TITLE: Pricing for internet sales channels in car rentals
AUTHORS: Oliveira, BB ; Maria Antónia Carravilla ; Oliveira, JF ; Raicar, P; Acácio, D; Ferreira, J; Araújo, P;
SOURCE: Operations Research and Big Data: IO2015-XVII Congress of Portuguese Association of Operational Research (APDIO),VOLUME: 15, PAGES: 139-147, PUBLISHED: 2015
DOI: https://doi.org/10.1007/978-3-319-24154-8_17

Pricing for internet sales channels in car rentals

Beatriz Brito Oliveira, Maria Antónia Carravilla, José Fernando Oliveira

INESC TEC and Faculty of Engineering, University of Porto, Portugal

Paula Raicar, Delfina Acácio, José Ferreira, Paulo Araújo

Guerin Car Rental Solutions, Portugal

Abstract Internet sales channels, especially e-brokers that compare prices in the market, have a major impact on car rentals. As costs are heavily correlated with unoccupied fleet, occupation considerations should be integrated with swift responses to the market prices. This work was developed alongside Guerin, a Portuguese car rental, to build a tool that quickly updates prices on e-brokers websites to increase total value. This paper describes the specificities of the problem and their implication on the solution, and presents an adaptative heuristic to update prices and the system's architecture.

Introduction

Similarly to other tourism-related sectors, the car rental business has been deeply impacted in the past years by internet sales, namely by the development of a new sales channel: broker websites that compare the offers of different competitors. The impact of this channel is especially relevant for car rentals due to the lack of differentiation of their product, if compared, for example, with the hotel business. As the vehicles and pick-up stations are the same and the clients are able to compare all the offers in the market with full transparency, the price takes an even more determinant role in their decision.

The ultimate goal of every company is to maximize its revenue. For car rental companies, the main slice of the costs is related with unoccupied fleet. Therefore, the "revenue challenge" deals not only with uncertain demand (highly dependent on the companies' positioning versus the other prices on the market); it also deals with the need to maximize the occupation of the fleet for each day, ensuring the cars were booked at the highest possible price. Moreover, for the e-brokers channel, it is of the utmost importance to be watchful and agile in order to respond to changes on the market prices. This requires processing a massive amount of data in an extremely short time-frame.

This paper presents the work developed in *Guerin Car Rental Solutions*, a Portuguese car rental company, to build a tool that allows for a swift, systematic, regular and profitable update of all the company's pricing positions in the market. This tool is based in an heuristic procedure that is adaptative in the way it continuously corrects the prices responding to the changes in the market conditions (demand and competitors' prices), in order to attract the right (number of) customers at each point in time and thus increasing the value collected for the fleet each day.

The Problem

Brief description

The main decision of this problem is setting the price to charge for a specific *search* that a customer makes online a certain number of days in advance (e.g. 30 days beforehand). In fact, this problem is highly dependent on the *antecedence* of the search versus the start of the reservation. The e-brokers channel is typically used by the *leisure* segment, allowing prices to vary over time (this is not true for the corporate segment, for example, where other reservation formats, such as pre-established contracts, may limit the price variation). Therefore, there is a need to balance the goal of occupying the fleet and the goal to do so at the highest possible price.

A search is characterized by the e-broker website where it is made, the starting date (vehicle pick-up) of the reservation, the rental length (in days), the pick-up station, and the type of vehicle required. The *number of days in advance* is calculated based on the starting date of the reservation (see Figure 1).

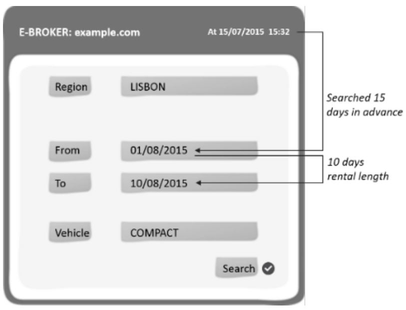

Fig. 1. Example of a seach

The goal is to develop a tool that is able to calculate, in short intervals (e.g. every two hours) the prices to set for each *search* the customers can make.

Important characteristics

One of the characteristics of this problem that influences the most the pricing decision-process is the *transparency* between competitors. When searching online on the e-brokers website, the customers search for a specific vehicle, location and dates and the results are retrieved for all competitors with an offer in the market, usually organized by price. This leads to a *best deal* effect, in which the competitor offering the lowest price gets the most attention, even if the price difference to the others is marginal. This can only be surpassed by some competitors, whose considerable market share and customer awareness can trigger customer preference even if their price is not the lowest in the market.

However, one can note that although the customers have full transparency between competitors, their searches are usually focused on specific dates and locations, *hindering the transparency between prices of the same company*. For example, if a customer wishes to rent a car for a leisure trip, he/she is not likely to change the trip dates (or the region of the car pick-up) in order to get a cheaper deal (this is not necessarily true for other businesses such as airline). Therefore, there is a *flexibility* for the car rental to set the prices of different searches independently of each other.

Nevertheless, it is important to bear in mind that the prices of the different searches are not completely independent: 1) the main slice of the costs of car rental companies derives from unoccupied fleet; 2) fleet occupation and price influence each other; low prices increase the pace at which new reservations are made, increasing the pace of fleet occupation (and high prices have the opposite effect) - it is thus possible to use the prices to accelerate/decelerate occupation rate; 3) a fleet can be occupied by a myriad of different searches (and thus prices) - in fact, the fleet of a certain vehicle type in a certain region is, in a certain day, occupied by reservations made in different e-brokers that started in different days and stations and will have different durations. The main challenge faced was thus related to the amount of data to process in order to calculate the price for every *search*, in a short period of time (two hours), including processing the current prices in the market for each competitor for each search, and the occupation of the fleet(s) affected. For the company considered in this paper, the amount of different searches for which updated prices must be calculated at each iteration is in the range of the tens of thousands.

Literature Review

This problem is herein regarded as a *revenue management* problem. In [1], revenue management is related with three different types of ``demand-management decisions'': structural decisions (related with the configuration of the sale -- e.g. auction), price decisions (related with the price to set for different products, customers, product life-cycle, ...) and quantity decisions (e.g., related with the allocation of resources to segments). The authors state the importance of recognizing the business context so as to understand the relevance of price and quantity flexibility, which will have a deep impact on revenue management strategies. For example, in the hotel business, it may difficult to increase capacity of rooms whilst prices are significantly easier to change. In fact, in the problem tackled in this paper, the main focus is on *price decisions*, as the flexibility to change prices is significantly superior to the one to change capacity. In [2], business characteristics that justify why companies adopt revenue management programs are reviewed. It is possible to verify that the problem herein described presents these characteristics. Firstly, as in most service-oriented problems, excess resources are impossible to store (in this case, if a car is not used some day, the capacity is lost). Also, pricing decisions are made with uncertain demand, and different customers with different willingness to pay have different demand curves while sharing the same resources. Moreover, the company is profit-oriented and able to freely implement the decisions.

The fact that this problem is related with a web-based sales channel has a deep impact on the problem definition. Already in 1998, it is argued that internet-based marketplaces decrease the customer cost to obtain information and compare offers, which promotes price competition; moreover, they increase the ability of the seller to charge different prices to different customers (or to charge different prices over time), which reduces customer surplus and increases company's profit ([3]).

Revenue management is historically linked with the airline business. In [4], the implementation of a revenue management system at Western Airlines is described, with a seat inventory control based on the Expected Marginal Seat Revenue (EMSR) decision model, which sets and revises booking limits to the number of seats available at different prices. This model takes into account the uncertainty of demand and is based on the value of the expected revenue per seat per class or segment, thus defining their protection levels (number of seats hold for sale for certain segments) and, consequently, booking limits. Over the time, revenue management has been applied to different sectors and situations. In [5], the maximization of revenue in a network environment is tackled by defining dynamic policies for the allocation of shared resources to different types of uncertain demand. The authors propose a solution based on approximate dynamic programming, which may have applications on airlines, hotels, car rentals, amongst other businesses.

Revenue management on car rental business was early on tackled by [6], who described the implementation process of the Yield Management System (YMS) in Hertz, designed to help decisions related with pricing, fleet planning and fleet deployment between stations. Hertz's YMS segmented the market with different-valued offers and helped decide when to make these offers. It also protected fleet for higher-value reservations when supply was short. Also in [7] the revenue management program of a different company is described - National Car Rental. This system was designed to *manage capacity*, tackling fleet planning issues, planned upgrades (with inventory protected using the above-mentioned EMSR model), overbooking, and creating a *Reservations Inventory Control* procedure for selection of the most profitable reservations amongst similar ones with different lengths of rent. It also tackled *pricing issues*: for different segments, the model recommended prices to maximize occupation based on a target utilization. This model for pricing, which inspired the heuristic proposed, is composed of two parts. Firstly, an elasticity model is created relating historic rates with variations in demand. Then, the comparison between occupation (or demand) *forecast* and *target* leads to the required change in booking pace. From the elasticity model it is thus possible to retrieve the rate that will induce the required change in the pace of demand.

More recently, a revenue management problem in a car rental network is tackled in [8]. The authors propose a stochastic programming approach to optimize fleet deployment between locations and capacity controls to protect fleet for higher revenue reservations, under a demand of probabilistic nature; in this context, the prices are not considered as decisions. Other works apply revenue management techniques to the car rental context, such as [9]. Here, the authors aim to allocate vehicles of different categories to different customer segments, following a framework on which the company must decide if it is more profitable to accept a rental request or not and thus define acceptance policies. A parallel can also be found with pricing problems. For example, in [10] dynamic pricing strategies are studied, which might be applied to the car rental context. In this work, a common formulation for allocation of capacity and dynamic pricing is presented.

The Proposed Solution

The proposed solution to set the prices for the e-brokers sales channel is a heuristic designed to be swift, adaptative to the market and fleet conditions, and fast to implement. Research on revenue management and pricing in car rental is growing significantly on the stream of optimal policies and controls for allocating the right customers to the right-priced offers. However, to the best of the authors' knowledge, there is still a gap on the development of methods that address the link between the need to protect fleet and the need to take in consideration competitors' prices and the company's competitive position. This was a specific requirement of the work herein developed.

This heuristic is based on the concept of *goal occupation*, which is described in this chapter. A full decision tool / system was also designed and implemented and is also described in this chapter, representing the functioning conditions surrounding the heuristic procedure. This tool allows the car rental company to parametrize the heuristic procedure based on its business sensitivity, as well as to monitor key fleets and seasons of the year, providing useful indicators related to regional fleet balancing, *real* margins applied by e-brokers and market price fluctuations.

Heuristic procedure based on goal occupation

The main objective of this problem is to set the prices to charge for each search, at each time distance to the reservation, so that the revenue of the car rental company is maximized. For that, one needs only to ensure that the capacity of each fleet is only booked to the maximum of its capacity by the different types of searches that influence it. However, the relation between the price to charge, the minimum price in the market for the same search, and the amount of reservations that one is able to get from it is intrinsically hard to define realistically. Therefore, the concept of *goal occupation curve* is introduced: the percentage of vehicles from a fleet that the company aims to have occupied with reservations for a certain date, at a certain time distance. For example, the company wants to have enough reservations to occupy 60% of fleet F on day D, 30 days before day D (see Figure 2).

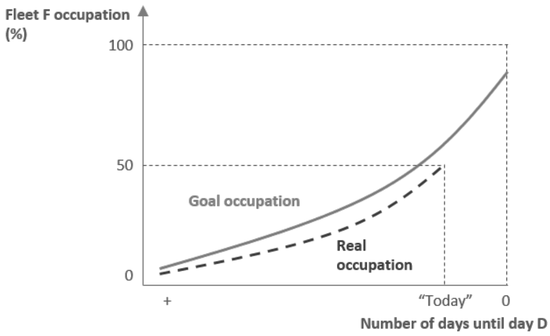

Fig. 2. Representation of the evolution of goal and real occupation of a fleet for a specific day

Following this goal occupation curve allows the company to increase the value attained for the fleet sold. That is to say that the company is able to define how much vehicles to hold for the "late" clients that are willing to pay more for them. This concept is parallel to the *target utilization* [7]. The heuristic proposed is thus based on the concept introduced in [7] that states that changes in the rates influence the difference between target and forecast occupation, which should be minimized. In our problem, as this procedure is designed to be run progressively and frequently (every two hours) and to be adaptive, actual occupation is used (not forecast). Therefore, in this heuristic, the prices charged are a mean to minimize the distance between the observable fleet occupation and the *goal occupation*, for a certain time distance to the reservation. Based on the discussion regarding the problem characteristics, it is assumed that companies are only able to get clients if their price is the lowest in the market. Therefore, if the real occupation is lower than the goal, the price should be set to be the lowest in the market (although never allowing for the price to fall below a certain minimum price). Conversely, when real occupation is higher than the goal, the company should increase the price in order to reduce occupation rate, yet striving to achieve the desired pricing position versus competitors. If the occupation becomes extremely high, however, the increase should become independent of the competitors' prices, so as to hinder more (undesired) occupation.

Real occupation is calculated based on the concept of *most constrained day*. In fact, a certain *search* whose price is being settled will be translated in a reservation that may last for more than one day. In order to be conservative, all calculations consider the most occupied day in the reservation. Also, to calculate the new price is critical to “see” the prices the customer “sees” for each player. Therefore, when deciding the price to settle, the *margin* the e-broker is applying on the company's price should also be added.

This procedure settles the price for each search independently of the other searches, although several searches influence the same fleet occupation, as seen in the discussion above. The only searches that are linked are the ones that share all characteristics except for the group, and whose hierarchy of the groups was previously set (e.g. the price of a compact car should always be lower than the price of a luxury model). The searches are thus mostly considered independent in order to agilize the procedure since its main consequence is a higher degree of conservatism. For example, if a certain fleet in under-occupied, this heuristic will decrease the price for all searches that influence this fleet (as if they were the only ones affecting it). The effect may be higher than expected due to this “over-kill”. However, as this procedure is adaptative, if this happens, in the next run the fleet will be slightly over-occupied and the prices will be adapted to this new context. In fact, this *easiness to adapt* is one of the most important characteristics of this procedure.

Full System Overview

Figure 3 aims to describe the working flows of the full system designed. The system is divided in two areas: a User Area and a Work Area. The first is where the heuristic is parametrized, as well as the frequency to run each search. It also allows the user to choose which key groups to monitor. The second is where the connection with the main input and output systems is established and the procedure itself is based.

There are four main types of inputs to this system. The first two types of inputs are provided by external systems while the latter are user-defined:

- The *prices* currently available for the customers on each e-broker website, for the company and all its competitors;
- The *occupation* of the fleets for each day in this horizon;
- The main parameters of the system;
- The key groups to monitor.

Every pre-defined interval of time (hourly or every two hours), the system follows three steps. Previously, the user has defined the schedule of each search, based on its characteristics. For this, the user may define several command lines, such as “recalculate prices for all searches/reservations starting next month” or “for all that take place on 2015 High Season”. From this, the first step of the system is to *list all the searches for whom to recalculate prices at this moment*. Secondly, the heuristic procedure recalculates prices for all the listed searches and sends them to the e-brokers. Finally, for the key monitoring groups, the main indicators are made available to the user.

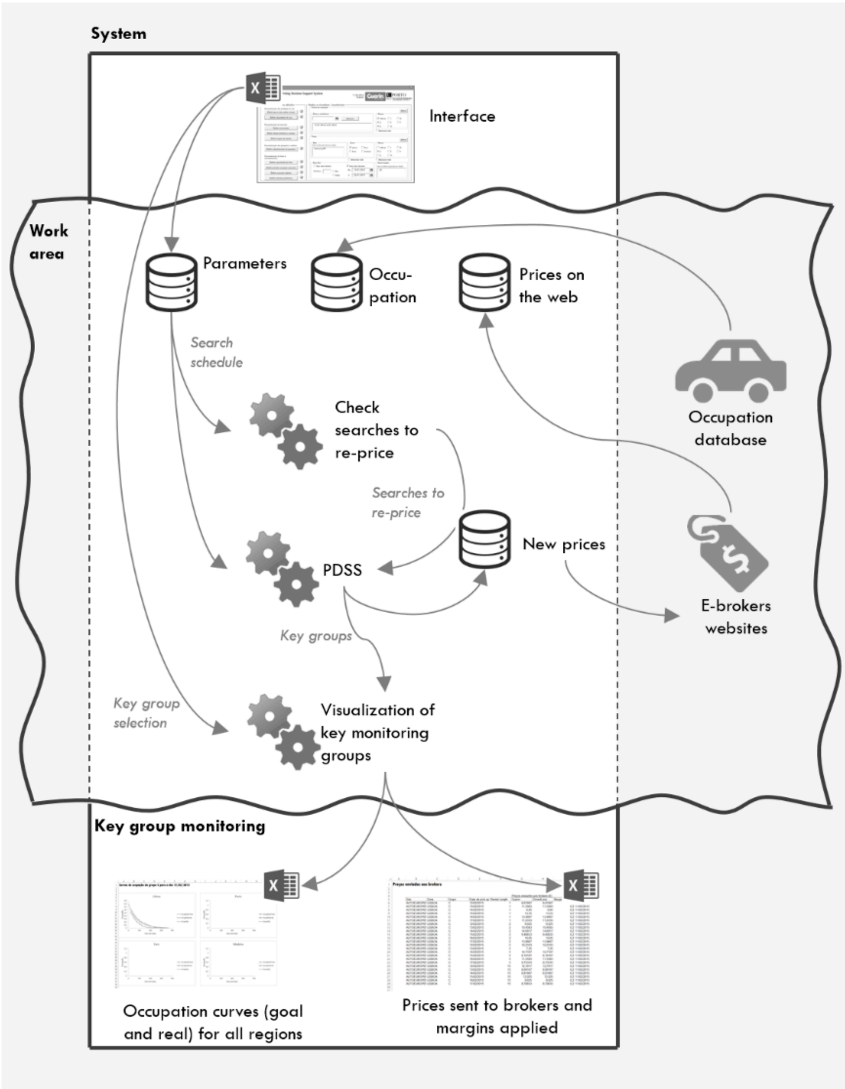

Fig. 3 . System overview

It is important to note that companies do not have much control over the margins applied by e-brokers and thus a potential margin is computed and used in step 2: this margin is equal to the last company's price retrieved from the e-brokers' website divided by the recalculated price sent to the e-broker on the last iteration.

For some pre-selected key groups, the evolution of the occupation and price/margins is also monitored. For example, the user may follow the evolution of a certain fleet's occupation for a specific week and compare different regions through interactive graphic displays.

Conclusions and Future Work

This system, currently being implemented on *Guerin*, will enable the company to adapt its prices to the occupation of the fleet and the fluctuations of the market, seizing significantly more value from the customer willingness to pay. Moreover, it will be possible to monitor key periods of the year or key vehicle groups, as well as the margins added to the prices by the e-brokers.

The future work lays ahead in two different dimensions. On the business side of the problem, there is a need to measure the actual impact of this system and, based on that, refine key parameters of the problem such as the *goal objective curve*. This is possible since this system is designed to save all the data for future research.

On the academic side of the problem, since this is, at the best of the authors knowledge, yet to be fully explored by the academic community, future work is needed to build models that are able to bring even more value to the company by maximizing the revenue and tackling all the prices that relate to the same fleet occupation in an integrated way. Moreover, as these models will lead to (realistic) large instances, solution methods to solve them will be required. In a second stage, it will also be interesting to include *fleet sizing and deployment* issues in the problem, integrating decisions of vehicle transfer between regions when occupations are unbalanced.

References

[1] Talluri, K. T. and Van Ryzin, G. J., 2006. *The theory and practice of revenue management*. Springer Science+Business Media.

[2] Netessine, S. and Shumsky, R., 2002. Introduction to the Theory and Practice of Yield Management. *INFORMS Transactions on Education*, 3(1):34-44.

[3] Bakos, Y., 1998. The emerging role of electronic marketplaces on the Internet. *Communications of the ACM,* 41(8):35-42.

[4] Belobaba, P. P., 1989. OR Practice - Application of a Probabilistic Decision Model to Airline Seat Inventory Control. *Operations Research*, 37(2):183-197.

[5] Bertsimas, D. and Popescu, I., 2000. Revenue Management in a Dynamic Network Environment. *INSEAD Working Paper Series 2000/64/TM*.

[6] Carroll, W. J. and Grimes, R. C., 1995. Evolutionary Change in Product Management: Experiences in the Car Rental Industry. *Interfaces*, 25(5):84-104.

[7] Geraghty, M. K. and Johnson, E. 1997. Revenue Management Saves National Car Rental. *Interfaces*, 27(1):107-128.

[8] Haensel, A. and Mederer, M., 2011. Revenue management in the car rental industry: A stochastic programming approach. *Journal of Revenue and Pricing Management*, 10(1):290-290.

[9] Guerriero, F. and Olivito, F., 2014. Revenue Models and Policies for the Car Rental Industry. *Journal of Mathematical Modelling and Algorithms in Operations Research*, 13:247-282.

[10] Maglaras, C. and Meissner, J., 2006. Dynamic pricing strategies for multiproduct revenue management problems. *Manufacturing & Service Operations Management*, 8(2):136-148.