Passenger Airline Revenue Management: Research Overview and Emerging Literature
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ABSTRACT
In light of advances in information technology, online ticket booking and payment systems, global deregulations in aviation sector, economic downturns and terrorist attacks, the airline revenue management practices enriched the literature during the last decade. This covers literature post McGill and Van Ryzin (Transportation Science, 1999) review paper. This review is for Seat Allocation. Studying about 10 papers, the review explores current developments in airline ticket booking system and makes it up-to-date.

Keywords-- revenue management, seat allocation.

I. INTRODUCTION
The main objective of airline ticket booking system is to accept or reject a discounted fare booking request. This was first proposed by Littlewood in 1972 and eventually caused the beginning of yield management. He introduced the revenue load factor which is nothing but the revenue for a flight as a percentage of the maximum possible revenue for that flight. This idea was different than previously monitored parameter of passenger load factor. (Littlewood, 1972) Littlewood modelled it in two class partitions of low yield and high yield passengers. He proposed that if the mean revenue from a high yield passenger is R and that from a low yield passenger is r, then for a aircraft with capacity C, the maximum allowed low yield booking is A (Protection level), the probability P that the demand for high-yield seats exceeds C–A, (i.e. P is the maximum risk that the acceptance of a low yield passenger will result in the subsequent rejection of a high-yield passenger) is given by

\[(1–P) ≤ r/R\] (1) (Littlewood, 1972)

This resembled the newsvendor type inventory model. This was analogous as both newspapers and airline seats are perishable inventories.

The problem of airline revenue optimization is complex with added constraints of revenue forecasting and demand distribution and booking arrival patterns. The first significant attempt towards optimization came from Peter Belobaba with his pioneering idea of “EMSR i.e. Expected marginal seat revenue” and he proposed two versions of heuristics known as EMSR-a and EMSR-b. The first version deals with aggregating protection levels whereas the second version deals with aggregating demands. The first one has limitation pooling effect whereas the second version overcomes this limitation. (Belobaba, 1989), (Belobaba, 1987) The exact optimality conditions were subsequently given by Brumelle and McGill (Brumelle & McGill, 1993) thus the single leg static revenue optimization problem with monotonic revenue was solved. (K. T. Talluri & Van Ryzin, 2004)

II. LITERATURE REVIEW
The literature in revenue management can broadly be classified across two time spans, pre 1999 and post 1999 for review purposes. This partition is based upon the advances in information technology and deregulations in aviation sector throughout the world that changed the complexion of airline ticket revenue management. This paper will focus on the literature post 1999 as the pre 1999 literature is well documented for review purposes by McGill et al (McGill & Van Ryzin, 1999) and will review to explore future directions in the field of revenue management.

III. SEAT ALLOCATION
The seat inventory control remained the most researched area in airline revenue management in pre-as well as post 1999 duration. The maximum research that happened in pre-1999 was with single leg seat inventory control due to its relative simplicity. The post 1999 period witnessed multi-leg seat inventory control which developed the network revenue management for airlines. This part was relatively complex hence extension of every work of single leg was not possible in multi leg. Though network revenue management literature was studied by (Ryzin & McGill, 1999) under seat allocation, its continuous development in all the four single leg areas (forecasting, pricing, seat allocation and overbooking) allowed the network revenue management to emerge as a separate area encompassing all other
IV. EMSR HEURISTICS IMPROVEMENTS

Following Belobaba’s work there were attempts to better the yield. As like pre-1999, post 1999 era also saw relaxation of conditions and generalizations of marginal seat revenue models. Table IV gives the summery of the papers post 1999 which proposed the betterment in EMSR heuristics under various conditions. The conventional EMSR-b was bypassed by (Ryzin & McGill, 2000) when they used adaptive algorithm for determining the seat protection level. While requiring only the historical observations of relative frequencies of seat filling, the algorithm determines the protection levels. Neither forecasting nor optimization is needed thus this can be less expensive alternate for a full-fledged revenue optimization system where mere simulation can generate the computational results.

(WER stands for Expected Revenue Gain) Wheatherford gave three models to better EMSR under different conditions. First, he compared EMSR heuristic with a new one called Leg Bid Price (LBP) and concluded that revenue improvements are feasible with LBP over EMSR of 2 % if load factor is 93-95 % and revenue improvement of 10-15 % if load factor is 95100% on legs. (L. Weatherford, 2002) Further, Weatherford (L. Weatherford, 2004) came up with a new heuristic decision rule, called dispersed fare rule (DFR). According to which the new decision rule can take advantage of the variability of actual fare values around the mean fare values to generate a significant revenue improvement over EMSR (2-6 per cent). This challenged the assumption of no fare dispersion within a class rather than to more realistic assumptions (wide dispersion of fares within classes). Finally, Wheatherford took into consideration the risk aspect and modified EMSR for risk consideration to call the modified EMSR as EMSU (expected marginal seat utility). A comparison is made between the differences in booking limits that are generated by the different risk preferences. Simulation was used to show the differences in expected revenues and expected utilities are between 1.6–4 per cent. (L. R. Weatherford, 2004) Huang et al went on to work on these lines and modified seat control policy for the single-leg dynamic RM problem, to take risk into consideration by discounting the marginal seat revenue and in order to reach a balance between average revenue and revenue variation for risk averse airlines, the authors introduced a compromise factor to relax the optimality condition in the classic DP model. (Kuancheng & Ko-Chen, 2011). The impact of dynamic capacity management was studied by de Boer (de Boer, 2004) where he proposed the derivative EMSR-d instead of EMSR-b to calculate the booking limits while taking into account the future capacity change. This approach can assure a revenue gain of 1 % over the conventional EMSR-b. Deng et al went on to suggest a marginal revenue-based capacity management (MRBCM) model. This new heuristic uses opportunity cost estimation that allocates available capacity to higher revenue generating customer segment when capacity is the constraint. (Deng, Wang, Leong, & Sun, 2008) Gallego et al presented new generalized EMSR formulations for the single-leg, nested, multiple fare, and multinominal logit demand model. This was an improvement over the popular EMSR-b model. (Gallego, Li, & Ratliff, 2009) Walczak et al proposed optimization with customer choice models with concept of marginal expected revenue data transformation (CEDT). This approach can be equivalently computed using the EMSR-b heuristic but with transformed problem data. The results show that CEDT/EMSR-b performs quite well compared to other methods. (Walczak, Mardon, & Kallesen, 2010)

V. CONCLUSION

The Theory and practice of passenger airline booking has moved from perishable inventory management to competitive dynamic pricing. Deregulations, presence of LCCs and third party online booking companies made the aviation sector both interesting and challenging. This paper covered all the developments of past 12 years in airline booking literature. This decade witnessed the emergence of network revenue management as a separate area in literature. Despite its complexity, there were successful attempts to model optimization. Finally the review explores current developments in airline ticket booking system and makes it up-to-date and suggests future directions of research in passenger airline ticket booking RM.

Research Gaps

Though there discussions regarding the performance analysis in many of the above papers, there is no comprehensive performance analysis tool to monitor the efficiency of a booking system and also there is no metric to compare booking system of one airline against its competitor. It is also worth exploring to compare actual data rather that simulated data to measure the performance of a RM system.

Research problem from above mentioned gaps

How to develop a performance monitoring tool to compare the efficiencies of various booking heuristics in passenger airline revenue management? Also how to extend this tool to measure airline’s booking system performance with actual data and compare it with the simulation results.
REFERENCES


