Performance Evaluation using Balanced Scorecard (BSC) and Fuzzy TOPSIS technique
Case Study : National Iranian Gas Company

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Abstract:
The goal of this study is to propose a tentative model for performance evaluation of provincial gas companies in the National Iranian Gas Company (NIGC),based on a combined approach including Balanced Score Card and Fuzzy TOPSIS. Balanced Score Card was used to design the performance evaluation index and Fuzzy Topsis to determin final scores and ranks of provincial gas companies. In the proposed approach, effective criteria for companies' performance evaluation were firstly determined on the basis of Balanced Score method, in four respects: customer, internal processes, growth/Learning, and financial. These criteria were subsequently finalized gathering expert opinions.The effectiveness of such criteria in companies' performance assessment were determined using questionnaire and expert opinions. Furthermore,due to the variable environment of the issue under consideration, the Fuzzy Topsis was drawn upon fuzzy concepts. eventually, the proposed hybrid approach was applied to assign final scors and ranks of five provincial gas companies, i.e. Ilam, Kermanshah, Lorestan, Markazi, and Hamedan.

Keywords: Balanced scorecard (BSC), Fuzzy TOPSIS, provincial gas companies, performance evaluation

1. Introduction:
Today, as economic territories border on each other, the world competition is given further dimensions. Attempt to raise productivity and to promote efficiency builds the main foundation for this competition. Improvement in organizational performance assists development and advancement.Different countries make investment in order to develop a performance evaluation approach and to employ measurement methods. Today,performance evaluation along with productivity acts as an incentive to economic development. Improvement in different resources including labor, capital, materials, energy, and data is pursued by all directors and managers of economic organizations, industrial-manufacturing corporations, and service departments. Focusing on efficiency of productions and services, organizations can stimulate growth and development and can follow a right path.Accordingly, organizations are required to gain awareness of concepts of performance evaluation and to formulate strategies for its improvement. Today, performance is evaluated by governments in general levels as well. One of crucial stages of performance measurement is a determination of efficient and measurable indicators.
Lack of performance evaluation system in different organizational levels including resources, objectives, and strategies is one of organizational disease symptoms. Consequently, for gaining awareness of their own quality and efficiency

especially in dynamic environments, organizations need an evaluation system. Defining new indicators and looking into performance evaluation trace back 1980s when big changes and developments occurred in management areas of study on the basis of criticisms against evaluations affected radically by financial criteria (Brem,Kreusel &Neusser,2008). Nevertheless, most advancements in performance evaluation trace back the end of 1980s and 1990s when performance was evaluated in multidimensional and balanced terms and directors and managers attempt to gather valuable data for making managerial decisions; yet next studies showed a gap between knowledge and its practical application (Garengo,Biazzo & Bititci,2005). Akbarzadeh (2012) attempts to map out practical strategies in organizations and corporations on the basis of balanced scorecard model (BSC). As this researcher points out, directors and experts should evaluate organizational performance and make decisions in accordance with accurate and precise information rather than assumptions and feelings. Shahverdi et al (2011) evaluate performance of 3 private banks in Iran by using balanced scorecard and multi-criterion decision making techniques (MCDM). In this study, directors and professionals choose 21 indicators for performance evaluation. Additionally, a Fuzzy Analytical Hierarchy Process (FAHP) takes place for measurement of relative weight of each indicator. Also, three analytical tools of MCDM including TOPSIS, VIKOR, and ElECTRE determine performance ranking of banks. Their findings show that customers' satisfaction is the most crucial indicator in banking departments.
Nejati et al (2009) examines parameters of service quality in aviation industry and offers their rankings in Iran by employing Fuzzy TOPSIS method. The findings demonstrated that flight safety, good appearance of airplane personnel, and supply of excellent services to customers round-the-clock are the most significant determinants of service quality in airplanes. It is worth noting that awareness of flight time by telephone is the least significant determinate. Moreover, most passengers prefer to travel with airplane.Lee et al (2008) propose a FAHP-and-BSC-based approach for evaluation of information technology in construction industry of Taiwan. BSC is offered for a hierarchical description from 4 viewpoints including finance, customer, internal business, and learning and growth. It provides each of these dimensions with performance indicators. A FAHP data system is ultimately established in order to develop guidelines for IT sectors of construction industry in Taiwan. Kaplan and Norton (2004) put emphasis on causal relationship between dimensions of BSC. They reveal that in analysis of BSC, there is a causal relationship between objectives and parameters of these dimensions. As prior studies have not still integrated BSC with Fuzzy TOPSIS for ranking. Therefore, the present study combines these two methods for ranking of 5 gas companies in Iran.

2. Balanced Score Card

Balanced scorecard is one of the most important posed instruments in the field of business in the last century. In the beginning of 1990, Robert Kaplan, professor of commercial academy of Harvard University along with David Norton being manager of a research company in this time, began a research program in order to assess successes factors of 12 top American companies and to study performance evaluation of these companies. Thus, Kaplan and Norton announced that due to do a complete evaluation of performance, performance of the organization should be evaluated in four perspectives:
1. Financial Perspective,2.Customer Perspective,3.Internal Processes Perspective,4.Learning & Growth Perspective
Kaplan and Norton's findings determined that successful companies define their objectives from the four perspectives of aims and select measures for evaluation, they designate lower aims from these measures during evaluative period, then they plan and fulfill administrative proceedings and innovations for achievement of these aims. Kaplan and Norton called this method of performance evaluation as a method of balance or balanced scorecard. (Kaplan & Norton 2004).
Balanced scorecard completes the financial indexes of last performances with the determiner indexes of future performances. Aims and indexes of balanced scorecard are determined by strategy and perspective of organization.These aims and indexes look at performance of organization in four aspects: financial, customer, internal process and growth and learning.
As it is shown in Figure 1, these four perspectives provide a frame for balanced scorecard (Kaplan & Norton,1996).

Figure 1. Perspectives of balanced scorecard

2.1Perspective and strategy:

Financial perspective: in order to achieve financial success, how should we encounter shareholders?

Customer perspective: in order to achieve our aims, how should we behave with customers?
Internal processes perspective: what commercial processes are necessary in order to satisfy shareholders and customers?
Growth and learning perspective: how do we promote individuals' abilities in order to achieve perspective?

2.2Financial perspective

In Financial perspective of balanced scorecard, economical results of utilizing strategies are evaluated. As financial operation can be evaluated with indexes like operational interest, capital return and surplus value rate in systems of planning, before strategic planning and control systems, it can be evaluated in balanced scorecard as an operation for performance evaluation and an instrument for controlling as well as financial performance with similar indexes and relations (Simons,2000).

2.3Customer perspective

In customer perspective of balanced scorecard, managers firstly designate customer and market's parts trending to compete. Designated parts will include customers as well as present and potential markets. This perspective balanced scorecard involves several public indexes and a series of secondary indexes. Essential indexes consist of customer satisfaction, customer preservation, attraction of new customer, profit per customer, market share in customer and market's parts (Kaplan & Norton, 1996).

2.4Learning and growth perspective

Learning and growth of organization derives from three principle sources of humanitarian power, information systems,instructions and organizational processes. Level of achievement to capabilities and special power are evaluated in these sources of learning and growth perspective of balanced scorecard.
In order to evaluate aims related to this perspective, factors like achievement rate of customer to information and internal processes by managers and operational employees are evaluated regarding information systems and coextensive rate of employees' motivations with goal of organization about instructions and organizational procedures (Simons, 2000).

2.5Internal processes perspective

In internal processes perspective of balanced scorecard, managers firstly designate key internal processes that should be emphasized due to fulfill strategy on them (these process enable the organization to value for the customer attraction and preservation and to provide shareholders' expectations) (Robert & Simons,Every business involves a collection of special processes in order to put a value on customer and financial results for shareholders. Procedure of balanced scorecard selects the concatenate model of Porter value as a public pattern for using
in perspective of internal processes which include three processes of innovation, operation and after-sales service(Kaplan & Notron,1996).

3. The Fuzzy TOPSIS method

In this method, which was proposed by Hwang and Yoon in 1981, m choices are evaluated based on n indices. The underlying logic of this method defines the (positive) ideal solution and the negative ideal one. The (positive) ideal solution is one which increases the benefit-related criterion and decreases those related to cost. The optimal choice is a choice that has the minimum distance from the ideal solution while keepsthe maximum distance from the negative ideal one. In other words, in TOPSIS-based ranking, choices being the most similar to the ideal solution achieve higher ranks.the target space between two example criteria is shown in the following figure. Here, A_+ and A_-represent the ideal and negative ideal solutions respectively. Compared with the A^2, the A^1 choice is located at a smaller distance from the ideal choice and a larger distance from the negative ideal one. (Habibi , Izadyar & Sarafrazi, 1393)

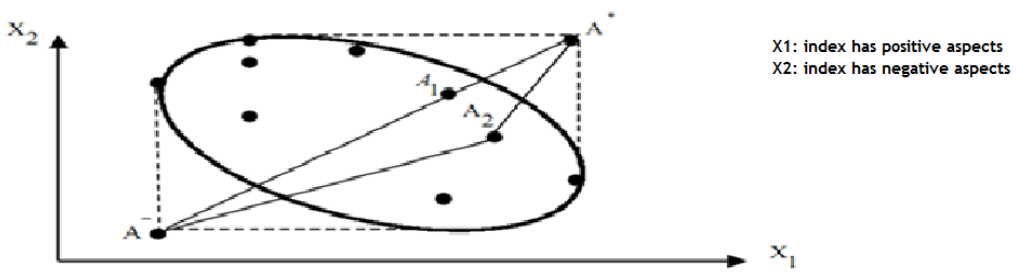

Figure 2 : The positive ideal solution and negative ideal solution

In this section, the fuzzy TOPSIS technique introduced by Chen (2000) is going to be used to rate companies.
This technique has been proposed in the following steps:

Step 1 : In the first step, assessment criteria and subject matter experts are identified.

Step 2: In this phase, the verbal measures presented in the following table are used to evaluate different choices in relation with assessment criteria. In other words, the following table can be used to determin choices' scores with regard to sub-criteria

Table 1. Linguistic scale to determine the rating of the sub-criteria option

Linguistic variables	Corresponding triangular fuzzy number
Very poor (VP)	(0،0،20)
Poor (P)	(0،20،40)
Fair (F)	(30،50،70)
Good (G)	(60،80،100)
Very good (VG)	(80،100،100)

Step 3: In this step, experts' evaluation of different choices with respect to the criteria will be aggregated using arithmetic mean.

Step 4: In this step, fuzzy decision matrix and normalized fuzzy decision matrix will be calculated and specified based on the following equation's.

$$\tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{11} & \dots & \tilde{x}_{11} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ \vdots & \vdots & \dots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mn} \end{bmatrix}$$

$$\tilde{W} = [\tilde{w}_1, \ \tilde{w}_2, \ \dots, \ \tilde{w}_n]$$

where $\tilde{x}_{ij}, \ \forall i,j$ and $\tilde{w}_j$, j =1, 2, … , n are linguistic variables. These linguistic variables can be described by triangular fuzzy numbers, $\tilde{x}_{ij}$ =(a_{ij}, b_{ij}, c_{ij}) and $\tilde{w}_j$ =(wj_1,wj_2,w_{j3}).

$$R = [\tilde{r}_{ij}]_{m \times n}$$

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^{max}}, \frac{b_{ij}}{c_j^{max}}, \frac{c_{ij}}{c_j^{max}} \right), \quad j \in B$$

$$\tilde{r}_{ij} = \left(\frac{a_j^{min}}{c_{ij}}, \frac{a_j^{min}}{b_{ij}}, \frac{a_j^{min}}{a_{ij}} \right), \quad j \in C$$

$$c_j^{max} = \max_i c_{ij} \quad if \ j \in B$$

$$a_j^{min} = \min_i a_{ij} \quad if \ j \in C$$

In the above equations, m is the number of choices, n is the number of the criteria, B represents benefit-related set of criteria and C represents cost-related set of criteria.

Step 5: Weighted normalized fuzzy decision matrix is calculated based on the following equations:

$$\tilde{V} = [\tilde{v}_{ij}]_{m \times n}$$

$$\tilde{v}_{ij} = \tilde{r}_{ij} \times w_j$$

In the above equation w_j shows the weight of the criterion j. in the present study, the output of the second phase of the proposed technique, i.e. fuzzy network analysis, would be the weight of w_j.

Step 6: Fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS) are determined in this phase.

$$FPIS \ : \ A^{*} = (\tilde{v}_1^{*}, \tilde{v}_2^{*}, ..., \tilde{v}_n^{*})$$

$$FNIS \ : \ A^{-} = (\tilde{v}_1^{-}, \tilde{v}_2^{-}, ..., \tilde{v}_n^{-})$$

Step 7: the distance of each choice from fuzzy positive ideal solution and fuzzy negative ideal solution is measured using the following equations:

$$d_i^{*} = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_{ij}^{*}), i = 1,2,...., m$$

$$d_i^{-} = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_{ij}^{-}), i = 1,2,...., m$$

If the two numbers $\tilde{v}_{ij} = (v_{ij}^{p}, v_{ij}^{m}, v_{ij}^{o})$ and $\tilde{v}_{ij}^{*} = (v_{ij}^{p*}, v_{ij}^{m*}, v_{ij}^{o*})$ are fuzzy, then the distance between these two fuzzy number is calculated from the following equation:

$$d(\tilde{v}_{ij}, \tilde{v}_{ij}^{*}) = \sqrt{\frac{1}{3}[\left(v_{ij}^{p*} - v_{ij}^{p}\right)^2 + \left(v_{ij}^{m*} - v_{ij}^{m}\right)^2 + \left(v_{ij}^{o*} - v_{ij}^{o}\right)^2]}$$

Step 8: Choice ranking based on proximity rate. Measuring the distances, in this last step, proximity rate can be obtained through the following equation:

$$CC_i = \frac{d_i^{-}}{d_i^{*} + d_i^{-}}, i = 1,2,...., m$$

Obviously, an alternative Ai is closer to the (FPIS, A*) and farther from (FNIS, A−) as CCi approaches to 1. Therefore, according to the closeness coefficient, we can determine the ranking order of all alternatives and select the best one from among a set of feasible alternatives.

4. An application:

In this study, among the various criteria, the most important are used in evaluating performance. Table 1 gives the list of the evaluation criteria in this study.

Table 2. List of evaluation criteria

Aspect	Criteria
Customer	(C1): Dealing with Customers' complaints Timely (C2): Necessary measures for avoidance of gas service interruption (C3): Training of safety and optimal consumption of natural gas
Internal processes	(C4): Proper Management of Activities (C5): Budgeting of Projects (C6): Control of Projects Quality
Learning and growth	(C7): Training of Employees (C6): Targeted Rewards for Employees (C9): Investment in Information Technology (C10): Total Quality Management
Financial	(C11): cost savings (current and energy, etc) (C12): Project Cost Management

These companies are as follows:

A1 : Ilam Province Gas Company
A2 : Kermanshah Province Gas Company
A3 : Lorestan Province Gas Company
A4 : Markazi Province Gas Company
A5 : Hamedan Province Gas Company

These corporations are evaluated and rank with regard to 12 identified criteria determined by BSC. Additionally, the ultimate scores of each corporation are measured by employing fuzzy TOPSIS method.

In the first step, 10 professions in each corporation expressed their viewpoints about its scores in fulfillment of criteria. Then, the collected data changed into related fuzzy numbers and the fuzzy decision matrix was normalized.

Table 3. Collected data changed into related fuzzy numbers

	A1	A2	A3	A4	A5
C1	(47,67,85)	(36,54,74)	(39,59,79)	(33,53,73)	(43,63,79)
C2	(68,88,100)	(52,72,88)	(67,87,97)	(68,88,100)	(55,75,85)
C3	(56,76,94)	(33,53,73)	(35,55,73)	(45,65,85)	(33,49,69)
C4	(53,73,91)	(39,57,77)	(42,62,82)	(41,61,79)	(30,48,68)
C5	(48,68,88)	(36,56,76)	(35,55,73)	(50,70,80)	(49,69,85)
C6	(47,67,85)	(24,40,60)	(21,41,61)	(36,56,76)	(33,51,71)
C7	(52,72,88)	(42,62,82)	(41,61,79)	(50,70,88)	(27,41,61)
C8	(42,62,82)	(27,45,65)	(44,64,82)	(33,53,73)	(21,39,59)
C9	(44,64,82)	(39,59,79)	(27,47,67)	(44,64,82)	(42,62,76)
C10	(51,71,91)	(30,48,68)	(39,59,79)	(21,41,61)	(36,54,74)
C11	(41,61,79)	(36,56,76)	(41,61,79)	(33,53,73)	(43,61,77)
C12	(50,70,88)	(30,46,66)	(33,53,73)	(39,57,77)	(36,54,74)

Table 4. Fuzzy normalized decision matrix

	A1	A2	A3	A4	A5
C1	(0.553,0.788,1)	(0.424,0.635,0.871)	(0.459,0.694,0.929)	(0.388,0.624,0.859)	(0.506,0.741,0.929)
C2	(0.68,0.88,1)	(0.52,0.72,0.88)	(0.67,0.87,0.97)	(0.68,0.88,1)	(0.55,0.75,0.85)
C3	(0.596,0.809,1)	(0.351,0.564,0.777)	(0.372,0.585,0.777)	(0.479,0.691,0.904)	(0.351,0.521,0.734)
C4	(0.582,0.802,1)	(0.429,0.626,0.846)	(0.462,0.681,0.901)	(0.451,0.67,0.868)	(0.33,0.527,0.747)
C5	(0.545,0.773,1)	(0.409,0.636,0.864)	(0.398,0.625,0.83)	(0.568,0.795,1)	(0.557,0.784,0.966)
C6	(0.553,0.788,1)	(0.282,0.471,0.706)	(0.247,0.482,0.718)	(0.424,0.659,0.894)	(0.388,0.6,0.835)
C7	(0.591,0.818,1)	(0.477,0.705,0.932)	(0.466,0.693,0.898)	(0.568,0.795,1)	(0.307,0.466,0.693)
C8	(0.512,0.756,1)	(0.329,0.549,0.793)	(0.537,0.78,1)	(0.402,0.646,0.895)	(0.256,0.476,0.72)
C9	(0.537,0.78,1)	(0.476,0.72,0.963)	(0.329,0.573,0.817)	(0.537,0.78,1)	(0.512,0.756,0.927)
C10	(0.56,0.78,1)	(0.33,0.527,0.747)	(0.429,0.648,0.868)	(0.231,0.451,0.67)	(0.396,0.593,0.813)
C11	(0.519,0.772,1)	(0.456,0.709,0.962)	(0.519,0.772,1)	(0.418,0.671,0.924)	(0.544,0.772,0.975)
C12	(0.568,0.795,1)	(0.341,0.523,0.75)	(0.375,0.602,0.830)	(0.443,0.648,0.875)	(0.409,0.614,0.841)

In the next step the weighted normalized fuzzy decision matrix is constructed.
An identical weight was given to all criteria in evaluation process,Accordingly the weight of any criterion is $\frac{1}{12}$.

Table 5. Fuzzy weighted decision matrix

	A1	A2	A3	A4	A5
C1	(0.02,0.029,0.037)	(0.016,0.024,0.032)	(0.017,0.026,0.034)	(0.014,0.023,0.032)	(0.019,0.027,0.034)
C2	(0.025,0.033,0.037)	(0.019,0.027,0.033)	(0.025,0.032,0.036)	(0.025,0.033,0.037)	(0.02,0.028,0.031)
C3	(0.022,0.03,0.037)	(0.013,0.021,0.029)	(0.014,0.022,0.029)	(0.018,0.026,0.033)	(0.013,0.019,0.027)
C4	(0.022,0.03,0.037)	(0.016,0.023,0.031)	(0.017,0.025,0.033)	(0.017,0.025,0.032)	(0.012,0.02,0.028)
C5	(0.02,0.029,0.037)	(0.015,0.024,0.032)	(0.015,0.023,0.031)	(0.021,0.029,0.037)	(0.021,0.029,0.036)
C6	(0.02,0.029,0.037)	(0.01,0.017,0.026)	(0.009,0.018,0.027)	(0.016,0.024,0.033)	(0.014,0.022,0.031)
C7	(0.022,0.03,0.037)	(0.018,0.026,0.035)	(0.017,0.026,0.033)	(0.021,0.029,0.037)	(0.011,0.017,0.026)
C8	(0.019,0.028,0.037)	(0.012,0.02,0.029)	(0.02,0.029,0.037)	(0.015,0.024,0.033)	(0.009,0.018,0.027)
C9	(0.02,0.029,0.037)	(0.018,0.027,0.036)	(0.012,0.021,0.03)	(0.02,0.029,0.037)	(0.019,0.028,0.034)
C10	(0.021,0.029,0.037)	(0.012,0.02,0.028)	(0.016,0.024,0.032)	(0.009,0.017,0.025)	(0.015,0.022,0.03)
C11	(0.019,0.029,0.037)	(0.017,0.026,0.036)	(0.019,0.029,0.037)	(0.015,0.025,0.034)	(0.02,0.029,0.036)
C12	(0.021,0.029,0.037)	(0.013,0.019,0.028)	(0.014,0.022,0.031)	(0.016,0.024,0.032)	(0.015,0.023,0.031)

After obtaining the fuzzy weighted decision table, we calculate the distance of each alternative from the positive ideal (FPIS, A*) and negative ideal (FNIS, A−) solutions. Finally we calculate the closeness coefficient (CCi)of each alternative.
The results of the modified fuzzy TOPSIS analysis are summarized in Table 6. Based on CCi values, the ranking of the alternatives in descending order are A1, A4, A5, A3 andA2.
According to the last step, the best alternative is A1.

Table 6.Fuzzy modified TOPSIS results

	d_i^+	d_i^-	CC_i
A1	0.002	0.102	0.981
A2	0.076	0.029	0.276
A3	0.058	0.027	0.318
A4	0.046	0.058	0.558
A5	0.071	0.034	0.324

5. Conclusion & Discussion:

Performance evaluation in an organization plays a significant role in making managerial decisions and setting out organizational guidelines and strategies. Withought sufficient knowledge of the organization's strengths and weaknesses, making sound strategic decisions would not be possible. Such a sufficient knowledge is gained through a systematic evaluation of the organization's performance. Meanwhile, performance evaluation plays an undeniable part in improving the organization's quality and utility.

The present study attempted to evaluate performance of 5 gas companies of Iran because of significance of performance evaluation in petroleum activities. These companies were evaluated and rank with regard to 12 identified criteria, by combining BSC and Fuzzy TOPSIS. The findings demonstrate highest scores and the highest ranking for Gas Company of Ilam province. Conversely, Gas Company of Hamadan Province gained the lowest score and the lowest ranking. The output of this method to be reminded that any weakness in the dimensions and the dimensions are its strong points. Using these outputs can be used to put the organization on the path to growth. This method can determine ranking of all decision making units. The analytical findings are indications of the proposed methods' strength. Along with simplicity and easy understanding, it has the following advantages: Support of fuzzy concept (lack of clarity and uncertainty), capacity for ranking (more effective decision making), and lightened calculative burden (feasibility of model solution). This proposed model helps directors and managers to make more accurate decisions and manage performance evaluation perfectly. This model can be applied to other industries and can be integrated with methods such as ELECTRE and DEA.

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Biography

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