Application of AHP Method to Cargo Airline Selection for Air Freight Forwarder
การประยุกต์ใช้วิธีการ AHP ในการเลือกสายการบินขนส่งสินค้า สำหรับผู้ขนส่งสินค้าทางอากาศ

Nisakorn Somsuk[1], Vatcharaporn Pookboonmee[2], Sutit Huangsuwan[3],
Koranut Sakulkrit[3], Sirirat Nakha[4], Sasirat Saikhoone[5]
นิศากร สมสุข[1], วัชราพร พุกบุญมี[2], สุฐิต ห่วงสุวรรณ[3],
กรณัฏฐ์ สกุลกฤติ[3], สิริรัตน์ นาคา[4], ศศิร์รัช สายขุน[5]
[1]Department of Industrial Engineering, Faculty of Engineering,
Rajamangala University of Technology Thanyaburi
[1]ภาควิชาวิศวกรรมอุตสาหการ คณะวิศวกรรมศาสตร์ มหาวิทยาลัยเทคโนโลยีราชมงคลธัญบุรี
[2]Office of Academic, Eastern Asia University
[2]สำนักวิชาการ มหาวิทยาลัยอีสเทิร์นเอเชีย
[3]School of Aviation, Eastern Asia University
[3]คณะการบิน มหาวิทยาลัยอีสเทิร์นเอเชีย
[4]Office of Educational Service, Eastern Asia University
[4]สำนักบริการการศึกษา มหาวิทยาลัยอีสเทิร์นเอเชีย
[5]School of Business Administration, Eastern Asia University
[5]หลักสูตรบริหารธุรกิจบัณฑิตมหาวิทยาลัยอีสเทิร์นเอเชีย
Received: December 30, 2020
Revised: February 28, 2021
Accepted: March 5, 2021

Abstract

Air freight forwarders play a key role in the air cargo industry. To air freight forwarders, making a reasonable decision to select the ‘best’ airline can be considered as a strategic tool to gain a competitive advantage. In previous study, the appropriate criteria and sub-criteria for selecting the air freight airlines were determined by Thai experts in logistics, and the Analytic Hierarchy Process--AHP model for selecting the best airline was developed. The aim of this paper was to extend our previous study by applying the AHP model to the Bollore Logistics (Thailand) Co., Ltd., a freight forwarder in order to select the ‘best’ airline through the view of the “managers”, and conducting sensitivity analysis via changing criteria weight values and changing the weight values of experts in order to investigate the robustness of the ranking results. From the freight manager’s point of view, the best airline was the

X Airline, in which the management gave the utmost importance to the price and reliability criteria respectively. According to the sensitivity analysis results, it can be concluded that there was the robustness of the decision results.

Keywords: Airline selection, Analytic Hierarchy Process, sensitivity analysis, air freight forwarder

บทคัดย่อ

ผู้ขนส่งสินค้าทางอากาศมีบทบาทสำคัญในอุตสาหกรรมการขนส่งสินค้าทางอากาศ สำหรับผู้ขนส่งสินค้าทางอากาศ การตัดสินใจอย่างสมเหตุสมผลเพื่อเลือกสายการบินที่ 'ดีที่สุด' ถือได้ว่าเป็นเครื่องมือเชิงกลยุทธ์เพื่อให้ได้เปรียบในการแข่งขัน ในการศึกษาก่อนหน้านี้ของคณะผู้วิจัย ได้ศึกษาเกณฑ์การเลือกสายการบินขนส่งสินค้าทางอากาศโดยผู้เชี่ยวชาญไทยในด้านโลจิสติกส์ และได้พัฒนาตัวแบบกระบวนการลำดับชั้นเชิงวิเคราะห์ (Analytic Hierarchy Process) สำหรับการเลือกสายการบินที่เหมาะสม สำหรับบทความวิจัยครั้งนี้มีวัตถุประสงค์เพื่อขยายการศึกษาก่อนหน้านี้โดยประยุกต์ใช้ตัวแบบ AHP ไปใช้กับบริษัท โบลโลเร่ โลจิสติกส์ (ประเทศไทย) จำกัด ซึ่งเป็นบริษัทขนส่งสินค้า เพื่อเลือกสายการบินที่ 'ดีที่สุด' ผ่านมุมมองของผู้จัดการ โดยเกณฑ์การเลือกสายการบินขนส่งสินค้าทางอากาศที่มีความสำคัญสูงสุดเรียงตามลำดับคือ ราคา และความน่าเชื่อถือ นอกจากนี้ยังได้ทำวิเคราะห์ความไวเพื่อตรวจสอบความแข็งแกร่งของผลการจัดอันดับด้วยการเปลี่ยนน้ำหนักเกณฑ์ และเปลี่ยนน้ำหนักของผู้เชี่ยวชาญ ผลการศึกษาพบว่า สายการบินที่ดีที่สุดในมุมมองของผู้จัดการ คือสายการบิน X และจากผลการวิเคราะห์ความไวสามารถสรุปได้ว่ามีความแข็งแกร่งของผลการตัดสินใจ

คำสำคัญ: การเลือกสายการบิน กระบวนการลำดับชั้นเชิงวิเคราะห์ การวิเคราะห์ความไว ผู้ขนส่งสินค้าทางอากาศ

Introduction

Air freight forwarder, as the servers to the shippers and the customers to the airlines, is a company involved in the service of shipping goods or cargo by air. Air freight forwarders play an important role in air cargo industry and in air cargo transport activity, in which "operations of air freight forwarders involve being entrusted with the shippers' cargo and at the same time, freight forwarders negotiate with airlines to transport their cargo to the required destination" (Chao, Lirn & Shang, 2013, p. 1672).

Today, there are many airlines and each airline has an incentive and offers for air freight forwarders to choose to use their own freight services. Air freight companies are often faced with the problem of choosing the best freight carrier (de Lima & Belderrain, 2016). One of key decisions in logistic management or freight management is the selection of the carrier or airline to move the firm's inbound and outbound freight (Meixell & Norbis, 2008). To freight forwarders, making a reasonable decision to select the 'best' airline can be considered as a strategic tool to gain the competitive advantages (Bhatnagar & Teo, 2009) including low operating costs, cost-effective operation, efficiency and operational agility, having the potential for quality performance, having lowtransportation costs, and reduce hidden costs or unnecessary expenses, etc.

Therefore, in making this decision, it should be based on a number of qualitative and quantitative factors. Managers typically consider multiple attributes (such as cargo safety, the speed of tracking the shipment, the availability of cargo space to support the transportation and the number of cargo flights that are sufficient to meet the needs), when making this decision, often focusing on cost and transit time as the primary criteria. However, as the cargo airline selection process often involves multiple criteria. Additionally, the importance of individual criteria often differs from company to company, and even within a company from one facility to the next (Meixell & Norbis, 2008).

Currently, many researchers have studied and developed a number of Multi-Criteria Decision Making--MCDM methods e.g. Weighted Sum Method--WSM, Weighted Product Method--WPM, Preference Ranking Organization Method for Enrichment Evaluation--PROMETHEE, The Elimination and Choice Translating Reality--ELECTRE, Analytic Network Process--ANP, and Analytic Hierarchy Process--AHP, etc. (Pohekar & Ramachandran, 2004). One of the effective MCDM methods, the most famous and widely used is the AHP method, because the AHP method has a hierarchical structure that mimics human thought processes, and AHP is ideal for making individual and group decisions. Besides, it is important to note that the views of or decision makers (managers) need to be taken into account while selecting the best airline to avoid bias.

Many studies apply AHP for several purposes, and some of them apply it in a specific context such as aviation industry context (see Mitsumoto & Somsuk, 2016; Polsuwan & Somsuk, 2016; Jeamjamroon & Somsuk, 2016; Jaroenphamin & Somsuk, 2018).

For the air freight forwarding business, an application of the AHP method in cargo airline selection, managers at different levels are required to make the decisions. However, high level managers tend to have a substantial amount of experience. Therefore, in case of equal importance of the managers, conducting sensitivity analysis via changing the weights of managers is needed in order to investigate the robustness of the AHP results.

In our previous works (Pookboonmee & Somsuk, 2020a; 2020b) have studied the appropriate criteria and their sub-criteria for the selection of air freight airlines from the view of a group of Thai experts in logistics, and the AHP model for selecting the best airline has been developed. In this study, we extend our prior work to cargo airline selection for the Bollore Logistics (Thailand) Co., Ltd., an air freight forwarder, in order to select the best airline based on the view of the company managers. Finally, this study conducts sensitivity analysis via changing criteria weights and changing the weights of experts in order to investigate the robustness of the ranking results as well.

Literature Review

Air cargo service and key players

The global air cargo industry has grown rapidly in recent decades and is now critical for the global economy. The global air cargo is an operation-intensive industry involving many participants and different specific operations. The participants include shippers, air freight forwarders, customs brokers, cargo terminals, ground handling services, and airlines (Chao, Lirn & Shang, 2013).

Airlines (or carriers) provide freight forwarders and shippers with services, including consultation, capacity booking, pickup, receiving, packaging, sorting, loading, transportation, dispatching, and cargo tracking and tracing. Table 1 summarizes the activities or operations of the key players in air cargo service (Feng, Li, & Shen, 2015). Air cargo transport is more complex than passenger transport because the former involves more players, more sophisticated processes, a combination of weight and volume, varied priority services, integration and consolidation strategies, and multiple itineraries of a network than the latter. The key differences between cargo and passenger operations have been highlighted in the literature (e.g., Bartodziej et al., 2009; Leung et al., 2009; Li et al., 2009; Wang & Kao, 2008). A summary is presented in the following.

Table 1

Activity/operation of key players in air cargo service.

Player	Activity/operation
Shipper	Make booking, Negotiate best rates, Select priority, Preparation of documents-customs, insurance, Track shipments, Accept billings and make payments, Place claims and repair changes
Forwarder	Make booking, Negotiate best rates, Select priority, Preparation of documents-customs, insurance, Track shipments, Accept billings and make payments, Place claims and repair changes, Booking acceptance, Bid for space-allotments, Distribution, Warehousing, Invoice shipper, Interact with multi-modal carriers, Massaging and transaction ability, Consolidation of shipments
Airline	Schedule cargo flight, Plan cargo routs Initialize and open flights for booking, Negotiate rates, Publish prices/rates, Provide distribution channels, Forecast cargo capacity, Segment and forecast cargo demand, Plan for no-show, cancellations and overbook, Set-up bid prices, Accept/reject shipments orders, Maximize revenue, Improve load factors, Track shipments, Accept bids from customers, Allocate cargo space-allotments, Resource management of terminal staff, Accept shipments tendered, Dangerous goods control, Package validation
Airports	Warehousing-storage, Customs, Security clearance, Dangerous goods control, Package validation, Notify captain, Facilitate smooth cargo operations
Consignee	Track shipments, Accept billings and make payments, Place claims and repair charges

Note. From Air cargo operations: Literature review and comparison with practices, by B. Feng, Y. Li and Z.-J. M. Shen, 2015, *Transportation Research Part C, 56*, p. 266. Copyright 2015 by Elsevier Ltd.

Criteria for selecting cargo airline

According to our previous work (Pookboonmee & Somsuk, 2020a), the appropriate criteria and their sub-criteria for the selection of air freight airlines from the view of a group of Thai experts in logistics has been studied as following: the preliminary six criteria and preliminary 32 sub-criteria were collected by reviewing relevant literature (e.g. Gardi, Sabatini & Ramasamy, 2016; de Reuck, Donald & Siemers, 2014; Updegrove & Jafer, 2017, etc.). All preliminary ones were then employed to assess their suitability for selecting best cargo airline, using data collected from an assessment form with 5-point Likert scale (1: least suitability, 5: most suitability), and asking for the opinions of a group of 30 experts, each having at least 8 years of experience in logistics, from 4 companies. The data were then analyzed with t-test at the significance level of 0.05. The results indicated that there were 6 suitable criteria (namely price, agility, reliability, ease of use, sociality, and process) and 22 suitable sub-criteria as shown in Table 2.

Table 2

Criteria and sub-criteria for selecting cargo airline in the view of Thai experts

Criteria	Sub-criteria (Code)
Price	Low price (P1), Variety rate (P2), Volume incentive (P3), Rate increase with lead time (P4)
Agility	Fast transportation time (A1), On time operation (A2), Global network (A3), Fast loading time at transit points (A4)
Reliability	Safety products (R1), Space during peak (R2), Cargo flights that enough or need (R3), Quick and proper action if any irregularity (R4), Accuracy of documents (R5)
Ease to use	Fast transportation time (E1), On time operation (E2), Global network (E3)
Sociality	Fast loading time at transit points (S1), Safety products (S2), Space during peak (S3)
Process	Service that meets customer needs (PC1), Service procedure standard and compliance (PC2), 24-hour information service center and problemsolving for customers (PC3)

Note. From The study of selection criteria for cargo airline. *In proceedings of Green ASIA and Sustainability Forum: BCG in Action; the New Sustainablie Growth Engine (Bio-Circular-Green Economy), 12 June 2020* (pp. 250-264), by V. Pookboonmee & N. Somsuk, 2020a. Pathum Thani: Eastern Asia University

Analytic Hierarchy Process

The AHP is a decision making procedure originally developed by Saaty (1977, 1980, 1986). Its primary use is to offer solutions to decision and estimation problems in multivariate environments. "The AHP establishes priority weights for alternatives by organizing objectives, criteria, and subcriteria in a hierarchic structure" (Bernasconi, Choirat & Seri, 2010, p. 699). AHP is a method used to solve complex multi-criteria decision making problems by giving systematic priority ranking (Wang, Sheng, Xi, & Ma, 2018). AHP is used to derive ratio scales from both discrete and continuous paired comparisons. These comparisons may be taken from actual measurements or from a fundamental scale which reflects the relative strength of preferences (Saaty, 1987, p. 161)

To make a decision in an organised way to generate priorities we need to decompose the decision into the following steps (Saaty, 2008).

1) Define the problem and determine the kind of knowledge sought.

2) Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).

3) Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.

The scale of importance is defined in Table 1 according to Saaty's nine-point scale for pairwise comparison. The nine-point scale is a scale of importance estimation ranging from equal to extreme importance: equal, moderate, strong, very strong and extreme importance. The numerical judgements corresponding to these linguistic descriptions are (1, 3, 5, 7, 9), with compromises (2, 4, 6, 8) between these judgements (Saaty & Vargas, 1998; Saaty, 1994) as shown in Table 3.

Table 3

AHP's fundamental scale according to Saaty (Saaty & Vargas, 1998; Saaty, 1994)

Intensity of importance on an absolute scale	Definition
1	Equal importance
3	Moderate importance of on over another
5	Essential or strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Intermediate values between the two adjacent judgements
Reciprocals	If activity i has one of the above numbers assigned to it when compare with activity j, then j has the reciprocal value when compared with i

4) Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority. The overall weight of each element with respect to the goal is then calculated by multiplying the local weight of an element by the weight of its preceding element. The judgements of each decision maker (expert) are finally synthesized using the geometric mean approach suggested by Saaty (Saaty, 1990).

Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtained.

The generalized algorithm of the AHP is represented in Fig. 1.

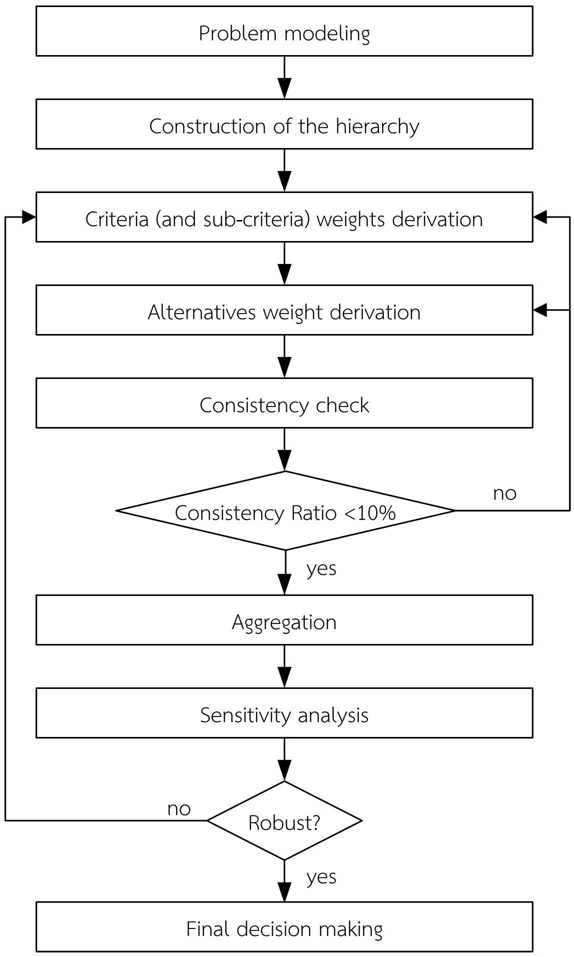

Fig. 1 Algorithm of the AHP

Note. Adapted from A research of procedures used in the analytic hierarchy process and visualization in sensitivity analysis, by V. V. Kotova, 2016, *Scientific Visualization, 8*(2), p. 59-84. Copyright 2016 by National Research Nuclear University "MEPhI"

Sensitivity analysis

In model building using the AHP, sensitivity analysis is a crucial step in determining if the solution is implementable and robust (Saaty & Vargas, 2013). A sensitivity analysis involves changing the weight values and calculating the new solution. In this study, sensitivity analysis via changing criteria weight values and changing the weight values of experts has been conducted in order to investigate the robustness of the ranking results.

Aggregation Methods in Group Decision Making based on AHP

For an effective the alternaive selection, by applying AHP to a multi criteria decision making (MCDM) model, the alternatives in group decision making will be assessed. To combine the preferences into a consensus rating based on AHP, there are two ways: aggregation of individual judgments (AIJ) and aggregation of individual priorities (AIP) (Dong, Zhang, Hong & Xu, 2010).

Consider an AHP group decision making problem. Let $D = \{ d_1, d_2, ..., d_m \}$ be the set of decision makers, and $\lambda = \{ \lambda_1, \lambda_2, ..., \lambda_m \}$ be the weight vector of decision makers, where

$$\lambda_k > 0, k = m, \sum_{k=1}^{m} \qquad (1)$$

Let $A^{(k)} = (a_{ij}^{(k)})_{nxn}$

be the judgment matrix provided by the decision maker d_k $(k = 1,2,....., m)$

As mentioned above, two of the methods that have been found to be the most useful in AHP group decision making are AIJ and AIP. In AIJ and AIP, the weighted geometric mean method is generally used as the aggregation procedure.

(1) The Aggregation of Individual Judgments–AIJ

For AIJ, the decision makers use the weighted geometric mean method to aggregate

Research Methodology

The study was based on the data collected from a previous study in 2019 in the Bollore Logistics (Thailand) Co., Ltd. In this study, we extend our prior works on determining the criteria for selecting the optimal cargo airline from the perspective of Thai experts individual judgement matrices to obtain a collective judgement matrix,

$$A^{(c)} = (a_{ij}^{(c)})_{nxn}$$, where

$$a_{ij}^{(c)} = \prod_{k=1}^{m} (a_{ij}^{(k)})^{\lambda_k}$$

Then, we use certain prioritization method to derive a collective priority vector

$w^{(c)} = (w_1^{(c)}, w_2^{(c)}, ..., w_n^{(c)})^T$ from $A^{(c)}$ to order the alternatives.

(2) The Aggregation of Individual Priorities --AIP Let $w^{(k)} = (w_1^{(k)}, w_2^{(k)}, ..., w_n^{(k)})^T$ be the individual priority vector derived from individual judgment matrix $A^{(k)}$ using certain prioritization method. Then, the collective priority vector obtained using AIP is using certain prioritization method. Then, the collective priority vector obtained using AIP is $w^{(c)} = (w_1^{(c)}, w_2^{(c)}, ..., w_n^{(c)})^T$, where,

$$w^{(c)} = \frac{\prod_{k=1}^{m} (w_i^{(k)})^{\lambda_k}}{\sum_{i=1}^{m} \prod_{k=1}^{m} (w_i^{(k)})^{\lambda_k}}$$

(Pookboonmee & Somsuk, 2020a) and selecting the best cargo airline with regard to multiple criteria decision alternatives through three groups of decision makers including managers, head officers, and operators (Pookboonmee & Somsuk, 2020b). However, this current study, we focus on the view of managers who are key decision makers in selecting the carrier or airline. We have applied our AHP model for selecting the best airline (in Fig. 2) (Pookboonmee & Somsuk, 2020b) to the Bollore Logistics (Thailand) Co., Ltd., a freight forwarder in order to select the 'best' airline through the view of the managers, and conducting sensitivity analysis via changing criteria weights and changing the weights of experts in order to investigate the robustness of the ranking results. The Bollore Logistics (Thailand) Co., Ltd. has three alternative airlines: X, Y, and Z airlines. All of these airlines provide export and import services on carriers and routes, to and from Thailand.

In this study, a spreadsheet program, Excel, was used to perform the calculations.

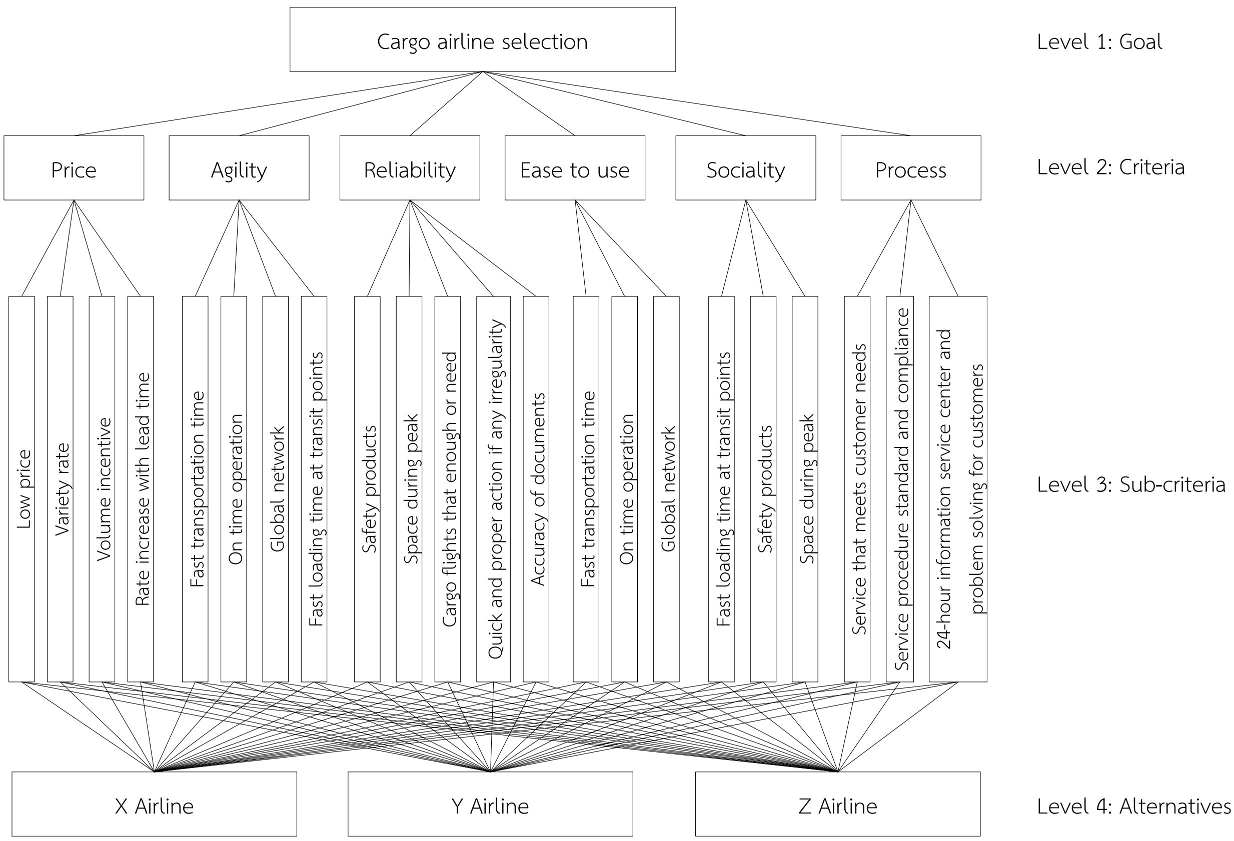

Fig. 2 The hierarchical structure for selecting the best cargo airline

In the current study, the research methodology was divided into three phases as follows:

The first phase, a key decision maker identification phase, this phase involved an identification of key stakeholders who would be directly or indirectly affected by the Bollore Logistics (Thailand) Co., Ltd.

The second phase, an application of the developed model (in Fig. 2) is conducted by applying it to the Bollore Logistics (Thailand) Co., Ltd. A group-based computation phase where a certain priority of each factor was computed based on the data collected from a previous study (Pookboonmee & Somsuk, 2020b) and their judgments were aggregated into a consensus rating was conducted through the geometric mean of judgments. In this phase, an AHP was applied to the Bollore Logistics (Thailand) Co., Ltd. to determine the airline weights and then select the best one from the manager point of view.

The last phase, a sensitivity analysis phase: changing criteria weights and changing the weights of experts in order to investigate the robustness of the ranking results are conducted.

Results and Discussions

A result of key decision maker identification

In this phase, four managers of the company were selected, in which their average professional experience in the freight forwarding business was 20.00 years with standard deviation of 5.29.

Results of applying AHP

The criteria, sub-criteria and airlines rankings by using AHP in the view of managers in the Bollore Logistics (Thailand) Co., Ltd. are shown in Table 4.

Table 4

Criteria, sub-criteria and airlines rankings by using AHP in the view of managers in the Bollore Logistics (Thailand) Co., Ltd.

Criteria	Weig	Ranking	Sub-criteria	Local Weight	Overall Weight	Ranking	Overall Weights		
							X	Y	Z
Price	0.424	1	Low price	0.260	0.110	2	0.542	0.152	0.305
			Variety rate	0.382	0.162	1	0.279	0.322	0.399
			Volume incentive	0.192	0.081	4	0.315	0.411	0.274
			Rate increase with lead time	0.166	0.070	5	0.710	0.158	0.132
Agility	0.096	4	Fast transportation time	0.277	0.027	15	0.647	0.187	0.165
			On time operation	0.357	0.034	9	0.618	0.147	0.235
			Global network	0.211	0.020	20	0.392	0.358	0.249
			Fast loading time at transit points	0.156	0.015	21	0.345	0.262	0.394

Table 4 (continue)

Criteria	Weig	Ranking	Sub-criteria	Local Weight	Overall Weight	Ranking	Overall Weights		
							X	Y	Z
Reliability	0.167	2	Safety products	0.371	0.062	6	0.625	0.154	0.222
			Space during peak	0.133	0.022	17	0.476	0.193	0.331
			Cargo flights that enough for need	0.169	0.028	13	0.408	0.236	0.356
			Quick and proper action if any irregulation	0.200	0.033	10	0.478	0.229	0.293
			Accuracy of documents	0.127	0.021	19	0.471	0.201	0.328
Ease of use	0.085	5	Easy tracing	0.319	0.027	14	0.425	0.249	0.326
			Easy booking	0.299	0.025	16	0.389	0.253	0.358
			Partnership	0.382	0.032	11	0.669	0.203	0.129
Social	0.072	6	Image	0.301	0.022	18	0.674	0.203	0.123
			Various promotion	0.124	0.009	22	0.275	0.330	0.396
			Government certification	0.575	0.041	7	0.400	0.256	0.344
Process	0.157	3	Service that meets customer needs	0.240	0.038	8	0.515	0.268	0.218
			Service procedure standard and compliance	0.558	0.088	3	0.375	0.180	0.445
			24-hour information service center and problem solving for customers	0.202	0.032	12	0.531	0.201	0.267
			Overall Priority Weight				0.464	0.237	0.299
			Ranking				1	3	2

Results of a sensitivity analysis

1 A sensitivity analysis via changing criteria weights

A sensitivity analysis was carried out by exchanging the weights of two criteria among themselves, while the weights of other criteria remain unchanged (Gumus, 2009; Hussain, Mandal & Mondal, 2018; Önüt, Kara & Isik, 2009) to analyze how changing the criteria weights influence on the ranking results. In this study, since there were five criteria, therefore, fifteen combinations were analyzed for the sensitivity analysis, in which each combination stated as a Scenario (S). Different names were given for each calculation. For example, the 'C1-2' meant that the weights of the 1st and 2nd criteria were switched (while the weights of the 3rd, 4th, 5th, and 6th criteria remained the same), and this new scenario was named 'S1'. The weights of alternatives were re-calculated, and then, the alternatives were re-ranked for each scenario, and finally graphically presenting how the overall ranking of airline alternatives changes. The results of sensitivity analysis are shown in Table 5 and Fig. 3.

Table 5

A sensitivity analysis results by exchanging the weights of two criteria

Scenarios		Alternatives		
		X Airline	Y Airline	Z Airline
S0 (Basic Scenario)	No-Change Scenario	0.464	0.237	0.299
S1	C1-2	0.500	0.221	0.279
S2	C1-3	0.488	0.218	0.294
S3	C1-4	0.492	0.225	0.283
S4	C1-5	0.479	0.230	0.291
S5	C1-6	0.468	0.220	0.312
S6	C2-3	0.465	0.239	0.296
S7	C2-4	0.464	0.237	0.299
S8	C2-5	0.462	0.237	0.300
S9	C2-6	0.470	0.238	0.292
S10	C3-4	0.463	0.240	0.297
S11	C3-5	0.459	0.242	0.299
S12	C3-6	0.463	0.237	0.300
S13	C4-5	0.464	0.237	0.299
S14	C4-6	0.469	0.239	0.292
S15	C5-6	0.466	0.240	0.293

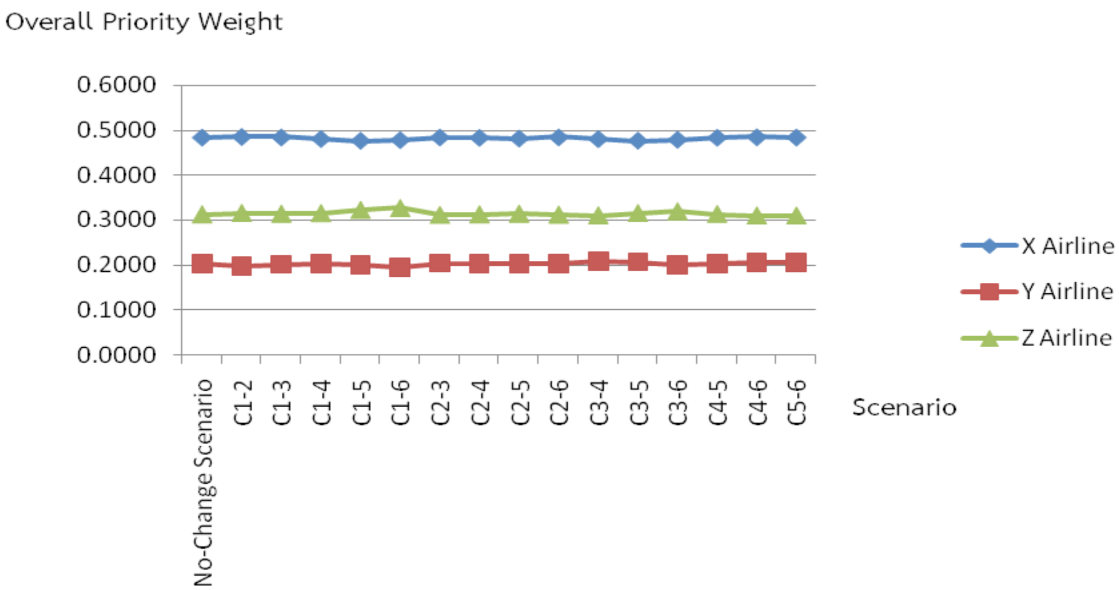

Fig. 3 Sensitivity analysis of ranking results when the weights of two criteria were exchanged

2. A sensitivity analysis via changing the weights of experts

Besides, a sensitivity analysis of the group weights was also applied to study the effects of differences on the importance of the expert groups. To achieve this, a sensitivity analysis was performed with different scenarios. In this study, fourteen different scenarios (different weights) as following; 1st manager: 2nd manager: 3rd manager: 4th manager weight ratios = 2:1:1:1, 1:2:1:1, 1:1:2:1, 1:1:1:2, 2:2:1:1, 2:1:2:2, … and 1:2:2:2, were assumed. Each weight (importance) ratio of four experts stated as a scenario (S). For example, the '2:1:1:1' meant that the weight of 1st manager is two times important than the other managers, while 2nd manager, 3rd manager, and 4th manager are equally important. This new scenario was named 'S1'. After combining the preferences into the consensus rating for an overall analysis by using the Aggregation of Individual Judgments--AIJ and the Aggregation of Individual Priorities--AIP (Dong, Zhang, Hong, & Xu, 2010), the weight of four experts taken into account was then changed. After that, the weights of airline alternatives were re-calculated by using AHP approach, and then, the alternatives were re-ranked for each scenario, and graphically presenting how the overall ranking of airline alternatives changes. The results of sensitivity analysis are shown in Table 6 and Fig. 4.

Table 6

A sensitivity analysis results by exchanging the weights of two criteria

Scenarios		Overall Priority Weight					
		AIJ			AIP		
		X Airline	Y Airline	Z Airline	X Airline	Y Airline	Z Airline
S0 (Basic Scenario)	1:1:1:1	0.464	0.237	0.299	0.470	0.232	0.298
S1	2:1:1:1	0.436	0.245	0.319	0.444	0.238	0.318
S2	1:2:1:1	0.455	0.239	0.306	0.461	0.235	0.305
S3	1:1:2:1	0.473	0.229	0.298	0.477	0.227	0.297
S4	1:1:1:2	0.493	0.233	0.274	0.496	0.229	0.274
S5	2:2:1:1	0.434	0.246	0.320	0.442	0.240	0.318
S6	2:1:2:1	0.448	0.237	0.316	0.453	0.232	0.314
S7	2:1:1:2	0.465	0.241	0.294	0.471	0.235	0.294
S8	1:2:2:1	0.463	0.233	0.304	0.467	0.230	0.303
S9	1:2:1:2	0.480	0.235	0.285	0.484	0.232	0.284
S10	1:1:2:2	0.496	0.227	0.277	0.498	0.225	0.277
S11	2:2:2:1	0.443	0.239	0.317	0.450	0.235	0.316
S12	2:2:1:2	0.458	0.243	0.299	0.465	0.236	0.298
S13	2:1:2:2	0.471	0.235	0.294	0.476	0.230	0.294
S14	1:2:2:2	0.484	0.230	0.286	0.487	0.228	0.285

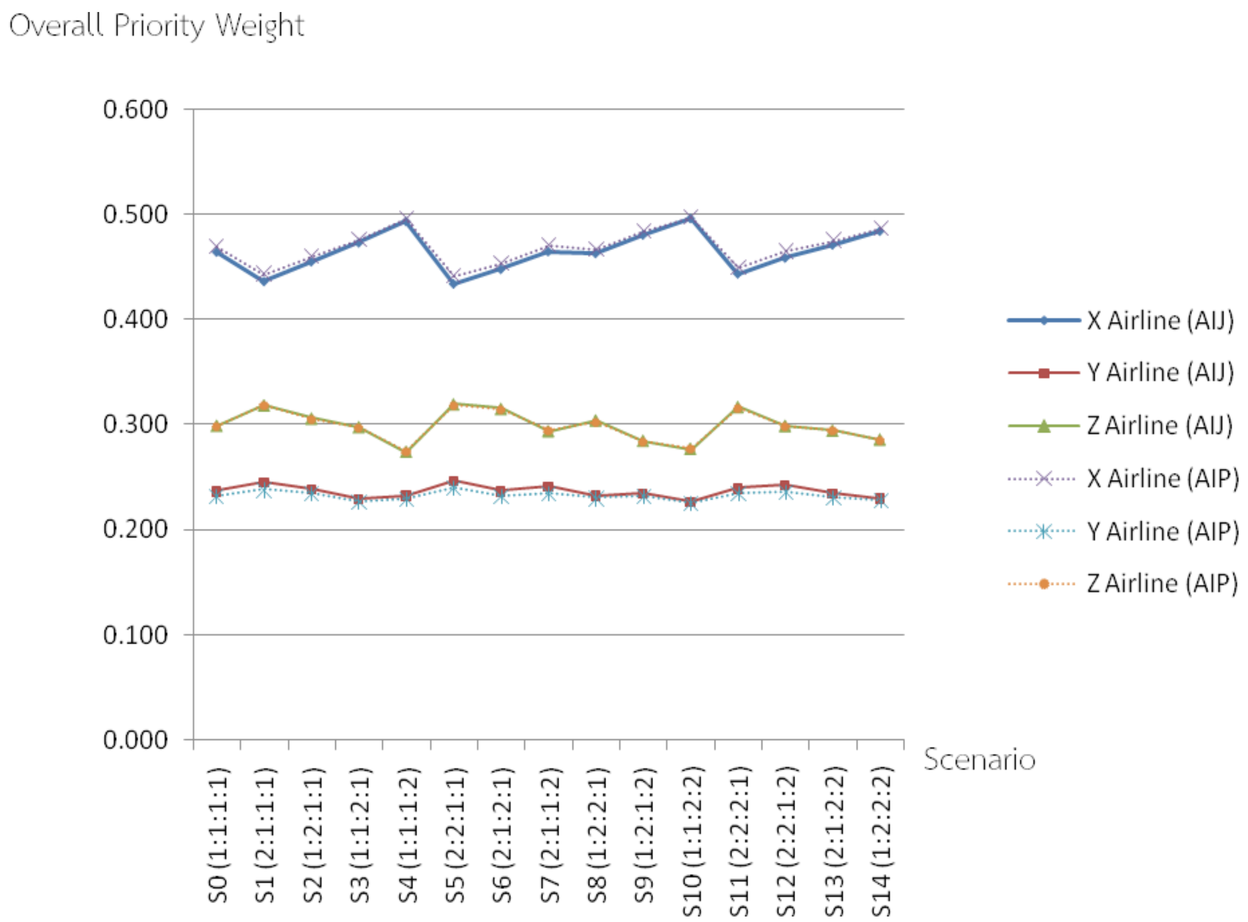

Fig. 4 A sensitivity analysis of ranking results when the weights of (importance) ratio of four experts were changed

Based on Fig. 3, the graphical results of a sensitivity analysis by changing the weight values of criteria showed that the overall rankings of airline alternatives are the same across all scenarios, as same as the graphical results of a sensitivity analysis by changing the weight values of experts in Fig. 4, the overall rankings of airline alternatives of all scenarios have similar patterns in the two aggregation methods: AIJ and AIP.

Conclusions

Based on the AHP results (Table 4), from the freight manager's point of view, the most important criterion is "price" followed by "reliability" with the overall weights of 0.424 and 0.167, respectively. The most important sub-criterion is "variety rate" followed by "low price" with the overall weights of 0.162 and 0.110, respectively, while the best airline is the X Airline with the overall weight of 0.464.

For the price criterion, not only the low price, but also the variety rate and volume incentive are considered as the most important sub criteria respectively. For the reliability criterion: shipping goods safely is very important, followed by shipping goods with quick and proper action if any irregulation.

For the price criterion, not only the low price, but also the variety rate and volume incentive are considered as the most important sub criteria respectively. For the reliability criterion: shipping goods safely is very important, followed by shipping goods with quick and proper action if any irregulation.

According to Table 5, the sensitivity analysis results by exchanging the weights of two criteria, the rankings of all scenarios have quite similar patterns as same as shown in Fig. 3, and the results by changing the weights of importance of four experts (Table 6), the rankings of all scenarios also have quite similar patterns (both AIJ and AIP) as shown in Fig. 4. It can be concluded that there is the robustness of the ranking results. Therefore, the AHP model is suitable to apply to the Bollore Logistics (Thailand) Co., Ltd. for the selection of freight airlines.

The results obtained from this research are practical in the current situation since the application of AHP to select the best cargo airline was based on literature reviews and inquiring of company experts, or even conducting sensitivity analysis. In case there are more alternative airlines or the selection criteria have been changed, the company can adapt the AHP model (Fig. 2) to calculate the new solution in order to comply with the changing situation/environment.

References

Anggorowati, A. (2017). The evaluation of freight forwarding business existences. *Advances in Engineering Research (AER), 147*, 714-726. https://doi.org/10.2991/grost-17.2018.62

Bernasconi, M., Choirat, C., & Seri, R. (2010). The Anatytic Hierarchy Process and the theory of measurement. *Management Science, 56*(4), 699-711. https://doi.org/10.1287/mnsc.1090.1123

Chao, C.-C., Lirn T.-C., & Shang, K.-C. (2013). Market segmentation of airline cargo transport. *The Service Industries Journal, 33*(15-16), 1672-1685. doi: 10.1080/02642069.2011.638920.

de Lima, M. G., & Belderrain, M. C. N. (2016). Structuring multicriteria model for airports selection for cargo airlines exclusively. *Ingeniare. Revistachilena de ingeniería, 24*(3), 465-479. http://dx.doi.org/10.4067/S0718-33052016000300011.

de Reuck, S., Donald, F., & Siemers, I. (2014). Factors associated with safety events in air traffic control. *Ergonomics SA: Journal of the Ergonomics Society of South Africa, 26*(1), 2-18.

Dong, Y., Zhang, G., Hong, W.-C., & Xu, Y. (2010). Consensus models for AHP group decision making under row geometric mean prioritization method. *Decision Support Systems, 49*(3), 281–289. https://doi.org/10.1016/j.dss.2010.03.003

Feng, B., Li, Y., & Shen, Z.-J. M. (2015). Air cargo operations: Literature review and comparison with practices. *Transportation Research Part C, 56*, 263-280. https://doi.org/10.1016/j.trc.2015.03.028.

Gardi, A., Sabatini, R., & Ramasamy, S. (2016). Multi-objective optimisation of aircraft flight trajectories in the ATM and avionics context. *Progress in Aerospace Sciences, 83,* 1-36. http://dx.doi.org/10.1016/j.paerosci.2015.11.006.

Jaroenphamin, P., & Somsuk, N. (2018). A selection of baggage handling error reduction projects using root cause analysis integrated with Analytic Hierarchy Process method. *EAU Heritage Journal Science and Technology, 12*(1), 110-120. (in Thai)

Jeamjamroon, S., & Somsuk, N. (2016). Key success factors for flight operations of Nok Airlines. *EAU Heritage Journal Science and Technology, 10*(2), 160-174. (in Thai)

Kotova, V. V. (2016). A research of procedures used in the analytic hierarchy process and visualization in sensitivity analysis. *Scientific Visualization, 8*(2), 59-84. http://sv-journal.org/2016-2/06/en/index.php?lang=en

Meixell, M. J., & Norbis, M. (2008). A review of the transportation mode choice and carrier selection literature. *The International Journal of Logistics Management, 19*(2), 183–211. doi: 10.1108/09574090810895951.

Mitsumoto, N., & Somsuk, N. (2016). Prioritizing the critical success factors for the cabin crew's training. *EAU Heritage Journal Science and Technology, 10*(1), 205-222. (in Thai)

Pohekar, S., & Ramachandran, M. (2004). Application of Multi-Criteria Decision Making to Sustainable Energy Planning-A Review. *Renewable and Sustainable Energy Reviews, 8*(4), 365-381. https://doi.org/10.1016/j.rser.2003.12.007.

Polsuwan, L., & Somsuk, N. (2016). Service quality development for low cost airline. *EAU Heritage Journal Science and Technology, 10*(3), 147-163. (in Thai)

Pookboonmee, V., & Somsuk, N. (2020a). The study of selection criteria for cargo airline. *In proceedings of Green ASIA and Sustainability Forum: BCG in Action; the New Sustainable Growth Engine (Bio-Circular-Green Economy), 12 June 2020* (pp. 250-264). Pathum Thani: Eastern Asia University (in Thai)

Pookboonmee, V., & Somsuk, N. (2020b). Multi-criteria decision making to select optimal cargo airline for air freight forwarder. *In proceedings of Green ASIA and Sustainability Forum: BCG in Action; the New Sustainable Growth Engine (Bio-Circular-Green Economy), 12 June 2020* (pp. 265-279). Pathum Thani: Eastern Asia University. (in Thai)

Saaty, T. L. (1980). *The Analytic Hierarchy Process: Planning, priority setting, resource allocation.* New York: McGraw-Hill.

Saaty, T. L., & Vargas, L. G. (2013). *Decision making with the analytic network process. International Series in Operations Research & Management Science* (2nd ed.). New York: Springer US. doi: 10.1007/978-1-4614-7279-7

Saaty, T.L. (2008). Decision making with the Analytic Hierarchy Process. *International Journal of Services Sciences, 1*(1), 83–98. https://doi.org/10.1504/IJSSCI.2008.017590

Updegrove, J. A., & Jafer, S. (2017). Optimization of air traffic control training at the federal aviation administration academy. *Aerospace, 4*(4), 50. https://doi.org/10.3390/aerospace4040050

Wang, S., Sheng, Z., Xi, Y., & Ma, X. (2018). The application of the Analytic Hierarchy Process and a new correlation algorithm to urban construction and supervision using multi-source government data in Tianjin. *International Journal of Geo-Information, 7*(2), 1-14. doi: 10.3390/ijgi7020050

Wu, S. (2003). *The study of consolidation decision problems for air cargo forwarders* (Doctoral dissertation). Institute of Transportation Technology and Management, National Chiao Tung University. Chiao Tung.