Revenue Management Model Based on Customer Behavior in The Aviation Industry

by Universitas Internasional Semen Indonesia

Submission date: 06-Jun-2022 06:13PM (UTC-0700)
Submission ID: 1851916270
File name: full_paper_oki_ICETSAS_2018.pdf (368.89K)
Word count: 3515
Character count: 18529

Revenue Management Model Based on Customer Behavior in The Aviation Industry

Oki Anita Candra Dewi[1, a)] and Muhammad Faisal Ibrahim [1, b)]

[1]Logistics Engineering Department, Universitas Internasional Semen Indonesia
Veteran Street, Gresik, Indonesia

Corresponding author: a)oki.dewi@uisi.ac.id
b)muhammad.ibrahim@uisi.ac.id

Abstract. Aviation industry often faced uncertainty demand and high level of cancellation. Revenue management in the airline is related to demand management policies to classify and estimate the various requests of pricing and capacity control. This study will develop airline revenue management model integrates luggage passengers with air cargo based on the control of air cargo space. The airline must pay attention to customer behavior due to high cancellation and no-show. In this case we deal with the aspect of the overbooking in which one of the ways to reduce the cost of spoilage due to cancellation or no show. Moreover, in this proposed model, we discuss the expected revenue function to maximize the expected revenue from the policies of accept or reject the booking requests between passengers and air cargo by the same airline. This study aims to develop expected revenue in the dynamic programming model in order to maximize the revenue expectations of the policy of accepting and rejecting booking request between passengers with air cargo in the same airline.

INTRODUCTION

Revenue Management (RM) usually refer to the airline industry which commonly offer different prices to maximize revenues. Airline has the characteristics of perishable products, namely products which do not have residual value if it passes a certain period which mean airlines will lost the opportunity of revenue if the tickets were not sold until the flight depart. RM is used to anticipate demand uncertainty problems in the future due to excess inventory may not be stored and used in the next period, while a seats and cargo space capacity offered always fixed and the fixed costs is high but marginal costs is low and often an important concern since its application. According to Luo Li and Ji- Hua [1] explains an airlines who implementing revenue management increase their revenue from 2% to 8%. RM in the airline has two types: (i) air passenger RM and (ii) air cargo RM. Passenger RM discusses the problem of seat capacity control which about the decision to accept or deny a booking request for a particular fare during the booking period, Dewi [2]. The earliest work of air passenger RM can be traced to Beckmann [3], Thompson [4] and Coughlan [5] which develops overbooking capacity allocation in the single flight with a different fare classes and uses static random variables. Lee and Hersh [6] generalized single seat booking to batch booking and the request probability based on poisson distribution arrival process to represent the demand pattern. According to Karaesman dan Van Ryzin [7] describe a model for a single flight with some fare classes and developing capacity allocation models by calculating the limit of booking request to estimates the expected revenue from demand.

Previous research which addresses the existence condition of overbooking can be found in Beckmann [8], Thompson [9] and Coughlan [10] which develops capacity allocation and overbooking for the single flight with static random variable of booking request. Subramanian et al. [11] take into account of overbooking, cancellation, no-show customer and considered the penalty due to overbooking. Overbooking is a policy to sell tickets exceeding the seat capacity. This policy has a risk and could potentially harm for the airline when the number of passengers show-up upon departure is exceeds of seat capacity because the airline must provide certain compensation of overbooking penalty.

In the air passenger RM literature, some papers discussing dynamic seat allocation models for a single flight. Lee and Hersh [12] and Subramanian, et al [13] discussing discrete-time booking period. Feng and Xiao [14] discussing continuous-time booking model. Luo Li and Ji-hua [1] developed a model under competition using continuous time.

The other source of significant airline operations for revenue are air cargo. Heinitz [15] and Huang and Lu [16] explains an air freight services or air cargo are important to supply chain of global trade. Based on Yamaguchi [17] inform about the largest two economies in the world, U.S. and Japan, more than 30% of internationally traded merchandise using air transportation. According to Boeing [18] describes the air cargo industry grew 5.9% annually over the next two decades. The characteristics of air cargo RM is different from passenger RM in many areas. Huang and Lu [19] explain the fundamental difference is the nature of the product. For the passenger RM, seat are the product in terms of the demand related by the customer and seat capacity.

However, air cargo product are control over the sales of their limited cargo space. Cargo consume multi dimensional capacity, i.e. weight and volume are two such dimensions (Amaruchkul, [20]). They formulate weight and volume of shipments are stochastic and developed several heuristics and bounds by decomposing the problem into one-dimensional sub-problem for weight and volume. The similar single-leg problem is proposed by Huang and Chang [21] that developed a heuristic to estimates the expected revenue from both weight and volume by sampling a limited number of point in the state space. Han et al. [22] developed a bid-price control policy based on a mixed integer programming (IP) model. Hoffmann [23] recently developed an efficient heuristic that exploits the structure of monotone switching curves to reduce the computational load. Zhuang et al. [24] proposed a general model and two heuristics that consistently outperform heuristics ignoring consumption uncertainty.

Air cargo RM is specifically discussed by several researchers. Becker and Dill [25], Amaruchkul et al. [26], Becker and Kasilingam [27], Becker and Wald [28], and Kasilingam [29], Bilings et al. [30], Slager and Kapteijns [31], Kasilingam [32], Levin et al [33] provided the background to air cargo RM and the complexities of the product which cargo space is so much more complicated. Luo, et al [34] creates two dimensional model (weight and volume) for overbooking issue with the aim of minimizing cost of spoilage and offloading. Haidar dan Cakanyildirim [35] continues the research of Luo et al. [36] with the aim of maximizing profit.

However, previous paper discuss dynamic programming on airline revenue management but none of models integrates passenger with air cargo that takes into account on two dimensions, namely cargo weight and volume based on the control of air cargo space. In this model, we present a markov decision process of the free sale passenger and air-cargo booking process for a single flight with the fare classes of both passenger and air-cargo. We specifically discuss the expected revenue function to maximize the expected revenue from the policies of accept or reject the booking requests between passengers and air cargo by the same airline. This study aims to develop expected revenue in the dynamic programming model in order to maximize the revenue expectations of the policy of accepting and rejecting booking request between passengers with air cargo in the same airline. Moreover, in this proposed model, we also deal with the aspect of the overbooking problems on the air passenger RM.

The remainder of this paper is organized as follows. Section 2 provides the model description to propose the model. Section 3 explore the dynamic programming model to illustrate the integration of passenger and air-cargo RM problem. Finally, summarizes and conclusions are drawn in section 4.

MODEL DESCRIPTION

In this study, we discuss seat and cargo allocation policy model for revenue management problem on single flights in the same airline. This study focuses in the dynamic single-leg revenue management problem on integration of passenger and air cargo with overbooking consideration. The feature of overbooking, cancellation and no-show is incorporated in the problem formulation for only passenger problem. The goal of this problem maximize total revenue from both passenger and air cargo. We develop a dynamic programming model on the same airline to optimize seat allocation of passenger considering overbooking as practiced by Subramanian et al. [37] and integration of air cargo revenue management considering two-dimension of weight and volume as practiced by Huang and Chang [38].

MODEL FORMULATION

In this section, we introduce in dynamic programming model for integration of passenger and air cargo on the same airline to compute the maximum expected revenue and determine the optimal policy. There are seat capacity is denoted by C. Generally $r_1 > r_2 > r_3 > \cdots > r_m$ dan $R_1 > R_2 > R_3 > \cdots > R_m$. The highest price class called high fare while the lower price is low fare. Each air passenger and air cargo contained m fare class and expressed by i where $i = 1,2,..,m$. r_i denoted as rate of type i on passenger and R_i is rate of class i on cargo. There are N decision periods or stages, number in reverse chronological order, *n=N, N-1,…,1, 0,* with stage *N* corresponding to the opening of the flight for reservation either air passenger or air cargo and stage *0* corresponding to its departure.

In this model, cancellation and no-shows occur at class independent rates, which allow us to use a one dimensional state variable. This research develop overbooking only on air passenger cases with corresponding penalties determined by an overbooking penalty function. At each stage, we assume that only one of the following events occurs: (1) an arrival customer of air passenger. The probability of each type is 0.5 and they request for a seat in fare class r_i; (2) an arrival customer of air cargo and they request for cargo with weight and volume in fare class R_i; (3) a cancellation by a customer of air passenger that currently holding a reservation. Booking requests in each fare class for event (1) and (2) according to time-dependent process. Based on the number of seat and capacity cargo already booked, we must decide whether to accept or reject each request. In addition, passenger who have already booked may cancel at any time on the *n* period. At this time, the passenger is refund an amount for class dependent. The passengers can also be no-shows at the time of departure and the passengers are not refunded anything.

Let P_{in} denote the probability of a request for a seat (air passenger) in fare class i in period n. And K_{in} denote the probability of a request for air cargo in the fare class i in period n. The probability of a cancellation is denoted by $q_n(x)$ that *x* is the number of reserved seat on air passenger. So, we have the total probability of each stage from the all event that can occur ex. request seat, request cargo or cancellation is:

$$\sum_{i=1}^{m}(P_{in} + K_{in}) + q_n(x) + P_{0n} + K_{0n} = 1 \qquad (1)$$

For all *x* and *n ≥1*

Where P_{0n} and K_{0n} represent the probability of no booking request. This model considering of overbooking as denoted by B, that means the additional number of seat offered on the passenger to response to their cancellation and no-shows. So the additional constraint, $x \leq C + B$.

As a function of the state x in period n, $U_n(x)$ denote the maximal expected revenue of operating the air passenger system over period *n to 0*. While losses due to no-show passenger was denoted by $H_n(x)$, is the total loss of revenue over period n to 0 because of cancellation and no-show.

$$U_n(x) = P_{0n}U_{n-1}(x) + \sum_{i=1}^{m} P_{in}\, max\{r_i + U_{n-1}(x+1) - [H_{n-1}(x+1) - H_{n-1}(x)], U_{n-1}(x)\} \qquad (2)$$

$$H_n(x) = \sum_{i=1}^{m} P_{in}H_{n-1}(x) + q_n(x)\big(Q + H_{n-1}(x-1)\big) \qquad (3)$$

Let denote $Y(x)$as the passenger who show-up when the stage 0. This means $x - Y(x)$) is no-show passenger. We have β denote the probability of no-show passenger and will occur only at the time of departure. However, because this model start with no seat booked at stage *N* and at most one customer arrive and accepted at most one request at each stage it follow at stage *n, x ≤ N – n*. It means that the number of reserved seat is less than the stage take place. Because each passenger have a probability of $(1 - \beta)$ to show-up when the time of departure, then $Y(x)$ can be expressed by binomial distribution $(x, 1 - \beta)$. If $Y(x) = C + B$ it would appear overbooking penalty and denote by π_i. Let E is the total expected revenue of the passenger, so we have

$$U_0(x) = E - \pi_i(Y(x) - C) \qquad (4)$$

At the stage $n = 0$, the possibility of other loss of revenue that may occur is the penalty of no-show passenger and denoted by d.

$$H_0(x) = (\beta.x.d) \qquad (5)$$

According to Huang and Chang [38], they formulate a multi-dimensional dynamic model for the cargo space control problem which weight and volume of various types of shipments are stochastics and calculated concurrently. The weight and volume of shipment type follows a distribution, which can be represented by a random variable. Let $z_n(v, w)$, be a maximum expected revenue based on the accumulated average volume v and the accumulated average weight w at period n and determine the optimal policy as equation bellow

$$z_n(v,w) = \sum_{i=1}^{m} K_{in} \max\{R_i + z_{n-1}(v + \overline{v_i}, w + \overline{w_i}), z_{n-1}(v,w)\} + K_{0n} z_n(v,w) \tag{6}$$

Let $\overline{v_i}$ as the average volume of type i and v as the accumulated average volume of the accepted bookings. The average weight of types i is denoted by $w_i$and w as the accumulated average weight of the accepted bookings. This equation will stop when $(v + \overline{v_i}) \geq v_k \; or \; (w + \overline{w_i}) \geq w_k$ that means if the accumulated volume of the accepted booking plus the occurring customer with volume of type i is more than the capacity of volume in the airline v_k then this customer will rejected as well as the weight constraint.

Focusses in this paper is develop the dynamic single-leg revenue management problem on integration of air cargo and passenger with overbooking consideration. The feature of overbooking, cancellation and no-show is incorporated in the problem formulation for only passenger problem, so the equation of both categories is:

$$V_n(x,v,w) = V_{n-1}(x,v,w) + U_n(x) + z_n(v,w) \tag{7}$$

$$\begin{aligned} V_n(x,v,w) = V_{n-1}(x,v,w) & \\ & + \left[P_{0n} U_{n-1}(x) + \sum_{i=1}^{m} P_{in}\, max\{r_i + U_{n-1}(x+1) - [H_{n-1}(x+1) - H_{n-1}(x)], U_{n-1}(x)\} \right] \\ & + \left[\sum_{i=1}^{m} K_{in} \max\{R_i + z_{n-1}(v + \overline{v_i}, w + \overline{w_i}), z_{n-1}(v,w)\} + K_{0n} z_n(v,w) \right] \end{aligned} \tag{8}$$

Where $V_n(x,v,w)$ is the sum of total expected revenue for passenger airline with overbooking, cancellation, and no-shows consideration and the total expected revenue of air cargo airline with two-dimension of volume and weight.

CONCLUSIONS

We have developed a dynamic seat and cargo allocation model for the same airline considering Overbooking, Cancellations, and No-Shows on the passenger. We have developed a dynamic programming to optimize ticket fares of both cargo and passenger simultaneously and dynamically over the selling horizon. We also have conducted several numerical experiments to examine the proposed model behavior in terms of total expected revenue.

In this study, refund for customers who cancel their reservation is different price when they wanted to buy for an airline ticket. The policy of open the fare classes is very take effect when decide to open all fare classes and step by step open from lowest price. Future research may consider numerical experiments and the relevance of refund with the price paid by the customer when he reserved the ticket as well as considering the overbooking of air cargo and extra baggage of the passenger with capacity sharing.

ACKNOWLEDGMENTS

The authors would like to express their thanks to the referees for their valuable suggestions and comments. This work is supported by Directorate of Research and Community Service (DRPM) Directorate General Research and Development of the Ministry of Research, Technology and Higher Education of The Republic of Indonesia (Ristek DIKTI) under Grant Junior Lecturer Research (Penelitian Dosen Pemula/PDP) No. 0045/E3/LL/2018

Institute for Research and Community Services- Universitas Internasional Semen Indonesia (UISI)

REFERENCES

1. Luo Li & Ji-Hua, P. Dynamic Pricing Model for Airline Revenue Management Under Competition. Systems Engineering - Theory & Practice, Vol 27, 11. 2007.

2. Dewi, Oki AC., Nurminarsih, Siti., Narulidea, Winda., Rusdiansyah, Ahmad. Revenue Management Model for Integration of Air Cargo and Passenger with Overbooking Consideration. Proceedings of the International Conference of Logistics and Supply Chain Management System. 2016.
3. Beckmann, Martin J. Decision and Team Problems in Airline Reservations. Econometrica.134–145. 1958.
4. Thompson, H.R. Statistical Problems in Airline Reservation Control. Operations Research Quarterly. 167-185. 1961.
5. Coughlan, J. Airline overbooking in the multi class case. Journal of the Operational Research Society. 50. 1999.
6. Lee, T. C. & Hersh, M. A Model for dynamic airline seat inventory control with multiple seat bookings. transportation science, 27(3) 252-265. 1993.
7. Karaesmen, I., and Van Ryzin, G. Overbooking with suitable inventory classes. Operation Research, 52, 83-104. 2004.
8. Beckmann, Martin J. Decision and Team Problems in Airline Reservations. Econometrica.134–145. 1958.
9. Thompson, H.R. Statistical Problems in Airline Reservation Control. Operations Research Quarterly. 167-185. 1961.
10. Coughlan, J. Airline overbooking in the multi class case. Journal of the Operational Research Society. 50. 1999.
11. Subramanian, J., Stidham, J. R. & Lauthenbacker, C. J. Airline yield management with overbooking, cancellation, and no show. transportation science, vol. 33 no. 2. 1999.
12. Lee, T. C. & Hersh, M. A Model for dynamic airline seat inventory control with multiple seat bookings. transportation science, 27(3) 252-265. 1993.
13. Subramanian, J., Stidham, J. R. & Lauthenbacker, C. J. Airline yield management with overbooking, cancellation, and no show. transportation science, vol. 33 no. 2. 1999.
14. Feng, Y. & Xiao, B. Maximizing revenues of perishable assets with a risk factor. Operations Research, 47(2) 337–341. 1999.
15. Heinitz, F., Hirschberger, M., & Werstat, C. The role of road transport in scheduled air cargo networks. Procedia-Social and Behavioral Sciences. 104,1198-1207. 2013.
16. Huang, Kuancheng & Lu, Heng. A linear programming-based method for the network revenue management problem of air cargo. Transportation Research Procedia 7, 459-473. 2015.
17. Yamaguchi, K., International trade and air cargo: Analysis of US export and air transport policy. Transportation Research Part E 44, 555-575. 2008.
18. Boeing, Boeing 2010-2011 World Air Cargo Forecast.http://www.boeing.com/commercial/cargo/wacf.pdf. Cross, R.G. 1997. Revenue Management: Hard-core Tactics for Market Domination. New York: Broadway Books. 2010.
19. Huang, Kuancheng & Lu, Heng. A linear programming-based method for the network revenue management problem of air cargo. Transportation Research Procedia 7, 459-473. 2015.
20. Amaruchkul, K., Cooper, W.L. and Gupta, D., Single-leg air-cargo revenue management. Transportation Science 41: 457–469. 2007.
21. Huang, K., Chang, K. An approximate algorithm fot the two-dimensional air cargo revenue management problem. Journal of Air Transport Management, 38, 36-42. 2010.
22. Han, D.L., Tang, L.C., Huang, H.C., A Markov model for single-leg air cargo revenue management under a bid-price policy. European Journal of Operational Research 200, 800-811. 2010.
23. Hoffmann, R., Dynamic capacity control in cargo revenue management - A new heuristic for solving the single-leg problem efficiently. Journal of Revenue and Pricing Management 12, 46-59. 2013a.
24. Zhuang, W., Gumus, M., Zhang, D., A single-resource revenue management problem with random resource consumptions. Journal of the Operational Research Society 63, 1213-1227. 2012.
25. Becker, B., Dill, N., Managing the complexity of air cargo revenue management. Journal of Revenue and Pricing Management 6, 175-187. 2007.
26. Amaruchkul, K., Cooper, W.L. and Gupta, D., Single-leg air-cargo revenue management. Transportation Science 41: 457–469. 2007.
27. Becker, B., Kasilingam, R., Success factors for the implementation of air cargo revenue management solutions. International Journal of Revenue Management 2, 254-271. 2008.
28. Becker, B., Wald, A., Challenges and success factors of air cargo revenue management. Journal of Revenue & Pricing Management 9, 171-184. 2010.
29. Kasilingam, R., Revenue management and air cargo, in “Revenue management: A practical pricing perspective”. In: Yeoman, I. And McMahon-Beattie, U. (Ed.). Palgrave Macmillan, Basingstoke. 2011.

30. Bilings, J.S., Diener, A.G., Yuen, B.B., Cargo revenue optimization. Journal of Revenue and Pricing Management 2, 69-79. 2003.
31. Slager, B., Kapteijns, L., Implementation of cargo revenue management at KLM. Journal of Revenue and Pricing Management 3, 80-90. 2004.
32. Kasilingam, R.G., Air cargo revenue management: Characteristics and complexities. European Journal of Operational Research 96, 36-44. 1997.
33. Levin, Y., Nediak, M., Topaloglu, H., Cargo capacity management with allotments and spot market demand. Operations Research 60, 351-365. 2012.
34. Luo, S., Cakanyildirim, M., Kasilingam, R.G., Two-dimensional cargo overbooking models. European Journal of Operational Research 197, 862-883. 2009.
35. Haidar. L.M. and Metin Cakanyildirim. Optimal overbooking limits of a two-dimensional cargo problem: a profit maximation approach. Journal of Revenue and Pricing Management. 2011.
36. Luo, S., Cakanyildirim, M., Kasilingam, R.G., Two-dimensional cargo overbooking models. European Journal of Operational Research 197, 862-883. 2009.
37. Subramanian, J., Stidham, J. R. & Lauthenbacker, C. J. Airline yield management with overbooking, cancellation, and no show. transportation science, vol. 33 no. 2. 1999.
38. Huang, K., Chang, K. An approximate algorithm fot the two-dimensional air cargo revenue management problem. Journal of Air Transport Management, 38, 36-42. 2010.

Revenue Management Model Based on Customer Behavior in The Aviation Industry

ORIGINALITY REPORT

24%	15%	26%	6%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	core.ac.uk Internet Source	8%
2	ben-israel.rutgers.edu Internet Source	7%
3	Ahmad RUSDIANSYAH, Hilman PRADHANA, Dira MARIANA, Naning A. WESSIANI. "Joint Dynamic Pricing Model for Two Parallel Flights Considering Overbooking, Cancellations, and No-Show Customers", Journal of the Eastern Asia Society for Transportation Studies, 2011 Publication	5%
4	Kuancheng Huang, Ko-chen Chang. "An approximate algorithm for the two-dimensional air cargo revenue management problem", Transportation Research Part E: Logistics and Transportation Review, 2010 Publication	4%

Exclude quotes	On	Exclude matches	< 3%
Exclude bibliography	On		

Revenue Management Model Based on Customer Behavior in The Aviation Industry

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6