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Innovative Applications of O.R

An option-based revenue management procedure for strategic airline alliances

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ABSTRACT

An airline has to decide whether to accept an incoming customer request for a seat in the airplane or to reject it in hope that another customer will request the seat later at a higher price. Capacity control, as one of the instruments of revenue management, gives a solution to this decision problem. In the presence of strategic alliances capacity control changes. For the case of two airlines in the alliance and a single flight leg we propose an option-based capacity control process. The determination of booking limits for capacity control is done with real options. A simulation model is introduced to evaluate the booking process of the partner airlines within the strategic alliance, considering the option-based procedure. In an iterative process the booking limits are improved with simulation-based optimization. The results of the option-based procedure will be compared with the results of the simulation-based optimization, the results of a first-come-first-served (FCFS) approach and ex post optimal solutions.

1. Introduction

Revenue management is a concept that dates back to the deregulation of the fares in the airline industry in the late 1970s. Due to deregulation, airlines are able to sell the same seats in the cabin of an aircraft to different customer segments at different prices during the booking period. With the aid of revenue management instruments – namely capacity control, dynamic pricing and overbooking – airlines try to maximize their profit generated from a limited seat capacity in deciding which fares to charge and how many seats to reserve for each customer segment. We refer to Talluri and van Ryzin [25] for a detailed description of revenue management instruments. This paper focuses on revenue management applications in the airline industry. But although the main focus of revenue management applications continues to be the airline industry, there are several other sectors in which the use of revenue management instruments makes significant contributions to the performance. Kimms and Klein [13] not only list several specific and general definitions of revenue management but also discuss requirements for implementing revenue management instruments as well as various fields of application. An overview of revenue management research in non-airline service sectors is given by McGill and van Ryzin [17].

The deregulation of the airline industry had further consequences on the market. Major airlines were confronted with the competition of low-cost carriers entering the markets. To meet arising challenges, major airlines, not able to profitably offer flights to markets with low demand, began to cooperate with regional carriers, which could meet the demand for low density markets profitably. According to Shumsky [22] major traditional carriers are forced by low-cost competitors to process an increasing amount of their traffic in airline alliances. The major strategic alliances in the passenger transport airline industry are Star Alliance, SkyTeam and oneworld. The passengers recognize strategic alliances if they book a code-sharing flight. A code-sharing agreement allows an airline to sell flight tickets under its own brand that are provided by its partners. Airlines have incentives to cooperate with other airlines within a strategic alliance due to new expected revenue potentials founded by greater airline networks, coordinated flight schedules and access to protected markets. Moreover, there are cost-cutting potentials justified by a higher load factor. Another motivation for building strategic alliances could be the generation of market entry barriers. Oum and Park [19] list further incentives for airlines to join strategic alliances. Capacity control procedures are employed to allocate seat capacity. For individual airlines not part of an alliance capacity control has attracted a lot of attention. In a seminal publication Littlewood [16] presented a model for two fare classes to solve a single-leg problem with the assumption that requests for tickets of different booking classes arrive in non-overlapping intervals in the order of increasing prices of the classes. Belobaba [3] generalized Littlewood's approach to a heuristic policy considering multiple fare classes. For a detailed overview of literature considering airline revenue management problems see McGill and van Ryzin [17]. There are multiple publications concerning the capacity control for a single airline not part of an alliance which in fact is already a highly complex problem. Talluri and van Ryzin [25] outline in detail current publications covering

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capacity control methods for a single airline. New decision problems concerning the capacity allocation occur if airlines build strategic alliances. In case of alliances, the capacity control not only has to sort out how many seats should be allocated to the different fare classes but also how the seats will be divided among the alliance partners. A range of possible concepts is imaginable from a free sale to apportioning blocks of capacity among the partners of the alliance. In a free sale the alliance partner airlines are allowed to access the seats for example in a first-come-first-served order. Boyd [6] specified the two common decision control mechanisms used in practice: In a blocked seat allotment procedure each airline will individually control the seats they have been assigned while in a free sale setting, the airline operating the considered flight provides access to the seats in the aircraft by providing information about seat availability to the non-operating alliance partners. However, the allotments assigned to the airlines in a blocked seat allotment procedure should be updated during the booking process depending on the demand observed so far to overcome the drawback of static allocations. In this paper a new option-based decision control for two partners within an alliance will be introduced. The goal of the option-based mechanism is to maximize the combined revenue of the alliance partners. According to Boyd [6], centralized decisions on the basis of combining the flight networks of the alliance partners and treating them as a single network cannot be made in alliances in the airline industry. The existence of airline specific highly complex revenue management IT-systems and the need for processing a large amount of data in real-time makes a centralized control system nearly impossible. Another aspect militates for a decentralized coordination: The airlines (if they do not merge) are autonomous and their revenue management concepts are developed for their special needs which improves the airlines competitive situation. Not only do the technical objections lead to a decentralized treatment but also antitrust arguments forbid centralized solutions. Due to these three aspects, only decentralized solution suggestions are of practical relevance. There are few publications regarding alliance revenue management. Brueckner and Whalen [8] conducted an empirical study analyzing the effects of strategic alliances on carriers' prices. In a follow-up study Brueckner [7] confirms that there are price advantages for passengers on international interline itineraries due to code sharing agreements. Vinod [27] describes coordination mechanisms for strategic alliances in the airline industry being considered by the carriers in practice. After the booking period, when all decisions concerning the acceptance or rejection of a request are made, the problem how the revenue will be fairly shared among the airlines in the alliance arises. This downstream problem is not an issue in this paper. Wright et al. [29] discuss price and revenue sharing mechanisms to master revenue management decisions across alliances. To the best of our knowledge, there is no literature that describes option-based capacity control models or methods for strategic alliances. The main contribution of our work to revenue management literature is an option-based capacity control procedure to divide the capacity among partners of a strategic alliance. This paper is organized as follows. In Section 2 we present an option-based capacity control procedure and illustrate how the booking limits are determined. The simulation of the booking processes of the alliance partners considering control with real options will also be described in Section 2. Section 3 contains the computational study, outlining the adopted test-bed and comparing the results of the introduced option-based control with the results of a first-come-first-served approach and the ex post optimal solutions. A simulation-based optimization procedure will be introduced in Section 3 and the results of this improvement technique will be compared to the performance of the option-based procedure as well as the FCFS and ex post optimal solutions. Section 4 concludes the paper and proposes further research activities.

2. Capacity control with real options

In the following real options to divide the capacity in the aircraft between the members of the alliance are considered. Amram and Kulatilaka [1] define an option as the right, but not the obligation, to take an action in the future. A classification of options as well as a survey of literature, describing other industries utilizing real options, is introduced in their monograph. There are also references on options especially in the context of revenue management. Anderson et al. [2] for example present a real option approach to revenue management that is dedicated to the car rental business. In his thesis Hellermann [12] discusses option contracts to develop a capacity-option pricing model for air cargo revenue management. The underlying idea of real options used in our procedures can be described as follows: An airline can buy an option by paying the option price up front to possess the right of buying the underlying asset at a fixed price in the future. To exercise the option and actually buy the asset, the airline has to pay a defined strike price. The following assumptions can be made in order to calculate the booking limits, which partition the capacity and allocate the capacity to each fare class, as our control variables in the capacity control. An alliance with two airlines is considered. One of the airlines, the operating carrier (OC), provides seats in an aircraft that is operated on a single flight leg. The other airline, the ticketing carrier (TC), can access the seats of the operating carrier by buying call options for the seats. We have chosen the term ticketing carrier based on the remarks of Brueckner [7]. Other papers refer to the ticketing carrier as marketing carrier (see [22]). We assume that the ticketing carrier does not operate a flight that is a direct substitute to the one operated by the operating carrier. In practice it is not uncommon for both airlines to act as operating and ticketing carriers, depending on which flight leg is being considered. That means if an airline is the operating carrier on a specific flight leg, the airline may serve as ticketing carrier on other flight legs.

Fig. 1 shows the interaction between the operating carrier and the ticketing carrier before and during the booking process. Before the booking process starts for a particular flight operated by the operating carrier, the operating carrier decides how many options to sell to the ticketing carrier. After the operating carrier announces the number of options that is available for sale, the option price and the strike price to the ticketing carrier, the ticketing carrier determines how many options to buy from the operating carrier. The number of options ranges from zero to the number of options the operating carrier offers to the ticketing carrier. The ticketing carrier pays the option price per seat to the operating carrier to reserve the seats by using options. During the booking process, the ticketing carrier can exercise an option by paying the strike price to the operating carrier. Consequently the ticketing carrier can sell a ticket for a seat in the aircraft of the operating carrier. If the demand for tickets within one of the ticketing carrier's classes is less than assumed, some of the options the ticketing carrier purchased from the operating carrier remain unexercised. To provide a form of re-optimization, the operating carrier has the right to buy back options from the ticketing carrier. By paying back the option price to the ticketing carrier, the operating carrier can access the seats reserved for the ticketing carrier during the booking process. Trigeorgis [26] describes such a buy-back opportunity as an option on options, which is applied for example in different resource allocation problems. An option on options is called compound option in the field of real option and financial option theory (compare [26,10]). In an optimal alliance solution however the operating carrier only accesses seats reserved for the ticketing carrier if the revenue that the operating carrier gains for accepting a seat request is greater than or equal to the strike price plus the option price. Without the buy-back option for the operating carrier, the introduced method would be similar to a blocked seat