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RANKING STRATEGIC OBJECTIVES IN A STRATEGY MAP BASED ON LOGARITHMIC FUZZY PREFERENCE PROGRAMMING AND SIMILARITY METHOD

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Abstract:
This paper aims to rank strategic objectives in a strategy map to improve the efficiency of strategy implementation. Objectives are ranked based on strategic destinations using the combination of Logarithmic Fuzzy Preference Programming (LFPP) and similarity method. In the first step, the weight of strategic destinations is obtained using LFPP technique; then objectives are ranked by similarity method. Similarity method uses the concept of alternative gradient and magnitude for effectively solving the general multi-criteria analysis problem. Finally, objectives are ranked in an actual strategy map. As a practical and efficient tool, the proposed approach can assist managers and decision-makers in drawing more efficient output from strategy maps.

Key words: *Balanced Scorecard (BSC), Logarithmic Fuzzy Preference Programming (LFPP), similarity method, Strategy map*

INTRODUCTION

The motivation for research is coming from the practical experience of the research group in strategic management.The research group have discovered that in the case of several strategies used in the companies no tool exist, which enable them to rank, prioritise and connect strategy directly to business processes. The purpose of this paper is to introduce how to rank strategic objectives in a strategy map to improve the efficiency of strategy implementation and to contribute to the strategy map formulation approach.

The authors propose a combination of Logarithmic Fuzzy Preference Programming and similarity method to increase the efficiency of the ranking of strategic objectives. The procedure starts with the drawing a strategy map, and then the significance level of strategic objectives is identified.

The existing strategic objectives ranking is one of the most critical steps in strategy implementation. Important objectives are those, which have the highest influence on achieving the expected results of an organisation's strategy.

The strategic ranking of objectives was validated by the prioritisation of fifteen strategic goals of case study company. Nerveless, the proposed decision approach can help decision-makers to choose and analyse strategy related factors and attributes efficiently. Regarding the application of the proposed approach, authors have shown that calculation of the criteria weights is important in similarity method, and they could change the ranking.

The paper included a feasibility case study for approval of findings, where authors have ranked the strategic goals of the provided by case study company.

Objectives are ranked based on strategic destinations using the combination of Logarithmic Fuzzy Preference Programming (LFPP) and similarity method. In the first step, the weight of strategic destinations is obtained using LFPP technique; then objectives are ranked by similarity method. Similarity method uses the concept of alternative gradient and magnitude for effectively solving the general multi-criteria analysis problem.

The content of the following research paper is organised as follows. Section two reviews the three methods of BSC, LFPP, and similarity to set the required theoretical foundation for the proposed approach. The third section is dedicated to the proposed approach, which is then employed in the fourth section in a case study. Finally, a conclusion is presented in the fifth section.

REVIEW ON BSC, LFPP, AND SIMILARITY METHODS

Balanced Scorecard (BSC)

There are extensive strategic control practices and methods which can evaluate the outcomes of activities performed by a business. One of the methods enabling periodical and systematic system controls is the Balanced Scorecard (BSC) developed by [1, 2]. The Balanced Scorecard (BSC) is a widely adopted performance management framework first described in the early 1990s. It is recommended as a basis for strategic management [3]. BSC -according to performance indicators- allows the expression of business vision and strategies and hence makes sure the formation of a framework, which is required for strategic assessment and management system. Although it is emphasised that conventional financial indicators are significant, BSC proposes that these indicators are inadequate to elucidate the business performance when they have the information referred to the previously happened events.

The research by [4] introduced the BSC system, which allows the combination of measurements concerning the past business performance together with the measures related to factors in which will take future performances. BSC is a strategic management control system. In BSC, strategic objectives have roots in the organisation's vision and strategy; therefore, they are categorised into four financial, clients, internal processes, learning and growth perspectives. Thereafter, objectives are linked based on a cause and effect relationship, which lead to what Kaplan and Norton call a strategy [5]. A strategy map is a picture of an organisation' strategy. Its key purposes include making possible the translation of strategy into operational expressions and explain to the employees how their jobs are connected to general objectives of the organization [6]. Strategy maps aimed at helping the organization concentrate on their strategies in an inclusive but brief and organised way. Based on four BSC's perspectives, strategy maps are constructed, and they connect strategy and BSC. Strategy maps explain all causal relationships in order that effectual strategies can be developed and arranged and after that accomplished optimally over time. Therefore, strategy maps (the actual terms of causal relationships of an organisation's strategy) are applied to give organisations ways to generate value [5, 7].

Strategy maps create a visual framework and a brief explanation of an organisation's strategy, and they can transform intangible assets into tangible products [8].

In a strategy map, the significant degree of the strategic objectives is an area for improvement [9]. In other words, the strategy map does not show which objectives help more to achieve an organisation's strategic destinations. This paper is addressed to rank existing strategic objectives in a strategy map by a combination of two LFPP and similarity techniques.

Strategy Formulation Based on Balanced Scorecard

Kaplan and Norton, in their research in the year 1992, built up BSC to complement conventional financial measures with working performance measures directed toward clients, internal processes, learning and growth activities [1]. They followed up to their studies and assert that scorecards enhance performance by strategy translation into concrete objectives, which are connected in a causal series of leading and lagging indicators containing diverse scorecards perspectives [10]. It is compatible with assertions that the expression of these connections is important since, for the success of a firm, intangible assets have become more and more significant. Another researcher, by the name of Haase in 2000, offered a fuzzy balance scorecard and executed its suggestion in the Active Scorecard system [11]. Also, a year after Chou and Liang used a fuzzy BSC for transport companies [12]. Afterwards, Dilla and Steingbart drew experimentation to study whether graphical and tabular exhibits could managers prevail over the problems related to use BSC for performance measurement [13]. Köppen and his colleagues in [14] applied a practical approach to predict relationships in a balanced scorecard system, which emerged under the subject of machine learning and intellect.

To connect strategic objectives, Thakkar has presented an ISM model, which causal directions are only considered [15]. After that, Chytas proposed a proactive fuzzy perceptive BSC, which seems an innovation in the stream [16]. Moreover, Bobillo [17] presented a fuzzy expert system for BSC system. For covering the BSC model, by considering all approaches.

Quezada [18] proposed a simple method for identifying strategic objectives; Objectives in which include in the strategy map. They used the SWOT (strengths, weaknesses, opportunities, threats) method for objective recognition. Wu [19] addressed to performance measurement of government via BSC and used fuzzy linguistic variables. His study can be considered as national research. Buytendijk [20] argue that scenario analysis can be applied in the strategy map. Because the future of the organisation is changeable and ambiguous, stable strategy map may lose its efficiency. Their study emphasises the strengths and weaknesses of strategy maps and scenario analysis and delineates a technique to create scenario-based strategy maps theoretically and by introducing a considerable instance.

Tohidi [21] illustrated how the strategy map applied in educational organisations and explained that required data were collected by strategic management via interview rather than BSC tool.
To build strategy map, two BSC-based types of research, which carried out by Tseng [22] and Jassbi [23] applied Decision Making Trial and Evaluation Laboratory (DEMATEL), but these investigations classify performance indicators into 'cause groups' and 'effect groups', without intensive analyses of complicated mutual relationships between indicators. Wu [24] offered a model for building strategy maps, which takes account the effect (including both effective paths and strengths) of KPIs.

LOGARITHMIC FUZZY PREFERENCE PROGRAMMING (LFPP)

Preliminaries

Fuzzy set theory was developed to extract possible primary outcomes from the information expressed in vague and imprecise terms [25]. A fuzzy set is defined by a membership function used to map an item onto an interval [0, 1] that can be associated with linguistic terms [26]. A triangular fuzzy number (TFN), a special case of a trapezoidal fuzzy number, is a very popular tool in fuzzy applications. According to the definition by Laarhoven and Pedrycz [27], a TFN should possess the following features.
Definition 1.A fuzzy number $\tilde{A}$ on X is a TFN if its membership functions $\mu_{\tilde{A}}(X)$: X→[0,1] equals:

$$\mu_{\tilde{A}}(x) = \begin{cases} \dfrac{x-l}{m-l} & l \le x \le m \\ \dfrac{x-u}{m-u} & m \le x \le u \\ 0 & oterwise \end{cases} \tag{1}$$

Where l and u are for the lower and upper bounds of fuzzy number $\tilde{A}$, respectively, and m is median value (Fig. 1).

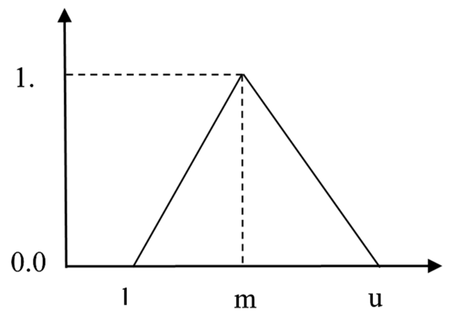

Fig. 1 A triangular fuzzy number $\tilde{A}$

According to Table 1, criteria compare with each other. After pairwise comparisons are finished at a level, a fuzzy reciprocal judgment matrix $\tilde{A}$ can be established as:

$$\tilde{A} = \{\tilde{a}_{ij}\} = \begin{bmatrix} \tilde{a}_{11} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & \tilde{a}_{22} & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{a}_{nn} \end{bmatrix} \tag{2}$$

Table 1
The linguistic scale and corresponding triangular fuzzy numbers

Linguistic scale	Explanation	Triangular fuzzy numbers	The inverse of triangular fuzzy numbers
Equal importance	Two activities contribute equally to the objective	(1, 1, 1)	(1, 1, 1)
Moderate importance	Experience and judgment slightly favour one activity over another	(1, 3, 5)	(1/5, 1/3, 1)
Strong importance	Experience and judgment strongly favour one activity over another	(3, 5, 7)	(1/7, 1/5, 1/3)
Very strong importance	An activity is favoured very strongly over another; its dominance demonstrated in practice	(5, 7, 9)	(1/9, 1/7, 1/5)
Demonstrated importance	The evidence favouring one activity over another is the highest possible order of affirmation	(7, 9, 11)	(1/11, 1/9, 1/7)

Where n is the number of the related elements at this level, and a_{ij} = 1/ a_{ij}.
A TFN is denoted as $\tilde{A}$ = (l,m,u) and the following are the operational laws of two TFNs, $\tilde{A}$_1 = (l_1,m_1,u_1) and, $\tilde{A}$_2 = (l_2,m_2,u_2), derived by [28, 29]:
Fuzzy number addition (+) :

$$\tilde{A}_1(+) = \tilde{A}_2 = (l_1, m_1, u_1)(+)(l_2, m_2, u_2) = \\ = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \tag{3}$$

Fuzzy number subtraction (-) :

$$\tilde{A}_1(-)\tilde{A}_2 = (l_1, m_1, u_1)(-)(l_2, m_2, u_2) = \\ = (l_1 - u_2, m_1 - m_2, u_1 - m_2) \tag{4}$$

Fuzzy number multiplication (×):

$$\tilde{A}_1(\times)\tilde{A}_2 = (l_1, m_1, u_1)(\times)(l_2, m_2, u_2) = \\ = (l_1 \times l_2, m_1 \times m_2, u_1 \times u_2) \tag{5}$$

$For\ l_i > 0, m_i > 0, u_i > 0$
Fuzzy number division (÷):

$$\tilde{A}_1(\div)\tilde{A}_2 = (l_1, m_1, u_1)(\div)(l_2, m_2, u_2) = \\ = (l_1 \div u_2, m_1 \div m_2, u_1 \div m_2) \tag{6}$$

$For\ l_i > 0, m_i > 0, u_i > 0$
This study adopts a triangular fuzzy number, which is the most common membership function shape.

The LFPP-based nonlinear priority method

In this method, Wang [30] adopted its logarithm by this approximate equation for the fuzzy pair-wise comparison matrix:

$$\ln \tilde{a} = (\ln l_{ij}, \ln m_{ij}, \ln lu_{ij})\ i,j = 1, \cdots, n \tag{7}$$

In other words, the logarithm of a triangular fuzzy judgment a_{ij} can be viewed as an approximate triangular fuzzy number, so its membership function can be determined as follows:

$$\mu_{ij}\left(\ln\left(\frac{w_i}{w_j}\right)\right)= = \begin{cases} \dfrac{\ln\left(\frac{w_i}{w_j}\right)-\ln l_{ij}}{\ln m_{ij}-\ln l_{ij}}, & \ln\left(\frac{w_i}{w_j}\right)\le \ln m_{ij}, \\ \dfrac{\ln u_{ij}-\ln\left(\frac{w_i}{w_j}\right)}{\ln u_{ij}-\ln m_{ij}}, & \ln\left(\frac{w_i}{w_j}\right)\ge \ln m_{ij}, \end{cases} \quad (8)$$

where:

$\mu_{ij}\left(\ln\left(\frac{w_i}{w_j}\right)\right)$is the membership degree of $\ln\left(\frac{w_i}{w_j}\right)$ owned by the approximate triangular fuzzy judgment $\ln\tilde{a} = (\ln l_{ij}, \ln m_{ij}, \ln lu_{ij})$.

It is very usual that we expect to get an accurate priority vector to maximize the minimum membership degree λ= min $\mu_{ij}\left(\ln\left(\frac{w_i}{w_j}\right)\right)$| i = 1,…, n-1 ; j = i+1,…, n}. The resulting model can be built as follows:

Maximize λ

Subject to:

$$\begin{Bmatrix} \mu_{ij}\left(\ln\left(\frac{w_i}{w_j}\right)\right) \ge \lambda, i=1,\dots,n-1; j=i+1,\dots,n, \\ w_i \ge 0, i=1,\dots,n, \end{Bmatrix} \quad (9)$$

Or as

Maximize 1- λ

Subject to

$$\begin{Bmatrix} \ln w_i - \ln w_j - \lambda\ln\left(\frac{m_{ij}}{l_{ij}}\right) \ge \ln l_{ij}, i=1,\dots,n-1; j=i+1,\dots,n, \\ -\ln w_i + \ln w_j - \lambda\ln\left(\frac{u_{ij}}{m_{ij}}\right) \ge -\ln u_{ij}, i=1,\dots,n; j=i+1,\dots,n, \end{Bmatrix} \quad (10)$$

It is observed that the normalisation constraint $\sum_{i=1}^{n} w_i = 1$ is not included in the above two correspondent models. This is because if the normalization constraint is included, the models will become complex by computation. Without loss of generality, before normalization, we can suppose w_i ≥ 1 for all i = 1, …, n such $\ln w_i \ge 0$ for i = 1, …, n. Observe that the nonnegative supposition for $\ln w_i \ge 0$ (i = 1, ..., n) is not necessary. The reason for making a negative value for λ is that there are no weights that can meet all the fuzzy judgments in Ã within their support intervals. Namely, all the inequalities:

$\ln w_i - \ln w_j - \lambda\ln\left(\frac{m_{ij}}{l_{ij}}\right) \ge \ln l_{ij}$ or

$-\ln w_i + \ln w_j - \lambda\ln\left(\frac{u_{ij}}{m_{ij}}\right) \ge -\ln u_{ij}$ can't hold simultaneously. Wang et al (2011) introduced nonnegative deviation variables δ_{ij} and η_{ij} for i = 1, …, n-1; j = i+1, …, n, to prevent k from taking a negative value, such that they meet the following inequalities:

$$\begin{aligned} &\ln w_i - \ln w_j - \lambda\ln\left(\frac{m_{ij}}{l_{ij}}\right) \ge \ln l_{ij}, i=1,\dots,n-1; j = i+1,\dots,n \\ &-\ln w_i + \ln w_j - \lambda\ln\left(\frac{u_{ij}}{m_{ij}}\right) \ge -\ln u_{ij}, i=1,\dots,n; j = i+1,\dots,n \end{aligned} \quad (11)$$

It is the most advantageous that the values of the deviation variables are the smaller, the better. Therefore, Wang et al. (2011) offered the following LFPP-based nonlinear priority model for fuzzy pairwise comparison matrix weight derivation:

Minimise $J = (1-\lambda)^2 + M.\sum_{i=1}^{n-1}\sum_{j=i+1}^{n}(\delta_{ij}^2 + \eta_{ij}^2)$

Subject to

$$\begin{Bmatrix} x_i - x_j - \lambda\ln\left(\frac{m_{ij}}{l_{ij}}\right) + \delta_{ij} \ge \ln l_{ij}, i=1,\dots,n-1; j=i+1,\dots,n, \\ -x_i + x_j - \lambda\ln\left(\frac{u_{ij}}{m_{ij}}\right) + \eta_{ij} \ge -\ln u_{ij}, i=1,\dots,n; j=i+1,\dots,n, \\ \lambda, x_i \ge 0, i=1,\dots,n \\ \delta_{ij}, \eta_{ij} \ge 0, i=1,\dots,n-1; j=i+1,\dots,n \end{Bmatrix} \quad (12)$$

where:

$x_i = \ln w_i$ for i = 1. . . n and M is a specific adequately large constant such as M = 10^3.

The main reason of introducing a big constant M into the above model is to discover the weights within the support intervals of fuzzy judgments without violations or with as little violations as possible.

Similarity Method

There are several methods for expressing conflict among two variables in multi-criteria analysis problems [31, 32, 33]. Among them, the notion of a variable's gradient explains the conflict between decision criteria in multi-criteria analysis problems, which is very common [34]. By using this approach, conflicting attribute between two variables is calculated so that conflict level among variables is shown.

Assume that A_i and A_j are two variables in the multi-criteria analysis problem; these two variables can be seen as two vectors in the m-dimensional space. The angle between A_i and A_j in m-dimensional aspects is a good measure of conflict between them. As in Fig. 2 has been shown, A_i and A_j don't have any conflict; if $\theta_{ij} = 0$ and when conflict is possible that $\theta_{ij} \ne 0$, where $\theta_{ij} \in (0, \pi/2)$. Therefore, when gradient $the\ \theta_{ij} = 0$ of both A_i and A_j has simultaneously a similar increase path, there isn't any conflict between them. When maturity situation of conflict is occurred θ_ij ≠ 0, for example, the gradients of A_i and A_j aren't coincident. Conflict degree between A_i and A_j is determined by the following formula:

$$\cos\theta_{ij} = \frac{\sum_{k=1}^{m} x_{ik}x_{jk}}{\left[(\sum_{k=1}^{m} x_{ik}^2)(\sum_{k=1}^{m} x_{jk}^2)\right]^{\frac{1}{2}}} \quad (13)$$

where the angle θ_{ij} between gradients of $(X_{i1}, X_{i2}, \cdots, X_{in},)$ and $(X_{j1}, X_{j2}, \cdots, X_{jn},)$ are the gradients of A_i and A_j.

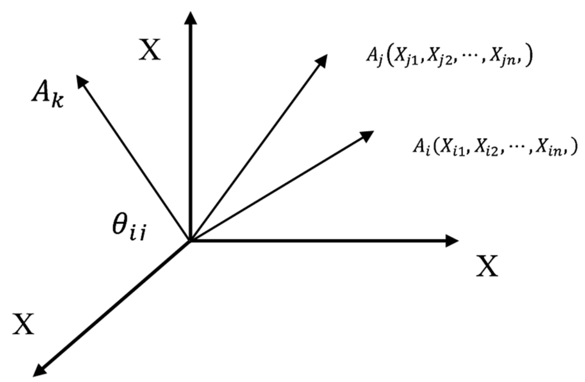

Fig. 2 Degree of conflict between alternatives by gradients

When conflict index is $\theta_{ij} = 0$, indicates that gradient vectors are situated in sima ilar path. Also, if $\theta_{ij} = \pi/2$, conflict index is 0, which imply that gradient vectors have a vertical relationship with each other. According to conflict degree between variables, similarity degree between variables can be calculated. We show the similarity degree between A_i and A_j with S_{ij}, similarity values of A_i and A_j are:

$$S_{ij} = \frac{\left(\sum_{k=1}^{m} x_{ik}^2\right)^{1/2} \cos \theta_{ij}}{\left(\sum_{k=1}^{m} x_{jk}^2\right)^{1/2}} \quad (14)$$

Where θ_{ij} is the angle between A_i and A_j, which explained completely above, growing S_{ij} shows a higher degree of similarity between A_i and A_j.

Rating approach is started by normalisation of decision matrix (15) to be assured that all applied criteria are appropriate and the normalization is carried out using Eq. (17):

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1m} \\ x_{21} & x_{22} & \dots & x_{2m} \\ \vdots & \vdots & & \vdots \\ x_{n1} & x_{n2} & \dots & x_{nm} \end{bmatrix} \quad (15)$$

$$W = (w_1, w_2, \cdots, w_n) \quad (16)$$

$$x'_{ij} = \frac{x_{ij}}{\left(\sum_{k=1}^{n} x_{ik}^2\right)^{1/2}} \quad (17)$$

Then, the normalised decision matrix is obtained:

$$X' = \begin{bmatrix} x'_{11} & x'_{12} & \dots & x'_{1m} \\ x'_{21} & x'_{22} & \dots & x'_{2m} \\ \vdots & \vdots & & \vdots \\ x'_{n1} & x'_{n1} & \dots & x'_{nm} \end{bmatrix} \quad (18)$$

Weighted performance matrix (Y), which reflects the performance of each variable compared to each criterion, is obtained by multiplying normalised matrix (18) by a weighted vector (16):

$$Y = \begin{bmatrix} w_1 x'_{11} & w_2 x'_{12} & \dots & w_m x'_{1m} \\ w_1 x'_{21} & w_2 x'_{22} & \dots & w_m x'_{2m} \\ \vdots & \vdots & & \vdots \\ w_1 x'_{n1} & w_2 x'_{n1} & \dots & w_m x'_{nm} \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} & \dots & y_{1m} \\ y_{21} & y_{22} & \dots & y_{2m} \\ \vdots & \vdots & & \vdots \\ y_{n1} & y_{n2} & \dots & y_{nm} \end{bmatrix} \quad (19)$$

Positive (or negative) ideal solution includes the best (or the worst) available criterion value of all criteria if each of criteria similarly decreases or increases their value [35]. In practice, in different multi-criteria analysis models, this concept has been used extensively for solving decision-making problems [36, 37, 38, 39, 40]. Based on this concept, positive ideal solution and negative ideal solution are calculated by performance matrix (19) which is:

$$\begin{cases} A^+ = (y_1^+, y_2^+, \dots, y_m^+) \\ A^- = (y_1^-, y_2^-, \dots, y_m^-) \end{cases} \quad (20)$$

where:

$$\begin{cases} y_j^+ = \max\limits_{i=1,2,\dots,n} y'_j \\ y_j^- = \min\limits_{i=1,2,\dots,n} y'_j \end{cases} \quad (21)$$

and

$$A_i = (y'_1, y'_2, \dots, y'_m)$$

The degree of conflict between each alternative A_i and the positive ideal solution (the negative ideal solution) is indicated in Fig. 3 and can be determined based on Eq. (13), given as:

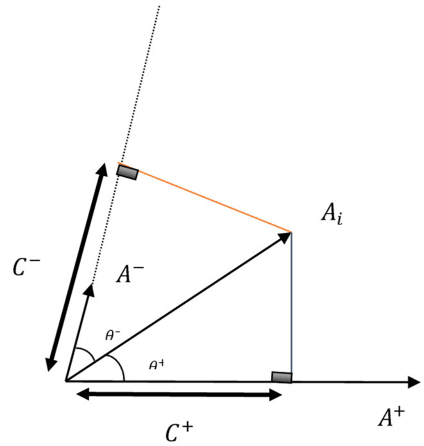

Fig. 3 Degree of conflict between A_i and A^{+-}

$$A_i . A^{\mp} = |A_i||A^{\mp}| \cos \Theta_i^{\mp}$$

$$A_i . A^{\mp} = \sum_{j=1}^{m} y'_{ij} \, y_j^{-+}$$

$$|A_i| = \left(\sum_{j=1}^{m} {y'_{ij}}^2\right)^{0.5}$$

$$|A^{\mp}| = \left(\sum_{j=1}^{m} {y_{ij}^{\mp}}^2\right)^{0.5}$$

$$\begin{cases} \cos \Theta_i^+ = \dfrac{\sum_{j=1}^{m} y'_{ij} \, y_j^+}{\left(\sum_{j=1}^{m} \boldsymbol{{y'_{ij}}^2}\right)^{0.5} \left(\sum_{j=1}^{m} \boldsymbol{{y_{ij}^{+}}^2}\right)^{0.5}} \\ \cos \Theta_i^- = \dfrac{\sum_{j=1}^{m} y'_{ij} \, y_j^-}{\left(\sum_{j=1}^{m} \boldsymbol{{y'_{ij}}^2}\right)^{0.5} \left(\sum_{j=1}^{m} \boldsymbol{{y_{ij}^{-}}^2}\right)^{0.5}} \end{cases} \quad (22)$$

As a consequence, the degree of similarity between each alternative A_i and the positive ideal solution and the negative ideal solution can be determined by

$$|C_i^{\pm}| = \cos \Theta_i^{\pm} * |A_i|$$

$$S_i^+ = \frac{|\boldsymbol{C_i^+}|}{|\mathbf{A^+}|} = \frac{\cos \Theta_i^+ * |\mathbf{Ai}|}{|\mathbf{A^+}|} = \frac{\cos \Theta^+ * \left(\sum_{j=1}^{m} \boldsymbol{{y'_{ij}}^2}\right)^{0.5}}{\left(\sum_{j=1}^{m} \boldsymbol{{y_{ij}^{+}}^2}\right)^{0.5}} \quad (23)$$

$$S_i^- = \frac{|\mathbf{A^-}|}{|\boldsymbol{C_i^-}|} = \frac{|\mathbf{A^-}|}{\cos \Theta_i^- * |\mathbf{Ai}|} = \frac{\left(\sum_{j=1}^{m} \boldsymbol{{y_{ij}^{-}}^2}\right)^{0.5}}{\cos \Theta * \left(\sum_{j=1}^{m} \boldsymbol{{y'_{ij}}^2}\right)^{0.5}} \quad (24)$$

Then, a total performance index for each alternative across all criteria can be obtained based on high priority alternatives should have the highest degree of similarity to the positive ideal solution and the lowest degree of similarity to the negative ideal solution.

$$P_i = \frac{S_i^+}{S_i^+ + S_i^-}, \quad i = 1,2, \dots, n \quad (25)$$

$$0 < P_i < 1$$
$$0^\circ \leq \theta < 90^\circ$$

Being high, the index scale indicates that the variable has a high priority.

Proposed multi-criteria analysis Technique can be expressed in the following algorithm form:

Step 1) determine the decision matrix (15).

Step 2) determine the weighted vector (16).

Step 3) normalise the decision matrix as in (18), which has been obtained by Eq. (17).

Step 4) calculate the weighted performance matrix (Y) in Eq. (19).
Step 5) determine a positive (negative) ideal solution (20) by Eq. (21).
Step 6) compute conflict index between alternatives and positive (negative) ideal solution by Eq. (22)
Step 7) calculate the similarity degree of variables between each alternative and positive (negative) ideal solution by Eq. (23) and Eq. (24)
Step 8) calculate the total performance index for any alternatives across each criterion by Eq. (25)
Step 9) ranking alternatives based on descending degree of the index value

The proposed LFPP-Similarity Integrated Technique

For ranking existing strategic objectives in a strategy map, strategic destinations have been viewed as decision criteria. Objectives score in decision matrix with regard to what extent are productive to achieve the destination.

The integrated approach, composed of LFPP and similarity methods, for strategic objectives ranking consists of 4 basic stages: (1) Data collection, (2) LFPP computations, (3) Similarity computations, (4) Decision making.

In the first stage, alternative equipment (strategic objectives) and the criteria (strategic destination) which will be used in their evaluation are determined and the decision hierarchy is formed. After determining the decision hierarchy, strategic destinations are weighted by LFPP in the second stage. In this stage, fuzzy pairwise comparison matrices are formed to determine the criteria weights. The experts make individual evaluations using the linguistic scale, to determine the values of the elements of pairwise comparison matrices then computing the geometric mean of the values obtained from individual evaluations, a final pairwise comparison matrix on which there is a consensus is found. The weights of the criteria are calculated based on this final comparison matrix.

In the next step of this stage, according to final comparison matrix, optimization problem is formed and this optimization problem will solve by using Genetic algorithm and the weights of criteria are determined. Strategic objectives priorities are found by using similarity computations in the third stage.

In this stage, by considering LFPP output as input of second step of similarity method, nine steps of similarity method mentioned in section (3.3) are carried out respectively.

Schematic representation of the proposed approach is presented in Fig. 4.

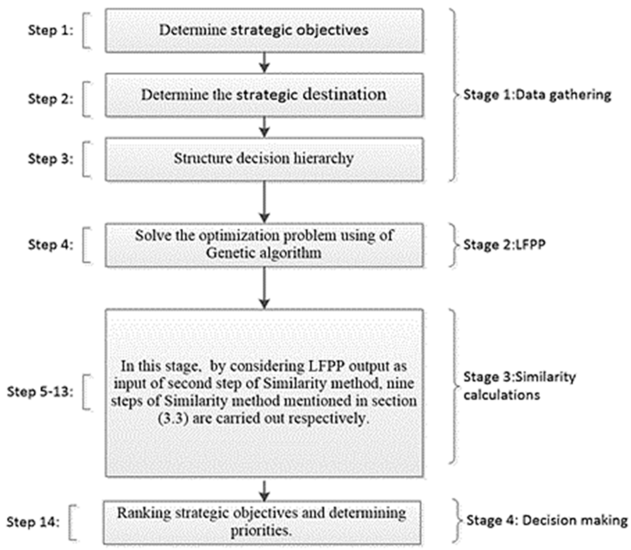

Fig. 4 Schematic representation of the process proposed for facility location selection

Case study: An application of the proposed approach

In this paper, existing strategic objectives in the strategy map of a company have been ranked based on their strategy's destinations.

Data collection

Consider the strategy map is shown in Fig. 5. In this case, six strategic destinations (SD) have been defined about vision, mission statement, and generic strategy. Strategy map has 15 strategic objectives (SO) too as below.

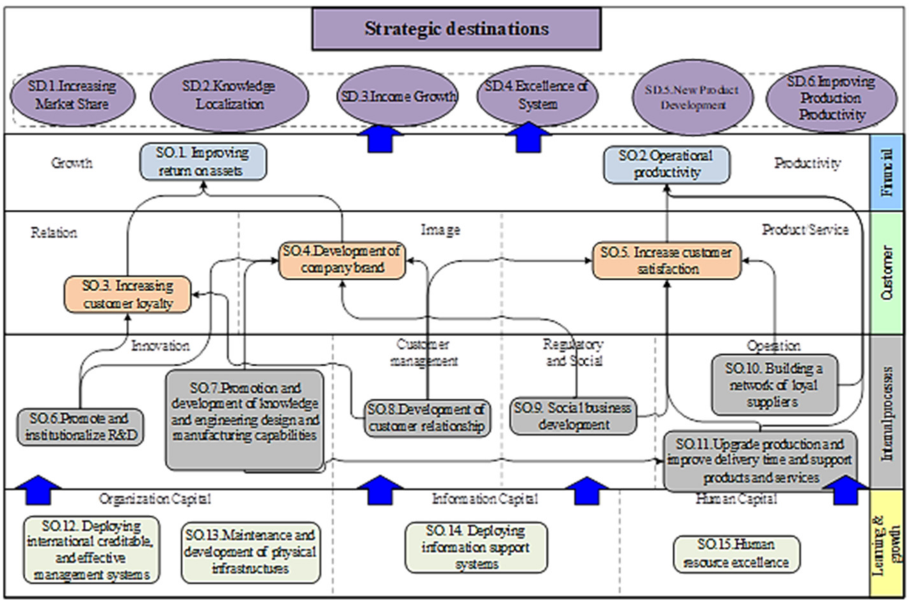

Fig. 5 The Strategy map

LFPP computations

In this stage, at first paired comparison matrix is formed between strategy's destinations, it is for determining the relative significance of destinations compared to each other. The experts are given the task of forming individual pairwise comparison matrix by using the scale given in Table 1. Geometric means of these values are found to obtain the pairwise comparison matrix on which there is a consensus (Table 2).

Table 2

Fuzzy comparison matrix

	C_1 (SD1)	C_2 (SD2)	C_3 (SD3)	C_4 (SD4)	C_5 (SD5)	C_6 (SD6)
C_1 (SD1)	(1,1,1)	(3,4,5)	(1,2,3)	(2,3,4)	(3,4,5)	(2,3,4)
C_2 (SD2)	(1/5,1/4, 1/3)	(1,1,1)	(1/4,1/3, 1/2)	(1/3,1/2, 1)	(1,2,3)	(3,4,5)
C_3 (SD3)	(1/3,1/2, 1)	(2,3,4)	(1,1,1)	(1,2,3)	(2,3,4)	(1/3,1/2, 1)
C_4 (SD4)	(1/4,1/3, 1/2)	(1,2,3)	(1/3,1/2, 1)	(1,1,1)	(1/2,3/2, 5/2)	(2,3,4)
C_5 (SD5)	(1/5,1/4, 1/3)	(1/3,1/2, 1)	(1/4,1/3, 1/2)	(2/5,2/3, 2)	(1,1,1)	(1,2,3)
C_6 (SD6)	(1/4,1/3, 1/2)	(1/5,1/4, 1/3)	(1,2,3)	(1/4,1/3, 1/2)	(1/3,1/2, 1)	(1,1,1)

After that, the fuzzy comparison matrix is formulated as a constrained optimisation problem (12), and this optimisation problem is solved by using of Genetic algorithm. To apply the Genetic algorithm, the MATLAB toolbox is used. The results obtained from solving optimisation problem using of Genetic algorithm are presented in Table 3.

Table 3

The weight of a strategy's destinations

ln w_1	**ln w_2**	**ln w_3**	**ln w_4**	**ln w_5**	**ln w_6**
3.575634	2.001404	2.703483	1.872948	1.09093	1.004523
w_1	w_2	w_3	w_4	w_5	w_6
0.291914	0.163394	0.220712	0.152907	0.089063	0.082009

Similarity computations

In this stage, alternatives are evaluated based on the criteria, then the decision matrix is formed. According to the previously stated criteria, the evaluations of these 15 alternatives, i.e., decision matrix, are shown in Table 4.

Table 4

Decision matrix

	SD.1	SD.2	SD.3	SD.4	SD.5	SD.6
SO.1	8.4	3.4	4.5	3.8	6.2	6.3
SO.2	7.3	2.7	5.1	2.7	6.9	7.01
SO.3	1.6	1.7	3.4	4.1	5.4	6.2
SO.4	2.1	3.4	3.4	3	8.3	8.1
SO.5	2.05	1.3	2.1	3.2	6.4	6.5
SO.6	2.4	8.4	5.3	3.4	5.4	7.2
SO.7	3.4	7.6	7.2	4.5	5.6	7.4
SO.8	2.7	3.1	3.5	4.3	6.3	6.8
SO.9	1.4	1.2	1.4	3.02	2.1	1.6
SO.10	3.4	3.7	6.8	4.8	6.2	6.8
SO.11	4.6	3.8	7.1	5.1	6.7	6.75
SO.12	3.4	6.5	5.8	5.4	5.7	5.86
SO.13	5.1	6.9	7.8	6.1	5.6	5.64
SO.14	4.8	7.1	6.57	6.3	5.3	5.1
SO.15	3.7	6.4	4.25	6.2	4.9	6.1
W	0.291914	0.163394	0.220712	0.152907	0.089063	0.082009

Based on Eq. (17) and Eq. (19), weighted normalised decision matrix has been obtained as follows (Table 5).

Table 5

Weighted performance matrix

	SD.1	SD.2	SD.3	SD.4	SD.5	SD.6
SO.1	0.149614	0.028360	0.048447	0.032961	0.024009	0.020890
SO.2	0.130021	0.022521	0.054906	0.02342	0.026720	0.023244
SO.3	0.028498	0.014180	0.036604	0.035564	0.020911	0.020558
SO.4	0.037403	0.028360	0.036604	0.026022	0.032141	0.026858
SO.5	0.036513	0.010844	0.022609	0.027757	0.024784	0.021553
SO.6	0.042747	0.070066	0.05706	0.029492	0.020911	0.023874
SO.7	0.060558	0.063393	0.077515	0.039033	0.021686	0.024537
SO.8	0.048090	0.025858	0.037681	0.037298	0.024397	0.022548
SO.9	0.024936	0.010009	0.015072	0.026196	0.008132	0.005305
SO.10	0.060558	0.030863	0.073209	0.041635	0.024009	0.022548
SO.11	0.081931	0.031697	0.076438	0.044238	0.025946	0.022382
SO.12	0.060558	0.054218	0.062443	0.04684	0.022073	0.019431
SO.13	0.090837	0.057554	0.083974	0.052912	0.021686	0.018701
SO.14	0.085494	0.059223	0.070732	0.054647	0.020524	0.016911
SO.15	0.065901	0.053384	0.045755	0.053779	0.018975	0.020227

Regarding the stages of similarity method angle and the similarity degree of each alternative have been obtained with the positive and negative ideal. By having the degree of positive and negative similarity, P_i (total performance index) is obtained, and alternatives are ranked based on it (Table 6).

Table 6

The values of $\cos\theta^{\mp}$, $S^{\mp}$, $\theta^{\mp}$, and P for all alternatives

	Θ+	Θ-	$\cos\theta^{+}$	$\cos\theta^{-}$	s+	s-	pi	rank
SO.1	16.12	28.61	0.961	0.878	0.808	0.211	0.793	1
SO.2	15.50	29.37	0.964	0.871	0.727	0.233	0.757	2
SO.3	29.64	19.53	0.869	0.942	0.294	0.562	0.344	13
SO.4	25.15	25.59	0.905	0.902	0.354	0.466	0.432	12
SO.5	25.53	19.23	0.902	0.944	0.282	0.610	0.316	14
SO.6	27.98	33.74	0.883	0.832	0.487	0.305	0.615	10
SO.7	21.36	27.09	0.931	0.890	0.601	0.278	0.684	6
SO.8	18.17	13.81	0.950	0.971	0.399	0.467	0.461	11
SO.9	23.62	3.10	0.916	0.999	0.193	0.958	0.167	15
SO.10	19.95	21.05	0.940	0.933	0.538	0.329	0.620	8
SO.11	14.30	18.85	0.969	0.946	0.633	0.292	0.684	5
SO.12	18.04	19.75	0.951	0.941	0.560	0.322	0.635	7
SO.13	12.64	19.11	0.976	0.945	0.736	0.253	0.744	3
SO.14	12.32	17.10	0.977	0.956	0.690	0.273	0.717	4
SO.15	16.81	14.85	0.957	0.967	0.551	0.339	0.619	9

Decision-making

About obtained values for pi, strategic objective 'Improving return on assets ‘identified as the most important objective of the strategic map, and 'Operational productivity’ is situated in the second priority. Similarly other objectives are placed which have been completely shown in Table (7).

According to the results, managers and experts know which objectives will help to achieve strategic destinations of their organisation. Concerning time and financial and non-financial facilities that they have, do appropriate planning for achieving strategy destinations.

Table 7
Ranking of 15 Strategic objectives

Rank		Strategic Objectives
1	SO.1	Improving return on assets
2	SO.2	Operational productivity
3	SO.13	Maintenance and development of physical infrastructures
4	SO.14	Deploying information support systems
5	SO.11	Upgrade production and improve delivery time and support products and services
6	SO.7	Promotion and development of knowledge and engineering design and manufacturing capabilities
7	SO.12	Deploying international creditable and effective management systems
8	SO.10	Building a network of loyal suppliers
9	SO.15	Human resource excellence
10	SO.6	Promote and institutionalize R&D
11	SO.8	Development of customer relationship
12	SO.4	Development of brand
13	SO.3	Increasing customer loyalty
14	SO.5	Increase customer satisfaction
15	SO.9	Social business development

CONCLUSIONS

Ranking of strategic objectives is critical in strategy map formulation. The current paper proposes a combination of Logarithmic Fuzzy Preference Programming and similarity method to increase the efficiency of the ranking of strategic objectives. The procedure starts from the drawing a strategy map, then the significance level of strategic objectives is identified. Important objectives are those who have the most influence on achieving expected results of organisation's strategy. Thus, ranking existing strategic objectives is one of the most critical steps in strategy implementation. In this paper, a decision approach is provided for ranking strategic objectives in a strategy map. The selection procedure compares alternatives based on the criteria; in this case, alternatives are strategic objectives, and criteria are strategic destinations.

Similarity and LFPP compound decision-making method is proposed. LFPP is used to assign weights to the strategic destinations, while similarity is employed to determine the priorities of the alternatives. The weights obtained from LFPP are imported to the decision-making process by using them in similarity computations, and the alternative priorities are determined based on weights. Similarity method uses the concept of alternative gradient and magnitude for effectively solving the general multi-criteria analysis problem. The concept of the degree of similarity between the alternatives and the ideal solution is combined to derive a total performance index of each alternative for the general multi-criteria analysis.

Additionally, regarding the application of the proposed approach, it is shown that calculation of the criteria weights is important in similarity method, and they could change the ranking. The proposed decision approach can help decision-makers to choose and analyze factors and attributes efficiently.

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