ATLANTIS PRESS

Advances in Engineering Research, volume 187

Third International Conference on Sustainable Innovation 2019 – Technology and Engineering (IcoSITE 2019)

Determining the Criteria for an Air Hub in Indonesia using an Analytical Hierarchy Process (AHP)

1st Gito Sugiyanto
Civil Engineering Department, Faculty of Engineering
Jenderal Soedirman University
Purbalingga, Central Java, Indonesia
gito_98@yahoo.com or ORCID: 0000-0002-1498-8967

2nd Purwanto Bekti Santosa
Civil Engineering Department, Faculty of Engineering
Jenderal Soedirman University
Purbalingga, Central Java, Indonesia
purwanto250@gmail.com

3rd Mina Yumei Santi
Center of Excellence Innovation of Applied Technology in Public Health
Health Polytechnic Ministry of Health
Yogyakarta, Indonesia
minayumeisanti80@gmail.com or ORCID: 0000-0001-5870-2070

***Abstract*—Provisions of infrastructure that encourage national connectivity will reduce transportation and logistics costs so that they can increase product competitiveness and accelerate economic growth. The application of an optimum hub and spoke airport model will improve the efficiency of transportation costs and the effectiveness of air transport logistics distribution. Efforts are being made to establish an airport as a hub airport by examining the parameters or criteria to be used. The aim of this research was to determine the parameters or criteria for establishing an airport as a hub airport using the Analytical Hierarchy Process method. The study locations were four international airports in Indonesia namely Soekarno Hatta International Airport in Cengkareng, Juanda International Airport in Surabaya, Ngurah Rai International Airport in Denpasar, and Sultan Hasanuddin International Airport in Makassar. Five parameters or criteria for determining whether an airport should become a hub airport werw examined, i.e. airport charges or airport costs, cargo handling capacity, time used for handling cargo, value-added service, and location and infrastructure aspects. With the value weight of 23.76%, the most influential parameter or criteria is airport charges or costs and this includes landing fees, airport parking fees, and security charges.**

Keywords— hub and spoke, airport, cargo handling, airport parking fees, analytical hierarchy process

I. INTRODUCTION

The airport business has changed quickly since it is a consistent growing segment inside the travel and transportation industries. More than 186 million passengers passed through the Indonesian airports in 2018 [1]. Airports have become not only nodes of new intermodal transport systems for people and goods, but also new cities, competing on a worldwide scale [2]. Travelers can choose more than one main carrier and airport from origin to their destination zone [3]. "A nation with a regional hub airport not only provides many job opportunities but also increases the nation's exports of electronic manufacturing products through high density air route networking and frequent flight schedules" [4].

The Herfindahl-Hirschmann Index (HHI), cargo volume, and freight ratio can be used to classify an airport as a hub airport or a spoke airport [5-6]. The freight ratio is the ratio between the amount of cargo and the number of passengers (kg/passenger) boarding in an airport. There are three options when it comes to bundling freight: on 'Through Unit Load Devices' (T-ULD) (all freight for the same flight at the hub airport), on 'Mixed Unit Load Devices' (M-ULD) (freight for different flights at the hub airport) and loose freight in trucks [7]. Flights to air freight hubs are likely to respond to fuel and transport costs [8]. Implementation of congestion pricing in a central business district [9], congestion charges for a private vehicle [10], identification of black spot locations to increase traffic safety [11-13], improvement in the materials and construction of road pavement [14-15] (and determining the maximum speed limit [16] are various methods that have been tried in order to reduce the transport costs of land transportation in Indonesia.

The optimal freight bundling configuration for carriers, takes into account the main key performance indicators. Three key performance indicators in freight transport are cost, un-loading time, and quality [7]. The number of hubs is one of the factors that affects the network structure of an airline [17], fuel cost and transport cost [18]. In its existing condition, the airline route network in Sumatra Island, Indonesia has not fully developed with the concept of hub and spokes. Based on the Herfindahl-Hirschmann Index, an analysis produces 2-hubs for domestic flights and 1-hub (Kualanamu International Airport) for international flights. Kualanamu International Airport in Deli Serdang, North Sumatra and Hang Nadim International Airport in Batam are hub airports in Sumatra Island for domestic flights [18].

Tsai and Su [19] used the Analytical Hierarchical Process (AHP) method to assess the political risk if the Taiwan Government intends to develop an air logistics hub in Northern Taiwan". The result of the study shows that "air hub policy and inland freight policy are the top two factors influencing an airport's degree of political risk". Tretheway and Kincaid in Reference [20] examined airport competition by "utilizing the four P's of marketing strategy and indicated that cargo traffic is very price sensitive". High rents and high costs of operation will adversely impact Dubai's status as a logistics hub [21]. Investments in transport infrastructure change accessibility patterns, but the measurement itself is not sufficient enough to assess the necessity of the investment, because knowledge on the optimal infrastructure level is needed [22]. The aim of this research was to determine the parameters or criteria for establishing an airport as a hub airport using the analytical hierarchy process method.

II. LITERATURE REVIEW

Sasaki et al. [23] considered "the hub airport selection problem as a one-stop multiple allocation p-hub median problem". A parameter that influences hub airport selections is

the passenger distance between airports' service networks [23]. Takase and Morikawa [24] investigated "passenger's hub airport and destination choices in Japan using repeated cross-section disaggregate air passenger data". Kim and Park [25] analyzed the connectivity of flight schedules using a temporal wave-system structure, Pedroni or Johansen co integration test methods [26], and bi-criteria single allocation hub location problems. The total time is considered to be a second criteria and the maximum service time for the hubs are minimized [27]. Bryan and O'Kelly [28] analyzed the hub location problem and its variants in air transportation. Connectivity is measured using a flow centrality indicator [29]. The variables that were used to define airport classification criteria were based on passenger characteristics and the terminal size in terms of the number of gates, international flights or domestic flights, and transfer passenger volume variables [30].

Multi Criteria Decision Making (MCDM) method is the process of a decision maker choosing between more than one alternative according to certain criteria [31-35]. Postorino and Praticò [36] used the multi criteria decision making methods to analyze the criteria that influence a regional multi airport system. Multi criteria decision making methods were used to evaluate solutions and alternatives for matching the runway capacity to demand [37]. A multi criteria decision making method was used to identify the aspects of the new route's feasibility [38]. The Multi Criteria Decision Analysis (MCDA) approach seems to be a very promising one when compared with Data Envelopment Analysis (DEA) [39].

The major factors influencing a carriers' choice of hub airports are the location of an airport, the airport quality, and third-party influences [40]. "Some of the service attributes that influence an airline's cargo hub airport selection behaviour are the geographical location of airports, congestion and delay, operational availability, bilateral agreements, local demand, political risk, and airport user charges". "The geographical location of airports is the most important service attribute which influences an airline's hub airport selection behaviour" [41]. A two stage least square technique was used to study factors influencing a carrier's choice of an air cargo transshipment airport". Major influencing factors in carriers' choice of hub airports i.e.: traffic flow patterns, airport infrastructure capacity, connecting times, service quality, and airport cost. The choice of an air cargo transshipment hub is more sensitive to time cost than the monetary costs such as landing fees and line-haul price [42]. Mostly attributable to the United States policy of encouraging competition between air carriers seeking to provide service to small communities [43]. Selection the criteria of air hub in Pearl River Delta (PRD) Region include: airport charges or airport cost, cargo handling capacity, infrastructure, value-added service, location, time used for handling cargo [44]. Oktal and Ozger [45] stated that factors affecting hub location in cargo transportation are aircraft range and trip cost, runway availability, and cargo traffic continuity of an airport. Study about the major factors that influence hub airport selection and airport competition in another country can be seen in Table I.

TABLE I. STUDY ABOUT THE MAJOR INFLUENCING FACTORS ON HUB AIRPORT SELECTION AND AIRPORT COMPETITION.

No.	Researcher (year)	Focus of the research	Major influencing factors on hub airport selection
1.	Rezaei et al. (2017)	Optimal freight bundling configuration for carriers	Cost, un-loading time, and quality.
2.	Oktal and Ozger (2013)	Factors affecting hub location in cargo transportation	Aircraft range and trip cost, runway availability, and cargo traffic continuity of an airport.
3.	Lirn (2010)	Airline's cargo hub airport's selection	Congestion and delay, geographical location of airports, bilateral agreement, political risk, operational availability, local demand, and airport user charge.
4.	Mendes and de-Neufville (2010)	Airport competition	Competition between air carriers.
5.	Yuen (2008)	Selection criteria of air hub in Pearl River Delta (PRD) Region	Airport charges or airport cost, cargo handling capacity, infrastructure, value added service, location, time used for handling cargo.
6.	Gardiner et al. (2005)	Carriers' choice of hub airports	Location of airport, airport quality, and third-party influences.
7.	Ohashi et al. (2005)	Carriers' choice of hub airports	Traffic flow patterns, airport infrastructure capacity, connecting times, service quality, and airport cost.
8.	Tretheway and Kincaid (2005)	Airport competition	Cargo traffic is very price sensitive,
9.	Takase and Morikawa (2005)	Passenger's hub airport and destination choices	Passenger flow.
10.	Tsai and Su (2002)	Air logistics hub in Northern Taiwan	Air hub policy and inland freight policy.
11.	Sasaki et al. (1999)	Hub airport selection	Number of passenger, distance between airports' service networks.

TABLE II. SERVICE ATTRIBUTES OF AN AIRLINE CARGO HUB AIRPORT [40].

Airport quality	Airport location	Third party influences
Labour	Competition from nearby airports	Political risk
Airport ground access	Geography of airports	Environmental restrictions
Infrastructure	Local demand	Bilateral agreements
Airport user charges	Operational availability (weather, snow)	Government legislation
Congestion and delay		Freight forwarders, Shippers, Consignees
		Airport marketing

III. METHOD

A. Study Location

The locations for the study were in four international airports in Indonesia, namely Soekarno Hatta International Airport in Cengkareng, Banten; Juanda International Airport in Surabaya, East Java; Ngurah Rai International Airport in Denpasar, Bali; and Sultan Hasanuddin International Airport in Makassar, South Sulawesi. The location of study can be seen in Fig. 1. The number of respondents to the questionnaire the analytical hierarchy process was 65 people.

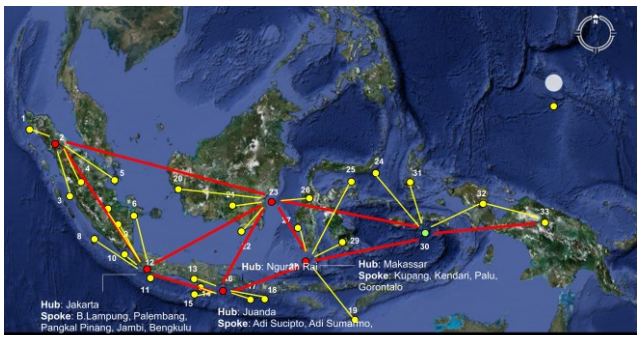

Fig. 1. Location of study in four international airports in Indonesia.

B. Analytical Hierarchy Process Method

The criteria of an airline's cargo hub airport are determined using analytical hierarchy process method. AHP includes four axioms: reciprocal relation, relation, pair-wise comparison of homogeneous elements, hierarchic, and systems dependence, and eexpectations about the validity of the rank and value of the outcome.

The following steps are involved in the Analytical Hierarchy Process (AHP) applications:

a. Construct a decision hierarchy with criteria related to the decision goal.
b. Collect input data to perform pair-wise comparisons of all the decision criteria.
c. Use an eigenvector method to estimate relative weightings of decision criteria.
d. Obtain a composite weight by aggregating the relative weights up the hierarchy to represent the relative importance of each alternative.

C. Research Design

In this study, there are five parameters or criteria to determine whether an airport should become a hub airport, i.e. airport charges or airport costs, cargo handling capacity, time used for handling cargo, value added services, location and infrastructure aspects. Based on the parameter or criteria then sub-criteria are determined as presented in Table III.

TABLE III. CRITERIA AND SUB-CRITERIA TO DETERMINE HUB AIRPORT

No.	Criteria	Sub-criteria
1.	Airport charges / airport costs	a. Landing fees b. Airport parking fees c. Security charges d. Government tax
2.	Cargo handling capacity	a. Available heavy equipment b. Skilled labour c. Extensive application of information technology
3.	Time used for handling cargo	a. Cargo loading time b. Unloading time c. Customs clearance time
4.	Value added services	a. One stop service b. High safety and security system c. Cargo tracking platform
5.	Location and infrastructure aspects	a. Location aspect b. Infrastructure aspect: road, bridges, utilities

IV. RESULTS AND ANALYSIS

A. Parameter on Hub Airport Selection

The major factors that influence carriers' choice of hub airports include location of airport, airport quality, and third-party influences [40]. Criteria of airport quality include the following: labour, airport ground access, infrastructure, airport user charges, and congestion and delay. Criteria of airport location include competition from nearby airports, geography of airports, local demand, and operational availability (i.e., weather such as, snow). Third party influences include political risk, environmental restrictions, bilateral agreements, government legislation, freight forwarders, shippers, consignees, and airport marketing.

There are five parameters or criteria to determine whether an airport should become hub airport i.e., airport charges or airport costs, cargo handling capacity, time used for handling cargo, value added services, location and infrastructure aspects. Airport charges or airport costs have four sub-criteria: landing fees, airport parking fees, security charges, and government tax. Cargo handling capacity has three sub-criteria: available heavy equipment, skilled labour, and extensive application of information technology. Time used for handling cargo has three sub-criteria: cargo loading time, un-loading time, and customs clearance time. Value added service has three sub-criteria: one stop service, high safety and security system, and cargo tracking platform. The location and infrastructure aspects have two sub-criteria: location and infrastructure (i.e., roads, bridges, and utilities).

B. Analytical Hierarchy Process Result

The results of the analytical hierarchy process analysis for the respondent 1's assessment can be seen in Table IV.

TABLE IV. ANALYTICAL HIERARCHY PROCESS RESULTS FROM RESPONDENT 1'S ASSESSMENT

	Criteria					Eigen vector	Criteria weights	Eigen value
	1	2	3	4	5			
1	1.00	0.33	0.67	1.33	1.67	0.9	0.146	5.00
2	3.00	1.00	2.00	4.00	5.00	2.6	0.438	5.00
3	1.50	0.50	1.00	2.00	2.50	1.3	0.219	5.00
4	0.75	0.25	0.50	1.00	1.25	0.7	0.109	5.00
5	0.60	0.20	0.40	0.80	1.00	0.5	0.088	5.00
						5.9	1.000	5.00
							CI =	0.00
							CR =	0.00

Based on Table IV, the results show that the weights for each criterion for establishing an airport as a hub airport based on respondent 1's assessment are as follows:

a. Criteria 1 (airport charges or airport costs) has a weight of 14.6%.
b. Criteria 2 (cargo handling capacity) has a weight of 43.8%.
c. Criteria 3 (time used for handling cargo) has a weight of 21.9%.
d. Criteria 4 (value added services) has a weight of 10.9%.
e. Criteria 5 (location and infrastructure aspects) has a weight of 8.8%.

Furthermore, AHP analysis for the next respondent is carried out in the same sequence and steps as the example in Table IV. The final results of the weights for each criterion for establishing an airport as a hub airport are obtained by summing the weight values for each criterion and then dividing by the number of respondents by as many as 65 people. The result of weights for each criterion to determine hub airport can be seen in Fig. 2. Based on Fig. 2, weights for each criterion as follows:

a. Criteria 1 (airport charges or airport costs) has a weight of 23.76%.
b. Criteria 2 (cargo handling capacity) has a weight of 20.24%.
c. Criteria 3 (time used for handling cargo) has a weight of 19.70%.
d. Criteria 4 (value added services) has a weight of 17.02%.
e. Criteria 5 (location and infrastructure aspects) has a weight of 19.28%.

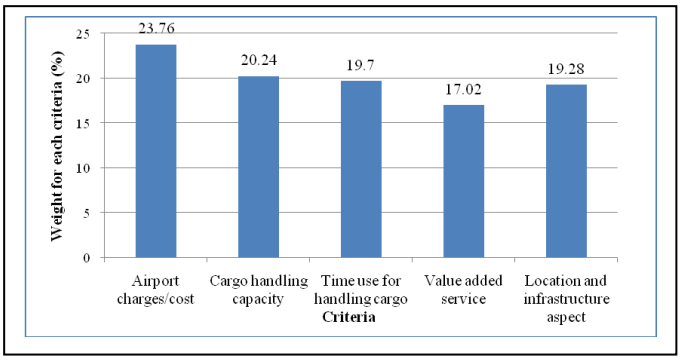

Fig. 2. Weights for each criterion to determine hub airport.

V. Conclusion and Recommendation

There are five parameters or criteria for determining whether an airport becomes a hub airport: airport charges or airport costs, cargo handling capacity, time used for handling cargo, value-added services, and location and infrastructure aspects. The most influential parameter or criteria is airport charges or airport costs that include landing fees, airport parking fees, and security charges; the value weight of this parameter is 23.76%.

Acknowledgment

"This research was carried out by the financial support of Directorate of Research and Community Services, Ministry of Research, Technology, and Higher Education, Republic of Indonesia through Research Grant" "*Penelitian Dasar* (Basic Research)". "All the contributions are acknowledged".

References

[1] Ministry of Transportation Republic of Indonesia, Lalu Lintas Angkutan Udara 2018. Jakarta: Directorate General of Air Transport Republic of Indonesia. Retrieved on 2019-02-15, http://hubud.dephub.go.id/?id/produksi/index.

[2] A. Marques and M. Galves, "Application of the Multi Criteria Decision Aid (MCDA) to the Industrial Airport Project of Viracopos," 2009. http://www.wctrs-society.com/wp-content/uploads/ abstracts/lisbon/selected/03124.pdf.

[3] G. Sugiyanto, P. B. Santosa, A. Wibowo, and M. Y. Santi, "Analysis of hub-and-spoke airport networks in Java Island, Indonesia based on cargo volume and freight ratio," Procedia Eng., vol. 125, pp. 556-563, 2015. http://dx.doi.org/10.1016/j.proeng.2015.11.061.

[4] K. Button, "Debunking some common myths about airport hubs," J. Air Transp. Manag., vol. 8 (3), pp. 177-188, 2012. https://doi.org/10.1016/S0969-6997(02)00002-9.

[5] G. Sugiyanto, P. B. Santosa, A. Wibowo, and M. Y. Santi, "Hub and spoke airport networks in Indonesia based on Herfindahl-Hirschmann Index (HHI)," Journal of Engineering and Applied Sciences, vol. 11 (8), pp. 1804-1810, 2016. http://medwelljournals.com/abstract/?doi=jeasci.2016.1804.1810.

[6] G. Sugiyanto, P. B. Santosa, A. Wibowo, and M. Y. Santi, "Airport classification based on Federal Aviation Administration and freight ratio (case study in Indonesia)," ARPN Journal of Engineering and Applied Sciences, vol. 12 (2), pp. 579-587, 2017a. http://www.arpnjournals.com/jeas/volume_02_2017.htm.

[7] J. Rezaei, A. Hemmes, and L. Tavasszy, "Multi-criteria decision-making for complex bundling configurations in surface transportation of air freight," J. Air Transp. Manag., vol. 61, pp. 95-105, 2017. https://doi.org/10.1016/j.jairtraman.2016.02.006.

[8] M. E. O'Kelly, "Air freight hubs in the FedEx system: Analysis of fuel use," J. Air Transp. Manag., vol. 36, pp. 1-12, 2014. https://doi.org/10.1016/j.jairtraman.2013.12.002.

[9] G. Sugiyanto, "The impact of congestion pricing scheme on the generalized cost and speed of motorcycle to the city of Yogyakarta, Indonesia," Journal of Engineering and Applied Sciences, vol. 11 (8), pp. 1740-1746, 2016. http://medwelljournals.com/abstract/?doi=jeasci.2016.1740.1746.

[10] G. Sugiyanto, "The effect of congestion pricing scheme on the generalized cost and speed of motorcycle," Walailak J. Sci. & Tech., vol. 15 (1), pp. 95-106, 2018 http://wjst.wu.ac.th/index.php/wjst/article/view/2347.

[11] G. Sugiyanto, A. Fadli, and M. Y. Santi, "Identification of black spot and equivalent accident number using upper control limit method," ARPN Journal of Engineering and Applied Sciences, vol. 12 (2), pp. 528-535, 2017b. http://www.arpnjournals.org/jeas/research_papers/rp_2017/jeas_0117_5650.pdf.

[12] G. Sugiyanto, "The cost of traffic accident and equivalent accident number in developing countries (case study in Indonesia)," ARPN Journal of Engineering and Applied Sciences, vol. 12 (2), pp. 389-397, 2017a. http://www.arpnjournals.org/jeas/research_papers/rp_2017/jeas_011_5631.pdf.

[13] G. Sugiyanto and M. Y. Santi, "Road Traffic Accident Cost using Human Capital Method (Case study in Purbalingga, Central Java, Indonesia) ," Jurnal Teknologi (Sciences and Engineering), vol. 79 (2), pp. 107-116, 2017. https://doi.org/10.11113/jt.v79.5375.

[14] G. Sugiyanto, "Characterization of asphalt concrete produced from scrapped tire rubber," Eng. Journal, vol. 21 (4), pp. 193-206, 2017b. https://doi.org/10.4186/ej.2017.21.4.193.

[15] G. Sugiyanto, "Marshall test characteristics of asphalt concrete mixture with scrapped tire rubber as a fine aggregate," Jurnal Teknologi (Sciences and Engineering), vol. 79 (2), pp. 55-64, 2017c. https://doi.org/10.11113/jt.v79.6965.

[16] G. Sugiyanto and S. Malkhamah, "Determining the maximum speed limit in urban road to increase traffic safety," Jurnal Teknologi (Sciences and Engineering), vol. 80 (5), pp. 67-77, 2018. https://doi.org/10.11113/jt.v80.10489.

[17] J. C. Martın and C. Roman, "Analyzing competition for hub location in intercontinental aviation markets," Transp. Res. Part E: Logist. Transp. Rev., vol. 40 (2), pp. 135-150, 2004. http://dx.doi.org/10.1016/s13665545(03)00037-1.

[18] G. Sugiyanto, P. B. Santosa, A. Wibowo, and M. Y. Santi, "Evaluation of hub-spoke airport networks in Sumatra Island, Indonesia to increase efficiency of air transportation," MATEC Web of Conferences, Vol. 195, 04009, 2018 ICRMCE 2018 https://doi.org/10.1051/matecconf/201819504009.

[19] M. C. Tsai and Y. S. Su, "Political risk assessment on air logistics hub developments in Taiwan," J. Air Transp. Manag., vol. 8 (6), pp. 373-380, 2002. https://doi.org/10.1016/S0969-6997(02)00016-9.

[20] M. Tretheway and I. Kincaid, "Competition between airports in the new millenium: what works, what doesn't work and why," February 16-18, 2005 8th Hamburg Aviation Conference, 2005, German www.intervistas.com/downloads/reports/CompetitionBetweenAirports.pdf.

[21] C. Fernandes and G. Rodrigues,b"Dubai's potential as an integrated logistics hub," The Journal of Applied Business Research, vol. 25 (3): pp. 77-92, 2009. https://clutejournals.com/index.php/JABR/article/download/1028/1012/.

[22] C. Hesse, C. Evangelinos, and S. Bohne, "Accessibility Measures and Flight Schedules: An Application to the European Air Transport," Eur. Transp., vol. 55 (6), pp. 1-23, 2013. www.istiee.org/te/papers/N55/ET_2013_55_6_Hesse%20et%20al.pdf

[23] M. Sasaki, A. Suzuki, and Z. Drezner, "On the selection of hub airports for an airline hub and spoke system," Comp. Oper. Res., vol. 26 (14), pp. 1411-1422, 1999. https://doi.org/10.1016/S0305-0548(99)00043-X.

[24] T. Takase and T. Morikawa, "Airport choice analysis of international passengers using time-series disaggregate data," Res. in Transp. Econ., vol. 13, pp. 197-210, 2005. https://doi.org/10.1016/S0739-8859(05)13009-1.

[25] J. Y. Kim and Y. Park, "Connectivity analysis of transshipments at a cargo hub airport," J. Air Transp. Manag., vol. 18 (1), pp. 12-15. 2012. https://doi.org/10.1016/j.jairtraman.2011.05.001.

[26] Md. M. Hakim and R. Merkert, "The causal relationship between air transport and economic growth: Empirical evidence from South Asia," J. Transp. Geogr., vol. 56, pp. 120-127, 2016. https://doi.org/10.1016/j.jtrangeo.2016.09.006.

[27] M. G. Costa, M. E. Captivo, and J. Clímaco, "Capacitated single allocation hub location problem-A bi-criteria approach," Comp. Oper. Res., vol. 35 (11), pp. 3671-3695, 2008. https://doi.org/10.1016/j.cor.2007.04.005.

[28] D. L. Bryan and M. E. O'Kelly, "Hub and spoke networks in air transportation: an analytical review," J. Reg. Sci., vol. 39 (2), pp. 275-295, 1999. https://doi.org/10.1111/1467-9787.00134.

[29] H. R. Déniza, P. S. Sanchez, and A. V. Dortac, "Classifying airports according to their hub dimensions: an application to the US domestic network," J. Transp. Geogr., vol. 33, pp. 188-195, 2013. https://doi.org/10.1016/j.jtrangeo.2013.10.011.

[30] V. Adikariwattage, A. G. de Barros, S. C. Wirasinghe, and J. Ruwanpura, "Airport classification criteria based on passenger characteristics and terminal size," J. Air Transp. Manag., vol. 24, pp. 36-41, 2012. https://doi.org/10.1016/j.jairtraman.2012.06.004.

[31] C. Prakash and M. K. Barua, "A robust multi-criteria decision-making framework for evaluation of the airport service quality enablers for ranking the airports," J. Qual. Assur. Hosp. Tour., vol. 17 (3), pp. 1-20, 2016. https://www.tandfonline.com/doi/abs/10.1080/1528008X.2015.1096753.

[32] A. Mardani, A. Jusoh, and E. K. Zavadskas, "Fuzzy multiple criteria decision-making techniques and applicationse two decades review from 1994 to 2014," Expert Syst. Appl., vol. 42 (8), pp. 4126-4148, 2015a. https://doi.org/10.1016/j.eswa.2015.01.003.

[33] A. Mardani, E. K. Zavadskas, Z. Khalifah, A. Jusoh, and K. M. Nor, "Multiple criteria decision-making techniques in transportation systems: a systematic review of the state of the art literature," Transport, vol. 31 (3), pp. 1-27, 2015b. https://doi.org/10.3846/16484142.2015.1121517.

[34] M. Deveci, N. Ç. Demirel, R. John, and E. Ozcan, "Fuzzy multi criteria decision making for carbon dioxide geological storage in Turkey," J. Nat. Gas Sci. Eng., vol. 27 (2), pp. 692-705, 2015. https://doi.org/10.1016/j.jngse.2015.09.004.

[35] W. Wang, X. Liu, and Y. Qin, "Multi-attribute group decision making models under interval type-2 fuzzy environment," Knowledge-Based Syst., vol. 30, pp. 121-128, 2012. https://doi.org/10.1016/j.knosys.2012.01.005.

[36] M. N. Postorino and F. G. Praticò, "An application of the Multi-Criteria Decision-Making analysis to a regional multi-airport system," Res. in Transp. Business & Manag., vol. 4, pp. 44-52, 2012. https://doi.org/10.1016/j.rtbm.2012.06.015.

[37] M. Janic, "A multi-criteria evaluation of solutions and alternatives for matching capacity to demand in an airport system: the case of London," Journal Transportation Planning and Technology, vol. 38 (7), pp. 709-737, 2015. https://doi.org/10.1080/03081060.2015.1059120.

[38] M. Deveci, N. Ç. Demirel, and E. Ahmetoglu, "Airline new route selection based on interval type-2 fuzzy MCDM: A case study of new route between Turkey - North American region destinations," J. Air Transp. Manag., vol. 59, pp. 83-99, 2017. http://dx.doi.org/10.1016/j.jairtraman.2016.11.013.

[39] M. E. Baltazar, J. Jardim, P. Alves, and J. Silva, "Air Transport Performance and Efficiency: MCDA vs. DEA Approaches," Proc.-Soc. Behav. Sci., vol. 111, pp. 790-799, 2014. https://doi.org/10.1016/j.sbspro.2014.01.113.

[40] J. Gardiner, I. Humphreys, and S. Ison, "Freighter operators' choice of airport: a three-stage process," Transp. Rev., vol. 25 (1), pp. 85-102, 2005. https://doi.org/10.1080/0144164042000218409.

[41] T. C. Lirn, "Study of airlines' cargo hub airport selection - an empirical study in Taiwan," Journal of the Eastern Asia Society for Transportation Studies, vol. 8, pp. 2355-2364, 2010. https://doi.org/10.11175/easts.8.2355.

[42] H. Ohashi, T. S. Kim, T. H. Oum, and C. Yu, "Choice of air cargo transshipment airport: an application to air cargo traffic to/from Northeast Asia," J. Air Transp. Manag., vol. 11 (3), pp. 149-159, 2005. https://doi.org/10.1016/j.jairtraman.2004.08.004.

[43] A. M. Mendes and R. de-Neufville, Air transportation policy for small communities: Lessons from the U.S. Experience, 14th ATRS, July 6-9, 2010, Oporto, Portugal http://ardent.mit.edu/airports/ASP_papers/Alda_RDN_JATS_v00_includesfiguresandtables.pdf.

[44] Yuen, S. S. M., "Selection Criteria of Air Hub in Pearl River Delta (PRD) Region: From Shippers' Perspective," International Forum on Shipping, Ports and Airports (IFSPA), Hongkong, 26-28 May 2008. https://www.polyu.edu.hk/lms/icms/ifspa2008/.../Simon,%20S.M.%20YUEN.pdf.

[45] H. Oktal and A. Ozger, "Hub location in air cargo transportation: A case study," J. Air Transp. Manag., vol. 27, pp. 1-4, 2013. https://dx.doi.org/10.1016/j.jairtraman.2012.10.009.