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Air Transport Projects Quality Assessments by Analytical Hierarchy Process (AHP)

The complex environment of aviation created dynamic air transport systems where the quality is vulnerable and directly sensitive to the supply side due to the high strategic level of driven market environments. The significance of quality quantifications has grown rapidly. Calculating quality factors is not a simple task, due to the heterogeneous, inseparable and incomprehensible characteristics of the system. For this purpose, the analytical hierarchy process (AHP) survey was distributed among two groups of 22 experts of pilots and ATCOs and applied by creating a three-level hierarchy model of the air transport supply quality to evaluate and weigh the critical characteristics. In the hierarchical structure, 4 main criteria, 15 first-level sub-criteria, and 12 second-level sub-criteria were used for the air transport supply quality model.

Keywords: *air transport, supply quality, multi-criteria decision-making, analytical hierarchy process, pilot, ATCO*

1. Introduction

The rise and development of the aviation world has enormous effects on each stakeholder (airlines, airports, air traffic management [ATM], aircraft manufacturers, and so on) in the air transport system, which are reflected in the real state of the system [1] and operator (pilots, air traffic controllers [2] in general, includes the environmental safety and security considerations, and cost/cost-benefit analysis of the used sources. As usual, the impact is evaluated at two levels: However, it appears insignificant when considering how aviation operators, [3] the tasks of operators (drivers, pilots, air traffic controllers, production process managers and their adaptation to the change of the main role affects the air transport supply quality process.

The importance of quality measurement in attaining organisational performance cannot be stressed enough [4]. The evaluation of system quality is crucial for determining an organisation's success or failure [5], [6]. As a result, traditional measures employ cardinal or ordinal scales to assess a system's quality [7].

The Analytic Hierarchy Process (AHP), a well-recognised Multi-Criteria Decision-Making (MCDM) tool for multiple objective ranking procedure and an outstanding way for dealing with sophisticated decision-making, is one of the approaches for determining supply quality [8], [9]. Many complex decision-making issues are solved using the AHP technique [10]. Administration, industry, manufacturing, health care and education are all places where AHP is applied. According to the decision-makers' pairwise comparisons of the criteria, AHP creates a weight for each assessment criterion.

Greater weights represent greater significance levels. AHP allocates a score to each preference according to the decision-makers' pairwise comparisons of the options based on that criterion.

During the last three decades, researchers have used AHP analysis which varies in terms of the theoretical background, questions type and the findings. Recently, the best compromised options have been selected through different real situations of the specific investigation. The approaches have been employed regularly by the decision-makers to prioritise the important parameters or norms, reduce uncertainty and improve the quality of decisions. Accordingly, for the practical purposes MCDM approaches have been proposed to solve problems.

Many previous studies employed AHP in aviation, Chao [11] dimensions and criteria for selecting a strategic cargo alliance were first collected and then screened using the Fuzzy Delphi Method (FDM) evaluated the quality service offered by the international air transport industry. The results indicate that reliability and assurance are major criteria for assessing the quality of service in this industry. Rezaei [12] studied the criteria used in selecting an appropriate retailer for the airline industry by showing conflicting quantitative and qualitative criteria in arriving at the criteria for the selection of a retailer. The most important criteria determined by the study in selecting a retailer is financial stability. Zietsman and Vanderschuren [13] evaluated and analysed the development of a multi-airport by studying the territorial competitiveness factor in airport development rather than infrastructure and economic activities. According to the results, Cape Town City requires a single-airport system up until the volume of passengers increases beyond the current 27 million annually. Bruno [14] highlighted service quality, attention on the customer and environmental impact in aircraft evaluation. The study determined that the most important factor in airlines is the size cabin luggage compartment.

Other AHP studies were designed for aviation operators, such as Oktal and Onrat [15], who employed AHP to characterise the essential criteria in the selection of airline pilot candidates by incorporating a Fuzzy Analytic Hierarchy Process (FAHP) into the Human Factors Analysis and Classifying System framework. Havle and Kılıç [16] determined and studied the circumstances that affect navigation mistakes in the North Atlantic Region. Kılıç and Ucler [17] used AHP Techniques to assess stress variables in student pilots.

The goal of the study is to evaluate the elements that influence the supply side of the aviation sector from the aviation operators' side. The current study examines the preferences of the two experts' groups based on the primary criteria. To create a general hierarchical model, the Analytic Hierarchy Process (AHP) is employed. These decision-making models are primarily built on three layers to develop evaluator preference loads for 1. the assessment procedure; 2. preventing complication; and 3. lacking information from other AHP functions. In this study, the Saaty Scale was utilised for scoring to depict lost data utilising matrices that could be computed using a particular technique. The rest of the paper is organised as follows: the applied methodology is introduced and explained in detail, then, the most significant results are illustrated mathematically and graphically, and lastly the essential aspects and criteria of the study are highlighted and how to deal with them in such circumstances.

2. Method

AHP is a strategy for organising and analysing complicated decisions firstly created by Thomas L. Saaty in the 1980s which is grounded on a mathematical and psychological basis [18]. When a choice is made, AHP provides an objective mathematic strategy for altering the personal priorities of an individual or a group [19].

Essentially, AHP works by establishing criteria for assessing priorities and alternatives. AHP is a decision-making and forecasting approach that provides percentage distributions of choice points in terms of influencing factors, which may be utilised to define the decision hierarchy.

AHP depends on individual benchmarks of a decision hierarchy, applying a predefined assessment scale like the Saaty Scale, containing the influences that impact decision-making and, if necessary, the importance of the decision points in relation to the factors that alter the decision. Therefore, variations in significance are converted into mathematical percentages on decision points. The steps to be taken to resolve a decision-making problem with AHP are summarised in Figure 1.

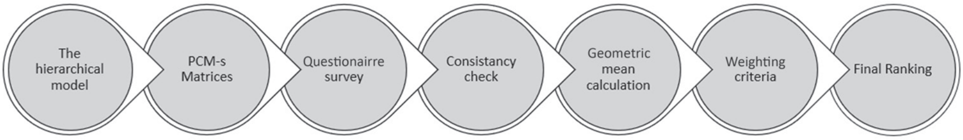

Figure 1
The steps of applying the AHP method [Authors]

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & . & . & a_{1j} & . & . & a_{1n} \\ \frac{1}{a_{12}} & 1 & . & . & a_{2j} & . & . & a_{2n} \\ . & & . & & & & & . \\ . & & & . & & & & . \\ \frac{1}{a_{1j}} & \frac{1}{a_{2j}} & . & . & a_{ij} & . & . & a_{in} \\ . & . & & & & . & & . \\ . & . & & & & & . & . \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & . & . & \frac{1}{a_{in}} & . & . & 1 \end{bmatrix} \quad (1)$$

Table 1
Saaty Scale [20]

Numerical values	Verbal scale	Explanation
1	Equal importance of both elements	Two elements contribute equally
3	Moderate importance of one element over another	Experience and judgment favour one element over another
5	Strong importance of one element over another	An element is strongly favoured
7	Very strong importance of one element over another	An element is very strongly dominant
9	Extreme importance of one element over another	An element is favoured by at least an order of magnitude
2, 4, 6, 8	Intermediate values	Used to compromise between two judgments

Firstly, developing the hierarchical model is based on the significant characteristics and aspects from the supply side of air transportation. Figure 2 displays the model with the components of each level.

The second step after building the conceptual model is creating the pairwise matrices, because the AHP makes use of the unique properties of pairwise comparison matrices (PCM). The intensity of the decision-makers' preference between specific pairs of options (A_i versus A_j, for all i, j = 1, 2,…, n) is represented in the matrix $A = [a_{ij}]$ illustrated in equation 1. They are commonly picked from a set of scales, such as the Saaty Scale (Table 1). If all of the components of matrix A are positive, transitive and reciprocal, it is said to be consistent [20], [21].

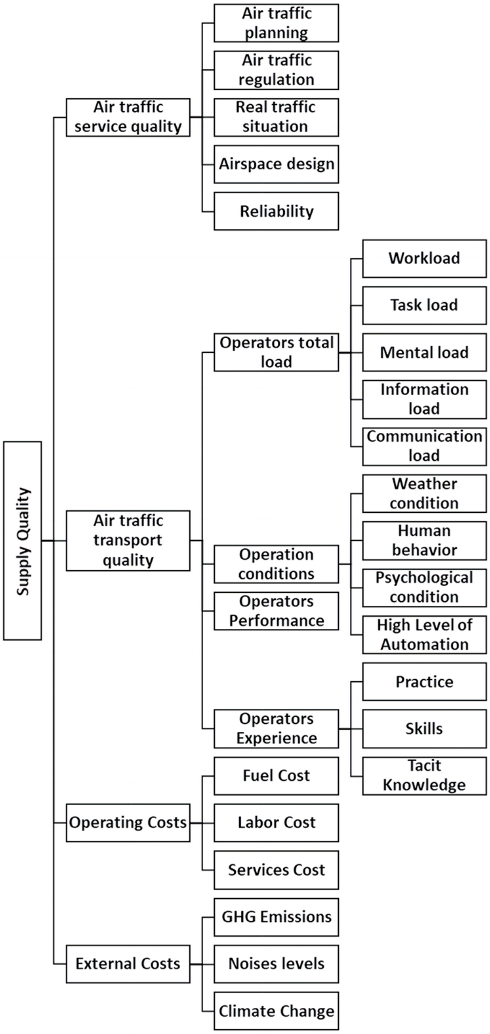

Figure 2
The hierarchical model [Authors]

An online AHP based survey was designed and distributed among pilots and Air Traffic Controllers (ATCOs), focused on the major characteristics of the air transport supply quality from various perspectives. The purpose of the questionnaire is to quantify the most important issues as seen through the eyes of the aviation operators since it could highlight different perspectives than that of the stakeholders, based on their experience and knowledge. The participants were arranged into two groups; there were 22 participants (8 females), 11 pilots, and 11 ATCOs. Because most experience matrices are inconsistent, the matrix consistency ratio (CR) should be smaller than 0.1. For each group, the CR is determined.

The geometric mean of each group was used to prioritise the influence of each feature in the model within the same level, using pairwise comparison matrices.

Calculating the normalisation term for a weight for a linked element such that the weights' components ultimately add up to 1. The aggregated eigenvector is then used to calculate the final score.

3. Results and discussion

After analysing and visualising the participants' opinions on the development of the air transportation system supply quality side, it is obvious that there will be some differences between the expert groups' perspectives due to differences in experience and understanding the real situation and its development in a more detailed way; however, the AHP method will give more consciousness and enlightenment about air transportation development based on pairwise comparisons than using the simple method. The geometric mean was used to aggregate the responses, as stated in the methodology. Tables 2 and 3 show the aspects (weights and consistency ratios) that have been computed for the first level in the air transport supply quality model characteristics from each group.

Table 2
First group air transport supply quality criteria [Authors]

First group					
Air transport supply quality	**Air traffic service quality**	**Air traffic transport quality**	**Operating costs**	**External costs**	**Weights**
Air traffic service quality	1.00	3.14	1.43	1.05	35.96%
Air traffic transport quality	0.32	1.00	1.31	0.74	18.20%
Operating costs	0.70	0.76	1.00	1.17	21.41%
External costs	0.95	1.36	0.85	1.00	24.43%
CR = 0.0579	Sum				100%

Table 3
Second group air transport supply quality criteria [Authors]

Second group					
Air transport supply quality	**Air traffic service quality**	**Air traffic transport quality**	**Operating costs**	**External costs**	**Weights**
Air traffic service quality	1.00	2.75	1.36	1.00	34.38%
Air traffic transport quality	0.36	1.00	0.98	0.97	18.72%
Operating costs	0.73	1.02	1.00	1.15	23.10%
External costs	1.00	1.03	0.87	1.00	23.80%
CR = 0.0380	Sum				100%

The results revealed that service quality had a significant influence in the decision-making process, impacting both groups' views significantly. Since service quality is the most crucial component in both sides' evaluations (see Figure 3), service quality may determine the real state of the air transportation system and the types of transportation projects that will have a significant impact on the system's economic development goals, such as performance, productivity, business activity and investment.

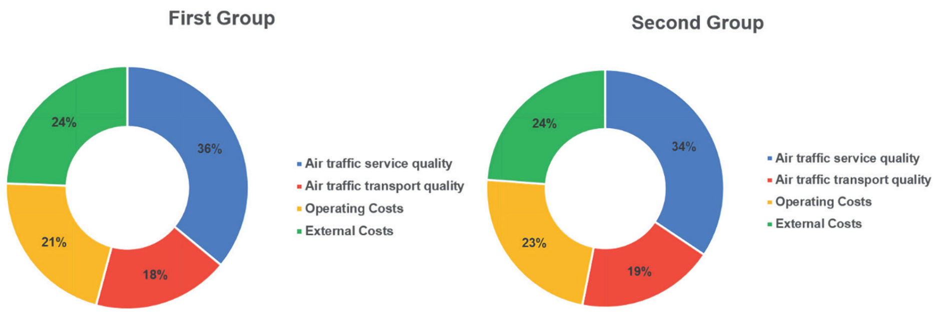

Figure 3
The hierarchical model first level criteria weights, first group and second group [Authors]

Combining the two groups' opinions together would show the variation due to the experience level and the job type (see Figure 4).

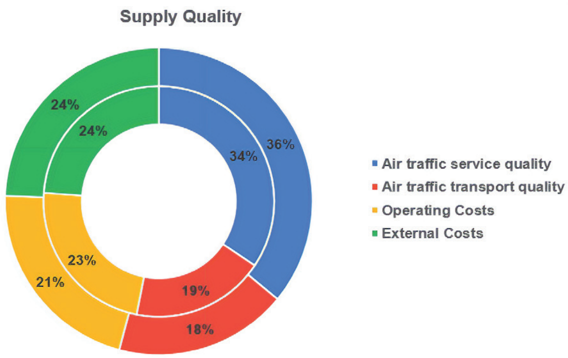

Figure 4
Air transport supply quality first level for both groups [Authors]

Looking into the second level of the model (see Figure 5) for the sub-criteria of the service quality also provides a clear overview of the specific issue from the pilots' and ATCOs' perspectives which are the reliability of the system and the real traffic situation, yet it is complicated to control the level of the criteria due to the dynamic nature of the system.

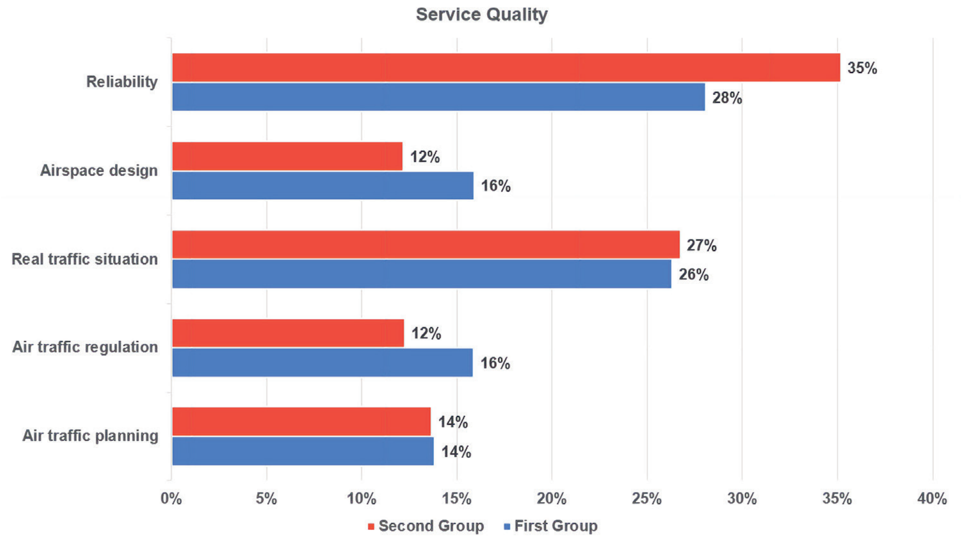

Figure 5
Air transport service quality for both groups [Authors]

4. Conclusion

The results showed the weighting percentages and scaling of the characteristics of the air transport supply quality model at each level of the hierarchy, which is a key measure of the critical component. Employing multi-criteria methods, notably AHP, played a vital role in gaining a better knowledge of the prospective environment and managing various perspectives. The discrepancies between the views are demonstrated using quantitative and qualitative criteria, as well as the conventional, classic and simplified analytical hierarchical process (AHP) decision-making approach.

The results of this questionnaire were based on 22 participants from two categories of aviation operators (pilots and ATCOs); however, the results may alter if more respondents and groups were included.

From both sides of the participants' perspectives, the results suggest that service quality is the most important factor in the air transport supply quality model, followed by external costs.

It should be mentioned that covering more numbers and groups of the operators would give a general illustration of the current situation and highlight the critical elements more accurately.

Further studies using different methods of MCDM could show more specific issues, like using the Analytical Network Process (ANP) which could show how each criterion and sub-criteria could affect each other on different levels.

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Légiközlekedési projektek minőségértékelése analitikai hierarchia eljárással (AHP)

A légi közlekedés komplex környezete dinamikus légiközlekedési rendszereket hozott létre, ahol a minőség sérülékeny és közvetlenül a kínálati oldalra érzékeny a vezérelt piaci környezet magas stratégiai szintje miatt. A minőségi számszerűsítések jelentősége gyorsan megnőtt. A minőségi tényezők kiszámítása nem egyszerű feladat, a rendszer heterogén, elválaszthatatlan és értelmezhetetlen jellemzői miatt. Ebből a célból az analitikus hierarchia folyamat (AHP) felmérést két, összesen 22 fős, pilótákból és ATCO-kból álló szakértői csoport között osztották ki, és a légi szállítás minőségének háromszintű hierarchia modelljének létrehozásával alkalmazták a kritikus jellemzők értékelésére és mérlegelésére. A hierarchikus felépítésben a légiközlekedési ellátás minőségi modelljénél 4 fő kritériumot, 15 első szintű alkritériumot és 12 másodszintű alkritériumot használtunk.

Kulcsszavak: *légi közlekedés, ellátási minőség, többkritériumos döntéshozatal, analitikus hierarchikus folyamat, pilóta, ATCO*

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