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Identifying indicators to evaluate the green performance of the units of department of water and Wastewater Company of Gazvin

Rahim Ehsani[1], Masumeh-Sadat Hoseyni-Sakkaki[2]

[1]Assistant Professor, Space Transportation Research Institute,
[2]Faculty of Industrial and Mechanical Engineering, Qazvin Branch, Islamic Azad University,

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ABSTRACT

In this paper, we identify indicators to evaluate the green performance of the units of department of water and wastewater of Gazvin using of the improved approach green balanced scorecard. So, the causal relationship between master perspectives and Priority between them is determined with DEMATEL method. To identify indicators, at first literature is reviewed and collected 34 indicators. Then, to interview with expert persons, 18 indicators related to the five perspectives of the balanced scorecard performance are selected.

KEYWORDS: Green performance evaluation, Green Balanced scorecard, DEMATEL, ANP

1. INTRODUCTION

Human resource plays an inevitable role in an organization and it is considered as a valuable capital and fundamental factor for improvement in organizations. Improvement of human resources is a key factor in state and nonprofit organization to enhance productivity. As experts' point of view, performance evaluation is a practical solution in human resource improvement. Moreover, there is no other procedure for managers to create effective human resource, except training and education, motivation, personality of workers and etc. To get this aim, performance of organization is evaluated in first step then having identified weak and strong points of organizations, corrective actions is considered to remove strong weakness points and strengthened strong points. Nowadays, environmental factors are attracting a lot of attention in industrial countries. Since there have made major effects such as: supportive financial activities of NGOs related to environment, great national and international increase in environmental regulations (United Nations, Europe Union), growing trend in manufacturing actions and recycling with ability of applying them for second times and cooperation of people in this trend (direct and indirect), diverse changes of climate caused by pollution of environment and earth heat has became major preference for medias [1]. Regarding mentioned points, for a company, its operation management that has minimum undesirable effects on environment (direct and indirect) has got growing priority. On the other hand, companies are not able to manage factors which cannot be evaluated [2]. Thus, performance evaluation is a fundamental factor in empowering the performance management, performance improvement and performance documentation. These are important scopes which are ignored in researcher's studies respect to rich resource of competitive advantage. Balanced Scored Card (BSC) has been introduced as a helpful tool for performance evaluation which can far control and plan organizations to fulfill the aims [3-5]. BSC disorders traditional and financial constraints, and evaluates an organization from four major perspectives such as financial perspective, customer perspective, internal business perspective and training and learning perspective [6].

2. LITERATURE REVIEW

There have been few studies in creating and applying BSC for green performance evaluation in industrial sites. Moreover, some researches in banking, textile and pharmacy industries have been conducted. Su and Lin (2010) [7] discussed environmental performance evaluation and strategic management applying BSC. In this study, structure of BSC performed in performance evaluation of automotive industry to identify internal and external relations, financial and nonfinancial and output and driving factors. In addition, they presented a hybrid method of ANP techniques and importance-performance analysis to green performance evaluation in uncertain environment. They integrated classic indicators of performance evaluation with green indicators in BSC. The indicators has been chosen from literature regarding five perspectives: financial, internal actions, extending and training customers and environmental, including financial perspective: growing budget, cost adjustment, attempts to identify new resources, financial productivity, growing urban incomes, cash flow, rate of return investment [8]. Internal actions perspective: workforce productivity, critical organizational standards, bureaucracy, organizational interactions, innovation of services, efficiency of workforce, cost effective suppliers, clear and specified goals [8]. Perspective: compatible training courses, salary, employees education, human resource, research and development, information, employee's knowledge about regulation [9] .customer perspective: customer satisfaction, services, lead time, customer respect, employee's responsibility, pure

Corresponding Author: Masumeh-Sadat Hoseyni-Sakkaki, Faculty of Industrial and Mechanical Engineering, Qazvin Branch, Islamic Azad University, Email: selva.sakkaki@gmail.com Tel: +98 281 3670051;

management, customer's vision [10]. environmental perspective: importance of green -green suppliers-indicators, clear and specified goals to make green urban activities, clean workplace – in service environmental training, capital return rate of environmental investments, creativity in green services, training courses related to environment, green suppliers, visions of environmentally friendly people [11]. ANP is more comprehensive method than AHP that is applied regarding relations and feedbacks to remove constraints of hierarchical method in MCDM [12]. This technique is able to integrate qualitative and quantitative information. Moreover, DEMATEL technique is developed to study complicated problems and it considers strategic and intuitive goals to introduce proper solution. They apply this method to construct an information chain [13]. In addition, it scores severity of interactions and seeks importance of feedbacks. There have been a lot of hybrid methods combined of these two techniques [13]. In this paper, using five steps questionnaire and interview, eighteen green performance evaluation indicators of 34 indicators are chosen from literature. Thus, we implemented DEMATEL to study cause and effect relations between perspectives, then applied ANP to allocate total weight of indicators.

3. METHODOLOGY

We organized a five step questionnaire that is included levels of very good, good, average, bad and very bad, to identify performance evaluation indicators that were answered by ten experts. Data collected from ten experts were integrated together and some below average removed according to water and wastewater company's indicators, thus only 18 performance evaluation indicators which scored above average were extracted. Furthermore, DEMATEL technique includes: 1. Calculating fuzzy decision matrix 2. Calculating average decision matrix 3. Defuzzification by applying CFCS 4. Calculating normalized matrix 5. Calculating total relation matrix 6. Calculating sum of the rows and columns (Cj,Ri) 7.Calculating Ri+Cj and Ri-Cj 8. Drawing caused and effect diagram 9. Calculating threshold p-value and drawing CRM diagram. In this technique caused and effect relations between perspectives were specified and values above P-value applied in drawing CRM diagram and values below P-value were removed. Finally ANP method were implemented to allocate weights to indicators. This technique includes: 1. Calculating pairwise comparison matrix 2. Calculating weight relative vectors using pairwise comparison matrix 3. Calculating super matrix 4. Convergence of super matrix.

4. Experimental results

In order to recognize green performance evaluation indicators in water and waste water company of Qazvin, after studding background and collecting indicators by means of interview and five step questionnaire (very good, good, average, bad, very bad) between 10 experts, we integrated gathered data with final ideas and removed indicators below average value, thus 18 indicators among 34 indicators were determined. Furthermore, DEMATEL technique that is an analytical and comprehensive technique for specifying complicated relations were engaged to assign caused and effect relations between perspectives. In contrast to AHP, this technique assumes that all criteria are independent and considers their relations, it calculates levels of these relations.

4.1. Applying DEMATEL technique

In the interest of determining interactions between criteria, questionnaires were distributed among 28 experts. Though, major criteria are analyzed together as if sub-criteria. Aiming to recognize interactions, fuzzy sets are applied. As table 1 shows, they are ordered from without interactions to considerable interactions and are assessed by experts.

Step 1: After questionnaire analysis, pairwise comparison matrix is calculated and adjusted to triangle fuzzy numbers, as table 2 display it.

Table 1. interactions between criteria

(0.7،0.9،1)	Without interaction
(0.5،0.7،0.9)	Low interaction
(0.3،0.5،0.7)	Average interaction
(0.1،0.3،0.5)	Much interaction
(0.0،1،0.3)	Considerable interaction

Table 2. Decision matrix of major criterias

		criteria														
			L			F			C			P			G	
criteria	L	0.00	0.00	0.25	0.75	1.00	1.00	0.75	1.00	1.00	0.50	0.75	1.00	0.25	0.50	0.75
	F	0.50	0.75	1.00	0.00	0.00	0.25	0.50	0.75	1.00	0.50	0.75	1.00	0.50	0،.75	1،00
	C	0.50	0.75	1.00	0.50	0.75	1.00	0.00	0.00	0.25	0.50	0.75	1.00	0.25	0.50	0.75
	P	0.50	0.75	1.00	0.50	0.75	1.00	0.50	0.75	1.00	0.00	0.00	0.00	0.25	0.25	0.50	0.75
	G	0.50	0.75	1.00	0.50	0.75	1.00	0.50	0.75	1.00	0.50	0.75	1.00	0.00	0.00	0.25

Step 2: Defuzzification using CFCS

This method is developed based on determining maximum and minimum value in triangle fuzzy numbers through four phases

Phase 1: Normalizing decision matrix

Using equations (1), (2), (3), calculate fuzzy decision matrix.

$$x_{rj}^{n} = (r_{ij}^{n} - \min l_{ij}^{n}) / D_{\min}^{\max} \quad (1)$$

$$xm_{rj}^{n} = (m_{ij}^{n} - \min l_{ij}^{n}) / D_{\min}^{\max} \quad (2)$$

$$xl_{rj}^{n} = (l_{ij}^{n} - \min l_{ij}^{n}) / D_{\min}^{\max} \quad (3)$$

Phase 2: Normalized values in left and right sides

Applying equations (4) and (5) normalizes values in left side that are shown as (ls) and normalizes values in right side that are shown as (rs).

$$xrs_{ij}^{n} = xr_{ij}^{n} / (1 + xr_{ij}^{n} - xm_{ij}^{n}) \quad (4)$$

$$xls_{ij}^{n} = xm_{ij}^{n} / (1 + xm_{ij}^{n} - xl_{ij}^{n}) \quad (5)$$

Phase 3: Total normalized crisp values

With use of equation (6-4), normalized crisp values are calculated

$$x_{ij}^{n} = \left[xls_{ij}^{n} (1 - xls_{ij}^{n}) + xrs_{ij}^{n} \times xrs_{ij}^{n} \right] / \left[1 - xls_{ij}^{n} + xrs_{ij}^{n} \right] \quad (6)$$

Phase 4: Calculating crisp values

Using equation (7) crisp values are calculated.

$$z_{ij}^{n} = \min_{ij}^{n} + x_{ij}^{n} \times D_{\min}^{\max} \quad (7)$$

Step 3: Calculating average decision matrix

After extracting ideas of 28 experts about criteria's interactions in decision matrix, total average of decision matrix is determined.

Step 4: Calculating normalized average matrix

With applying equation (8-4) average matrix is calculated.

$$S = \max\left(\max_{1 \le i \le n} \sum_{j=1}^{n} a_{ij}; \max_{1 \le j \le n} \sum_{i=1}^{n} a_{ij} \right) \quad (8)$$

Step 5: Calculating total relation matrix

With applying equation (9-4) total relation matrix is calculated

$$T = D(I - D)^{-1} = \left[t_{ij} \right]_{n \times 1} \quad (9)$$

Step 6: Calculating sum of rows and columns (r_i, c_i)

Having calculated total relation matrix, we calculate sum of rows (r_i) that shows influences of i-th criteria on other criteria and sum of columns (c_j) that shows influences of other criteria on j-th criteria.

Step 7: Calculating r_i+c_j and r_i-c_j and weights of indicators

Table 3. Calculating ri - ci and ri+ci

r+c	r-c
20.00	1.00
19.19	-0.53
19.91	0.01
19.83	0.23-
18.10	-0.28

Step 8: Drawing caused and effect relations diagram

Figure (1) illustrates caused and effect relations between criterias, thus horizontal axis shows ri+cj and vertical axis shows ri-cj. Criterias above horizontal line indicate causes and criterias below horizontal line indicate effects. Regarding values achieved in previous step, if ri-cj gains positive values i-th criteria will be considered as a cause and if it gains negative values it will be considered as an effect. According to the diagram, learning perspective (L), customer perspective (C) are considered as effects and internal perspective (P), financial perspective (F) and green perspective (G) are known as effects.

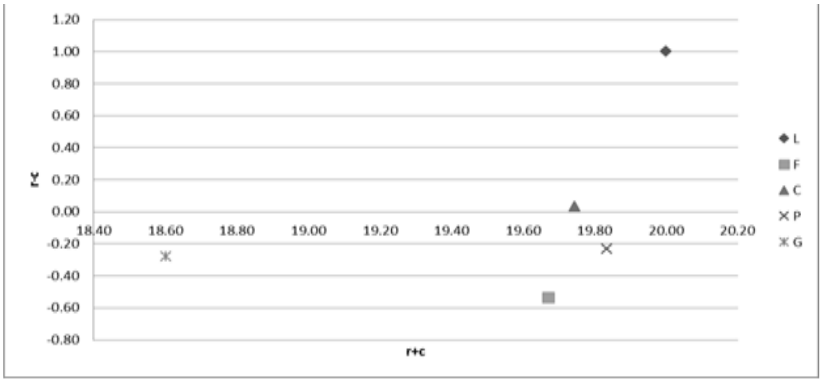

Figure. 1. Caused and effect relations diagram

Step 9: Calculating threshold P- value and drawing CRM diagram

All arrays in total relation matrix suggest amount of influences of criteria i on criteria j. To separate small causes and calculate threshold p-value, only values in total relation matrix which have more influence value than p-value are shown in CRM diagram. P- value is defined as equal to average arrays of total relation matrix. Average value in relation matrix for major criteria is 1957, thus according to this value, total relation matrix is convert to table 4 and CRM diagram is produced.

Table 4. total relation matrix according to thrashold

		criteria				
		L	**F**	**C**	**P**	**G**
criteria	**L**	0.00	2.21	2.15	2.19	2.06
	F	0.00	0.00	0.00	2.00	0.00
	C	1.96	2.08	0.00	2.06	0.00
	P	0.00	2.06	2.02	0.00	0.00
	G	0.00	0.00	0.00	0.00	0·00

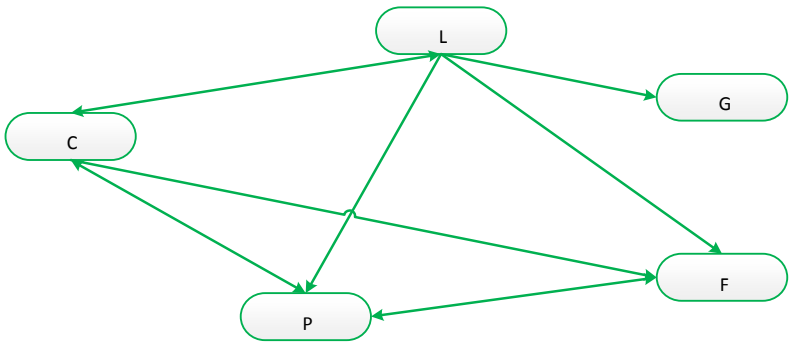

Figure. 2. CRM diagram

2.4. Applying ANP technique to analyze weights of indicators

Having completed applications of DEMATEL to analyze caused and effects relations in evaluation perspectives and constructing network evaluation, we produce a questionnaire based on previous step. In this phase expert's ideas about importance and preference of one criteria to others, according to main objectives are collected. Moreover, pairwise comparison matrix is constructed and relative weights of performance evaluation indicators are extracted by means of MATLAB and EXCEL. On the other hand, relative weighted vectors are extracted from pairwise comparison matrix to calculate compatibility of pairwise comparison matrix. In

agreement of literature, if relative compatibility is below 0.1, amount of compatibility is acceptable otherwise all comparisons should be rearranged. In spite of relations between four perspectives of BSC shown in CRM diagram and aiming to calculate relative weights of evaluation indicators in each perspective, an standard ANP questionnaire is designed. Moreover, ideas of 10 experts are collected using weighted mean. In this phase, pairwise comparison matrix are calculated regarding direction of arrows between five perspectives. Normalized vector of relative weights in each matrix and unweight suppermatrix are calculated by EXCEL. In the next step, we weighted un-weighted supermatrix. Classic method for normalizing includes deviding all individual arrays of a column by sum of the column to produce a unit vector. It is assumed that all clusters have same weights and it is known that influence of one cluster on other clusters is different in various situation. Thus, same weights for clusters is not a proper assumption. Unnormal supermatrix is exchanged to a normal supermatrix by dividing all individual arrays by sum of the column. Having produced weighted supermatrix exponentiation of matrix is calculated to reach convergence. In this study exponent 12 with 3 decimal numbers gave a proper convergence. Total weights achieved from supermatrix are considered as total weights for indicators that shown in table 5.

Table 5. Total weights of indicators using supermatrix

Indicator survey	Total weights of indicator
(F) financial	
budget growth	0.09
financial productivity	0.08
urban income growth	0.16
(C) customer	
customer satisfaction	0.06
service quality	0.03
Customer (referred) vision	0.01
(P) internal process	
human resource	0.05
information resource	0.6
importance of research	0.17
empowerment	0.09
(L) training and growth	
workforce productivity	0.16
Bureaucracy	0.07
Interactions with other organizations	0.06
performance evaluation system	0.03
(G) environment	
importance of environmental and green indicators	0.01
green suppliers	0.12
clean workplace	0.05
in service courses in environmental field	0.06

5.Conclusion

In this work, caused and effect relations between major perspectives of BSC using fuzzy DEMATEL. There are five perspectives: internal process, learning and growth, customer and green which are major perspectives of BSC. They are investigated by means of DEMATEL technique about their caused and effect relations. According to figure 1, it can be understood that learning and growth perspective has made more influences

rather than other perspectives in water and waste water company in Qazvin. In other words, there is an effective influence in training and growth perspective.

We also introduce financial and green perspectives that get effects from other perspectives. It should be mentioned that there have been slight influences from green and financial perspectives but respecting to DEMATEL technique the influences were below threshold that caused to eliminate the influences. Furthermore, internal process perspective has made more caused and effect influences on financial and customer perspectives. In other words, it is able to affect them and get influence from them, as well. Customer perspective has made caused and effect relation with training and growth, financial and internal perspectives but an slight relation with green perspective was identified. Though, green perspective is an only effect of training and growth perspective, it can be referred that this parameter may affect environment. After recognizing effects of the five perspectives, considering green perspectives and customers from QFD aspects, sub-indicators were extracted from literature. Then we applied the five perspectives, 18 indicators were identified as major indicators according to experts ideas. Then sub-indicators of each perspective were evaluated and their weights were calculated using ANP method.

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