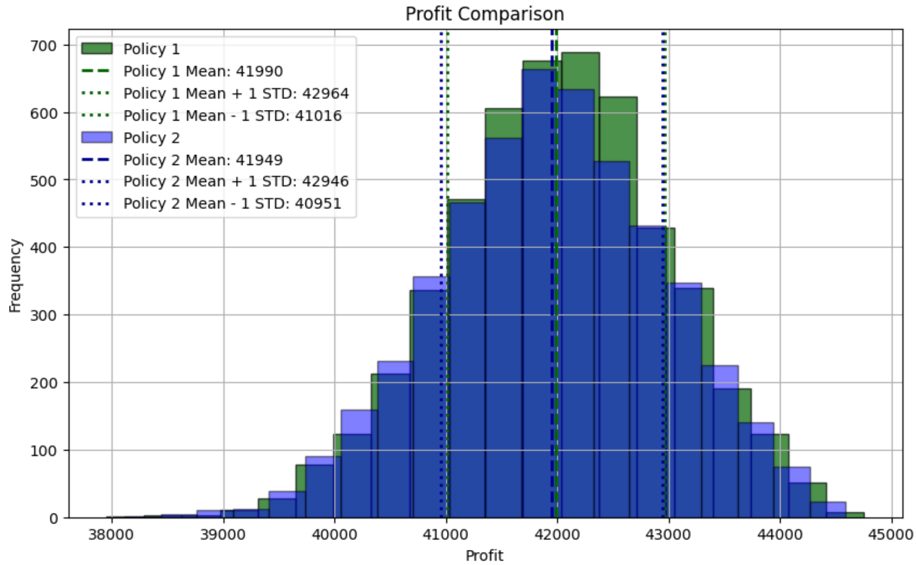
Incorporating the no-sale coach option into the pricing model provides nuanced control over sales, initially resulting in a modest profit boost. Notably, both policies align at a profit apex of approximately $42,135 when overbooking is capped at 9 seats. However, profitability discrepancies become more pronounced with overbooking exceeding this cap, particularly noticeable after 10 seats. This trend indicates a critical point where additional overbooking starts incurring disproportionate costs, diminishing the marginal benefit of selling extra seats. The ability of the new policy to withhold coach sales likely helps mitigate these risks by maximizing first-class revenue on selective days, highlighting the delicate balance between revenue maximization and the financial risks associated with overbooking.



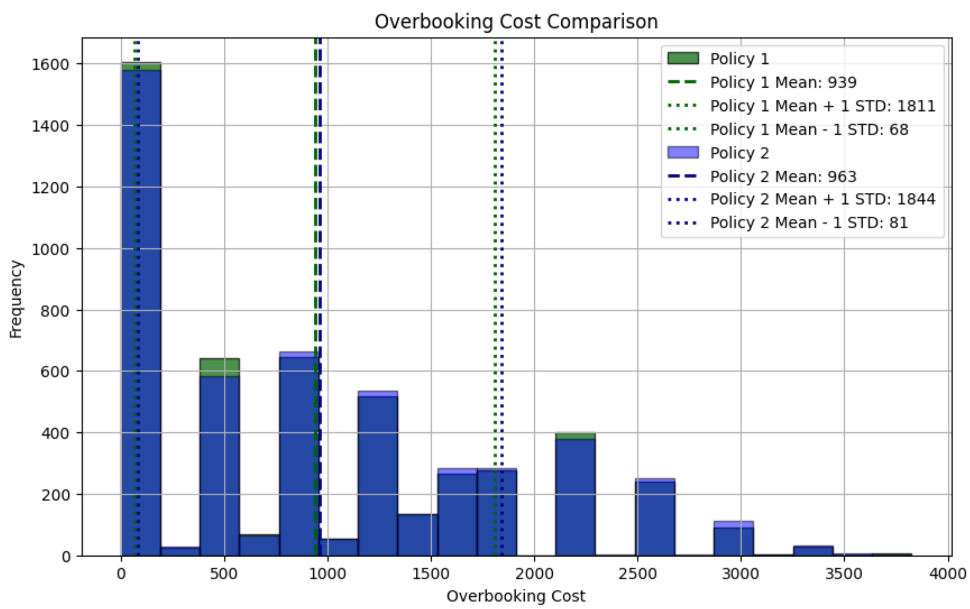
4. Simulations

Simulations were conducted for both the original and new no-sale policies to simulate ticket sales and passenger show-up rates on the day of departure, considering probabilities associated with different pricing choices. By running multiple simulations, statistical estimates of expected revenues, overbooking costs, and ultimately flight profits were generated. These simulations are crucial as they incorporate the inherent variability and randomness in customer behavior, providing a robust and realistic estimate of financial outcomes under different strategies. By comparing simulations under various overbooking policies, the airline can empirically assess the impact of overbooking levels on profitability and make data-driven decisions to optimize its strategy.

Upon examining the outcomes of the overbooking policies, the differences in performance between Policy 1 and Policy 2 are marginal but notable. Policy 1 shows a slightly higher mean revenue at $42,929 compared to Policy 2's $42,912, marginally higher average profit at $41,990 versus $41,949. The difference in revenue and profit, while minimal, leans in favor of Policy 1, indicating a slight edge in economic efficiency.



The frequency of overbooking in the coach class is similar between both policies (79.58% for Policy 1 and 79.66% for Policy 2). This high frequency highlights that in approximately 80% of instances, the airline must manage the ramifications of overbooking, which is significant from an operational and customer service standpoint. Looking at the costs associated with overbooking, Policy 2 incurs an average of $962.73 compared to Policy 1's $939.19. The higher costs under Policy 2 are accompanied by a slightly higher standard deviation in overbooking cost volatility. This indicates that Policy 2 carries a tad more unpredictability in terms of overbooking cost.



Moreover, the volatility of profits, indicated by the standard deviation, is higher for Policy 2 at $997, compared to Policy 1's $974. Even though the increase in volatility is not substantial, it suggests that the financial outcomes under Policy 2 are less predictable.

In essence, while the numerical differences between the two policies are not drastic, they collectively tilt in favor of Policy 1 when considering a balance between revenue optimization and predictability. The airline might prefer the slightly more stable and predictable nature of Policy 1, which could facilitate better planning and customer experience management, even though it does not outperform Policy 2 by a large margin.