Marginal revenue transformation in airline seat inventory control with two fare families and two markets - DTU Orbit (09/11/2019)

This paper considers the single-leg airline seat inventory control problem with fare classes divided into two fare families and demand for the fare classes segmented into two markets. The main contribution of this paper is that the seat inventory control problem is solved using the marginal revenue (MR) transformation of Fiig et al. (T. Fiig, K. Isler, C. Hopperstad, and P. Belobaba. Optimization of Mixed Fare Structures. Submitted to Journal of Revenue and Pricing Management, 2009), which enables the implementation of the more complex policy in traditional class-based revenue management systems. The reason for considering a two-market and two-family seat inventory control problem is the objective of airlines such as SAS and Air Canada to serve both the business and leisure market while at the same time controlling sell-up behavior in the undifferentiated fare. A fare family is defined by a set of fare classes that are fully undifferentiated except for their price levels and customers will therefore always buy the lowest fare available within a family. We assume that the families are separated in terms of restrictions on service and flexibility and that there exists buy-up from the lowest to the highest fare class. We also assume that the markets are perfectly separable. Suppose that family 1 consists of the highest fare classes. Then the control problem is to decide which fare class from family 1 and 2 to offer at each point in time in each market. We can also decide not to offer any fare class from family 2. The set of classes that the airline chooses to open is called a policy. Let S denote a set of two fare classes \((i,j)\), where \(i\) is a fare class from family 1 and \(j\) is a fare class from family 2. We allow the fare class from family 2 to be the empty element, which corresponds to not offering any lower classes for sale. Furthermore, let \(Q(S)\) denote the total probability of purchase of set \(S\) and \(R(S)\) the total expected revenue from offering set \(S\). The application of the MR transformation to the scenario with two fare families and two markets can be described in three overall principles. 1) MR transformation from fare families to fare classes The first principle is that given a specific market the adjusted fare defined by the MR transformation is calculated for the subsets of fare classes on the efficient frontier of the set of points \((Q(S),R(S))\), for all \(S\). In the case of two fare families the sets on the efficient frontier does not necessarily represent nested policies. 2) Nesting of fare family policies The second principle is that given a specific market the subsets on the efficient frontier are forced to be nested. The primary purpose of this principle is that it enables the continued use of the existing control mechanism in class-based RM systems. The result of enforcing the nesting property is that the adjusted fare for an individual fare class is found as the marginal revenue when the class is initially offered, i.e. nesting ensures that there is a unique marginal revenue value that can be assigned to the fare classes. The result of the elimination of non-nested sets is that potentially optimal sets are discarded but on the other hand it allows a very elegant way of implementation in existing class-based RM systems. The result of the first two principles is a set of independent fare classes in a given market. 3) MR transformation in perfectly separable markets The third principle is that the MR transformation is carried out for each market separately and because of our assumption of perfectly separable markets this results in independent fare classes across both fare families and markets. Based on the three principles above we can then optimize the control problem with adjusted fare classes using dynamic programming models that assume independent demand for each fare class. We present numerical results to illustrate the model and the performance of the dynamic programming algorithm. The results demonstrate that the computational complexity of the dynamic programming models is tolerable, which is a result of the undifferentiated fare structures for which only a single decision variable exists for each fare family.

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