An Algorithm for Decomposing Mixed Market Hotel Data & its Relation to Revenue Management

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ABSTRACT

The hotel industry has a history of employing revenue management to enhance profits. Hotel managers' performance is measured by revenue, cost, and quality. Hotel managers set availability restrictions and price for hotel rooms but have little control of costs. Our research focuses on forecasting in hotel revenue management.

INTRODUCTION

Successful revenue management programs are found the majority of times in industries where managers can forecast with some accuracy customer demand. The travel and hospitality industry has a history of employing revenue management to enhance profits. Airlines, rental car agencies, cruise lines, and hotels are all examples of industries that have been associated with revenue management. All of these industries have applied revenue management in one manner or another. Whether it is complex overbooking models in the airline industry or simple price discrimination (i.e., having a tiered price system for those making reservations ahead of time versus walk-ups) for hotels.

The performance of hotel managers is measured along three principal components: revenue, cost, and quality. Hotel managers set availability restrictions and price for hotel rooms. Availability and price are principal components of hotel revenue management. Revenue management typically has wide flexibility and significant responsibility for overall hotel performance. Most hotel managers do not control fixed investment costs and generally speaking any controllable variable costs tend to be relatively standard rates. Cost management thus does not have large managerial flexibility but rather is a limited control responsibility for overall hotel performance. Quality measures of performance include customer satisfaction and quality inspections. As with costs, measures of hotel quality performance are generally not widely variable but rather are a limited control responsibility for overall hotel performance. Of the three components of hotel management performance, revenue management is the single most controllably variable measure.

Lee [7] reported that accurately forecasting demand is cornerstone to any revenue management system and that a 10-percent improvement in forecast accuracy could result in an increase in revenue of between 1.5 to 3.0 percent. Therefore, our research focuses on forecasting in the revenue management system.

HOTEL REVENUE MANAGEMENT AND PERFORMANCE

A number of researchers have studied hotel revenue management in general. Bitran and Mondschein [3] spoke to room allocation; Weatherford [10] proposed a heuristic for booking of customers, Baker and Collier [1] [2] compare five booking control policies, and Goldman et al. [4] extends Baker and Collier's by comparing performance using simulation. More specifically, forecasting in hotel revenue management has also been studied. Kimes [6] studied the issue of hotel group forecasting accuracy and Weatherford and Kimes [9] compare forecasting methods for hotel revenue management. Schwartz and Cohen [8] investigate the subjective estimates of forecast uncertainty by hotel revenue managers whereas Weatherford, Kimes, and Scott [11] speak more quantitatively to the concept of forecasting aggregation versus disaggregation in hotel revenue management. Weatherford, Kimes, and Scott [11] determine that disaggregated forecasts are much more accurate than in their aggregate form. Under their study, aggregation is done over average daily rate and length-of-stay.

Rate class and length-of-stay are important variables that influence hotel performance and in turn improved forecasting of these variables should assist in optimizing revenue. In fact it can be said that at an individual hotel, hotel revenue management is measured along these two dimensions: rate class and length-of-stay. Along these dimensions, ceteris paribus, hotel management is improved by increasing the performance measure. For example, higher rate classes generate higher revenue and/or longer lengths-of-stay generate greater revenue.

This paper considers a set of hotel price and quantity data over three years. Because the hotel industry experiences very seasonal demand, single demand estimation is unsatisfactory. The different markets for the hotel because of seasonality must be decomposed from the aggregate data. This paper presents an algorithm for decomposing data from an aggregation of markets.

RESEARCH METHOD AND HOTEL DATA

The fundamental problem is illustrated in figure one below. Figure one shows the relationship over a three-year period of quantity of rooms sold to the average sales price. A simple regression line is included which not only fits poorly with a low R2, but also more importantly has a slope that is at odds with fundamental economic theory. That is, as the price increases, the quantity of rooms sold should decrease. The reason for this observation in the data is that hotel demand is highly seasonal and thus the data as a whole is a conglomeration of different markets.

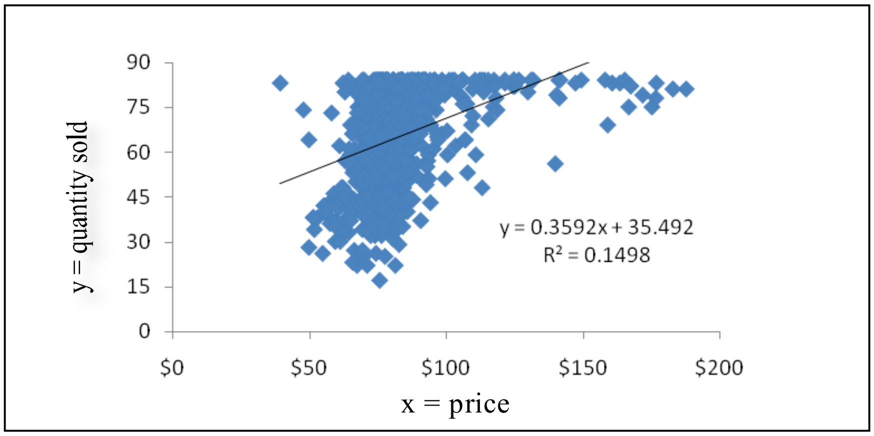

FIGURE 1–Aggregate relationship of quantity sold (y) to price (x).

In order to decompose the aggregate market data, we begin with the observation that hotel managers may be generally modeled as revenue maximizers. If one is to use linear estimates of demand then it can be inferred that the best estimate of demand assuming that the hotel manager is accuratley maximizing revenue is to note that the average rate is $82.69 and average occupancy is 65 rooms. A linear estimate of demand must also pass through the point $165.38 = $82.69*2 with an occupancy of zero. The resulting estimate of market demand from this assumption of revenue maximization is in Figure 2.

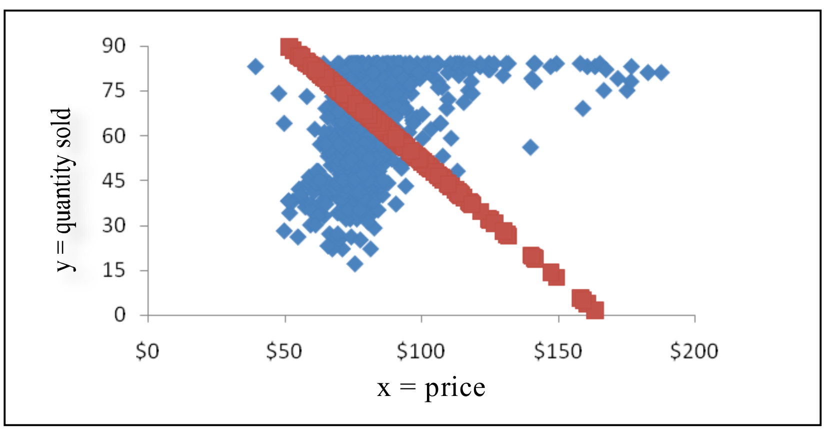

FIGURE 2–Demand estimate assuming effective revenue maximization

It should be clear that Figure 2 does not present a sufficient estimation model. Although it does have a downwardly sloping demand curve, it is clearly quite a poor estimate. However, the process of decomposing demand begins from this starting point. No single line can well estimate the data, so additional model components are necessary. These model components are added iteratively.

Define two model components each by their relationship to the prior estimate. That is, if the actual quantity sold is less than the estimated quantity this is component one (the lower component). If the actual quantity sold is greater than or equal to the estimate quantity, then this is component two (the higher component). Any standard error measurement may be used as an objective function for the program, herein we've used RMSE. Given the x-intercept and the y-intercept for the previous model, constrain the optimisation so the for component 1, the x-intercept and y-intercept are less than those from model 1, and that for component 2, the x-intercept and y-interpcet are greater than or equal to those from model 1. The results from this estimation is shown below in Figure 3. The aggregate data has been decomposed with two estiamed demand lines representing two seasons in the data: a high season and a low season. Although it is clear that this model has obvious limitations it is also clear that this system has advanced the overall goal of decomposing the market. This process can be repeated for any number of model components.

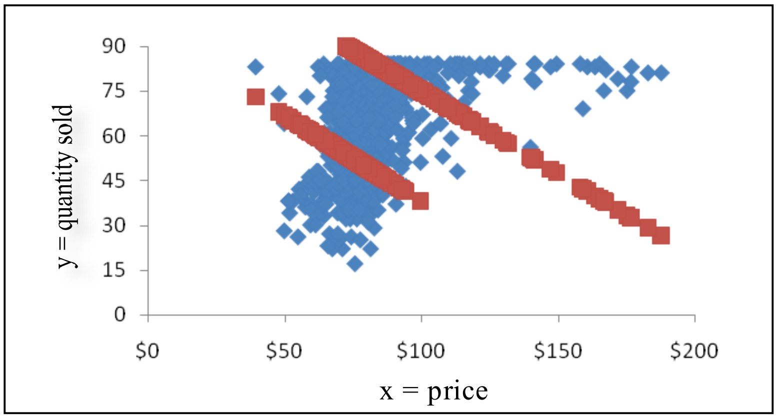

FIGURE 3–Aggegate data decomposed into two markets or seasons

Figure 4 is illustrative of the further improvement in the next step of the algorithm.

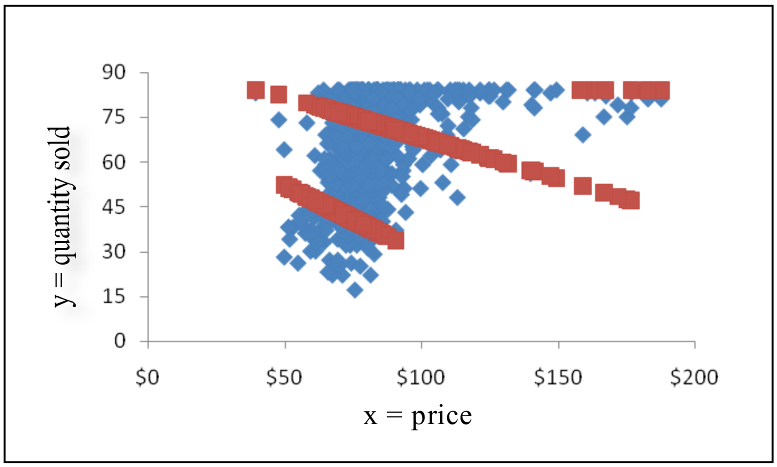

FIGURE 4–Aggregate data decomposed into three seasons

ALGORITHM

Determine the parameters for a single linear model. If demand is linear and the hotel is maximizing revenue, then the average price and quantity is the optimal combination. Also from the assumption, one may also determine that the x-intercept of the resulting line must pass through the point equal to twice the average price. Also the y-intercept must pass through the point equal to twice the average quantity. These values XINT(1) and YINT(1) form the criteria for separating the aggregate data in to its constituent parts.

Estimate two lines with the following constraints:

L1 is such that its x-intercept is less than XINT(1) and its y-intercept is less than YINT(1).

L2 is such that its x-intercept is greater than XINT(1) and its y-intercept is greater than YINT(2).

Sequentially this process can be repeated for any number of model components. Suppose that n linear components have been constructed with x-intercepts and y-intercepts, respectively for each of the i components, XINT(i) and YINT(i). Estimate then n+1 model components such that for the first component its x-intercept and y-intercept are less than XINT(1) and YINT(1), respectively. For the jth component, constrain the estimation so that the x-intercept is greater than or equal to XINT(j-1) and less than XINT(j), and similarly for the y-intercept.

The resulting model does effectively decompose the existing aggregate market data. The iterative process can terminate using any information criteria or to any standard of estimation. Because of the constraints on the intercepts each of the model components will have a downwardly sloping demand curve. From these components then the manager may determine for these seasons the individual revenue maximizing price for that season.

MANAGERIAL IMPLICATIONS AND CONCLUSION

Revenue management in the hotel industry has come along way since its beginnings in the 1980's. It has been said that in the early days of revenue management the hotel industry's philosophy was akin to a used car lot negotiation. However, as revenue management practices have become more mature, the industry has done a much better job of structuring its policies. In fact, the common practice of room discounting from the past has evolved into revenue management. Hanks, Cross, and Noland [5] state that the ideal conditions for implementing revenue management in a hotel include: (1) Low variable costs, (2) High fixed costs, (3) Perishable inventory, (4) Variable demand patterns, (5) Ability to forecast future demands, and (6) Ability to segment customer on their willingness to pay.

Although all of these conditions are important to successful revenue management, the ability to forecast future demands and to segment customers are the most important and most of the time the most difficult to achieve. Decomposing this customer data into segments is critical to maximizing hotel revenue. If a manager can easily draw market segments from aggregate data the hotel property can take advantage of optimal pricing and availability strategies. Hotels can then use revenue management for their entire inventory of rooms instead of discounting haphazardly. Discounts can be made available when demand is weak and closed when demand is strong.

The next step for a manager to take once these segments are determined for a hotel property is to create a set of logical rules and/or restrictions that outwardly segment customers on their needs, behavior, and willingness to pay. It has been found that logical rules such as non-refundability or advance purchase rates have proven successful for certain market segments that have been identified. Future research includes linking decomposed market segments for hotel properties with sets of logical rules for pricing.

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