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Dynamic capacity allocation for airlines with multi-channel distribution

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A R T I C L E I N F O

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A B S T R A C T

Due to fierce competition in markets, recently, many airlines have faced the challenge of reducing channel distribution costs. However, channel distribution decisions are often made separately from inventory allocation decisions in practice. Thus, in this study, we propose a dynamic programming model to derive the optimal policy and investigate customer-shift behaviours in a problem setting with the above two issues combined. The numerical experiment results illustrate that introducing the channel distribution into the airline revenue system significantly improves the revenues and efficiently reduces the channel distribution costs. The improvement comes mainly from a better match between channels and fare classes and a subsequent risk reduction of revenue losses.

1. Introduction

This paper addresses the capacity allocation problem in different distribution channels with the airline industry as the background. In existing systems and models (see Fig. 1), airlines use their revenue management system to select the capacity and price in different fare classes, and then the decisions of capacity and price are provided through indirect channels (Global Distribution Systems (GDSs) and travel agents) and direct channels (Airline websites). After that, customers can purchase tickets from travel agents or airline websites. In such a system, airlines use their revenue management system to optimize the inventory without considering the effects of distribution channels. Demand from different channels is always fulfilled, if possible, with the first come, first serve rule. At the same time, the travel agencies, without informing the airline company, always execute their capacity strategy with the aim of increasing their own profits. Some travel agencies even increase the product's price or decrease some fare capacities. This decentralized marketing strategy associated with travel agencies can sometimes damage the airline's revenue management system, and as a consequence, it even reduces the airline's revenues and increases the costs.

One survey of the distribution channel issues with airline executives demonstrates that apart from the costs of indirect channels including GDS's fees and the commission fees of travel agencies, airline executives are also frustrated by the inadequate policy transparency of travel agencies that may often conflict with the aim of the revenue management policies of the airlines (Harteveld, 2012). Thus, some airlines cut off all channels for lowering the costs and avoiding the conflict. For instance, some low-cost carriers (LCCs) only sell on their own websites. However, one immediate disadvantage is the loss of customers due to lack of indirect channels. Thus, some LCCs have tried to return to the traditional airline sales system. The example of LCCs implies that eliminating all indirect channels is not the best strategy to confront the market environment. It is significant for the airlines to establish an efficient capacity allocation model that integrates the revenue management system and the channel distribution system so that the decisions and optimization have a wider reach in order to cover interrelated issues in revenue management and channel distribution simultaneously. With the support of such a system, the airlines can allocate cabin capacity in different fare classes and different channels based on selling seasons and demand.

In this paper, we propose a dynamic model to describe the decision behaviours when revenue management and channel distribution management are integrated from the airlines' perspective. To enhance revenue management, we introduce factors to describe the channel distribution characteristics into a dynamic programming model. The model proposes a two-decision mechanism in the presence of the demand for one seat. One decision chooses the fare class, and the other selects the channel. With this fundamental mechanism in the model, we use the bid-price optimal policy to ensure that the airline maximizes their revenues. The new model can make airlines allocate the capacity efficiently among both different fare classes and different channels based on the demand and sales period.

In the paper, we further extend the study to consider the customer shift behaviours after being rejected by high-cost channels. The goal is to show how the customer shift behaviours influence our two-decision

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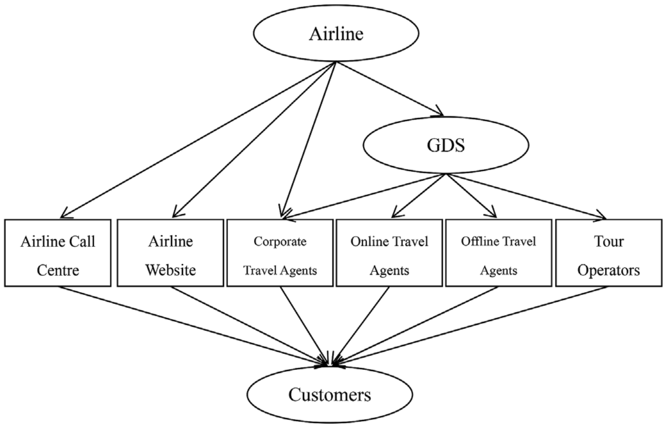

Fig. 1. Channel distribution system.

mechanism. Those models and mechanisms well reflect the airlines' decision behaviour and customer behaviour with the consideration of the channel distribution effect. Therefore, the results of this study can enhance the decision-making process of the airlines for the capacity allocation problem.

Accordingly, the current study makes three contributions in the literature. First, we propose a dynamic capacity control model that integrates the revenue management and channel distribution decisions. The modelling framework can be further used for other relevant issues in the airlines. Second, we develop the optimal policy for the airlines on the basis of this model. The results can be implemented in practice. Third, we realize that the customer shift behaviour can influence the results of the model and subsequently the decisions of airlines. The numerical experiments demonstrate that airline revenues will increase more than 3% in a simple integrated system with two channels compared to the independent model. Further improvement is possible in more complicated situations. This study also analyses the reasons for improvements in different situations (such as multi-channels have better improvements than a single-channel and the model has a better match of channels and fare classes) so that management insights are obtained for airlines.

The rest of the paper is structured as follows. Section 2 reviews the revenue management literature and the airline channel distribution literature. Section 3 defines the problem mentioned above and proposes the mathematical formulation. Section 4 derives the optimal policy for fare and channel capacity allocation. Section 5 extends the model with the consideration of customer shift behaviours. Section 6 shows numerical examples and analysis. Finally, Section 7 concludes the results of study.

2. Literature review

This study concerns two streams of literature regarding capacity control in airlines and multiple-channel distribution management. Thus, we first review the literature that demonstrates several aspects of capacity control in airlines. Then, we review the literature about channel distribution management.

The first stream of literature is related to capacity control. As mentioned before, capacity control as a traditional and significant aspect of revenue management has been reported in many studies. The earliest research on capacity control was Littlewood (1972), which proposed a static model for two fare classes on a single flight leg. Based on this early work, Belobaba (1987a, 1987b; 1989) extended the two-fare-class model to the multiple-fare-class model and developed an effective heuristics solution (EMSR, expected marginal seat revenue) to solve this single-leg problem. EMSR was then widely used in airline industries. After that, some assumptions in static single-leg models were relaxed by Brumelle and McGill (1993), Curry (1990), Robinson (1995), and Wollmer (1992). The optimal policy can be executed in a nested allocation rather than non-overlapping periods. Lee and Hersh (1993) developed a dynamic single-leg model that allows for the customers to arrive in an arbitrary order. Apart from the abovementioned literature, there are some other academic papers related to dynamic single-leg capacity control, such as Young and van Slyke (1994), Brumelle and Walczak (1997), Lautenbacher and Stidham (1999), Liang (1999), Subramanian et al. (1999), Zhao (1999) and Talluri and van Ryzin (2004). Among these works, some consider the influence of different demands, some analyse group bookings under the dynamic single-leg model, some develop the dynamic model with overbooking, cancellation and no-shows, and some introduce customer behaviours and propose single-leg choice models. A review of these single-leg models can be found in Talluri and van Ryzin (2006, Chapter 3). Apart from the airline industry, some non-service industries have widely discussed the capacity control problem. Barut and Sridharan (2004) proposed a dynamic capacity allocation procedure model (DCAP) in the make-to-order (MTO) manufacturing environment. The DCAP model dynamically allocates short-term constrained capacity to multiple product classes in multiple periods. Barut and Sridharan (2005) further extended the former DCAP model by relaxing two assumptions. We need to note that there are some similarities and differences between the DCAP model and our model. Obviously, the application of the DCAP model has a focus on the manufacturing industries (especially for make-to-order manufacturing processes). In this case, the demand for each fare class is not necessarily unit-sized. Thus, when a large-sized order for a high value class is rejected, a small-sized order for a low value class can be accepted, given that there is available capacity. Conversely, in our model, a maximum of one customer comes in each time period. When the system rejects a customer in a high value class, the revenue will be directly lost. Furthermore, our model considered the multi-channel effect on capacity control in the airline industry, whereas the channel effect is not included in the DCAP models.

The second stream of literature is the multi-channel distribution, which has been mentioned widely in traditional manufacturing products' marketing literature since the rapid development of e-commerce. An overview of the literature can be found in Simchi-Levi et al. (2004). In airlines, multi-channel distribution has been implemented for many years, but only a few studies have focused on the effect of multi-channel distribution on airlines' revenues. Jarach (2002) showed that internet-based ticketing in airlines would bring some changes for airline companies through the analysis of the impact on the e-commerce-oriented airline. Shon et al. (2003) proposed that online channels would dominate the ticket market compared to traditional channels. Alamdari and Mason (2006) demonstrated that changes were taking place in airline distribution and predicated that the direct channels would substantially increase in airlines. Through an empirical survey of customers, Yoon et al. (2006) discovered that the airlines' e-commerce activity might have important effects on their ticket distribution channels. Castillo-Manzano and López-Valpuesta (2010) analysed the customer choice behaviours in purchasing air tickets from the traditional channel and online channel. In our paper, we will also discuss the impacts of airlines' operations management on the air ticket distribution channels. Ruiz-Mafé et al. (2009) and Bigné et al. (2010) studied the motivations and barriers for customers to purchase tickets on websites. Apart from the airline industry, some studies have also investigated same channel distribution issues in similar industries, such as hotels and high-speed rails. Choi and Kimes (2002) conducted some simulations to test the effects of electronic distributions on hotel revenue management. Cheng and Huang (2014) adopted an empirical survey for Taiwan's high-speed rail industry to identify the ticketing channel preference for customers. Fountoulaki et al. (2015) reported the new channel distribution for travel and tourism using on the case of Crete.

In summary, there is substantial research work assessing the issue of capacity control in airline revenue management. Most of these studies assume that the customer is directly facing the airlines. In these models,