**Team 9**

**550 Analytical Decision Making**

**Project: Hotel Reservations (Linear Programming)**

**Date 3/12/2023**

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# I. PROJECT INFORMATION 1

**COURSE NAME:** TBANLT 550 Analytical Decision Making

**QUARTER:** Winter 2022

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**DATE:** 03/11/2023

**TEAM NAME:** Team 3

**FINAL PROJECT TITLE:** Hotel Reservations (Linear Programming)

**INTEGRITY STATEMENT:**

I certify that I have completed this assignment within the Academic Integrity guidelines presented in the UW General catalog. Further, I certify that I do not have any knowledge of any other individual(s) violating these guidelines.

**SIGNATURE:**

| Last Name, First Name | Signature | Date |
|---|---|---|
| Hima Bindu Yamasani | | 13-March-2023 |
| Kajal Taele |  | 13-March-2023 |
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# II. PROJECT INFORMATION 2

## 1. Project Background

Hotel ABC is a medium-sized hotel in Miami that offers various services, including accommodations (7 room types), dining, and other amenities. The hotel uses different reservation platforms to enable guests to schedule dates, length of stay, room selection, extras, and payment all in one place. However, the current reservation system does not use optimization techniques to maximize revenue. The decision variables in this project include the number of rooms to be reserved and the average price of each room. The constraints include minimum and maximum room availability for each room type as per demand on regular days and holiday season. Assumptions include a number of rooms as per demand.

This will require analyzing the data available from the reservation system and other sources to identify trends and patterns in guest behavior and demand. The project will involve collecting and analyzing data, developing the Linear Programming Model, and testing the model against actual reservations to validate its accuracy. Once validated, the model will be implemented into the hotel's reservation system, and staff will be trained to use it effectively.

The successful implementation of the Linear Programming Model will result in increased revenue for Hotel ABC, improved guest satisfaction, and streamlined operations for the hotel's staff.

## 2. Project Significance

Firstly, the model will allow the hotel to make more informed decisions regarding pricing, room availability, and guest preferences. By considering the most important variables, constraints, and assumptions, the model will enable the hotel to optimize its revenue and profitability.

Secondly, the implementation of the model will streamline operations for the hotel's staff, reducing the need for manual intervention and increasing efficiency. This will allow staff to focus on other important tasks, such as guest services and marketing.

Thirdly, the model will improve guest satisfaction by providing a more personalized experience. By considering guest preferences, such as room type and length of stay, the model will enable the hotel to offer tailored recommendations to each guest.

Overall, the significance of this project lies in its potential to increase revenue and efficiency for Hotel ABC, improve guest satisfaction, and provide a blueprint for other businesses to implement similar optimization models.

## 3. Problem Statement

Hotel ABC's reservation system enables guests to schedule dates and lengths of stay, room selection, extras, and payment all in one place using different reservation platforms. The aim of the project is to create Linear Programming Model with optimization which will maximize the revenue. The project involves the most important variables such as Decision Variables, constraints, and assumptions together with the associated probabilities and uncertainties, which are chosen.

Aim

Hotel Room booking optimization to maximize revenue for hotel ABC.

Summary

There are multiple challenges of hotel reservation booking starting with price as it can vary widely depending on the time of year, location, and other factors, communication or language barrier while making a reservation, security, rating, etc. Hotels focus on guest acquisition and spend their available resources on marketing. While it promotes customer engagement and awareness, it is not a controllable factor for hotel ABC which will directly contribute to generating output as revenue. However, the availability of rooms is one challenge that can be controlled by hotels, and its optimization and promotion of rooms as per optimized numbers can bring significant gains in terms of revenue. This project focuses on optimizing room booking for availability and promoting the same to customers to generate optimum revenue.

The dataset we fetched from Kaggle carries details of room reservations for the year 2017-2018 for hotel ABC. From the available variable list dates (day, month & year) and room type (room type 1 to 7), we observed each day the price of room changes, which was attributed to other variables like no. of adults, children, meal type, parking, special request, etc. which contributes to price change.

*The assumption* from our end also entailed that prices on regular days will vary compared to weekends and holidays (prices will be higher due to large demand and supply gap) which was validated by dataset analysis of days vs price. Further, we analyzed the average price of each room throughout the year as the first step. Then we took a sample of 1 month of data from the dataset for December 2018(dates 1$^{st}$ to 31$^{st}$) to carry out our optimization which can be replicated by hotel ABC MoM to gain maximum revenue.

Method of Analysis for Regular Dates

1. Find the average price per room for 7 different rooms available from room type 1 to room type 7.
2. As the next step we looked at 1$^{st}$-week dates (2$^{nd}$-8$^{th}$), days Sunday to Saturday to find the actual room booking and find the total revenue generated for the hotel.

3. Finding 2nd week actual revenue with dates (9th to 15th), days Sunday through Saturday
4. Constraints
    - This included identifying the total demand for room types 1 to 7, which was 415 rooms.
    - We put maximum and minimum constraints on each room type 1 to 7 for each day, based on assumptions and demand through analysis of the same from the available dataset and total rooms available at hotel ABC.
5. We used the build excel solver and simplex method to give our input variables, constraints, and objective function to get the details of maximized revenue with optimized room occupancy.

Findings

1. Average room price of Room type 3 is the lowest at 110$ and the average room price of room 6 is the highest at 273$ with an average booking of 0 and 4 per day respectively.
2. Total revenue generated during 1st week dates (2nd-8th): $64,978.8
3. Total revenue generated during 2nd week dates (9th-15th): $34,058.1
4. After optimization we found, of all the rooms maximum booking received is usually for Room type 1, hence by creating a scarcity of room type 1 and generating demand for other rooms like room types 3,5,6 which are highly priced per night through promotions/discounts/marketing/communication during room booking/special offers/requests, the hotel can generate more revenue with less booking also.

Exceptions

We observed that the volume of hotel bookings on the 2nd and 8th of the month of December ’2018 for Room type 1 was extremely high and did not incline toward the average. *Assuming* this is due to group booking, conference, etc., hence, to minimize errors in optimization we looked at week 2 data of December ‘2018 and carried optimization accordingly for the week with step-by-step analysis.

Result

Total revenue generated during the 2nd-week dates (9th-15th), using linear programming and optimization of rooms at hotel ABC was: $46065.7 which was 35.25% more than the actual revenue generated for the same dates.

## III. Decision Alternatives

The hotel reservation data gives details regarding hotel room booking details like the number of adults, number of children, booking date, the average price of the room, booking status, etc. In our

journey to answer the problem statement, we have tried to optimize the revenue of the hotel. Dynamic pricing strategies that adjust room rates based on demand, seasonality, and day of the week allow hotels to control prices during peak periods, such as weekends and holidays while offering discounts during low-demand periods like weekdays. Thus, we have considered the below alternatives:

- Room booking demand and pricing on regular days including weekends
- Room booking demand and pricing on holidays

We applied the linear programming optimization technique to optimize the hotel's revenue for December. We have considered the average pricing of rooms on regular days bookings and holiday season bookings from the dataset.

Firstly, the number of bookings was considered for the second week of December 2 – December 8 as per the data provided in the dataset. The demand constraints for each room type are based on the past bookings shown in the data and the total availability of rooms for each room type. The result obtained using the linear programming optimization technique for regular weekdays and weekends was higher than the actual revenue generated by the hotel.

| **Actual Revenue Generated (in USD)** | **Optimized Revenue (in USD)** |
|---|---|
| 34058.1 | 46065.7 |

- Thus, the optimized revenue was **35.2% higher** than usual.

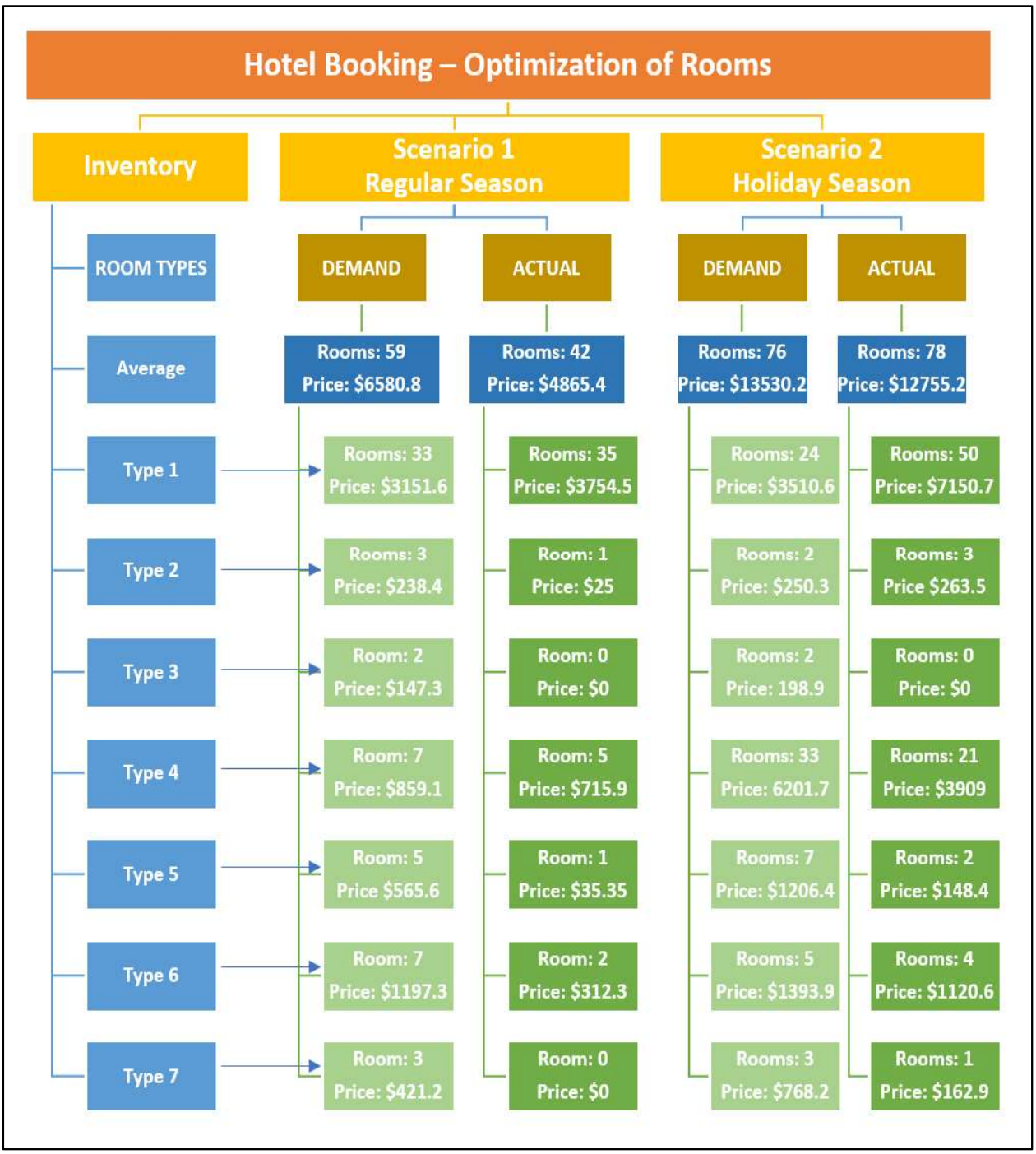
Secondly, to understand the pattern and trend for the holiday season we have considered the dates December 22 – December 31, which is a well-demanded holiday season. Thus, looking at the bookings made from the dataset we have taken the demand constraints for each type of room as per their availability. The pricing was taken on average for these days only, which was higher than usual as mentioned. However, the number of bookings would be less in count as well, depending on the prices and offers promoted by other hotels in the area. Upon applying the linear programming optimization, we were able to obtain a higher revenue for the holiday season.

| **Actual Revenue Generated (in USD)** | **Optimized Revenue (in USD)** |
|---|---|
| 127552.8 | 135302.03 |

- The optimized revenue for the holiday season was **6% higher**.

## IV. Figural Model of Decision Process

You should create and include a figure of the problem you are modeling. This figure should resemble, but not be an exact replica, of the modeling mechanism you are incorporating into your final assessment.




**Figural Model for Room Optimization**

# V. Project Research

## 1) Research Methodology

For building an optimization model using linear programming for ABC Hotel, our team has used several research techniques. We explored and researched many websites and finally decided to go with Kaggle to get our dataset (Kaggle, n.d.). We gathered the relevant data from this dataset which included the number of rooms available on weekdays, the number of rooms available on weekends, the number of rooms actually booked, the average price per room, revenue generated, and booking status.

We also checked the hotel booking cancelation rates to verify the numbers mentioned in the dataset. The average cancelation rates between the years 2016 to 2019 varied from 24% to 40%.

According to the study by HotelManagement.net, cancellation rates for hotels are increasing as guests have become accustomed to free cancellation policies that have been made popular (and encouraged) mainly by Booking.com and channels and apps such as Tingo or Service, which are designed to cancel and rebook hotel rooms at each rate drop (Hertzfeld, 2019).

After formulating the problem statement, we identified the objective of the model, defined the decision variables, and establish the constraints. To complete our project we performed model validation, and sensitivity analysis selected the optimization algorithm and evaluated the performance of the model.

## 2) Evaluation Methods and Evaluation Measures

Challenges

1. Finding a dataset: Our team faced challenges while deciding the dataset of hotel reservations aligning with our goal. It was crucial to identify the right decision variables and constraints to match our goal and their impact on our output objective variable. We found many datasets with variables such as room sq foot, amenities (like gym, pool available), number of reviews, reviews per month, other amenities, and neighborhood but these variables did not have a positive impact or relations with our objective function of maximizing the revenue related to hotel room booking optimization for operations teams at hotel ABC

2. Identifying the right input variables: The second issue we faced is choosing the right set of variables within the dataset, while the outcome was based on input if the customer will honor the booking or cancel the booking it did not give us much insight on working with profitability

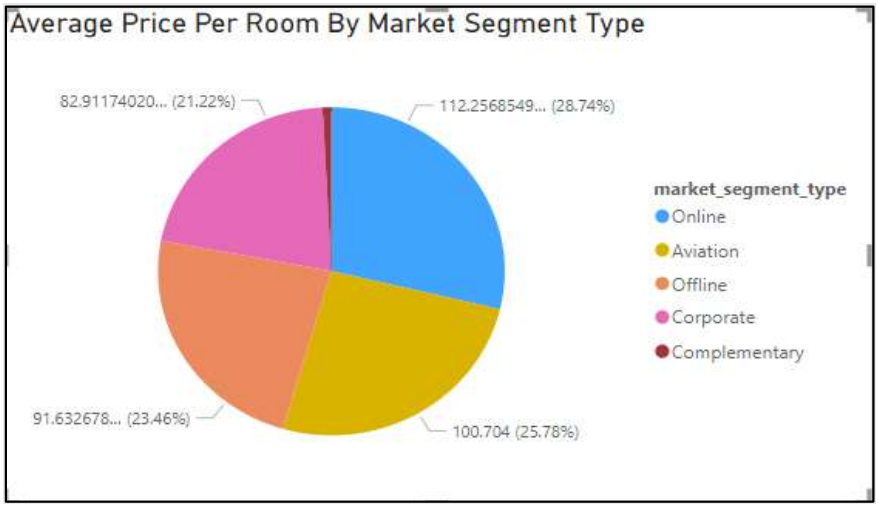
maximization. So, our team researched more on the available dataset and carried out the analysis, and found variables like room type, the average price per room, number of weekend nights, etc. on a Hotel ABC dataset. And finally, we were able to figure out our problem statement that will help maximize the revenue.

## Summary

Our team has chosen the Linear Programming method on our chosen dataset to analyze the optimization of revenue for the ABC Hotel. LP is a mathematical technique used to optimize a linear objective function subject to a set of linear constraints. In this project, the objective function is to maximize revenue, and the constraints are the various limitations and assumptions associated with the hotel's reservation system.

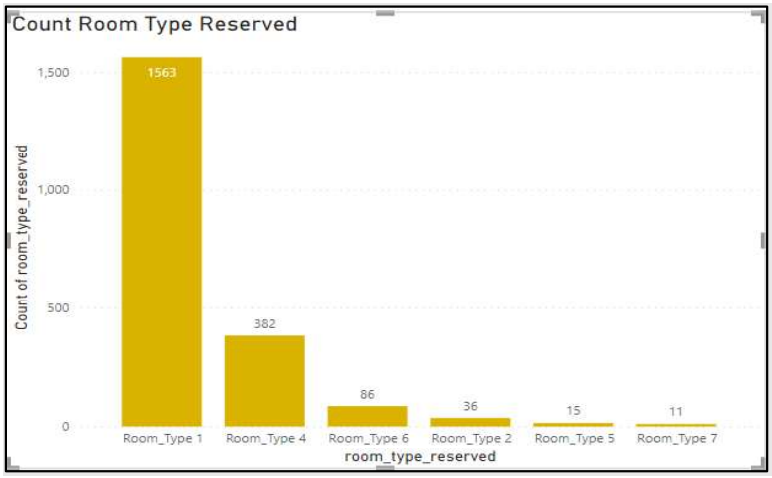
Finally, our team identified the decision variables, constraints, and assumptions that will be included in the LP model. Our team validated the LP model by testing it against actual reservation data. This will involve comparing the predicted revenue generated by the LP model with the actual revenue generated by the hotel's reservation system. Any discrepancies between the two will be analyzed and addressed to improve the accuracy of the LP model.

1. Average Price per Room by Market Segment Type



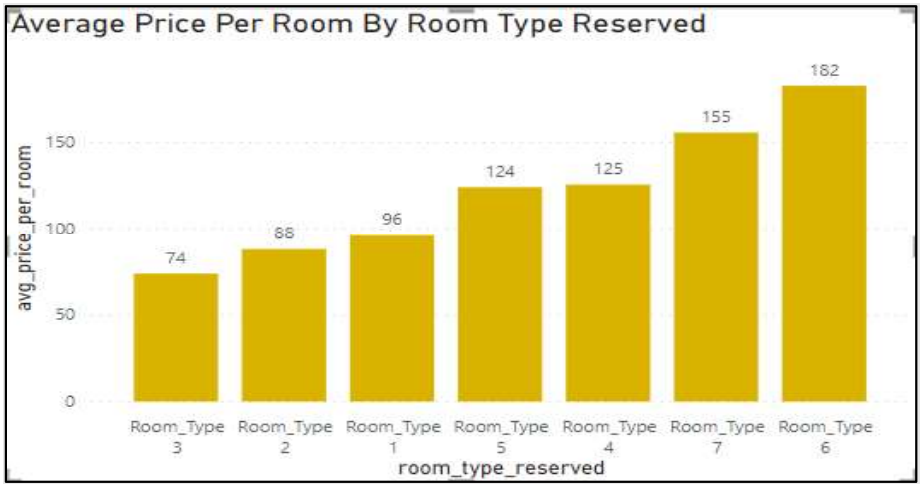

The market segment is divided into categories like online, aviation, offline, corporate, and complimentary. This segment defines the way by which the Hotel is receiving their bookings. The maximum number of rooms are booked via Online and Aviation channels, whereas complementary seems to be the lowest among all. Hence Hotel ABC can focus on online channels for the promotion of rooms they have available which will maximize their revenue and push them via the marketing and sales team.

2. Count room type reserved



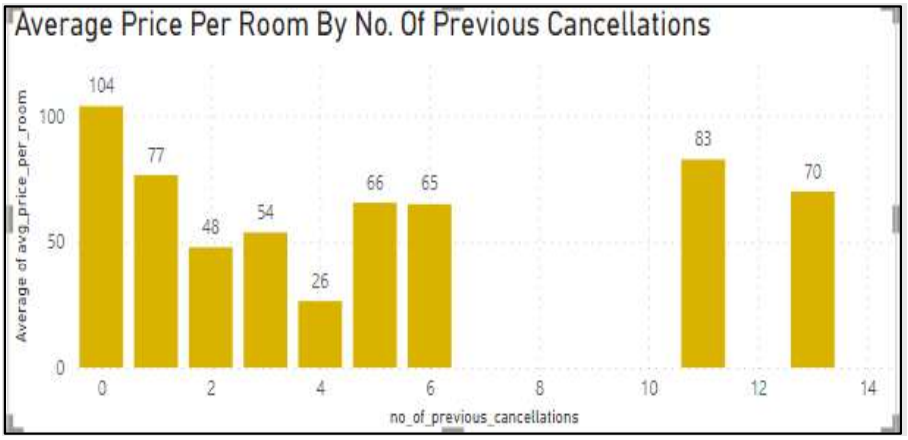

From the graph, it is evident that Room Type 1 is booked the maximum times as compared to all the seven room types. The average bookings made for Room Type 3 are with reference to the data provided in the dataset, making it the least (as the count is Zero). Next, Room Type 7 is at the bottom with an average booking count of 11. This difference between different rooms can be attributed to the average price per room and the total rooms available as per room type. But with the room optimization technique, this count for other rooms like room types 5 and 7 can go up by applying LP strategy application during marketing practices and sales pitches.

3. Average Price per room by room type reserved



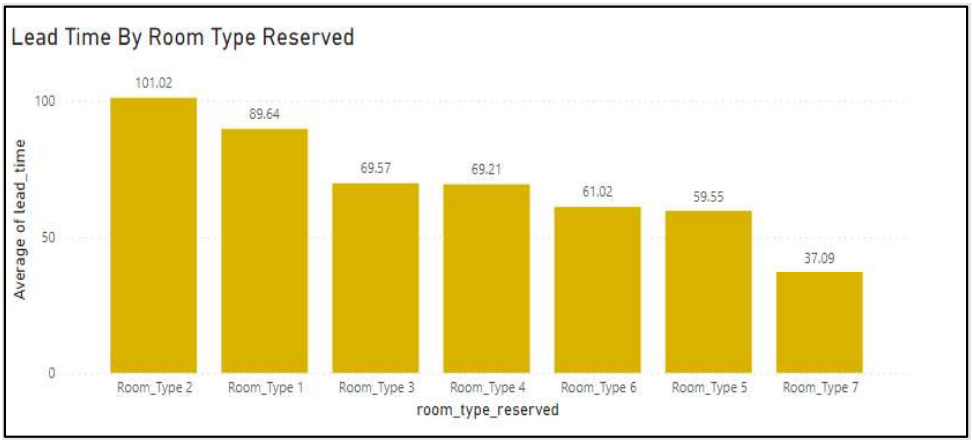
To solidify our findings on the count of room variation we looked at avg price per room, Room Type 6 has the highest average price ($182.21) among all the room types. The average room price of Room Type 3 as per the bookings made in December seems to be the lowest ($74). Although the booking count was less for Room Type 7, the average price generated from it is $155, the second highest among all 7 types of rooms. This provides insight into the fact that the count of Room Type 7 is low because of the high price.

4. Average price per room by no. Of previous cancellations



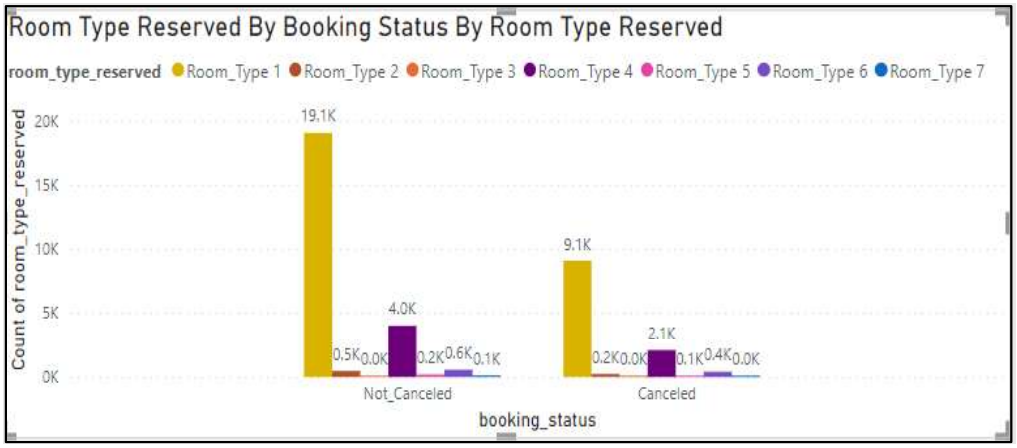

For the total dataset available for the year 2017-18 for hotel room booking of hotel ABC, we found, in December 2018the cancellation trend and there was a high cancellation rate with a count of 10 to 14 cancellations by the same guest during the period. Hence Hotel ABC can focus on identifying the reason for cancellation and provide customer services to satisfy their demands and maximize their growth and revenue overall.

5. Lead time by room type reserved



Lead Time refers to the time in which customers book the hotel in advance. As observed in the graph, Room Type 2 seems to be booked a maximum of times in advance. The average price of room type 2 is the second least, thus the hotel management team could offer an upgrade to the customers for another room type which has less lead time and higher price compared to room type 2. This would improve the hotel's revenue.

6. Room type reserved by booking status




While we see the number of customers who honor the booking overall for all room types 1 to 7 is high, there is still 35% of no-shows/cancellations. Especially for room type 1 and room type 4 cancellations are high. Hotel ABC should research the same and identify reasons to eliminate such high cancellations by being proactive and improving their operational efficiency related to hotel booking trends.

## 3) Scenarios

Mr. Michael Jones and his wife currently live in California and want to go on a vacation to Miami (The busiest tourism destination) in 2023. He is thinking of the following feasible options.

### Scenario 1: Michael's visit on Regular Days (With No Uncertainty)

Michael is planning a full week's vacation before the Christmas holidays with his partner to Miami city. They have a specific date range in mind (9$^{th}$ December to 16th December) and are excited to explore the city's attractions and restaurants.

Michael researched hotels in the Miami area and finds hotel ABC that fits their needs and budget for a week. They were pleased to see that the prices are significantly lower than they would be

during the holiday season compared to other hotels, giving them the certainty that they're getting a good deal. Michael calls hotel ABC to book hotel room 1 of ABC for his weekend getaway, choosing the "pay now" option to avoid any surprises later. But the staff mentions there is an upgrade available to room_3 in hotel ABC with a discount of 10% which holds more amenities than room 1. In this way ABC hotel capitalizes on the overall profit/revenue, also Michael is happy to have secured a room at a more affordable price and is excited about the trip. When they arrive at the hotel, Michael and his partner are impressed by the amenities and location. They enjoy their weekend getaway, exploring the city, and trying new restaurants.

**Scenario 2: Michael's visit on Holiday (With Uncertainty from Higher Prices/Surge)**

Michael is planning a last-minute holiday trip to a popular Miami destination. He wants to go on vacation during the holiday season (Christmas) from 21st December for a week, but he knows that he only wants to go during the holiday season due to his office. He starts researching hotels in the area, but he's shocked by the high prices. Michael feels uncertain about booking a hotel at such a high price. He decides to hold off on booking a hotel and instead sets up price alerts(online) for the hotels that he's interested in.

As the holiday season gets closer, Michael starts receiving alerts for hotels with lower prices. He finds a hotel ABC that fits his needs and budget, but it's still more expensive than he was hoping to pay. He is hesitant to book the hotel, but he knows that prices will only go up as the date gets closer. Michael decides to book the hotel for his holiday vacation, feeling uncertain about whether he is getting the best deal. He chooses the "pay later" option to give himself some flexibility in case he finds a better deal later.

As the date of her trip gets closer, Michael continues to receive alerts for hotels with lower prices. He starts to regret booking the hotel when he did, knowing that he could have saved some money if he had waited. Despite the uncertainty, He receives an update from hotel ABC that he can upgrade from room 1 booked by him priced at 110$ to room 6 at the same price with only 100$ additional charge (special offer) for the entire stay of the week. This was possible as Hotel ABC at their operational end identified through their hotel optimization that they have availability of room 6 in excess and they can still gain additional benefit along with guest satisfaction, attracting the customer to be a repeat guest with this gesture without shelling additional money. Hence Michael is happy to gain additional services at this rate and opts for the same which is a win-win for both provider ABC and customer Michael

**Summary tasks to be performed as part of the analysis:**

**Above mentioned two scenarios will be performed with the following tasks:**

- Used a linear programming method and optimization to identify the scenario which maximizes the revenue of hotel ABC as a decision variable.

- Performed a sensitivity analysis on the optimal decision with all 7 room types during regular days and holidays.

# VI. PROJECT DATA AND MODEL

## I. Data for the period December 2018:

| Dates | RoomType1 | RoomType2 | RoomType3 | RoomType4 | RoomType5 | RoomType6 | RoomType7 | Day |
|---|---|---|---|---|---|---|---|---|
| 1 | 52 | | | 14 | | 4 | | Saturday |
| 2 | 115 | 4 | | 16 | | 3 | | Sunday |
| 3 | 60 | | | 11 | | 7 | | Monday |
| 4 | 50 | | | 13 | | 1 | | Tuesday |
| 5 | 66 | | | 6 | 1 | 1 | | Wednesday |
| 6 | 46 | | | 8 | 1 | 2 | | Thursday |
| 7 | 58 | 5 | | 21 | 1 | | | Friday |
| 8 | 107 | 4 | | 14 | | 8 | 1 | Saturday |
| 9 | 73 | | | 12 | | | | Sunday |
| 10 | 37 | 1 | | 5 | | 5 | 2 | Monday |
| 11 | 15 | | | 4 | | 1 | | Tuesday |
| 12 | 31 | | | 3 | 1 | | | Wednesday |
| 13 | 33 | | | 3 | | 1 | | Thursday |
| 14 | 28 | | | 5 | | | | Friday |
| 15 | 28 | | | 5 | 1 | 1 | | Saturday |
| 16 | 68 | 2 | | 15 | | 1 | | Sunday |
| 17 | 39 | | | 5 | | 3 | | Monday |
| 18 | 39 | | | 2 | | 2 | | Tuesday |
| 19 | 39 | | | 5 | 1 | 4 | 1 | Wednesday |
| 20 | 37 | | | 2 | | | | Thursday |
| 21 | 45 | | | 5 | 1 | 1 | | Friday |
| 22 | 32 | 2 | | 9 | 1 | 4 | | Saturday |
| 23 | 35 | 4 | | 14 | 1 | 6 | 1 | Sunday |
| 24 | 35 | 2 | | 15 | 2 | 1 | | Monday |
| 25 | 28 | 4 | | 11 | | 2 | 2 | Tuesday |
| 26 | 46 | 2 | | 46 | | 7 | | Wednesday |
| 27 | 112 | | | 25 | 4 | 5 | 1 | Thursday |
| 28 | 56 | 4 | | 21 | | 2 | 1 | Friday |
| 29 | 72 | 2 | | 23 | | 7 | 1 | Saturday |
| 30 | 55 | | | 33 | | 4 | 1 | Sunday |
| 31 | 26 | | | 11 | | 3 | | Monday |

## II. Room Availability and Average Pricing details for regular days and holidays

| | RoomType1 | RoomType2 | RoomType3 | RoomType4 | RoomType5 | RoomType6 | RoomType7 |
|---|---|---|---|---|---|---|---|
| No.of Available rooms | 120 | 10 | 15 | 50 | 10 | 10 | 5 |
| Average Price for room | 95.91853217 | 87.84855491 | 73.67857143 | 125.2873172 | 123.7336226 | 182.2128364 | 155.1982911 |
| Average Price during Holiday Season | 143.8777983 | 131.7728324 | 110.5178571 | 187.9309757 | 185.600434 | 273.3192547 | 232.7974367 |

## III. Scenarios:

### 1. Demand and Revenue for regular days

**Actual Bookings as per data given:**

| Dates | RoomType1 | RoomType2 | RoomType3 | RoomType4 | RoomType5 | RoomType6 | RoomType7 | Day |
|---|---|---|---|---|---|---|---|---|
| 9 | 73 | | | 12 | | | | Sunday |
| 10 | 37 | 1 | | 5 | | 5 | 2 | Monday |
| 11 | 15 | | | 4 | | 1 | | Tuesday |
| 12 | 31 | | | 3 | 1 | | | Wednesday |
| 13 | 33 | | | 3 | | 1 | | Thursday |
| 14 | 28 | | | 5 | | | | Friday |
| 15 | 28 | | | 5 | 1 | 1 | | Saturday |

**Decision Variables - Optimized Bookings using LP (Solver):**

Decision Variables

| Dates | RoomType1 | RoomType2 | RoomType3 | RoomType4 | RoomType5 | RoomType6 | RoomType7 |
|---|---|---|---|---|---|---|---|
| 9 | 60 | 8 | 10 | 10 | 10 | 10 | 5 |
| 10 | 20 | 4 | 4 | 5 | 1 | 5 | 1 |
| 11 | 15 | 3 | 0 | 5 | 1 | 5 | 1 |
| 12 | 15 | 3 | 0 | 5 | 1 | 5 | 1 |
| 13 | 25 | 0 | 0 | 5 | 1 | 3 | 1 |
| 14 | 50 | 1 | 0 | 8 | 8 | 8 | 5 |
| 15 | 45 | 0 | 0 | 10 | 10 | 10 | 5 |

**Constraints:**

| | | Demand | | RT_1 > | <= | RT_2 > | <= | RT 3 > | <= | RT 4 > | <= | RT 5 > | <= | RT 6 > | <= | RT 7 > | <= |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 113 | <= | 120 | Sunday | 0 | 60 | 0 | 8 | 0 | 10 | 0 | 10 | 0 | 10 | 0 | 10 | 0 | 5 |
| 40 | <= | 40 | Monday | 0 | 20 | 0 | 4 | 0 | 5 | 0 | 5 | 0 | 1 | 0 | 5 | 0 | 1 |
| 30 | <= | 30 | Tuesday | 0 | 15 | 0 | 4 | 0 | 5 | 0 | 5 | 0 | 1 | 0 | 5 | 0 | 1 |
| 30 | <= | 30 | Wednesday | 0 | 15 | 0 | 4 | 0 | 5 | 0 | 5 | 0 | 1 | 0 | 5 | 0 | 1 |
| 35 | <= | 35 | Thursday | 0 | 30 | 0 | 4 | 0 | 5 | 0 | 5 | 0 | 1 | 0 | 3 | 0 | 1 |
| 80 | <= | 80 | Friday | 0 | 50 | 0 | 4 | 0 | 8 | 0 | 8 | 0 | 8 | 0 | 8 | 0 | 5 |
| 80 | <= | 80 | Saturday | 0 | 80 | 0 | 8 | 0 | 10 | 0 | 10 | 0 | 10 | 0 | 10 | 0 | 5 |

**Actual Revenue Generated:**

| Actual Revenue Generated during week 2 | 34058.1 |
|---|---|

**Optimized Revenue (maximized):**

| Optimized Revenue-Objective | 46065.7101 |
|---|---|

**Improved by:**

| Percentage Increased | 35.25630447 |
|---|---|

## 2. Demand and Revenue for Holiday Season

### Actual Bookings as per data given:

| Holiday Season Dates | RoomType1 | RoomType2 | RoomType3 | RoomType4 | RoomType5 | RoomType6 | RoomType7 |
|---|---|---|---|---|---|---|---|
| 22 | 32 | 2 | | 9 | 1 | 4 | |
| 23 | 35 | 4 | | 14 | 1 | 6 | 1 |
| 24 | 35 | 2 | | 15 | 2 | 1 | |
| 25 | 28 | 4 | | 11 | | 2 | 2 |
| 26 | 46 | 2 | | 46 | | 7 | |
| 27 | 112 | | | 25 | 4 | 5 | 1 |
| 28 | 56 | 4 | | 21 | | 2 | 1 |
| 29 | 72 | 2 | | 23 | | 7 | 1 |
| 30 | 55 | | | 33 | | 4 | 1 |
| 31 | 26 | | | 11 | | 3 | |

### Decision Variables - Optimized Bookings using LP (Solver):

| Dates | RoomType1 | RoomType2 | RoomType3 | RoomType4 | RoomType5 | RoomType6 | RoomType7 |
|---|---|---|---|---|---|---|---|
| 22 | 20 | 0 | 0 | 40 | 8 | 7 | 5 |
| 23 | 12 | 0 | 0 | 30 | 8 | 7 | 5 |
| 24 | 12 | 0 | 0 | 30 | 8 | 7 | 3 |
| 25 | 0 | 0 | 0 | 45 | 1 | 3 | 1 |
| 26 | 20 | 5 | 10 | 45 | 5 | 2 | 1 |
| 27 | 20 | 5 | 8 | 30 | 5 | 2 | 2 |
| 28 | 37 | 0 | 0 | 30 | 10 | 7 | 4 |
| 29 | 55 | 9 | 0 | 25 | 10 | 7 | 4 |
| 30 | 53 | 0 | 0 | 30 | 5 | 7 | 5 |
| 31 | 15 | 0 | 0 | 25 | 5 | 2 | 3 |

### Constraints:

| | | Demand | | RT_1 > | <= | RT_2 > | <= | RT 3 > | <= | RT 4 > | <= | RT 5 > | <= | RT 6 > | <= | RT 7 > | <= |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | <= | 80 | Saturday | 0 | 30 | 0 | 10 | 0 | 15 | 0 | 40 | 0 | 8 | 0 | 7 | 0 | 5 |
| 62 | <= | 62 | Sunday | 0 | 20 | 0 | 8 | 0 | 15 | 0 | 30 | 0 | 8 | 0 | 7 | 0 | 5 |
| 60 | <= | 60 | Monday | 0 | 20 | 0 | 8 | 0 | 15 | 0 | 30 | 0 | 8 | 0 | 7 | 0 | 3 |
| 50 | <= | 50 | Tuesday | 0 | 25 | 0 | 10 | 0 | 10 | 0 | 45 | 0 | 5 | 0 | 3 | 0 | 1 |
| 88 | <= | 105 | Wednesday | 0 | 20 | 0 | 5 | 0 | 10 | 0 | 45 | 0 | 5 | 0 | 2 | 0 | 1 |
| 72 | <= | 150 | Thursday | 0 | 20 | 0 | 5 | 0 | 8 | 0 | 30 | 0 | 5 | 0 | 2 | 0 | 2 |
| 88 | <= | 88 | Friday | 0 | 40 | 0 | 10 | 0 | 15 | 0 | 30 | 0 | 10 | 0 | 7 | 0 | 4 |
| 110 | <= | 110 | Saturday | 0 | 55 | 0 | 10 | 0 | 15 | 0 | 25 | 0 | 10 | 0 | 7 | 0 | 4 |
| 100 | <= | 100 | Sunday | 0 | 55 | 0 | 8 | 0 | 15 | 0 | 30 | 0 | 5 | 0 | 7 | 0 | 5 |
| 50 | <= | 50 | Monday | 0 | 50 | 0 | 5 | 0 | 10 | 0 | 25 | 0 | 5 | 0 | 2 | 0 | 3 |

**Actual Revenue Generated:**

| | |
|---|---|
| Actual Revenue Generated during Holidays season | 127553 |

**Optimized Revenue (maximized):**

| | |
|---|---|
| Revenue Generated during Holiday Season: | 135302.0356 |

**Improved by:**

| | |
|---|---|
| Percentage Increase | 6.075282443 |

## VII. Conclusion

While many factors or variables from the dataset like the number of adults, meal type, car parking, special request, and additional factors like customer service, quality of room maintenance, and personalized experiences attract a booking and increase guest satisfaction the controllable factor at hotel operations end can yield better results on profitability.

In a dynamic environment, which is technology-driven, it is essential to leverage analytics and optimize tasks to reduce manual intervention. In our project linear programming served the purpose to make informed decision making. Through the strategic approach of optimization carried out by our team by estimating average room prices and demand forecast based on date preferences (Regular days and holidays week), we have been able to suggest a method for hotel ABC to work towards revenue maximization.

Overall, we scrutinized our data to analyze the available variables, and their trends created scenarios and figural models, and decision alternatives to conclude and gain insights on the problem statement to suggest solutions for change and capture the impact on profitability.

The linear programming method used helped us to showcase an additional revenue generation of 35.25% and 6% on regular days and weekends respectively when compared to actual revenue generation by hotel ABC as per the considered data and constraints.

Hence, in conclusion, Hotel ABC can generate additional revenue by optimizing room booking for the room types available to gain not just profitability but also a competitive advantage.

# VIII. Sensitivity Analysis

## Scenario 1:

Constraints

| Cell | Name | Final Value | Shadow Price | Constraint R.H. Side | Allowable Increase | Allowable Decrease |
|---|---|---|---|---|---|---|
| **$V$8:$V$14 <= $X$8:$X$14** | | | | | | |
| $V$8 | | 113 | 0 | 120 | 1E+30 | 7 |
| $V$9 | | 40 | 73.67857143 | 40 | 1 | 4 |
| $V$10 | | 30 | 87.84855491 | 30 | 1 | 3 |
| $V$11 | | 30 | 87.84855491 | 30 | 1 | 3 |
| $V$12 | | 35 | 95.91853217 | 35 | 5 | 25 |
| $V$13 | | 80 | 87.84855491 | 80 | 3 | 1 |
| $V$14 | | 80 | 95.91853217 | 80 | 35 | 45 |

Variable Cells

| Cell | Name | Final Value | Reduced Cost | Objective Coefficient | Allowable Increase | Allowable Decrease |
|---|---|---|---|---|---|---|
| **$O$8:$U$14** | | | | | | |
| $O$8 | RoomType1 | 60 | 95.91853217 | 95.9185322 | 1E+30 | 95.9185322 |
| $P$8 | RoomType2 | 8 | 87.84855491 | 87.8485549 | 1E+30 | 87.8485549 |
| $Q$8 | RoomType3 | 10 | 73.67857143 | 73.6785714 | 1E+30 | 73.6785714 |
| $R$8 | RoomType4 | 10 | 125.2873172 | 125.287317 | 1E+30 | 125.287317 |
| $S$8 | RoomType5 | 10 | 123.7336226 | 123.733623 | 1E+30 | 123.733623 |
| $T$8 | RoomType6 | 10 | 182.2128364 | 182.212836 | 1E+30 | 182.212836 |
| $U$8 | RoomType7 | 5 | 155.1982911 | 155.198291 | 1E+30 | 155.198291 |
| $O$9 | RoomType1 | 20 | 22.23996074 | 95.9185322 | 1E+30 | 22.2399607 |
| $P$9 | RoomType2 | 4 | 14.16998348 | 87.8485549 | 1E+30 | 14.1699835 |
| $Q$9 | RoomType3 | 4 | 0 | 73.6785714 | 14.16998348 | 73.6785714 |
| $R$9 | RoomType4 | 5 | 51.60874573 | 125.287317 | 1E+30 | 51.6087457 |
| $S$9 | RoomType5 | 1 | 50.05505121 | 123.733623 | 1E+30 | 50.0550512 |
| $T$9 | RoomType6 | 5 | 108.534265 | 182.212836 | 1E+30 | 108.534265 |
| $U$9 | RoomType7 | 1 | 81.51971971 | 155.198291 | 1E+30 | 81.5197197 |
| $O$10 | RoomType1 | 15 | 8.069977259 | 95.9185322 | 1E+30 | 8.06997726 |
| $P$10 | RoomType2 | 3 | 0 | 87.8485549 | 8.069977259 | 14.1699835 |
| $Q$10 | RoomType3 | 0 | -14.1699835 | 73.6785714 | 14.16998348 | 1E+30 |
| $R$10 | RoomType4 | 5 | 37.43876224 | 125.287317 | 1E+30 | 37.4387622 |
| $S$10 | RoomType5 | 1 | 35.88506773 | 123.733623 | 1E+30 | 35.8850677 |
| $T$10 | RoomType6 | 5 | 94.36428153 | 182.212836 | 1E+30 | 94.3642815 |
| $U$10 | RoomType7 | 1 | 67.34973623 | 155.198291 | 1E+30 | 67.3497362 |
| $O$11 | RoomType1 | 15 | 8.069977259 | 95.9185322 | 1E+30 | 8.06997726 |
| $P$11 | RoomType2 | 3 | 0 | 87.8485549 | 8.069977259 | 14.1699835 |
| $Q$11 | RoomType3 | 0 | -14.1699835 | 73.6785714 | 14.16998348 | 1E+30 |
| $R$11 | RoomType4 | 5 | 37.43876224 | 125.287317 | 1E+30 | 37.4387622 |
| $S$11 | RoomType5 | 1 | 35.88506773 | 123.733623 | 1E+30 | 35.8850677 |
| $T$11 | RoomType6 | 5 | 94.36428153 | 182.212836 | 1E+30 | 94.3642815 |
| $U$11 | RoomType7 | 1 | 67.34973623 | 155.198291 | 1E+30 | 67.3497362 |
| $O$12 | RoomType1 | 25 | 0 | 95.9185322 | 27.81509047 | 8.06997726 |
| $P$12 | RoomType2 | 0 | -8.06997726 | 87.8485549 | 8.069977259 | 1E+30 |
| $Q$12 | RoomType3 | 0 | -22.2399607 | 73.6785714 | 22.23996074 | 1E+30 |
| $R$12 | RoomType4 | 5 | 29.36878498 | 125.287317 | 1E+30 | 29.368785 |
| $S$12 | RoomType5 | 1 | 27.81509047 | 123.733623 | 1E+30 | 27.8150905 |
| $T$12 | RoomType6 | 3 | 86.29430427 | 182.212836 | 1E+30 | 86.2943043 |
| $U$12 | RoomType7 | 1 | 59.27975897 | 155.198291 | 1E+30 | 59.279759 |
| $O$13 | RoomType1 | 50 | 8.069977259 | 95.9185322 | 1E+30 | 8.06997726 |
| $P$13 | RoomType2 | 1 | 0 | 87.8485549 | 8.069977259 | 14.1699835 |
| $Q$13 | RoomType3 | 0 | -14.1699835 | 73.6785714 | 14.16998348 | 1E+30 |
| $R$13 | RoomType4 | 8 | 37.43876224 | 125.287317 | 1E+30 | 37.4387622 |
| $S$13 | RoomType5 | 8 | 35.88506773 | 123.733623 | 1E+30 | 35.8850677 |
| $T$13 | RoomType6 | 8 | 94.36428153 | 182.212836 | 1E+30 | 94.3642815 |
| $U$13 | RoomType7 | 5 | 67.34973623 | 155.198291 | 1E+30 | 67.3497362 |
| $O$14 | RoomType1 | 45 | 0 | 95.9185322 | 27.81509047 | 8.06997726 |
| $P$14 | RoomType2 | 0 | -8.06997726 | 87.8485549 | 8.069977259 | 1E+30 |
| $Q$14 | RoomType3 | 0 | -22.2399607 | 73.6785714 | 22.23996074 | 1E+30 |
| $R$14 | RoomType4 | 10 | 29.36878498 | 125.287317 | 1E+30 | 29.368785 |
| $S$14 | RoomType5 | 10 | 27.81509047 | 123.733623 | 1E+30 | 27.8150905 |
| $T$14 | RoomType6 | 10 | 86.29430427 | 182.212836 | 1E+30 | 86.2943043 |
| $U$14 | RoomType7 | 5 | 59.27975897 | 155.198291 | 1E+30 | 59.279759 |

**Scenario 2:**

Variable Cells

| Cell | Name | Final Value | Reduced Cost | Objective Coefficient | Allowable Increase | Allowable Decrease |
|---|---|---|---|---|---|---|
| $N$19 | Wednesday RoomType1 | 20 | 0 | 143.877798 | 41.7226357 | 12.1049659 |
| $O$19 | Wednesday RoomType2 | 0 | -12.1049659 | 131.772832 | 12.1049659 | 1E+30 |
| $P$19 | Wednesday RoomType3 | 0 | -33.3599411 | 110.517857 | 33.3599411 | 1E+30 |
| $Q$19 | Wednesday RoomType4 | 40 | 44.05317747 | 187.930976 | 1E+30 | 44.0531775 |
| $R$19 | Wednesday RoomType5 | 8 | 41.7226357 | 185.600434 | 1E+30 | 41.7226357 |
| $S$19 | Wednesday RoomType6 | 7 | 129.4414564 | 273.319255 | 1E+30 | 129.441456 |
| $T$19 | Wednesday RoomType7 | 5 | 88.91963845 | 232.797437 | 1E+30 | 88.9196385 |
| $N$20 | Thursday RoomType1 | 12 | 0 | 143.877798 | 41.7226357 | 12.1049659 |
| $O$20 | Thursday RoomType2 | 0 | -12.1049659 | 131.772832 | 12.1049659 | 1E+30 |
| $P$20 | Thursday RoomType3 | 0 | -33.3599411 | 110.517857 | 33.3599411 | 1E+30 |
| $Q$20 | Thursday RoomType4 | 30 | 44.05317747 | 187.930976 | 1E+30 | 44.0531775 |
| $R$20 | Thursday RoomType5 | 8 | 41.7226357 | 185.600434 | 1E+30 | 41.7226357 |
| $S$20 | Thursday RoomType6 | 7 | 129.4414564 | 273.319255 | 1E+30 | 129.441456 |
| $T$20 | Thursday RoomType7 | 5 | 88.91963845 | 232.797437 | 1E+30 | 88.9196385 |
| $N$21 | Friday RoomType1 | 12 | 0 | 143.877798 | 41.7226357 | 12.1049659 |
| $O$21 | Friday RoomType2 | 0 | -12.1049659 | 131.772832 | 12.1049659 | 1E+30 |
| $P$21 | Friday RoomType3 | 0 | -33.3599411 | 110.517857 | 33.3599411 | 1E+30 |
| $Q$21 | Friday RoomType4 | 30 | 44.05317747 | 187.930976 | 1E+30 | 44.0531775 |
| $R$21 | Friday RoomType5 | 8 | 41.7226357 | 185.600434 | 1E+30 | 41.7226357 |
| $S$21 | Friday RoomType6 | 7 | 129.4414564 | 273.319255 | 1E+30 | 129.441456 |
| $T$21 | Friday RoomType7 | 3 | 88.91963845 | 232.797437 | 1E+30 | 88.9196385 |
| $N$22 | Saturday RoomType1 | 0 | -41.7226357 | 143.877798 | 41.7226357 | 1E+30 |
| $O$22 | Saturday RoomType2 | 0 | -53.8276016 | 131.772832 | 53.8276016 | 1E+30 |
| $P$22 | Saturday RoomType3 | 0 | -75.0825768 | 110.517857 | 75.0825768 | 1E+30 |
| $Q$22 | Saturday RoomType4 | 45 | 2.330541768 | 187.930976 | 1E+30 | 2.33054177 |
| $R$22 | Saturday RoomType5 | 1 | 0 | 185.600434 | 2.33054177 | 41.7226357 |
| $S$22 | Saturday RoomType6 | 3 | 87.7188207 | 273.319255 | 1E+30 | 87.7188207 |
| $T$22 | Saturday RoomType7 | 1 | 47.19700275 | 232.797437 | 1E+30 | 47.1970027 |
| $N$23 | Sunday RoomType1 | 20 | 143.8777983 | 143.877798 | 1E+30 | 143.877798 |
| $O$23 | Sunday RoomType2 | 5 | 131.7728324 | 131.772832 | 1E+30 | 131.772832 |
| $P$23 | Sunday RoomType3 | 10 | 110.5178571 | 110.517857 | 1E+30 | 110.517857 |
| $Q$23 | Sunday RoomType4 | 45 | 187.9309757 | 187.930976 | 1E+30 | 187.930976 |
| $R$23 | Sunday RoomType5 | 5 | 185.600434 | 185.600434 | 1E+30 | 185.600434 |
| $S$23 | Sunday RoomType6 | 2 | 273.3192547 | 273.319255 | 1E+30 | 273.319255 |
| $T$23 | Sunday RoomType7 | 1 | 232.7974367 | 232.797437 | 1E+30 | 232.797437 |
| $N$24 | Monday RoomType1 | 20 | 143.8777983 | 143.877798 | 1E+30 | 143.877798 |
| $O$24 | Monday RoomType2 | 5 | 131.7728324 | 131.772832 | 1E+30 | 131.772832 |
| $P$24 | Monday RoomType3 | 8 | 110.5178571 | 110.517857 | 1E+30 | 110.517857 |
| $Q$24 | Monday RoomType4 | 30 | 187.9309757 | 187.930976 | 1E+30 | 187.930976 |
| $R$24 | Monday RoomType5 | 5 | 185.600434 | 185.600434 | 1E+30 | 185.600434 |
| $S$24 | Monday RoomType6 | 2 | 273.3192547 | 273.319255 | 1E+30 | 273.319255 |
| $T$24 | Monday RoomType7 | 2 | 232.7974367 | 232.797437 | 1E+30 | 232.797437 |
| $N$25 | Tuesday RoomType1 | 37 | 0 | 143.877798 | 41.7226357 | 12.1049659 |
| $O$25 | Tuesday RoomType2 | 0 | -12.1049659 | 131.772832 | 12.1049659 | 1E+30 |
| $P$25 | Tuesday RoomType3 | 0 | -33.3599411 | 110.517857 | 33.3599411 | 1E+30 |
| $Q$25 | Tuesday RoomType4 | 30 | 44.05317747 | 187.930976 | 1E+30 | 44.0531775 |
| $R$25 | Tuesday RoomType5 | 10 | 41.7226357 | 185.600434 | 1E+30 | 41.7226357 |
| $S$25 | Tuesday RoomType6 | 7 | 129.4414564 | 273.319255 | 1E+30 | 129.441456 |
| $T$25 | Tuesday RoomType7 | 4 | 88.91963845 | 232.797437 | 1E+30 | 88.9196385 |
| $N$26 | Wednesday RoomType1 | 55 | 12.10496589 | 143.877798 | 1E+30 | 12.1049659 |
| $O$26 | Wednesday RoomType2 | 9 | 0 | 131.772832 | 12.1049659 | 21.2549752 |

| | | | | | | |
|---|---|---|---|---|---|---|
| $O$26 | Wednesday RoomType2 | 9 | 0 | 131.772832 | 12.1049659 | 21.2549752 |
| $P$26 | Wednesday RoomType3 | 0 | -21.2549752 | 110.517857 | 21.2549752 | 1E+30 |
| $Q$26 | Wednesday RoomType4 | 25 | 56.15814336 | 187.930976 | 1E+30 | 56.1581434 |
| $R$26 | Wednesday RoomType5 | 10 | 53.82760159 | 185.600434 | 1E+30 | 53.8276016 |
| $S$26 | Wednesday RoomType6 | 7 | 141.5464223 | 273.319255 | 1E+30 | 141.546422 |
| $T$26 | Wednesday RoomType7 | 4 | 101.0246043 | 232.797437 | 1E+30 | 101.024604 |
| $N$27 | Thursday RoomType1 | 53 | 0 | 143.877798 | 41.7226357 | 12.1049659 |
| $O$27 | Thursday RoomType2 | 0 | -12.1049659 | 131.772832 | 12.1049659 | 1E+30 |
| $P$27 | Thursday RoomType3 | 0 | -33.3599411 | 110.517857 | 33.3599411 | 1E+30 |
| $Q$27 | Thursday RoomType4 | 30 | 44.05317747 | 187.930976 | 1E+30 | 44.0531775 |
| $R$27 | Thursday RoomType5 | 5 | 41.7226357 | 185.600434 | 1E+30 | 41.7226357 |
| $S$27 | Thursday RoomType6 | 7 | 129.4414564 | 273.319255 | 1E+30 | 129.441456 |
| $T$27 | Thursday RoomType7 | 5 | 88.91963845 | 232.797437 | 1E+30 | 88.9196385 |
| $N$28 | Friday RoomType1 | 15 | 0 | 143.877798 | 41.7226357 | 12.1049659 |
| $O$28 | Friday RoomType2 | 0 | -12.1049659 | 131.772832 | 12.1049659 | 1E+30 |
| $P$28 | Friday RoomType3 | 0 | -33.3599411 | 110.517857 | 33.3599411 | 1E+30 |
| $Q$28 | Friday RoomType4 | 25 | 44.05317747 | 187.930976 | 1E+30 | 44.0531775 |
| $R$28 | Friday RoomType5 | 5 | 41.7226357 | 185.600434 | 1E+30 | 41.7226357 |
| $S$28 | Friday RoomType6 | 2 | 129.4414564 | 273.319255 | 1E+30 | 129.441456 |
| $T$28 | Friday RoomType7 | 3 | 88.91963845 | 232.797437 | 1E+30 | 88.9196385 |

Constraints

| Cell | Name | Final Value | Shadow Price | Constraint R.H. Side | Allowable Increase | Allowable Decrease |
|---|---|---|---|---|---|---|
| $U$19 | Wednesday | 80 | 143.8777983 | 80 | 10 | 20 |
| $U$20 | Thursday | 62 | 143.8777983 | 62 | 8 | 12 |
| $U$21 | Friday | 60 | 143.8777983 | 60 | 8 | 12 |
| $U$22 | Saturday | 50 | 185.600434 | 50 | 4 | 1 |
| $U$23 | Sunday | 88 | 0 | 105 | 1E+30 | 17 |
| $U$24 | Monday | 72 | 0 | 150 | 1E+30 | 78 |
| $U$25 | Tuesday | 88 | 143.8777983 | 88 | 3 | 37 |
| $U$26 | Wednesday | 110 | 131.7728324 | 110 | 1 | 9 |
| $U$27 | Thursday | 100 | 143.8777983 | 100 | 2 | 53 |
| $U$28 | Friday | 50 | 143.8777983 | 50 | 35 | 15 |

## IX. Next Steps

There are several next steps we would like to recommend to ABC Hotel to further improve the model's performance and achieve better results. These would include

- Implementing the recommended optimization technique using LP it in the hotel's booking system and integrating the model with the hotel's reservation software or developing a new software application.
- They can do real-time monitoring as it is important to monitor its performance in real-time. This could help identify any issues or errors in the model and make necessary adjustments to improve its accuracy and effectiveness.
- Updating the model's data inputs, refining its algorithms, or adding new features to the model.
- Collaboration with stakeholders such as hotel managers, revenue managers, and sales teams is an important step to ensure that the model is aligned with the hotel's business objectives and to gather feedback on its effectiveness.

- Provide training and education for hotel staff on how to use the optimization model as it will help ensure that it is being used effectively and to its full potential.

## References

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