International Journal of Advanced Science and Technology
Vol. 29, No. 7s, (2020), pp. 3571-3579

# Design of Optimum Commercial Airline Fare Using a Hybrid Algorithm of AHP, DEMATEL-ANP and Goal Programming

Budi Sukoco[1*], M. Dachyar[2] and Farizal[3]
*Industrial Engineering Department*
*Universitas Indonesia, Kampus Baru UI, Depok, Indonesia*
*[1]budi.sukoco@hotmail.com, [2]mdachyar@yahoo.com, [3]farizal@eng.ui.ac.id*

***Abstract***

*Designing airfare is a way to manage the competitiveness level and increase market share to enhance profitability. Implementation of a pricing strategy becomes very important for the airline since determining its airfare is known as a very complex process. This research aims to find the optimum airfare based on the schedule in the tourist-based destination during peak season by sequential method comprised of Analytical Hierarchy Process (AHP), Decision-Making Trial and Evaluation Laboratory - Analytic Network Process (D-ANP) and Goal Programming. The case study of this research applied to an Indonesian airline company.*

***Keywords:*** *Airline fare strategy, Analytical Hierarchy Process, D-ANP, Fare optimization, Goal Programming, Hybrid algorithm*

## 1. Introduction

Passenger commercial flights have grown an average of 5% per year in the past 30 years and an average of 3.7% of Annual Gross Domestic Product (GDP) per country so they are estimated to be growth by 4% - 5 % per year in the next 10-15 years [1]. The passenger flown will be 1.7 times in 2035 compared to the current number [2].

The demand for passenger commercial flights in Indonesia grew 6.6% per year within 2014 – 2018 and triggered airlines in Indonesia in increasing their capacity to fully absorb the demand to 7.8% per year during 2014 – 2018 [3]. There is a gap rate between demand rate and capacity offered rate then it drives the intense competition among the airlines. Seat Load Factor (SLF) of the airline in Indonesia has fallen at the level of 78% in 2018 or it was 5% from the SLF rate in 2014 [4]. The competitive market situation urged airlines in Indonesia to implement a precise pricing strategy in its fare to maintain its competitiveness level, business continuity, and increase the market share [5], [6].

Designing airfare prices is a way to manage the competitiveness level and increase market share to enhance profitability [6]. The commercial airline industry provides a tough business since it has a small operating margin, high fixed operating costs, required huge capital expenses, governed by strict authority and taxation regulation as well as high volatility demand caused by season, disease, warfare, and terrorism [7]. Hence, the implementation of a pricing strategy becomes very important for the airline since determining its airfare is known as a very complex process. Commercial flights ride 80% of the global tourist traffic and the tourism industry is an industry with high seasonal characteristics since its escalation demand depends on the season and holiday period. As one of the related industries to the tourism industry, the reduced price as part of a pricing strategy is needed during the low season period to create demand and set high prices in the peak season to maximize the profitability [6].

A tight competition, decreasing SLF and various factors which influence the production costs of airlines are the challenge for airlines include airlines in



ISSN: 2005-4238 IJAST

Indonesia. As a result, their financial performance has not been able to set profit in recent years. To recover financial performance and considering the aviation fuel prices, as one of the major production cost components, is higher by 12% compared to 2018 as well as the depreciation of the Indonesian Rupiah, Airlines in Indonesia should raise the airfare price massively in all flight schedules and classes to maintain the achievement of profit targets [8]. The airfare price increased between 40% - 100% and impacted the number of passengers flown in August 2019 reduced 21% compared to August 2018 YoY [9].

Considering all of those complexities, the pricing strategy becomes very important to be implemented by the airline [10]. Multi-criteria decision-making methods and goal programming methods can support the process of airfare price optimization [11]. Optimum airfare prices will give a positive outcome for the airline since it means the customers will get a competitive price. By providing a competitive price offering, it will support the airline in maintaining its customers' convenience and increase the customers' intention to purchase frequently as they are influenced by the comparison price offered by the airline and competitors [12].

## 2. Methods

This research used a sequential method comprised of AHP, D-ANP, and Goal Programming and used the flight schedule data-sets of an airline in Indonesia in the tourist-based destination during the peak season and the experts' judgments data-sets.

### 2.1. Pricing Strategy

In general, the commercial flight is not a finished product since it needs to be provided only for customer who has a personal or business trip so the customer will look the prices at the lowest level possible and the airline should consider the elasticity of demand [13]. Demand could be categorized into elastic demand and non-elastic demand [6]. Tourism is an industry with an elastic demand where tourists will decline if the travel costs increase. The elasticity of tourism demand will reflect directly on the demand characteristic of the airline. The passengers on holiday purposes are categorized as price-sensitive and insensitive to time constraints passenger so they are willing to change travel dates and the destination airport to get the lowest possible fares.

One of the common pricing strategies implemented by airlines is cost-based pricing with the target profit [6]. This strategy manages the profit goal and simulates how many seats should be sold to achieve the targeted profit in a breakeven chart. This strategy is close and related to yield management which is a technique to maximize revenue by controlling the number of units sold in a certain airfare class dynamically [14].

### 2.2. Operation Research

Operation research is related to the decision-making process where the purpose of all decisions created is to minimize the effort or to maximize the benefit [15]. The implementation of a pricing strategy could be supported by this operation research since it will provide the maximum or minimum values of a function which is being its optimization goal. Operation research is used to manage the optimization process which refers to the efforts to achieve the best result [16]. Scientific approaching in operation research is sometimes used to support decision-making and this scientific approach usually uses the mathematics model [17].

### 2.3. Multi-Criteria Decision-Making (MCDM)

Multi-Criteria Decision-Making (MCDM) is an analysis technique used to select or determine the priority level of alternatives from the available alternatives. MCDM is consist of Multi-Attribute Decision Making (MADM) and Multi-Objective Decision Making (MODM). A technique is used to determine the attributes of an assessment, such as TOPSIS, AHP, Analytic Network Process (ANP), MAUT, and the outranking method is categorized as MADM. While MODM is a technique used to determine the solution of one or several objectives that have specific constraints, such as Linear Programming, Goal Programming, and DEA.

In this research, the sequential method comprises of AHP, D-ANP, and Goal Programming is developed to find the optimum airfare price based on the schedule in the tourist-based destination during peak season. This hybrid algorithm is used to choose the best strategy due to its multi-criteria nature [18]. DEMATEL is a decision-making method that presents a complex structure of causal relationships using a matrix that was developed by The Battelle Memorial Institute, a research center located in Geneva [19]. This method is very effective in analyzing the cause and effect of relationships between factors in a system through structural modeling. ANP is a decision-making method that ignores the dependency relationship between elements that are in different levels in a hierarchy [20]. The integration of DEMATEL and ANP is conducted to improve the ability to make models in the decision-making process.

Goal Programming is a formula model used to respond to the real situations in the solution's concept for multi-criteria[21]. A method using a mathematical approach to achieve optimum value with the variables set of an issue and it has several goals is named as Zero One Goal Programming (ZOGP) [22]. it is a model used to deal with the MCDM problem with limited resources and got the expected goals [23].

## 3. Result and Discussion

The experts' judgment was conducted by the participation of five experts from that airline, including 4 senior managers and an analyst. Research is managed with sequential steps as follow:

### 3.1. Determine the Variable Matrix of Pricing Strategy

In the Indonesian aviation industry, the peak season is the period between June to August and November to December so airlines also could apply short-term strategies such as production based on demand and dynamic pricing. A production-based on-demand strategy is managed through the capacity adjustment according to the seasonality by maximizing the capacity during peak season. Dynamic pricing is managed through tactical fare for certain markets and channels as well as adjusting the airfare prices according to the target market and price sensitivity to increase the airline's average fare gradually.

The difference in airfare prices offered by airlines for the weekend departure flights and weekdays departure flight can affect the passenger's purchase decisions [24]. This price difference is caused by different demand levels. In the example, the demand on weekends during the holiday period (peak season) is higher than the demand on weekends during the regular season [24]. The price elasticity is also shown towards the departure hours where the demand tends to be elastic in the afternoon and inelastic during the morning because early morning flight is usually dominated by business-oriented passengers [25].

Destination characteristics also influence the difference between airfare prices offered. It can be categorized into business-oriented destinations and tourist-based destinations [25]. This research decided Denpasar as the object of research because this destination has the highest passenger in Indonesia after Jakarta and it dominated by tourist passengers. The variable matrix has been developed in this research shown in table 1.

**Table 1. Variable Matrix of Pricing Strategy**

| Destination | Season | Departure Day | Departure Hours |
|---|---|---|---|
| **Tourist-based Destination** | Peak Season | Monday Flight<br>Tuesday Flight<br>Wednesday Flight<br>Thursday Flight<br>Friday Flight<br>Saturday Flight<br>Sunday Flight | Morning Flight<br>Afternoon Flight<br>Evening Flight<br>Night Flight |
| **Tourist-based Destination** | Regular Season | Monday Flight<br>Tuesday Flight<br>Wednesday Flight<br>Thursday Flight<br>Friday Flight<br>Saturday Flight<br>Sunday Flight | Morning Flight<br>Afternoon Flight<br>Evening Flight<br>Night Flight |
| **Business-oriented Destination** | Peak Season | Monday Flight<br>Tuesday Flight<br>Wednesday Flight<br>Thursday Flight<br>Friday Flight<br>Saturday Flight<br>Sunday Flight | Morning Flight<br>Afternoon Flight<br>Evening Flight<br>Night Flight |
| **Business-oriented Destination** | Regular Season | Monday Flight<br>Tuesday Flight<br>Wednesday Flight<br>Thursday Flight<br>Friday Flight<br>Saturday Flight<br>Sunday Flight | Morning Flight<br>Afternoon Flight<br>Evening Flight<br>Night Flight |

### 3.2. Flight Schedule Selection for Pricing Strategy

The selection of flight schedules for pricing strategy was conducted by the participation of five experts from the company through a questionnaire. The experts were chosen because they have specific experience and knowledge about the flights' schedules should be considered their demand and price sensitivity when determined the airfare price. The analysis of the questionnaire's result on this stage is managed using geo-mean with the acceptance threshold value ≥ 3,6 [26].

Some flight schedules will be eliminated from the research variable whenever they didn't reach the acceptance threshold value [27]. The selected flight schedule to be analyzed on the further step is showed in table 2.

**Table 2. Selected Flight Schedule in Tourist-based Destination during Peak Season**

| Departure Days | Departure Hour | Geo-mean | Analysis |
|---|---|---|---|
| **Monday** | Morning Flight | 4,78 | Accepted Element |
| | Afternoon Flight | 4,78 | Accepted Element |
| | Evening Flight | 4,52 | Accepted Element |
| | Night Flight | 3,00 | Rejected Element |
| **Tuesday** | Morning Flight | 3,00 | Rejected Element |
| | Afternoon Flight | 3,37 | Rejected Element |
| | Evening Flight | 3,00 | Rejected Element |
| | Night Flight | 3,00 | Rejected Element |
| **Wednesday** | Morning Flight | 3,78 | Accepted Element |
| | Afternoon Flight | 3,78 | Accepted Element |
| | Evening Flight | 3,78 | Accepted Element |
| | Night Flight | 3,78 | Accepted Element |
| **Thursday** | Morning Flight | 3,78 | Accepted Element |
| | Afternoon Flight | 3,78 | Accepted Element |
| | Evening Flight | 3,78 | Accepted Element |
| | Night Flight | 3,78 | Accepted Element |
| **Friday** | Morning Flight | 4,19 | Accepted Element |
| | Afternoon Flight | 4,19 | Accepted Element |
| | Evening Flight | 5,58 | Accepted Element |
| | Night Flight | 5,58 | Accepted Element |
| **Saturday** | Morning Flight | 5,58 | Accepted Element |
| | Afternoon Flight | 4,19 | Accepted Element |
| | Evening Flight | 4,19 | Accepted Element |
| | Night Flight | 4,44 | Accepted Element |
| **Sunday** | Morning Flight | 4,64 | Accepted Element |
| | Afternoon Flight | 4,64 | Accepted Element |
| | Evening Flight | 4,64 | Accepted Element |
| | Night Flight | 4,64 | Accepted Element |

The flight schedules which did not reach the acceptance threshold value are Monday morning flight, Tuesday morning flight, Tuesday afternoon flight, Tuesday evening flight, and Tuesday night flight.

### 3.3. Prioritize the Selected Flight Schedule for Pricing Strategy

AHP is used to analyze the questionnaire's result to get the priority of the selected flight schedule for pricing strategy. The questionnaire is participated by five experts from the company. They gave their experience and knowledge in prioritizing a pair of flight schedules according to both demand and price sensitivity when determined the airfare price. The priority level of the flight schedule which would be used on the further step is showed in table 3.

The scheduled flight with the highest priority is the Friday night flight and the lowest priority is the Wednesday night flight, the Wednesday morning flight, the Wednesday evening flight, and the Monday morning flight.

**Table 3. The Priority Flight Schedules in Tourist-based Destination during Peak Season**

| Scheduled Flight | Weight | Priority |
|---|---|---|
| Friday Night | 0.174 | 1 |
| Friday Afternoon | 0.159 | 2 |
| Friday Evening | 0.138 | 3 |
| Saturday Morning | 0.075 | 4 |
| Thursday Night | 0.067 | 5 |
| Friday Morning | 0.052 | 6 |
| Saturday Afternoon | 0.046 | 7 |
| Thursday Evening | 0.031 | 8 |
| Saturday Night | 0.029 | 9 |
| Sunday Afternoon | 0.026 | 10 |
| Thursday Afternoon | 0.026 | 11 |
| Sunday Morning | 0.025 | 12 |
| Sunday Evening | 0.025 | 12 |
| Saturday Evening | 0.024 | 14 |
| Sunday Night | 0.023 | 15 |
| Thursday Morning | 0.023 | 16 |
| Monday Morning | 0.023 | 17 |
| Wednesday Afternoon | 0.006 | 18 |
| Monday Afternoon | 0.005 | 19 |
| Wednesday Night | 0.005 | 20 |
| Wednesday Morning | 0.005 | 20 |
| Wednesday Evening | 0.005 | 20 |
| Monday Evening | 0.005 | 20 |

### 3.4. Calculate Interrelationship Weight among the Selected Flight Schedule

Interrelationship weight among the selected flight schedule was conducted by the participation of five experts from the company through a questionnaire then it would be analyzed D-ANP. The interrelationship weight is showed in table 4. The Friday flights have the bigger weights among the others' schedules in the amount of 0.0687 averagely. It means the seat load factor (SLF) may increase when the airline decided to lower the airfare price.

### 3.5. Calculate the Optimum Airfare Price

Z0GP and Goal programming are used to set the optimum airfare price based on the priority level of the selected flight schedule and the interrelationship weight among the selected flight schedule. Based on the calculation using zero-one goal programming, the optimum airfare price could be set on the all selected flight

schedule except Wednesday morning flight and Wednesday evening flight since both schedule flight given 0 on the Z0GP.

**Table 4. Interrelationship Weight among the Selected Flight Schedules**

| Departure Day | Departure Hour | R+C Value |
|---|---|---|
| **Monday** | Morning<br>Afternoon<br>Evening | 0,0317<br>0,0314<br>0,0314 |
| **Wednesday** | Morning<br>Afternoon<br>Evening<br>Night | 0,0317<br>0,0311<br>0,0357<br>0,0350 |
| **Thursday** | Morning<br>Afternoon<br>Evening<br>Night | 0,0415<br>0,0428<br>0,0428<br>0,0567 |
| **Friday** | Morning<br>Afternoon<br>Evening<br>Night | 0,0687<br>0,0687<br>0,0687<br>0,0687 |
| **Saturday** | Morning<br>Afternoon<br>Evening<br>Night | 0,0561<br>0,0561<br>0,0339<br>0,0339 |
| **Sunday** | Morning<br>Afternoon<br>Evening<br>Night | 0,0334<br>0,0334<br>0,0334<br>0,0334 |

The objective function of the Z0GP and goal programming in this research are formulated as follows:

$$\text{Max } Z = (t_1.x_1)+(t_2.x_2)+\ldots+(t_i.x_i) \quad (1)$$

Whereas,
Z = revenue (Indonesian Rupiah);
t = optimum airfare price (Indonesian Rupiah);
x = optimum seat load factor (seat);
i = selected flight schedule.

Goal programming is applied to find the solution of optimum airfare price and optimum seat load factor. The optimum airfare price and optimum seat load factor are showed in table 5.

## 4. Conclusion

Designing airfare is a crucial managerial role to manage the competitiveness level and increase market share to enhance profitability. Considering its importance and complexity, in this paper, a proposed method is developed to find the optimum airfare price and optimum seat load factor. The proposed method comprises AHP, D-ANP, and Goal Programming. Further research can develop the proposed

methodology using historical data instead of expert judgment to understand actual demand and behavior among the flight schedule.

**Table 5. Optimum Airfare Price and Seat Load Factor (SLF)**

| Departure Days | Departure Hour | Optimum Airfare Price (Indonesian Rupiah) | Optimum SLF (Seat) |
|---|---|---|---|
| **Monday** | Morning<br>Afternoon<br>Evening | 1,436,000<br>1,289,660<br>1,300,995 | 778<br>426<br>497 |
| **Wednesday** | Morning<br>Afternoon<br>Evening<br>Night | 1,436,000<br>1,369,801<br>1,298,441<br>1,293,651 | 778<br>928<br>481<br>451 |
| **Thursday** | Morning<br>Afternoon<br>Evening<br>Night | 1,345,855<br>1,309,616<br>1,301,793<br>1,259,967 | 778<br>928<br>502<br>240 |
| **Friday** | Morning<br>Afternoon<br>Evening<br>Night | 1,322,228<br>1,311,851<br>1,272,578<br>1,295,886 | 630<br>565<br>319<br>465 |
| **Saturday** | Morning<br>Afternoon<br>Evening<br>Night | 1,323,345<br>1,319,733<br>1,302,751<br>1,321,908 | 637<br>558<br>508<br>628 |
| **Sunday** | Morning<br>Afternoon<br>Evening<br>Night | 1,345,855<br>1,345,855<br>1,282,157<br>1,259,647 | 778<br>778<br>238<br>238 |

## 5. Reference

[1] P. Belobaba, A. Odoni, and C. Barnhart, *The Global Airline Industry*, Second. West Sussex: John Wiley & Sons, Ltd, 2016.
[2] J. Harckham and E. Toler, "Aviation Industry Overview," in *ASCE Air Transportation Group 20th Annual Conference*, 2017.
[3] P. Kinanti, W. Yulianingsih, R. Pratiwi, and I. Hamidah, *Statistik Perhubungan 2018*. Jakarta: Pustikom - Kementerian Perhubungan, 2019.
[4] CAPA, "Indonesia Domestic Airline Market : Rapid Growth, Rivalry Intensifies," *Centre For Aviation*, 2018.
[5] K. Button, Á. Costa, F. Costa, and C. Cruz, "Problems of cost recovery by European airlines since market liberalization," *Transp. Plan. Technol.*, vol. 34, no. 2, pp. 125–138, 2011.
[6] M. A. Camilleri, Travel Marketing, Tourism Economics and the Airline Product, no. January 2018. 2018.
[7] P. S. Dempsey, "The Airline Business," 2011.
[8] Liputan6.com, "5 Hal Penyebab Naiknya Harga Tiket Pesawat," *Liputan6.com*, 2019. [Online]. Available: https://www.liputan6.com/lifestyle/read/4015331/5-hal-penyebab-naiknya-harga-tiket-pesawat. [Accessed: 19-Oct-2019].
[9] BPS-Statistics Indonesia, "Jumlah Penumpang yang Berangkat pada Penerbangan Domestik di Bandara Utama Indonesia, 2006-2019 (Orang)," *BPS-Statistics Indonesia*, 2019. [Online]. Available: https://www.bps.go.id/linkTableDinamis/view/id/812.
[10] V. Bilotkach, A. A. Gaggero, and C. A. Piga, "Airline pricing under different market conditions:

Evidence from European Low-Cost Carriers," *Tour. Manag.*, vol. 47, pp. 152–163, 2015.
[11] S. Dožić, "Multi-criteria decision-making methods: Application in the aviation industry," *J. Air Transp. Manag.*, vol. 79, no. June, p. 101683, 2019.
[12] M. Dachyar, F. M. Esperanca, and R. Nurcahyo, "Loyalty Improvement of Indonesian Local Brand Fashion Customer Based on Customer Lifetime Value (CLV) Segmentation," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 598, no. 1, 2019.
[13] The Airline Monitor, "Airlines 101," no. November. pp. 1–30, 2000.
[14] T. J. Smith, *Pricing Strategy - Setting Price Levels, Managing Price Discounts, & Establishing Price Structures*. Mason, USA: South-Western Cengage Learning, 2012.
[15] A. Astolfi, "OPTIMISATION An introduction," *J. Anal. Psychol.*, vol. 55, no. 5, pp. 617–635, 2010.
[16] N. Andreasson, a Evgrafov, and M. Patriksson, "An Introduction to Continuous Optimization: Foundations and Fundamental Algorithms," p. 400, 2007.
[17] W. L. Winston, *Operations research*, Fourth., vol. 73, no. C. California: Brooks/Cole - Thomson Learning, 1971.
[18] M. Mostamand, S. H. Razavi Hajiagha, and M. Daneshvar, "Selecting Strategies by Considering Budget Limitation: A Hybrid Algorithm of SWOT-DEMATEL-ANP and Binary Programming with Grey Information," *Informatica*, vol. 28, no. 3, pp. 485–503, 2017.
[19] L. R. Bacudio *et al.*, "Analyzing barriers to implementing industrial symbiosis networks using DEMATEL," *Sustain. Prod. Consum.*, vol. 7, no. February, pp. 57–65, 2016.
[20] T. L. Saaty, "Decision making — the Analytic Hierarchy and Network Processes (AHP/ANP)," *J. Syst. Sci. Syst. Eng.*, vol. 13, no. 1, pp. 1–35, 2006.
[21] Lindo System Inc., "Optimization Modeling with LINGO," no. 312, p. 617, 2006.
[22] C. Liao, "A Zero-one Goal Programming Model for Marketing Project Selection," vol. 40, pp. 77–88, 2009.
[23] W. H. Tsai, J. L. Hsu, C. H. Chen, W. R. Lin, and S. P. Chen, "An integrated approach for selecting corporate social responsibility programs and costs evaluation in the international tourist hotel," *Int. J. Hosp. Manag.*, vol. 29, no. 3, pp. 385–396, 2010.
[24] C. H. Wen and Y. Yeh, "Modeling air travelers' choice of flight departure and return dates on long holiday weekends," *J. Air Transp. Manag.*, vol. 65, pp. 220–225, 2017.
[25] C. Morlotti, M. Cattaneo, P. Malighetti, and R. Redondi, "Multi-dimensional price elasticity for leisure and business destinations in the low-cost air transport market: Evidence from easyJet," *Tour. Manag.*, vol. 61, pp. 23–34, 2017.
[26] R. L. Johnson and G. B. Morgan, *Survey Scales - A Guide to Development, Analysis, and Reporting*. New York: The Guilford Press, 2016.
[27] M. Dachyar and F. Dewi, "Improving university ranking to achieve university competitiveness by management information system," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 83, no. 1, 2015.