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Why It Is Difficult to Apply Revenue Management Techniques to the Car Rental Business and What Can Be Done About It

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ABSTRACT

Revenue management systems are used by airlines, hotels, and cruise lines to manipulate prices and availability of inventory in real-time, in order to increase profit. We discuss the reasons that the revenue management problem is more complex when applied to the car rental business. We then show how to simplify the model formulation and provide the human-computer interaction, organization, and procedures to make the problem tractable for the car rental business.

Keywords

Revenue Management, Forecasting, Optimization

1 INTRODUCTION

Revenue management systems are widely used to make tactical decisions for companies in the travel industry, in particular, airlines (Smith et al. 1992), hotels (Bitran and Mondschein 1995), and cruise lines (Ladany and Arbel 1991). In addition to the year-round practice of higher rates during periods of peak demand and lower rates when demand is weak, travel companies use revenue management systems to manipulate rates and the availability of inventory within each booking period. This results often in customers paying different prices for the exact same product.

Interfacing with the real-time reservations systems, revenue management systems utilize the latest information from the reservations systems and transmit back pricing directives and availability limits for the remaining inventory. As reservations are booked, changed, or cancelled, the revenue management systems modify their forecasts and reevaluate pricing and availability decisions with the objective of capturing the most revenue or profit for a given flight, a specific hotel night, or a particular cruise.

The problem of optimizing revenue or profit is solved by first forecasting demand at different price levels, given the reservations holding and the booking lead time. Then, a dynamic or linear programming algorithm determines the pricing and availability limits for the remaining inventory in order to maximize revenue or profit. This process is repeated each day (or more often) until the flight departs, the hotel check-in day is reached, or the cruise leaves.

In all cases, the inventory is a fixed, known quantity. The number of seats by category (first-class, business, economy)

on a given flight is essentially fixed. The number of hotel rooms by type at a given hotel is fixed. The number of staterooms by type on a given cruise is fixed. Furthermore, this inventory is a perishable commodity. If a seat is left vacant on a flight, a room vacant at a hotel, a cabin vacant on a cruise, the value of that inventory can never be recovered. The company might discount the product to try to prevent that. On the other hand, the company would not discount a unit of inventory, if it thought that a full-fare customer will reserve it later in the booking period. Revenue management systems evaluate these trade-offs repeatedly during the booking period. The algorithm sets prices and availability to get the most revenue or profit out of this fixed inventory while it still can be sold.

At first thought, it seemed that there would be a direct transfer of these ideas to another travel business, the car rental business (Carroll and Grimes 1995; Geraghty and Johnson 1997; Steinhardt and Gonsch 2010). The car rental business also has real-time reservations systems and the need to price and control its perishable inventory to maximize revenue or profit. However, this turns out to be a more difficult problem.

In this paper, we examine the revenue management problem for companies in the car rental business. The mathematical model consists of a forecast component followed by an optimization component, as in the revenue management systems of other travel businesses, but the mathematical components are more complicated in the car rental business. We describe the business issues that cause these complications and the impact they have on the forecast and optimization components. Then we suggest both model formulation changes and operational changes to make the problem tractable.

2 PROBLEM COMPLEXITY

The problem is more complex for the car rental application, because, as we will see, demand is more difficult to forecast, supply is not a fixed, known quantity and so also must be forecast, and the forecast and optimization components need to solve the problem across a planning horizon, not just for one event.

Demand

Car rental demand is difficult to forecast, in part because of business practices and in part because of the way customers make their travel plans. A credit card is not required to book a reservation, and so customers often reserve multiple times and from several companies as they shop for the best rate. They often do not cancel reservations, since there is no penalty and also they want to ensure that a vehicle will be there when they arrive. Therefore, no-show factors are high.

The car rental decision is usually made last when planning travel, so reservations are made close to the checkout date, resulting in short lead times.

Further, unlike airlines and cruise lines, the car rental demand varies with length of rental. This is a complication shared with the hotel business, but in the hotel business, the length of stay variability is in a narrow range and the room capacity is fixed. In the car rental business, this requires forecasting and optimizing over a planning horizon (typically a rolling three week period), since earlier rentals will impact future supply. In contrast, in the airline business, we are only dealing with one flight and in the cruise business, with one cruise to forecast and to optimize.

This implies that demand must be predicted at the micro-market level of car class **and** length of rental (which we will call rental product) for the planning horizon. There is a large number of car classes and length of rental combinations, and adding to the difficulty, reservation counts can be small in many of these categories. Forecasting demand by rental product for different price tiers would be even more difficult.

Supply

Supply is another complicating factor. Supply is variable, dependent on both company and customer decisions. Car inventory by car class at a rental station varies over the long term, because of company vehicle purchase and sale decisions. Over the short term, supply varies because of the company shuttling cars between locations to satisfy demand, customers returning cars that were rented from other locations, and customers returning cars at times other than stated at checkout.

The forecast component needs to predict both rental demand and the supply of vehicles. The supply forecast requires predicting when and where cars already on rent will return and also when and where future rentals in the planning horizon will return. The latter is a second level of estimation.

Instead of optimizing profit by adjusting price to fill a fixed, known capacity as in the other travel businesses, in the car rental business, the optimization component needs to determine the optimal allocation of supply to each rental product. For example, a model decision might be to limit reservations for longer rentals of a certain car class that cross over a peak day and accept shorter rentals that would check in before the peak day.

To account for the ability of the company to move cars between locations to meet demand, an added requirement of the optimization component is to determine the shuttling decisions, which in turn will affect future supply.

3 MODEL SIMPLIFICATION

To solve the revenue management problem, we reduce the complexity of the mathematical formulation by a series of factoring, decoupling, and aggregation approaches.

Factor and Decouple

We factor the global problem into a set of geographical sub-problems, one for each management area (fleet owner). This mirrors the business organization and the way car rental companies plan, manage, distribute, and account for their fleets. Further, rentals between fleet owners are rare, and when they occur, we can assume they balance out. We can then decouple these sub-problems, so that each fleet owner can be modeled, forecast, and optimized separately, greatly reducing the size and complexity of the optimization component.

We factor the problem further by separating the allocation decision from the pricing decision. We assume that the historical relationship of pricing to competition has not changed. Then we can forecast demand by rental product without regard to pricing. The optimization component first determines the allocation of supply to rental products and then determines any pricing action within that allocation. If it determines, for example, that it will need to suspend reservations for a rental product at a future date, it can first raise the price tier for that rental product to get added profit while slowing demand.

Aggregate

To further simplify the model, within each fleet owner, we aggregate individual rental stations, which are in close proximity and have the same rate structures and variable costs, into location groups (districts). We assume, because of the close proximity, that cars are available instantaneously for all stations within a district. Shuttling then only needs to be evaluated between districts within a fleet owner. Demand and supply forecasts are made at the district level. If the optimization component recommends suspending certain reservations or changing the price for certain rental products, those recommendations would then apply to all rental stations in the district.

We also aggregate rental products into product groups that have sufficient numbers and consistency to be forecast accurately and that can be treated as one with regard to pricing and allocation decisions. The grouping would vary by the size of the district. For example, the car rental companies have as many as sixteen car classes, which may be aggregated into perhaps three car groups (economy, midsize, and premium), and the length of rental component may be grouped into perhaps one-day, two-day, three-day, and weekly rentals.

The aggregation described above improves the accuracy of the forecast component and reduces the choices required of the optimization component. Once the optimization component produces its recommendations for a fleet owner at the aggregate level (district, car group, length of rental group), the results are mapped back to the original level of detail (rental station, car class, rental days) needed by the reservations systems. Since the groupings were established so that the recommendations at the aggregate level would apply identically at the detailed level, this involves simply hierarchical tables of the grouping of rental stations, car classes, and rental days.

4 SOCIAL-TECHNICAL SYSTEM

Once we have simplified the model formulation, we need to put in place an environment for interacting with the model, an environment in which field personnel are confident they can implement the model decisions, and everyone involved is convinced that the model recommendations will provide the greatest profit.

We extend the term “revenue management system” broadly to encompass the mathematical model for pricing, allocation, and fleet distribution decisions, the resulting computer software that executes the model and interfaces with the reservations systems, and the people and procedures needed to make it work. The human-computer interaction and the organization and procedures established around the model are of major importance for the system to be successful (Piccoli, 2012). We discuss the social-technical system that needs to be established and how the users would interact within this overall system. We discuss the importance of a motivated, team approach for implementing the results

The users of the system are headquarters’ analysts and field personnel. In a car rental company, typically headquarters makes decisions on pricing, allocation, and the purchase and sale of vehicles. Field personnel make shuttling and daily operational decisions. The revenue management system makes all these decisions, crossing organizational boundaries.

The objective is to create an environment for shared decision-making. The user interface needs to provide sufficient information for the field personnel to be confident in the inputs, understand the reasons for the decisions, and be comfortable to implement the results. The user interface needs to support headquarters’ analysts, so they can evaluate and transmit the recommendations. At the same time, it has to hide the detailed data and underlying mathematics.

The users are supported by a graphical user interface and an on-line query system. They are provided with information in their knowledge domain to evaluate the model inputs and recommendations. The analysts and field personnel are trained in the approach and the objective of the model, in the user interface, and in the standard queries. As they gain experience with the model, they become an integral part of the process.

To help address the difficulty of forecasting demand and supply, the user interface provides the ability for field personnel to adjust current-day activity, based on the latest local information. They might make changes due to events, such as new cars arriving ahead of or behind schedule, weather and traffic-related impacts on demand and supply, competitor car availability that would affect the demand forecast.

For example, if the tunnel from Logan Airport to downtown Boston is crowded and cars cannot be shuttled, the supply in the model for the downtown location would be reduced. If weather conditions at Logan are causing flight delays, the demand forecast would be adjusted. If a competitor runs out of cars, walkup demand forecasts would be increased. After entering such modifications, the model is rerun, and the new recommendations are transmitted to the reservations systems.

Field personnel also can modify times to ready returned cars for the next rental, account for counter delays, and adjust for discrepancies in check-in times. Better reflecting the current conditions at the rental stations not only improves the model input and thus its output, but gives field personnel greater ability to implement the model recommendations and more confidence in the results.

To give an example of the user interface, we discuss three types of interactive displays that support the needs of the users.

One display is the Operations Report. It is similar in layout to the standardized field reports used by many car rental companies, but it is generated by the model and is interactive. This display shows at the level of district and fleet owner, for each day of the planning horizon, the number of starting cars on the lot, the number of cars planned to be shuttled in and out, the reservations holding, the projected demand, the number of cars recommended to rent, the number of cars returning, and the resulting final car count at the end of the day. This serves first as a way to synchronize the model with what is happening in the field. Second, it allows field personnel to adjust the current-day data as needed. Third, it identifies the short-term plan for the field personnel to implement.

A second type of display is an interactive On-rent Graph. It gives a high-level picture of rental demand vs. vehicle supply over the planning horizon, identifies the actions the model recommends, and visually shows their impact. The On-rent Graph is color-coded to show the portion of the total car inventory needed each day for current rentals, booked future rentals, and projected reservations. It displays this information by fleet owner and by district. This is a tactical, discussion document that is used to evaluate the model assumptions over the planning horizon and to determine if other fleet decisions should be made. Headquarters’ analysts can use this display to analyze peak days of vehicle usage and examine alternative scenarios.

The third type of display is the Control Screen. It shows the detailed model recommendations to suspend reservations and change rates for each rental station, rental product, and day of the planning horizon. The analysts use this screen to transmit the directives instantaneously to the reservations systems.

5 CONCLUSION

Revenue management systems change the way car rental companies operate, resulting in greater profitability. For example, instead of stopping reservations when bookings net of expected no-shows and cancellations reach the supply level, companies can pinpoint in advance precisely when to suspend rental products and when to adjust rates to increase profit. Instead of moving large numbers of cars from the airport to the downtown area to handle weekend demand, companies can now selectively move only those that will be profitable. Now tactical pricing, availability, and fleet distributions decisions can be made in concert to optimize profit and gain a competitive advantage.

We explained how to deal with the issues that add complexity to the revenue management problem in the car rental industry. We did this by simplifying the model structure and building upon human/computer interaction. In doing so, we tried to find the right balance between information loss and information overload, both in the model formulation and the information presented to the users. We needed to find the right level of detail at which to forecast and to optimize. As we simplified the model, we saw opportunities to integrate the decision-making to better reflect our objectives and reality.

Through a specific application, we demonstrated techniques that are useful in tackling complex problems, making them tractable, and producing meaningful results. More generally, the approach of factoring, decoupling, and aggregation is a way to simplify other complex modeling situations. The idea of a social-technical system also has implications beyond this application. Setting up the organization, procedures, and appropriate user interface around the computer system is necessary for any complicated system to be successful.

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