A Decision Support System for Performance Evaluation

Ramadan AbdelHamid
ZeinEldin
Associate Professor
Operations Research Department
Institute of Statistical Studies and
Research
Cairo University

ABSTRACT
This paper presents a model based decision support system (DSS) for evaluating performance. Performance evaluation in business is difficult. Multicriteria methods are used for evaluation of performance of public and private organizations. The proposed system is based on financial ratios and some methods such as Analytic Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Simple additive weighting (SAW). AHP is a theory of measurement through pairwise comparisons and relies on the judgements of experts to derive priority scales and it is used to determine the criteria weights. TOPSIS is used to help select the best alternative with a finite number of criteria. SAW is the most widely used method because it is simple and easy to use and understand. The developed decision support system is implemented with a real application.

General Terms
Decision Support System, Multicriteria Decision Making

Keywords
Decision Support System, model base, AHP, TOPSIS, SAW, Performance

1. INTRODUCTION
In the environment of uncertainty and complex situations today, it is difficult to measure or evaluate the performance. It has always been an important topic for organizations whatever they are public sector or private sector. Given the growing complexity and uncertainty in many decision situations, helping managers use quantitative models to support their decision-making and planning is an important research topic. In recent years, multicriteria methods have been increasingly used for quantitative evaluation of complicated economic or social processes.

Decision support systems (DSSs) are computer technology based solutions that can be used to support decision making and problem solving. Model-driven DSSs are computerized systems that use financial models, process models, or model-based optimization models, for example, to assist the user in decision making [1]. The main kinds of decision models integrated in model-based DSS are statistical models, optimization models, simulation models, heuristic models and multi-criteria methods [2].

In the literature, there are many methods used for performance evaluation such as AHP, TOPSIS and SAW. The AHP presents a flexible, easily understood way to assist the decision-maker in formulating his problem in a logical and rational manner. The TOPSIS is based upon the concept that the optimal alternative should have the shortest distance from the positive idea solution and the farthest distance from the negative idea solution. Although the concept of TOPSIS is rational and understandable, and the computation involved is uncomplicated, the inherent difficulty of assigning reliable subjective preferences to the criteria is worth of note. The global interest in the TOPSIS method has exponentially grown; there are wide range of real-world applications for the TOPSIS method such as supply chain management and logistics, design, engineering and manufacturing systems, business and marketing management, health, safety and environment management, human resources management, energy management, chemical engineering, water resources management, and other applications [3].

The SAW method is one of the simplest, natural and most widely used multicriteria evaluation methods. It clearly demonstrates the idea of integrating the values and weights of criteria into a single estimating value – the criterion of the method [4].

Podvezko [4] describes the main features of multicriteria evaluation methods SAW and COPRAS *(Complex Proportional Assessment*) and their common and diverse characteristics, as well as defining and demonstrating the properties of the method COPRAS, which are of great theoretical and practical value. The advantage of SAW is simple and easy to use and understand, while TOPSIS considers positive and negative ideal solutions as anchor points to reflect the contrast of the currently achievable criterion performances [5]. Kelemenis and Askounis [6] proposed a new TOPSIS approach to support the decision making on IT professional selection. Singh and Benyoucef [7] presented a methodology based TOPSIS for solving multi-attribute reverse auction problem of e-sourcing. Tavana and Hatami-Marbini [8] presented a framework based on the AHP and TOPSIS that for the Integrated Human Exploration Mission Simulation Facility project at the Johnson Space Center to assess the priority of a set of human spaceflight mission simulators. Joshi et al. [9] developed a benchmarking framework that evaluates the cold chain performance of a company using A Delphi-AHP-TOPSIS based methodology for continuous improvement. In the literature, financial ratios are incorporated into multicriteria decision making models such as AHP, TOPSIS, and Data Envelopment Analysis (DEA) [10].

In this paper, a model based DSS for performance evaluation and ranking the units evaluated is proposed. The rest of the paper is organized as follows. Section 2 is assigned to the model based DSS which includes short description for the TOPSIS method, SAW method and AHP method. Section 3 is devoted for implementing the proposed DSS with a real application from Egyptian drug industry. Finally, the conclusions and points for future research are presented in section 4.

2. THE MODEL-BASED DSS

Loebbecke and Huyskens [2] proposed five-stage methodology for developing a model based DSS.

1- Identifying potential decision criteria:
2- Collecting field data for empirical modeling:
3- Choosing method for selecting relevant decision criteria.
4- Selecting relevant decision criteria.
5- Developing DSS modules.

In this research, seven decision criteria to help in performance evaluation are identified; these criteria are summarized in table 1. When implementing the developed DSS, field data are collected for eight companies for the last eight years as shown in table 2. The AHP method is used to determine the weight for the criteria determined to build the proposed DSS. TOPSIS and SAW approached are used through the model based DSS to evaluate the performance. The following subsections summarize the methods used in the model based DSS.

2.1 The AHP Method

AHP addresses how to determine the relative importance of a set of activities in a multi-criteria decision problem. The AHP method is based on three principles: first, structure of the model; second, comparative judgment of the alternatives and the criteria; third, synthesis of the priorities. In the literature, AHP has been widely used in solving many complicated decision-making problems. One of the main advantages of AHP is its simplicity compare to previous decision support methods. It also enables qualitative and quantitative into the same decision making methodology by giving a basis for eliciting, discussing, recording, and evaluating the elements of a decision. It uses hierarchal way with goals, sub goals or factors and alternatives [11].

The procedures of the AHP involve six essential steps [12-14]:

1. Define the unstructured problem and state clearly the objectives and outcomes.
2. Decompose the complex problem into a hierarchical structure with decision elements (criteria, detailed criteria and alternatives).
3. Employ pairwise comparisons among decision elements and form comparison matrices.
4. Use the eigenvalue method to estimate the relative weights of the decision elements.
5. Check the consistency property of matrices to ensure that the judgments of decision makers are consistent.
6. Aggregate the relative weights of decision elements to obtain an overall rating for the alternatives.

After determining the criteria and computing their weights, the consistency of data should be tested. If consistency of data is more than 0.1, revision of pairwise comparison must be done and continue until consistency rate reach to less than 0.1.

Test of consistency:

The following steps will show how the test of consistency will be done [15].

1- Calculate the weighted sum vector (WSV): multiplying the comparison matrix by the weight column to get the WSV.

2. Calculate the Consistency vector (CV) by dividing the weighted sum vector by the weight vector.

3- Compute the average of the Consistency vector to obtain λ_{max} where λ_{max} = sum/ number of criteria (N)

4- Compute the Consistency Index (CI):

CI = (λ_{max} - N)/(N-1), where n is the matrix size

5- Compute the Consistency Ratio (CR): CR = CI/RI

Consistency ratio will be computed as follows as the amount of Random Index (RI) could be got by looking at table 1, according to the value of n (n is size of matrix which is number of criteria).

Table 1: The Average Stochastic Uniformity Index Target Value of Judgment Matrix

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.85	0.9	1.12	1.24	1.32	1.41	1.45	1.51

2.2 Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

TOPSIS, developed by Hwang and Yoon in 1981, is a simple ranking method in conception and application. The standard TOPSIS method attempts to choose alternatives that simultaneously have the shortest distance from the positive ideal solution and the farthest distance from the negative-ideal solution. The positive ideal solution maximizes the benefit criteria and minimizes the cost criteria, whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria. TOPSIS makes full use of attribute information, provides a cardinal ranking of alternatives, and does not require attribute preferences to be independent. To apply this technique, attribute values must be numeric, monotonically increasing or decreasing, and have commensurable units [3].

The TOPSIS has the following steps: [10, 16-18]

Let $A = \{A_1, A_2, \ldots., A_m\}\ m \geq 2$ be a discrete set of m feasible alternatives and $U = \{u_1, u_2, \ldots., u_n\}$ be a finite set of attributes. The problem data is represented in a decision matrix where the rows represent the alternatives and the columns represent the attributes.

1- Construct normalized the decision matrix.

There are benefit attributes and cost attributes in the real problems. In order to measure all attributes in dimensionless units and facilitate inter-attribute comparisons, the following formulas are introduced to normalize each attribute value x_{ij} in decision matrix into a corresponding element r_{ij} in normalized decision matrix given

$r_{ij} = x_{ij} / \sqrt{\sum_{i=1}^{m} (x_{ij})^2}$, for benefit attribute x_{ij}; $i \in M, j \in N$ and

$r_{ij} = 1 - x_{ij} / \sqrt{\sum_{i=1}^{m} (x_{ij})^2}$, for cost attribute x_{ij}; $i \in M, j \in N$

Where x_{ij} and r_{ij} are the original and normalized score of decision matrix respectively.

2- Construct the weighted normalized decision matrix

Suppose that $W = \{w_1, w_2, \ldots., w_n\}$T is the weight vector of the attributes where $w_j \geq 0, \sum_{j=1}^{n} w_j$. $w_{ij} = w_j r_{ij}$.

3- Determine the positive ideal and negative ideal solutions

$A^+ = \{v_1^+, \ldots, v_n^+\}$ positive ideal solutions where $v_i^+ = \{\max\ (v_{ij})\ \text{if } j\ \in J; \min(v_{ij})\ \text{if } j\ \in J^-\}$

$A^- = \{v_1^-, \ldots, v_n^-\}$ negative ideal solutions where $v_i^- = \{\min\ (v_{ij})\ \text{if } j\ \in J; \max(v_{ij})\ \text{if } j\ \in J^-\}$

4- Calculate the separation measures for each alternative.

The separation from positive ideal alternative is $S_i^+ = [\sum(v_i^+ - v_{ij})^2]^{\frac{1}{2}}, i = 1, \ldots, m$. Similarly, the separation from negative ideal alternative is $S_i^- = [\sum(v_i^- - v_{ij})^2]^{\frac{1}{2}}, i = 1, \ldots, m$.

5- Calculate the relative closeness to the ideal solution C_i

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-}, 0 < C_i^* < 1,$$

select the alternative with C_i close to 1.

Since $S_i^+ \geq 1$ and $S_i^- \geq 1$ then $C_i \in [0, 1]$

6. Rank the preference order.

A set of alternatives then can be ranked by preference according to the descending order of C_i; in other words, larger C_i means better alternative.

2.3 Simple Additive Weighting (SAW)

The SAW method is a commonly known and very widely used method for providing a comparative evaluation procedure in MCDA. SAW uses all criterion values of an alternative and employs the regular arithmetical operations of multiplication and addition [5]. SAW which is also known as weighted linear combination or scoring methods is a simple and most often used multi attribute decision technique. The method is based on the weighted average. An evaluation score is calculated for each alternative by multiplying the scaled value given to the alternative of that attribute with the weights of relative importance directly assigned by decision maker followed by summing of the products for all criteria. The advantage of this method is that it is a proportional linear transformation of the raw data which means that the relative order of magnitude of the standardized scores remains equal [15]. The steps of SAW can be described as follows [4], [15]:

1- Obtain the normalized decision matrix from the decision matrix using the following:

$r_{ij} = x_{ij} / x_j^*$ if the jth criterion is a benefit criterion, and

$r_{ij} = x_j^- / x_{ij}$, if the jth criterion is a cost criterion

2- Obtain the weighted decision matrix by multiplying each column of normalized decision matrix by the corresponding weight:

3- Obtain the score for each company by summing the weighted values for each company and rank the companies according to this sum.

3. AN APPLICATION

In the Egyptian drug market, there are public sector companies and private sector companies. The public sector companies are divided into 8 companies for producing drugs, 2 for commerce and distribution and there is another one for manufacturing chemicals and drug requirements. The performance of the 8 production companies is measured because they have the same circumstances and the same general rules.

First, the criteria that will be used to measure the performance for the selected companies must be determined. Most research papers take number of employees, equity, revenues and profit as important factors. The author has met the general manager of public sector information center (BSIC), a financial analyst expert, and other experts to take their advice in determining the most important criteria. So, the factors considered in this research are number of employees (it measures the company ability to solve the unemployment problem), the net of assets, the equity, the net revenues, net profit; to measure the profitability of the company and its revenues; the added value of the company to the Egyptian economy, and the export. Table 2 presents the important criteria:

Table 2: Criteria Description

Criteria	Description
C1	Number of Employees
C2	Net assets
C3	Equity
C4	Net revenue
C5	Net profit
C6	Added value
C7	Exports

After determining the important criteria to measure the performance of the selected companies, the required data for these criteria is collected. The last eight years (from 2004 to 2011) is taken as a series of data to measure the performance of these companies. Table 3 shows the average of the seven criteria for the eight companies which is called decision matrix.

Table 3: The Companies Data (Decision Matrix)

	C1	C2	C3	C4	C5	C6	C7
CO1	1547	252185	151428	208960	38516	110907	19610
CO2	1809	238866	107616	289090	19763	55964	12081
CO3	1665	289990	112329	136707	20667	54967	21534
CO4	2715	312581	161156	263700	40972	107563	11414
CO5	2654	372433	164842	244577	32869	88041	26503
CO6	2630	350040	161344	314131	45774	111402	32728
CO7	2474	401264	233196	244910	42233	90888	30835
CO8	1379	152475	79698	146648	15493	52829	13851

3.1 Determining the Weights:

For TOPSIS and SAW methods, the weight of each criterion from the seven criteria identified by some experts must be determined. To determine these weights, two surveys are developed; one for asking the experts to determine the weight for each criteria, and the second for asking the experts to put scale from 1 to 9 to show the importance of each criterion comparing with other criteria based on Analytical Analytic Hierarchy Process (AHP). The two surveys are filled by two different groups of 7 experts. Table 4 shows the average weight for each criterion determined from the first survey.

Table 4: Criteria Weight Determined By Experts

Criteria	Description	Weight
C1	Number of Employees	0.05
C2	Net assets	0.14
C3	Equity	0.21
C4	Net revenue	0.20
C5	Net profit	0.19
C6	Added value	0.11
C7	Exports	0.10

Using AHP technique for determining the criteria weights

According to the steps defined in section 2.1, table 5 shows the comparison matrix that has been got from the experts. Table 6 shows the comparison matrix with normalized columns and the weights for the criteria.

Table 5: Comparison Matrix Determined By Experts

Criteria	C1	C2	C3	C4	C5	C6	C7
C1	1.000	0.200	0.111	0.143	0.143	0.333	0.333
C2	5.000	1.000	0.200	0.333	0.333	1.000	3.000
C3	9.000	5.000	1.000	3.000	3.000	7.000	7.000
C4	7.000	3.000	0.333	1.000	1.000	5.000	5.000
C5	7.000	3.000	0.333	1.000	1.000	5.000	5.000
C6	3.000	1.000	0.143	0.200	0.200	1.000	1.000
C7	3.000	0.333	0.143	0.200	0.200	1.000	1.000
Sum	35.000	13.533	2.263	5.876	5.876	20.333	22.333

Test of consistency:

The consistency Rate calculated was 0.037 that is less than 0.1, indicating sufficient consistency. The weighted sum vector is calculated as shown in table 7 and Table 8 shows the Consistency vector (CV)

λ_{max} = sum/ number of criteria (N) = 51.093/7 = 7.299

CI = (λ_{max} - N)/(N-1) = (7.299 – 7)/(7-1) = 0.049, where n is the matrix size

CR = CI/1.32 = 0.037, where 1.32 is got from table 1 when n = 7. So the Consistency Index is indicating that the opinion of experts is sufficient.

3.2 Using TOPSIS Method to Measure the Performance

According to the steps described in section 2.2, the normalized decision matrix is shown in table 9.

Table 9: The Normalized Decision Matrix Using TOPSIS

	C1	C2	C3	C4	C5	C6	C7
CO1	0.0633	0.0850	0.1226	0.0959	0.1616	0.2009	0.0952
CO2	0.0866	0.0763	0.0619	0.1835	0.0425	0.0511	0.0361
CO3	0.0734	0.1124	0.0675	0.0410	0.0465	0.0493	0.1148
CO4	0.1950	0.1306	0.1389	0.1527	0.1829	0.1889	0.0322
CO5	0.1863	0.1854	0.1453	0.1313	0.1177	0.1266	0.1738
CO6	0.1831	0.1638	0.1392	0.2167	0.2283	0.2027	0.2651
CO7	0.1620	0.2153	0.2907	0.1317	0.1943	0.1349	0.2353
CO8	0.0503	0.0311	0.0340	0.0472	0.0261	0.0456	0.0475

The weighted decision matrix

a. using the weight proposed by experts from survey one in table 4, table 10 shows the weighted decision matrix.

b. using the weight obtained using AHP from table 6, table 11 shows the weighted decision matrix.

Table 10: The Weighted Decision Matrix Using TOPSIS Method

	C1	C2	C3	C4	C5	C6	C7
CO1	0.0032	0.0119	0.0257	0.0192	0.0307	0.0221	0.0095
CO2	0.0043	0.0107	0.0130	0.0367	0.0081	0.0056	0.0036
CO3	0.0037	0.0157	0.0142	0.0082	0.0088	0.0054	0.0115
CO4	0.0098	0.0183	0.0292	0.0305	0.0347	0.0208	0.0032
CO5	0.0093	0.0260	0.0305	0.0263	0.0224	0.0139	0.0174
CO6	0.0092	0.0229	0.0292	0.0433	0.0434	0.0223	0.0265
CO7	0.0081	0.0301	0.0611	0.0263	0.0369	0.0148	0.0235
CO8	0.0025	0.0044	0.0071	0.0094	0.0050	0.0050	0.0047

Table 11: The Weighted Decision Matrix Using TOPSIS and AHP Methods

	C1	C2	C3	C4	C5	C6	C7
CO1	0.0016	0.0073	0.0481	0.0189	0.0318	0.0110	0.0046
CO2	0.0022	0.0066	0.0243	0.0361	0.0084	0.0028	0.0017
CO3	0.0018	0.0097	0.0264	0.0081	0.0092	0.0027	0.0055
CO4	0.0049	0.0112	0.0544	0.0301	0.0360	0.0104	0.0015
CO5	0.0047	0.0159	0.0569	0.0259	0.0232	0.0070	0.0083
CO6	0.0046	0.0141	0.0546	0.0427	0.0450	0.0111	0.0127
CO7	0.0040	0.0185	0.1140	0.0259	0.0383	0.0074	0.0113
CO8	0.0013	0.0027	0.0133	0.0093	0.0052	0.0025	0.0023

3- The positive ideal and negative ideal solutions: tables 12 and 13 show these solutions.

4- The separation measures for each company.

In this step, the separation from positive (S_i^+) and negative (S_i^-) ideal companies for the TOPSIS and TOPSIS based on AHP as shown in table 14

Table 14: The Separation Ideal Companies

	TOPSIS		TOPSIS _AHP	
	S_i^+	S_i^-	S_i^+	S_i^-
CO1	0.0515	0.0390	0.0727	0.0463
CO2	0.0693	0.0300	0.0988	0.0306
CO3	0.0733	0.0162	0.1017	0.0159
CO4	0.0440	0.0486	0.0629	0.0572
CO5	0.0429	0.0444	0.0637	0.0529
CO6	0.0326	0.0665	0.0596	0.0695
CO7	0.0199	0.0739	0.0185	0.1092
CO8	0.0838	0.0020	0.1152	0.0014

5- The relative closeness to the ideal solution C_i

After calculating the relative closeness to the ideal solution, the companies can be ranked according to the value of C_i where the company which has a larger value has a higher rank as shown in table 15. Although the weights are determined by the experts from two surveys by two different ways, the TOPSIS method gives the same rank for the two weights.

Table 15: The Relative Closeness to the Ideal Solution and the Rank of the Companies

	TOPSIS		TOPSIS _AHP	
	C	$Rank$	C	$Rank$
CO1	0.4306	5	0.3888	5
CO2	0.3020	6	0.2362	6
CO3	0.1813	7	0.1353	7
CO4	0.5248	3	0.4763	3
CO5	0.5087	4	0.4539	4
CO6	0.6709	2	0.5383	2
CO7	0.7875	1	0.8553	1
CO8	0.0229	8	0.0122	8

The best company is CO7 then CO6, CO4, CO5, CO1, CO2, CO3 and CO8

3.3 Using SAW method to measure the performance:

The normalized decision matrix is shown in table 16.

Table 16: The Normalized Decision Matrix using SAW

	C1	C2	C3	C4	C5	C6	C7
CO1	0.5697	0.6285	0.6494	0.6652	0.8414	0.9956	0.5992
CO2	0.6665	0.5953	0.4615	0.9203	0.4317	0.5024	0.3691
CO3	0.6134	0.7227	0.4817	0.4352	0.4515	0.4934	0.6580
CO4	1.0000	0.7790	0.6911	0.8395	0.8951	0.9655	0.3487
CO5	0.9774	0.9282	0.7069	0.7786	0.7181	0.7903	0.8098
CO6	0.9688	0.8723	0.6919	1.0000	1.0000	1.0000	1.0000
CO7	0.9113	1.0000	1.0000	0.7796	0.9226	0.8159	0.9422
CO8	0.5081	0.3800	0.3418	0.4668	0.3385	0.4742	0.4232

The weighted decision matrix

a. using the weight proposed by experts from survey one in table 4, table 17 shows the weighted decision matrix and the rank of each company.

b. using the weight obtained using AHP from table 6; table 18 shows the weighted decision matrix and the rank of each company.

Finally, table 19 and figure 1 summarize the rank of the companies according to the two methods with the different methods for determining the weights.

Table 19: the summary of the company ranks

	TOPSIS		SAW	
	Experts	AHP	Experts	AHP
CO1	5	5	5	5
CO2	6	6	6	6
CO3	7	7	7	7
CO4	3	3	4	3
CO5	4	4	3	4
CO6	2	2	1	2
CO7	1	1	2	1
CO8	8	8	8	8

Depending on the opinions of experts, the rank of companies 4, 5, 6, and 7 are different according to the two methods but the companies has the same rank depending on the weight calculated using AHP.

4. CONCLUSIONS

The methods SAW and TOPSIS are widely used for multicriteria evaluation. Though they may seem to be different, both methods have a number of common features and properties. It is found that the two methods gave the same companies rank when they based on AHP for determining the criteria weights but they gave different rank when taking the criteria weights direct from the experts.

The main issue in measuring efficiency is the weights assigned to the criteria. Although the weights are got from two different groups of experts in two different ways, but this area of research still needs other way to determine the values of these weights because the experts provide different weights to the same criterion. A further research may compare the results obtained in this paper with the ones from the other methods. Also, a further research can consider other quantitative and qualitative criteria.

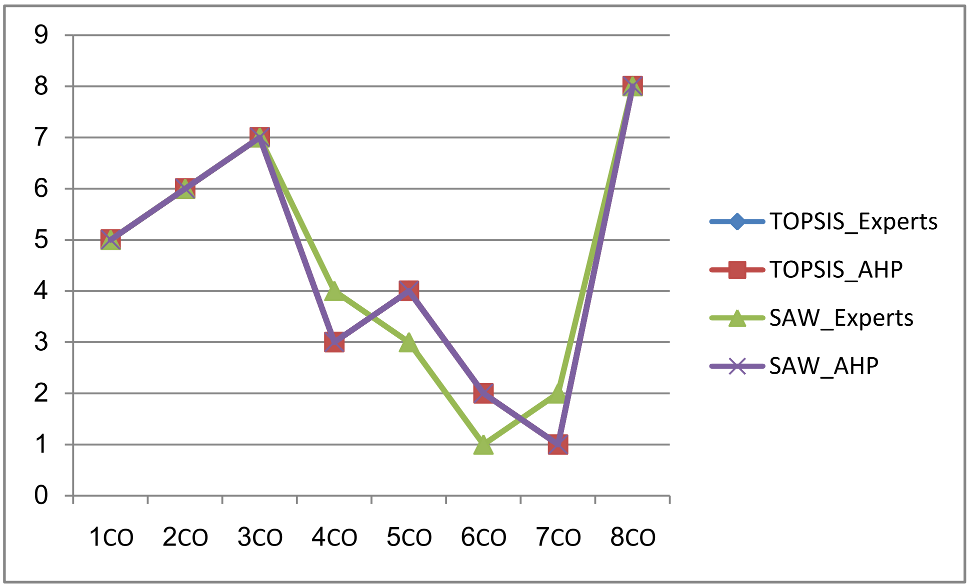

Figure 1: The ranks of the companies according to the used methods

Table 6: The Normalized Comparison Matrix and the Weights

Criteria	C1	C2	C3	C4	C5	C6	C7	weight
C1	0.029	0.015	0.049	0.024	0.024	0.016	0.015	0.025
C2	0.143	0.074	0.088	0.057	0.057	0.049	0.134	0.086
C3	0.257	0.369	0.442	0.511	0.511	0.344	0.313	0.392
C4	0.200	0.222	0.147	0.170	0.170	0.246	0.224	0.197
C5	0.200	0.222	0.147	0.170	0.170	0.246	0.224	0.197
C6	0.086	0.074	0.063	0.034	0.034	0.049	0.045	0.055
C7	0.086	0.025	0.063	0.034	0.034	0.049	0.045	0.048
Sum	1	1	1	1	1	1	1	1

Table 7: The Weighted Sum Vector.

Criteria	C1	C2	C3	C4	C5	C6	C7		Weight		WSV
C1	1.000	0.200	0.111	0.143	0.143	0.333	0.333		0.025		0.176019
C2	5.000	1.000	0.200	0.333	0.333	1.000	3.000		0.086		0.617713
C3	9.000	5.000	1.000	3.000	3.000	7.000	7.000		0.392		2.946432
C4	7.000	3.000	0.333	1.000	1.000	5.000	5.000	X	0.197	=	1.469701
C5	7.000	3.000	0.333	1.000	1.000	5.000	5.000		0.197		1.469701
C6	3.000	1.000	0.143	0.200	0.200	1.000	1.000		0.055		0.397646
C7	3.000	0.333	0.143	0.200	0.200	1.000	1.000		0.048		0.340306
Sum	35.000	13.533	2.263	5.876	5.876	20.333	22.333		1		

Table 8: The Consistency Vector (CV)

Criteria	C1	C2	C3	C4	C5	C6	C7	Sum
CV	7.148	7.182	7.508	7.460	7.460	7.235	7.101	51.093

Table 12: The Positive and Negative Ideal Solutions

max (A^+)	0.0098	0.0301	0.0611	0.0433	0.0434	0.0223	0.0265
min (A^-)	0.0025	0.0044	0.0071	0.0082	0.0050	0.0050	0.0032

Table 13: The Positive and Negative Ideal Solutions using AHP

max (A^+)	0.0049	0.0185	0.1140	0.0427	0.0450	0.0111	0.0127
min (A^-)	0.0013	0.0027	0.0133	0.0081	0.0052	0.0025	0.0015

Table 17: The Weighted Decision Matrix and the Rank using SAW

	C1	C2	C3	C4	C5	C6	C7	Sum	Rank
CO1	0.0285	0.0880	0.1364	0.1330	0.1599	0.1095	0.0599	0.7152	5
CO2	0.0333	0.0833	0.0969	0.1841	0.0820	0.0553	0.0369	0.5718	6
CO3	0.0307	0.1012	0.1012	0.0870	0.0858	0.0543	0.0658	0.5259	7
CO4	0.0500	0.1091	0.1451	0.1679	0.1701	0.1062	0.0349	0.7832	4
CO5	0.0489	0.1299	0.1484	0.1557	0.1364	0.0869	0.0810	0.7873	3
CO6	0.0484	0.1221	0.1453	0.2000	0.1900	0.1100	0.1000	0.9159	1
CO7	0.0456	0.1400	0.2100	0.1559	0.1753	0.0897	0.0942	0.9108	2
CO8	0.0254	0.0532	0.0718	0.0934	0.0643	0.0522	0.0423	0.4025	8

Table 18: The Weighted Decision Matrix and the Rank using SAW Based AHP

	C1	C2	C3	C4	C5	C6	C7	Sum	Rank
CO1	0.0142	0.0540	0.2545	0.1310	0.1658	0.0548	0.0288	0.7032	5
CO2	0.0167	0.0512	0.1809	0.1813	0.0851	0.0276	0.0177	0.5605	6
CO3	0.0153	0.0622	0.1888	0.0857	0.0889	0.0271	0.0316	0.4997	7
CO4	0.0250	0.0670	0.2709	0.1654	0.1763	0.0531	0.0167	0.7744	3
CO5	0.0244	0.0798	0.2771	0.1534	0.1415	0.0435	0.0389	0.7585	4
CO6	0.0242	0.0750	0.2712	0.1970	0.1970	0.0550	0.0480	0.8675	2
CO7	0.0228	0.0860	0.3920	0.1536	0.1818	0.0449	0.0452	0.9262	1
CO8	0.0127	0.0327	0.1340	0.0920	0.0667	0.0261	0.0203	0.3844	8

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