White Paper: Forecasting Room Demand at Marriott Hotels

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Executive Summary

Decision theory breaks complex business decisions into smaller, more manageable components parts. Without a framework to analyze complex business problems, the diversity of outcomes can be overwhelming.

One method available to managers that assists in analyzing complex decisions is decision tree diagrams. Decision trees are graphical representations of the various options available from an initial decision. A number of branches will spread out from each decision point, creating the impression of a tree. This is a method used to organize and evaluate all available information to enhance the quality of decisions made.

The issue of capacity utilization is extremely important for industries with fixed, but time sensitive, inventories. Hotels, airplanes, movie theatres, sports stadiums and concert halls all have a fixed number of beds or seats available and, unlike many other industries (for example packaged goods), do not typically carry excess inventory that can quickly be made available to meet increased demand. In this sense, these assets are perishable goods; if the seat on an airplane or the room in a hotel is not used on a given flight or night, the revenue is lost forever. This paper proposes calling these types of businesses as operating in **time sensitive fixed capacity** areas.

Inventory or yield management is another challenge facing firms with time sensitive inventories. Since many customers will make a reservation with a hotel or airline, but fail to show up, overbooking reservations is common. However, the specific level of overbooking is a challenge facing companies, since these firms want to minimize the disruption to customers, by not having inventory available to customers with reservations on the one hand, while maximizing revenues on the other.

This paper examines how decision trees can be used to decide whether a Marriott hotel chain should accept a reservation request from a tour company despite possibly straining capacity.

Quantitative Analysis:

Using decision theory to forecast the demand for rooms at Marriott Hotels

Introduction

Decision theory breaks complex business decisions into smaller, more manageable components parts. Without a framework to analyze complex business problems, the diversity of outcomes can be overwhelming. One method available to managers, which assists in analyzing complex decisions, is decision tree diagrams. Decision trees are graphical representations of the various options available from an initial decision. A number of branches will spread out from each decision point, creating the impression of a tree. This is a method used to organize and evaluate all available information to enhance the quality of decisions made.

This paper examines how decision trees can be used to analyze a business decision involving the overbooking of rooms at a Marriott hotel.

Capacity Utilization

The issue of capacity utilization is extremely important for industries with fixed, but time sensitive, inventories and who are dependent upon customers for revenue. Hotels, airplanes, movie theatres, sports stadiums and concert halls all have a fixed number of beds or seats available, and unlike many other industries (for example packaged goods), do not carry excess inventory that can quickly be made available to meet increased demand. In this sense, these assets are perishable goods; if the seat on an airplane or the room in a hotel is not used on a given flight or night, the revenue is lost forever. This paper proposes calling these types of businesses as operating in **time sensitive fixed capacity** areas.

It is important for these industries to understand how capacity can be maximized in order to maximize revenues. Although hotels and airlines rely on customer reservations to optimize demand and customer bookings, a simple reservation does not guarantee that the customer will actually show up. Particularly challenging for these firms is the discrepancy between the goals of maximizing revenue, which often involves overbooking to account for the no shows, with the importance of maintaining customer satisfaction, and not turning away customers with reservations.

Background on the case

The analysis used in this example is based on a case from the Darden Graduate School of Business Administration at the University of Virginia[1]. All figures presented in this paper are in US dollars.

Summary of the case

A 1,877 room downtown Marriott Hotel is approached by a tour operator seeking 60 rooms for next Saturday (August 18, 2001). As of today (August 7, 2001), the hotel has reservations for 1,839 rooms for that day, indicating an availability of 38 rooms.

However, downtown business hotels have higher no show rates on the weekends. The contribution margin from a room is about $90, since the low variable costs arise primarily from cleaning the room and check in/out. Alternatively, if a customer with a reservation is denied a room at the hotel, the front desk will find a comparable room somewhere in the city, transport the guest there, and provide some gratuity. If the customer is a Marquis cardholder (a frequent guest staying more than 45 nights a year with the hotel chain), he or she would receive $200 cash, plus the next two stays at the Marriott free. It is difficult to place a cost value on a denied room; for the sake of this case, it will be valued, goodwill and all, at twice the cash gratuity: $400[2].

The hotel has available to it historical data on demand for rooms in the hotel; appendix 1 shows demand for dates from May 23, 2001 (week 1) to August 18, 2001 (week 14)[3]. Demand figures include the number of turned down requests for a reservation on a night when the hotel stopped taking reservations because of capacity, plus the actual number of rooms occupied that night. Also included in appendix 1 is the number of rooms booked as of the Tuesday morning of the week prior to each date. Additionally, there is a calculation for pickup ratios; between a Tuesday one week ahead, and any date, new reservations are added, reservations were cancelled, some guests decided to stay longer, and some result in no shows. The net effect was a final demand that might be larger than Tuesday's bookings (a ratio greater than 1.0), or smaller than Tuesday's bookings (a ratio less than 1.0).

The goal of the analysis is to determine whether to accept the tour reservation of 60 or not.

[1] Weatherford, Larry "Marriott Rooms Forecasting", Case UVA-QA-0389, Darden Graduate School, University of Virginia, 1989.

[2] Although beyond the scope of this paper, it seems logical to conclude that in the event of overbooking, the most frequent guests (those with a higher level within a hotel's loyalty program) would likely have a room available, inconveniencing infrequent guests instead.

[3] Note: The dates from the original case have been changed from 1987 to 2001.

Limitations outside the nature of this case

Under ideal circumstances, a longer historical period would be used. The analysis included here assumes that occupancy for a Saturday in mid August will be consistent with a pattern established since mid May. Ideally, historical data would be available for a longer time period (including previous data for the month of August).

Secondly, this analysis assumes that there are no major holidays or special events (such as a major concert or sporting event) occurring on August 18th. The presence of events could potentially skew the results.

Thirdly, this analysis assumes that the hotel does not hold any extra inventory set aside for “special guests” (ie: the Presidential suite, should the President of the United States arrive unexpectedly), and also assumes that all rooms are available for purchase, and are not out of service or being renovated.

Fourthly, this analysis assumes that customers are not charged for one night’s reservation should they fail to show up. Such procedures will likely increase revenue opportunities, while decreasing the no-show rate (albeit, in many cases, in circumstances where hotels use this penalty, customers often have until 6 pm of the day of reservation to cancel their bookings).

Analysis

The first step in the analysis is to calculate preliminary statistics. These include:

Summary (of Saturday demand):	21,078
Mean (of Saturday demand):	1,622
Standard deviation (of Saturday demand):	251.42

Note: Mean booking rounded upwards; a hotel cannot sell ‘half’ a room.

The next step in the analysis is to identify the probability that the hotel will be full on August 18th, 2001. To do this, we first calculate the Z-score. The formula for doing this calculation is:

$$Z = (\text{point of interest} - \text{mean}) / \text{standard deviation} \qquad (1)$$

or

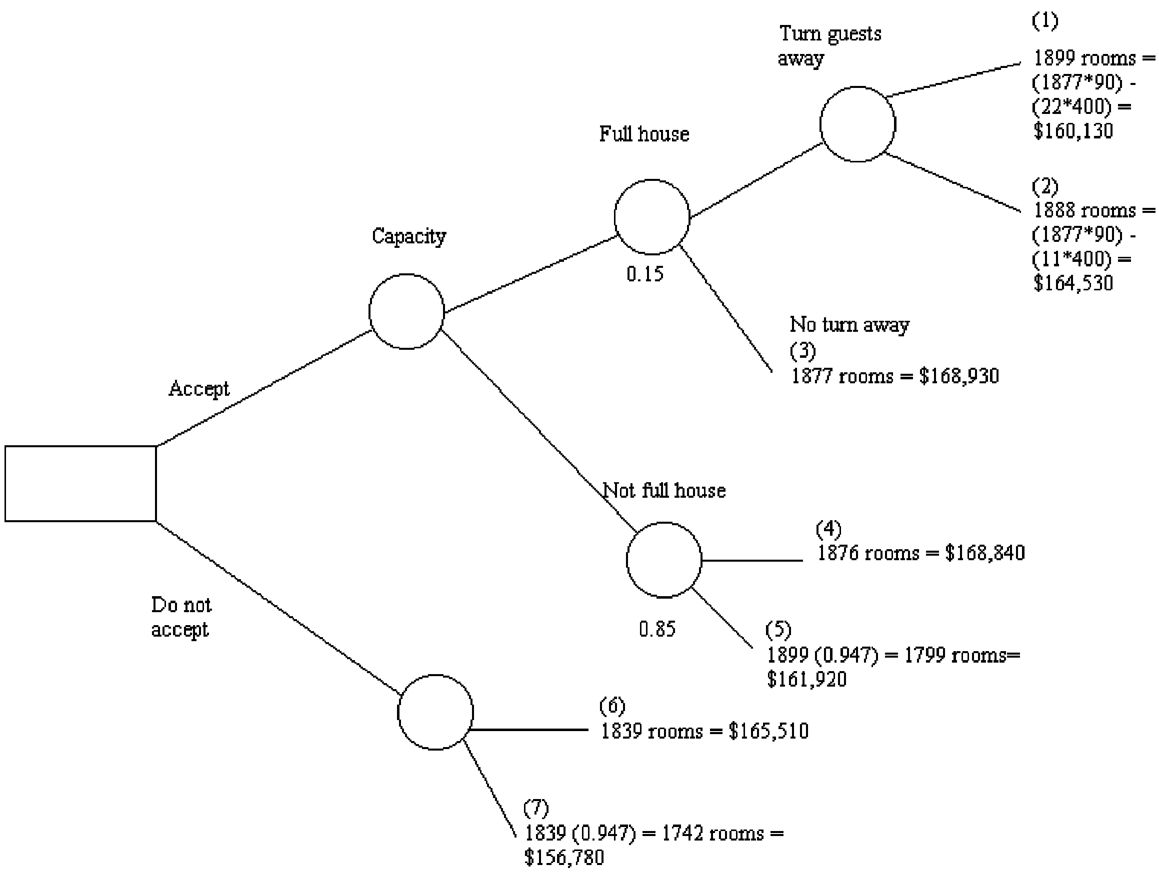
$$Z = (1877 - 1622) / 251.42$$

$$Z = 1.01$$

This z-score is very close to one standard deviation. Assuming a normal distribution, the Z-score corresponds to 0.3438. There is a 50 percent chance of being above or below the center of mean in any normal distribution. Combining these pieces of information, there is a 0.8438 (0.5000 + 0.3438) probability that 1877 or fewer rooms will be used, and conversely, a 0.1562 probability of utilizing 1877 rooms or more.

Decision Tree Diagram

The decisions facing the Marriott Hotel can be understood through examining the decision tree diagram:



In this diagram, square boxes represent a decision node. This illustrates a choice of one alternative, from a number of possible alternatives, that the Marriott Hotel makes. The circles represent chance nodes. Chance nodes are points of chance or probability over which the company has no control.

Discussion of Decision Tree

This presents a brief discussion of the decision tree, starting with each of the end nodes (on the right hand side of the diagram). For the purposes of this analysis, the marginal room contribution ($90) is assumed to be a proxy for actual room revenue.

Decision 1: This decision represents the worst-case scenario for the Marriott Hotel. They accept the tour reservation, and all guests show up. As a result, 22 guests will be turned away. The total revenue generated from this option is $160,0130 (including $8,800 paid to re-accommodate overbooked guests). This is the most risky alternative.

Decision 2: This decision represents the overbooking of 11 guests, and results in total room revenue of $164,530, including $4,400 paid to re-accommodate overbooked guests.

Decision 3: This represents the optimal situation for the hotel; a completely full house. Having guests in all 1877 rooms represents total revenue of $168,930.

Decision 4: This node represents close to full capacity; 1876 out of a total 1877 rooms are booked, resulting in revenues of $168,840.

Decision 5: This node is one of the most likely situations. The hotel accepts the tour operator booking, but realizes that only 94.70% of the guests will actually show up; the historical pickup ratio. Therefore, as a result of 1,899 total possible reservations, only 1,799 rooms are actually used for the night, contributing $161,920 towards total revenue.

Decision 6: This node assumes that the hotel does not accept the tour company reservation, and that all 1839 guests who have a reservation show up, and that no other reservations are made from August 7th to August 18th. Total revenue for this case is $165,510.

Decision 7: This decision involves the hotel declining the tour company reservation, and having 94.70% of all registered guests check in. As a result, only 1,742 rooms (from the original 1,839) are used, resulting in revenue of $156,780. This is the least risky alternative.

Discussion of the results

With many tree diagrams, especially with one involving demand for a time sensitive product, like hotels, there are nearly infinite numbers of possible combinations resulting from the marginal effects of adding a single guest, from the point of initial demand (1839) to some point of over-capacity (1899). Rather than an exhaustive examination of every possible demand combination, this discussion will focus on the following possible scenarios:

- Optimal: defined as a full house (or one guest short of a full house).
- Practical: defined as the most likely situation.
- Pessimistic: defined as turning guests away
- Risk adverse: defined as not accepting the reservation in the first place.

For each scenario described above, an Expected Monetary Value (EMV) is calculated. The EMV includes potential revenue with the probability of an event occurring; the probability must sum to unity at each event circle.

Optimal: Defined as a full house, or very close to a full house. The EMV for this scenario can be calculated as: ($168,930*0.15) + ($168,840*0.85) = $190,392.

Practical: Defined as accepting the tour booking, but having a number of no-shows. The number of rooms included in the analysis is 1877 and 1799, resulting in an EMV of: ($168,930*0.15) + ($161,920*0.85) = $162,971.

Pessimistic: Defined as accepting the tour reservation, and having all reserved rooms accounted for, resulting in 22 guests being turned away. In this example, the probability of a full house is defined as 0.3438, while the probability of utilizing all 1899 reservations is 0.3643. This difference (0.02) represents the probability of having an excess capacity of 22 guests. The EMV for this scenario is defined as: ($168,930*0.15) + ($161,920*0.85) – ($8,800*0.02) = $162,795.

Risk Adverse: Defined as declining the tour operator's request, this scenario involves a 5% probability of maintaining all 1,839 reservations, and recognizing actual demand based on 94.70% utilization. These probabilities were selected based on an examination of the historical data, and result in a best guess on the part of the author. The EMV in this instance is: ($165,510*0.05) + ($156,780*0.95) = $157,216.

Decision Trees – Other applications

Decisions trees are a tool available to managers for understanding and analyzing a variety of possible decisions. Other examples of the possible applications include:

- Determining the likelihood of discovering oil, and whether a geologist should pay for additional seismic information or not. The expected revenue from any reserve is analyzed along with the probability of successfully drilling for oil.
- Determining the possible course of action by a merchant banker following a takeover bid.

Conclusion

Based on the results of this analysis, the Marriott hotel should definitely accept the reservation from the tour operator. The EMV's for all three scenarios involving accepting the tour reservation exceed the EMV from declining the reservation. This indicates that the hotel can expect to benefit financially by accepting this reservation, even when accounting for the probability of excess capacity.

By utilizing a methodical decision tree analysis, this paper demonstrates how complex decisions can be broken down into their component parts, and managed using an understanding of the business decision at hand, combined with a practical dosage of basic statistics.

About the author

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Appendix 1 – Historical Demand and Booking Data

Week	Day	Demand	Tuesday Bookings	Pick up Ratio
1	Saturday	1,470	1,512	0.972
2	Saturday	1,854	2,034	0.912
3	Saturday	1,537	1,455	1.056
4	Saturday	1,795	1,885	0.952
5	Saturday	1,847	2,018	0.915
6	Saturday	1,298	1,356	0.957
7	Saturday	1,486	1,372	1.083
8	Saturday	1,729	1,801	0.960
9	Saturday	1,924	2,105	0.914
10	Saturday	1,765	2,086	0.846
11	Saturday	1,773	1,941	0.913
12	Saturday	1,058	1,123	0.942
13	Saturday	1,542	1,562	0.987
14	Saturday	--	1,839	--
Total		**21,078**	**22,250**	**0.947**

Note:

- Historical data presented for Saturdays only (data for Sundays to Fridays intentionally omitted).
- Total figures above represent the weeks 1-13 only (the Tuesday demand for week 14 is omitted from the total).