ENTROPY-TOPSIS METHOD TO EVALUATE VIETNAM AIRLINES' DOMESTIC GROUND HANDLING PERFORMANCE

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Abstract - Ground handling is an important part of airline's frequently outsourced services occurring in the airport. This study aims to introduce an entropy-Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) Method to evaluate Vietnam Airlines' domestic ground handling system. The entropy will be used to calculate the weight of each criterion set by the airline company and the TOPSIS will be used to calculate the performance rankings of 17 ground handlers in 2017. As a result, "safety" is figured out to be the most important criterion and the rankings based on 7 criteria and related suggestion will also be given.

Keywords - Entropy-TOPSIS, Ground Handling, Performance Evaluation, Vietnam Airlines.

I. INTRODUCTION

Vietnam Airlines (VNA), the flag carrier of Vietnam, has recently launched a program to evaluate the ground handling service quality offered at 17 domestic airports. This was a part of its strategic management in order to improve the quality of its domestic service system. Although VNA also offers ground handling services as a part of its business, it can provide self-handling for only 4 out of 17 domestic airports in main cities as Hanoi, Ho Chi Minh, Da Nang, NhaTrang. For the remaining domestic airports, it outsources the services from local airport authorities. In outsourcing, the literature has indicated the importance of setting up an appropriate management process which can assist an airline company to encounter the risk of control loss [1]-[2]. VNA provides a full range of services containing ticketing reservation, ground services and in-flight services. Among these, it recognizes that airport ground services are of importance because they have direct impact on passengers' experience. The airline company therefore governs the ground service quality by using a Service Level Agreement (SLA) signed between VNA and the ground handlers and by assigning its representatives at the airports to coordinate and supervise the on-site service quality level. The SLA includes a set of service standards which are mutually agreed. It also comprises targeted goals to control the overall ground handling provider's performance. The indicators or criteria of the SLA generally cover the punctuality of in-coming and out-going flights, check-in process, boarding process, staffing attitude, passengers' complaints, mishandled baggage and mishandled personal travel documents. With the view of better satisfying passengers flying with VNA, the program is to evaluate the performance of the domestic ground handlers by addressing ranking levels of service quality among them. Besides that, based on the evaluation results, the carrier will take a managerially purposeful actions to station managers to boost up the efficiency and effectiveness of the services. To support thisVNA's evaluation, the authorswish to recommend the entropy-TOPSIS method to rank the performance of the system. The data used was the 2017 data that VNA consolidated. It is believed that this method is suitable because it is objectivity-based. Moreover, unlike the useful ranking techniques, for example,MAUT, ANP, MACBETH, AHP, etc., TOPSIS needs relatively low inputs for required input information, while offering complete ranking with a closeness score. In the rest of this paper, Section 2 emphasizes service quality, and its criteria in air industry service. Section 3 proposes the research methodology, and Section 4 describes and then discusses the results of the data analysis. Finally, some relevant conclusions and suggestions are presented in Section 5.

II. LITERATURE REVIEW

2.1 Service quality in the airline industry

There is an unambiguous relationship between service quality and profitability in academic literature. In 2018, Lin et al. claimed that offering superior quality has been of key importance which assisted the business to be able to be survival and successful in the competing business environment [3]. This view is supported by Hill et al. (2016) who wrote that superior quality can lower company's costs, differentiate its products as well as charge a premium price [4]. Hence, in the airline industry, by enhancing degree of service quality, the airline company can reduce operating costs and increase market share and return on investment (ROI), improve flexibility, and maximize transportation efficiency [5]. That also supports the motto "service quality improvement results to profitability improvement". In the air service industry, it is realized that in focusing more on service quality, management thinking has been changed towards

customer orientation [6]-[3]. Carriers have aimed at satisfying passengersas well as meeting customer expectations. There has been evidence that it is crucial to understand what customers actually expect and want in order to offer the foreseen high-quality service (e.g. [7]-[8]-[9]-[10]-[11]). In their study, Fuzzy weighted SERVQUAL method was proposed by Chou et al. (2011) to assess passenger's perceptions and the service quality differences between passenger's perceptions and expectations [10]. There might exist meaningful gaps affiliated to passenger service expectations and perceptions of service quality by the related frontline managing personnel as claimed in astudy of carrier service quality through a process perspective [7].

2.2 Criteria and sub-criteria for ground handling evaluation

Ground handling services have been received little attention from literature. Scholars mainly have focused on evaluation of service quality of an airline so they insufficiently covered the services. The services were commonly included in ground servicesat the airport(e.g. [12]-[13]-[14]-[15]). In individual research, they utilized either some of the following coherentcriteria: baggage mishandling, check-in process, boarding process, customer complaints, staff attitude, staff professional knowledge skills, language skills, waiting time, and punctuality, etc.[12]-[15]-[16]-[17]-[18]-[19]-[20]-[21] or they specifically studied only one criterionlike baggage handling[22], consumer complaint [16], denied boarding [23], and on-time arrivals [24].

III. METHODOLOGY

3.1 Application of the entropy-TOPSIS for airport ranking

In 1981, Yoon and Hwang introduced the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [25]. This method is to solve complex decision problems in the real-world. With TOPSIS, a minimal number of inputs can be used whereas the output is yet the output is easily understandable. The principle concept of TOPSIS is that the best solution offered has the shortest distance to the positive ideal solution (PIS) and the furthest distance from the negative ideal solution (NIS). In 1947, Shannon proposed the Entropy Weight Method (EWM) deriving from Shannon entropy model [26]. The method's advantage is elimination of subjectivity which enable to produce the results in more accord with facts. With the method, the index's weight can be identified based on an amount of information. The process of the entropy-TOPSIS method consisted of 8 steps which were applied for 17 domestic airports (seeAppendix) regardingthe 7 criteria (see Table 1).

Step 1.Constructing the initial matrix

In this step, an initial evaluation matrix is created with n assessment criteria and m alternatives. With the intersection of each alternative and criteria given as $x_{ij,,}$the initial decision matrix D is as follows:

$$D=\left[x_{ij}\right]_{m\times n}=\begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array}\begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}_{m\times n} \end{array}, i=1,\ 2,...,m;\ j=1,\ 2,...,n. \quad (1)$$

Step 2Constructing the normalized decision matrix

The initial decision matrix needs to be normalized to form the matrix by using the normalization method.

$$r_{ij}=\frac{x_{ij}}{\sqrt{\sum_{i=1}^{m}x_{ij}^2}},\qquad i=1,\ 2,...,m;\ j=1,\ 2,...,n. \quad (2)$$

$$R=\left[r_{ij}\right]_{m\times n}=\begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array}\begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}_{m\times n} \end{array}, \ i=1,\ 2,...,m;\ j=1,\ 2,...,n. \quad (3)$$

Step 3Computing the objective weights with Entropy

The criteria weights are objectively determined by the information entropy method.

$$e_j=-\frac{1}{\ln m}\sum_{i=1}^{m}r_{ij}\ln r_{ij},\qquad i=1,\ 2,...,m;\ j=1,\ 2,...,n. \quad (4)$$

Recalculate the weight of each evaluation criterion $W = (w_1, w_2,\ldots, w_n)$

$$w_j=\frac{1-e_j}{\sum_{j=1}^{n}\left(1-e_j\right)},\qquad i=1,\ 2,...,m;\ j=1,\ 2,...,n. \quad (5)$$

Step 4 Constructing the weighted normalized decision matrix

According to normalized decision matrix R and the gained entropy weight w_j, constructing the weighted normalized decision matrix R is as follows.

$$v_{ij}=r_{ij}\times w_j \quad (6)$$

$$V=\left[v_{ij}\right]_{m\times n}=\begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array}\begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{bmatrix}_{m\times n}, \quad i=1,\ 2,...,m;\ j=1,\ 2,...,n. \quad (7)$$

Step 5Determining the positive ideal and negative ideal solutions

$V^+ = \{v_1^+, v_2^+, \ldots, v_n^+\}$ positive ideal solution (8)

$V^- = \{v_1^-, v_2^-, \ldots, v_n^-\}$ negative ideal solution (9)

Step 6Calculating the relative distance for each alternatives

The distance from the positive ideal alternative is calculated as following:

$$S_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2}, \quad i = 1, 2, ..., m; \; j = 1, 2, ..., n. \quad (10)$$

The distance from the negative ideal alternative is expressed as following:

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2}, \quad i = 1, 2, ..., m; \; j = 1, 2, ..., n. \quad (11)$$

Step 7 Calculating the closeness coefficient to the ideal solution Ci

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-} \quad (12)$$

Then, choose the alternative with value of C_i closest to 1.

Step 8 Ranking the preference order

The decision-makers can make a choice of the alternatives in ranking order.

3.3 Sample characteristics

The data used have been collected from quarterly SLA performance reports on ground handling companies at 17 airports located in Vietnam.The original data was multiplied several times due to confidentiality concerns.7 criteria werechosen and the data on the 7 criteria rooted from different sources are described in the Table 1.

Check-in Boarding Check-in queue time Staff attitude	The data items for the first four criteria originated from passenger surveys are administered monthly. Passenger surveys are conducted on basis of online and on-flight. Moreover, the scores are also affected by the figures derived from VNA intranet records in term of customer complaints and the random examination by VNA staff. This rate is per 1,000 passengers.
Baggage	This criterion values are collected from World Tracer system, which helps to trace lost baggage worldwide and the intranet records of customer feedback. The values present the mishandled baggage rate reported per 1,000 passengers.
Safety	The values in this criterion are based on safety rule violation cases occurred for any VNA flight in each port. An amount of incidents, risk levels and frequency factor determine the points deduction.
On-time performance (OTP)	Pushback time of an aircraft is collected and compared with estimated departure time to define if the flight is punctual or not. The time at which a movement message is auto-sent is used to count the pushback time.

Table 1: Criteria used in the study

IV. DATA ANALYSIS AND DISCUSSION

4.1 Constructing the initial decision matrix

According to the collected data, initial decision matrix was created by the equation (1) (see Table 2).

Airport	Check-in	Boarding	Check-in queue time	Staff attitude	Baggage	Safety	OTP
CXR	141.0500	140.3750	154.7625	77.3813	265.6221	299.3750	198.9324
DAD	141.0500	140.3750	154.7625	77.3813	265.6221	299.3750	198.9324
HAN	136.6000	138.9500	143.0625	71.5313	262.3294	299.7656	180.3825
SGN	120.6000	139.3250	108.0000	54.0000	239.4264	299.7813	223.8514
BMV	92.4500	129.1000	69.6375	34.8188	257.4201	300.0000	203.7740
DLI	154.8750	133.5000	113.9625	56.9813	214.7539	300.0000	179.0324
HPH	128.7750	117.5250	91.3500	45.6750	286.4671	299.8438	61.9532
HUI	130.0500	152.6750	100.5000	50.2500	217.5861	299.5313	102.4489
PQC	134.4500	128.9750	126.1875	63.0938	202.8616	299.8438	133.4378
VCA	99.6000	102.0250	60.9000	30.4500	219.3879	299.8438	181.3526
VII	152.6750	145.4000	114.7125	57.3563	300.0000	300.0000	216.9877
PXU	133.1750	118.8750	77.9625	38.9813	263.2011	300.0000	109.5367
UIH	161.6500	136.2000	163.1625	81.5813	229.3256	300.0000	168.2409
VDH	140.6000	135.3250	89.8875	44.9438	270.1692	300.0000	197.2156
THD	120.4500	126.8000	107.1750	53.5875	250.0000	300.0000	244.2516
VCL	109.6000	96.3667	51.8000	25.9000	300.0000	300.0000	179.7302
TBB	111.1333	124.4333	76.1000	38.0500	275.0000	298.9063	223.8690

Table 2: The initial decision matrix

4.2 Constructing the normalized matrix

The normalization matrix was calculated by the equation (2), (3) and the it was presented in the Table 3.

Airport	Check-in	Boarding	Check-in queue time	Staff Attitude	Baggage	Safety	OTP
CXR	0.2607	0.2608	0.3378	0.3378	0.2520	0.2422	0.2638
DAD	0.2607	0.2608	0.3378	0.3378	0.2520	0.2422	0.2638
HAN	0.2524	0.2581	0.3123	0.3123	0.2488	0.2425	0.2392
SGN	0.2229	0.2588	0.2358	0.2358	0.2271	0.2425	0.2968
BMV	0.1708	0.2398	0.1520	0.1520	0.2442	0.2427	0.2702
DLI	0.2862	0.2480	0.2488	0.2488	0.2037	0.2427	0.2374
HPH	0.2380	0.2183	0.1994	0.1994	0.2717	0.2426	0.0821
HUI	0.2403	0.2836	0.2194	0.2194	0.2064	0.2423	0.1358
PQC	0.2485	0.2396	0.2755	0.2755	0.1924	0.2426	0.1769
VCA	0.1841	0.1895	0.1329	0.1329	0.2081	0.2426	0.2405
VII	0.2821	0.2701	0.2504	0.2504	0.2846	0.2427	0.2877
PXU	0.2461	0.2208	0.1702	0.1702	0.2497	0.2427	0.1452
UIH	0.2987	0.2530	0.3562	0.3562	0.2175	0.2427	0.2231
VDH	0.2598	0.2514	0.1962	0.1962	0.2563	0.2427	0.2615
THD	0.2226	0.2356	0.2340	0.2340	0.2371	0.2427	0.3239
VCL	0.2025	0.1790	0.1131	0.1131	0.2846	0.2427	0.2383
TBB	0.2054	0.2312	0.1661	0.1661	0.2609	0.2418	0.2968

Table 3: Normalization matrix

4.3 Computing the with Entropy

The Table 4 revealed objective criterion weights, which were determined by the equation (4) and (5). The importance of the criteria isranked top down as safety; boarding process; baggage; check-in process; check-in queue time and staff attitude; on-time performance (W6>W2>W5>W1>W4=W3>W7). The ranking of "safety" is consistent with the literature which frequently considers this criterion as the top priority.

Weights	W_1	W_2	W_3	W_4	W_5	W_6	W_7	W_8
	0.1463	0.1475	0.1357	0.1357	0.1474	0.1493	0.1382	1.0000

Table 4: VNA's criterion weights

4.4 Determining the ideal solutions

Following the entropy calculation, the positive ideal and negative ideal solutions of the domestic ground handling services were determined by the equation from (6) to (9) (see Table 5)

V+	0.0437	0.0418	0.0483	0.0483	0.0420	0.0362	0.0448
V-	0.0250	0.0264	0.0153	0.0153	0.0284	0.0361	0.0114

Table 5: Positive ideal solution and negative ideal solution

4.5 Calculating the relative distance measures

And then, the relative distance for each ground handler's performance were computed by the equation (10) and (11) (see Table 6)

Positive	S_1^+	S_2^+	S_3^+	S_4^+	S_5^+	S_6^+	S_7^+	S_8^+	S_9^+
	0.0121	0.0121	0.0171	0.0275	0.0449	0.0272	0.0468	0.0396	0.0305
	S_{10}^+	S_{11}^+	S_{12}^+	S_{13}^+	S_{14}^+	S_{15}^+	S_{16}^+	S_{17}^+	
	0.0506	0.0211	0.0453	0.0176	0.0330	0.0278	0.0524	0.0400	
Negative	S_1^-	S_2^-	Si_3^-	S_4^-	S_5^-	S_6^-	S_7^-	S_8^-	S_9^-
	0.0537	0.0537	0.0477	0.0407	0.0294	0.0391	0.0232	0.0285	0.0367
	S_{10}^-	S_{11}^-	S_{12}^-	S_{13}^-	S_{14}^-	S_{15}^-	S_{16}^-	S_{17}^-	
	0.0224	0.0461	0.0206	0.0551	0.0352	0.0427	0.0259	0.0342	

Table 6: The relative distance for each alternatives

4.5 Calculating Ci to rank the preference order

Finally, the domestic ground handling services provided to VNA's passengerswere ranked based on calculation of Ci by the equation (12). The results were described in the Table 7. According to the findings (see Table 7), it is obvious that CXR, DAD, UIH are the top three airports because they archived the highest points of Ci. VNA may offer incentives for these airports to encourage them to maintain their excellence. However, to maintain in the best place, CXR and DAD have to solve some problems relating conformance with safety regulations. Similarly, UIH needs to improve baggage and OTP handling. In contrast, the three bottom up airports are VCA, PXU, VCL due to the lowest Ci values. VCA's performance was significantly lower than expectedin 5 out of 7 criteria as check-in, boarding, check-in queue time, staff attitude and baggage. PXU was very good at safety control butthe rate of its flight punctuality was under big concerns. Although VCL

was the best of all for carrying out baggage process and safety tasks, it was extremely under expected for boarding process, check-in queue time and staff attitude. It should shorten waiting time for passengers and improve staffing communication with passengers. Furthermore, as mentioned early in introduction, 4 airports where VNA's subsidiary company provides ground handling are ranked the 1st for CXR (Nha Trang city) and DAD (Da Nang city); the 4th for HAN (Hanoi Capital) and 7th for SGN (Ho Chi Minh city). Their performance met service standard. However, SGN should receive more attention because SGN wasoverloaded which has affected the effectiveness and efficiency of the airport operation in general. It might take longer check-in time as well as baggage mishandling occurring in SGN until its terminal 3, which is under construction, gets ready for operation.Apart from detailed rankings, it is evident that 2017 ground handling performance provided by VNA has been better than that by outsourcing providers at the domestic airports.

Airport	Ci	Ranking	Airport	Ci	Ranking	Airport	Ci	Ranking
CXR	0.8159	1	HPH	0.3317	14	UIH	0.7573	3
DAD	0.8159	1	HUI	0.4190	12	VDH	0.5163	10
HAN	0.7353	4	PQC	0.5462	9	THD	0.6057	6
SGN	0.5968	7	VCA	0.3071	17	VCL	0.3307	15
BMV	0.3964	13	VII	0.6860	5	TBB	0.4608	11
DLI	0.5897	8	PXU	0.3130	16			

Table 7: Ranking of 2017 ground handling services at 17 domestic airports

V. CONCLUSION

In this paper, the combined entropy-TOPSIS method has been adopted to evaluate Vietnam Airlines' ground handling performance at 17 airports located in Vietnam. The evaluation results indicated the critical importance of safety and presented the performance ranking orders of 17 ground handlers. The ranking results may assist VNA's top managers in making decision on how to effectively improve the quality of the service. They can also decide a plan focusing on weaker airports by using means of SLA and station managers who are appointed to coordinate with supervise the service. By so doing, the company can ensure the service satisfying the flyers in order to prevail in the intensifying airline competitiveness. Besides the findings, it is realized that there are some benefits of the entropy-TOPSIS method. With the method, the evaluation procedure becomes simple but rigorous. The results obtained for all the alternatives are satisfactory because the chosen alternative always has the shortest distance to the positive ideal solution and the farthest distance from the negative ideal solution. Additionally, the weight determined by entropy method avoids the subjectivity relevant to other methods of weight determination or the calculating complex.

APPENDIX

Airport names using IATA code

1	CXR	Cam Ranh International Airport	9	PQC	Phu Quoc International Airport
2	DAD	Da Nang International Airport	10	VCA	Can Tho International Airport
3	HAN	Noi Bai International Airport	11	VII	Vinh International Airport
4	SGN	Tan Son Nhat International Airport	12	PXU	Pleiku Airport
5	BMV	Buon Me Thuot Airport	13	UIH	Phu Cat Airport
6	DLI	Lien Khuong Airport	14	VDH	Dong Hoi Airport
7	HPH	Cat Bi International Airport	15	THD	Thanh Hoa Airport
8	HUI	Phu Bai Airport	16	VCL	Chu Lai International Airport
			17	TBB	Tuy Hoa Airport

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