Simultaneous Optimization of Capacity Decision and Pricing Policy of a Hotel in Stochastic Demand Environment

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ABSTRACT

In the context of the hotel industry, one of the biggest and capital-intensive challenges a decision maker has is to decide on the capacity of the hotel. While taking this decision, the decision maker needs to take seasonality of demand into consideration. Also, the interplay between price and demand also play a major role on this decision. In this study, an effort is made to simultaneously identify the optimal capacity and pricing policy of a hotel in the presence of a stochastic demand environment. Differential calculus is used to identify the solution. Both capacity and price are considered as decision variables for the decision maker. To comply with reality, the seasonality in demand is incorporated in the form of bi-level demand. Numerical illustrations are also shown to explain the decision-making process. This study offers a starting point for an entrepreneur to decide both capacity and pricing for their upcoming hotel.

KEYWORDS

Bi-Level Demand, Capacity, Hospitality, Hotel Industry, Newsvendor Model, Optimization, Pricing, Stochastic Demand

INTRODUCTION

According to a survey done by USAToday, the interior dimension of an average hotel room, which includes a full bathroom, is approximately 13 feet by 25 feet[1], resulting in an approximate size of 325 square feet. According to the same study, in the United States, the average number of rooms in a hotel is approximately 115[1]. Therefore, average land requirement of a hotel in the United States is approximately 48,000 square feet.

To estimate the cost of construction of a "medium priced" hotel which includes a lobby lounge and the facilities and workforce to manage 24-hour room service, the following cost components are to be included:

- According to Hawkins Research, Inc., the managers tend to use "Best" quality materials and techniques while undertaking hotel construction projects to ensure minimal wear and tear or

replacement cost. According to their estimates, the average cost of such building is roughly $22.2 million[1]. However, this estimate excludes the cost of acquiring the land and any demolition cost;
- According to the same study, the materials cost would approximately be $9.8 million, labor cost would be approximately $8.9 million, and the heavy machinery cost would approximately be $935,000[1].

It is apparent from the above numerical figures that the capacity decision of a hotel is extremely capital intensive. Also, once this decision is taken, it is extremely difficult for a manger to undo it. On the other hand, extant literature related to inventory management leads the managers to believe that mismatch between demand and supply would lead to reduction in profit margin either in the form of unsold inventory, or in the form of lost sales due to stock-out. The effect of mismatch is more pronounced in the context of hotel industry, as neither excess inventory (which essentially is the capacity of the hotel) can be carried forward to the successive period; nor unmet demand can be fulfilled in the subsequent periods.

However, the demand for the hotel industry remains stochastic, and the supply, which is constrained by the capacity, becomes rigid. Therefore, to minimize the mismatch between demand and supply, the managers need to leverage the demand using the pricing strategy. Hence, the managers need to come up with such pricing strategy that the expected profit value is maximized given the hotel capacity. However, it is imperative for the manager to take the interplay between price and demand into account while taking the capacity decision at the outset. On the contrary, a foolish capacity decision would lead to either underutilization or overutilization of resources, leading to unrealistic pricing strategy, finally leading to exit from the market. Therefore, it is very important for a manager to simultaneously optimize the expected profit with respect to the capacity and the pricing strategy while take the optimal decision.

This paper is organized as follows: the following section gives a review of extant literature on the relevant areas. Then a basic newsvendor model is first developed in the context of hotel industry. Then the newsvendor model is extended to the context of bi-level demand. Next, the newsvendor model in bi-level demand environment is optimized with respect to both price and capacity to obtain optimal price and capacity. Numerical examples are provided for illustration purpose.

LITERATURE REVIEW

Existing economic literature includes extensive research on the relationship between uncertainty in demand and firm capacity. In one of the earliest works in this area, Hartman (1972) has shown that the firms should go for capacity expansion to mitigate uncertainty in demand based on the assumption of a linear homogeneous production function. Later, Pindyck (1982) has shown that the direction of relationship between demand uncertainty and capacity expansion decision depends on the curvature of the marginal adjustment cost function.

In his study on the relationship between demand uncertainty and investment decision, Abel (1983) has deduced that higher demand uncertainty leads to a higher current rate of capital investment. Paraskevopoulos, Karakitsos, & Rustem (2011) have used simulation model to show that uncertainty in demand indeed causes significant amounts of excess capacity in several periods the context of PVC industry. Gu (2003) have estimated the optimal room capacity for Las Vegas Strip casino hotels in presence of demand uncertainty to check using aggregate operation statistics of a single-period inventory model. Several researchers have made attempts to empirically establish the relationship between uncertainty in demand and excess capacity as hypothized by Abel in the context of hotel industry (C. M. Chen & Lin, 2013; Lee & Jang, 2012; Zheng & Gu, 2013). Lee & Jang (2012) have argued that uncertainty in demand may give rise to overcapacity problem in the context of US hotel industry as well. Chen & Lin (2013) have empirically tested the effects of uncertainty in demand on hotel capacity for the international tourist hotels in Taiwan from 1996 to

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