

An Integrated MCDM Method in Ranking BSC Perspectives and key Performance Indicators (KPIs)

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ABSTRACT

The balanced scorecard (BSC) approach is an effective technique for performance evaluation. BSC can better reflect the dependence and feedback problems of each factor in real world situations. This study aims at developing a set of appropriate key performance indicators according to (BSC) approach for SAPCO using multiple criteria decision making(MCDM) method. We provide key performance indicators through literature reviews and experts' idea in SAPCO, which is one of the biggest vehicle spare suppliers in Iran. The proposed study uses decision making trial and evaluation laboratory (DEMATEL) and analytic network process (ANP), respectively to measure the casual relationship between the perspectives as well as the relative weights. The results based on ANP method shows that "Customer" is the most influential factor. In addition, internal process, financial and learning and growth are in two to four positions. Three important key performance indicators are as bellow: Total price of parts, Customer satisfaction and Lack of parts in production.

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1. Introduction

In recent years, changes in the global economic and financial environment have resulted in changes in the marketplace. The growth and profit in the global competition will be possible by key questions such as: What are the mission and vision of our company and what strategies would guide us to the predefined goals. To do so, there are different strategy models such as Porter five big forces, SWOT and finally BSC model. Kaplan and Norton (1992) are believed to be the first who introduced the idea of balanced score card (BSC). Since then, the idea of BSC has been widely used in wide areas of sciences. Kaplan and Norton (1996) stated that the financial topics do not necessarily represent the main success factors of an organization. Abran and Buglione (2003) incorporated BSC with QEST model in technology sector. Davis and Albright (2004) implemented a comprehensive study on the relationship between the BSC factors and key financial figures. Kaplan and Norton (2004) explained various methods on changing intangible assets into value-added wealth. On the other word, when a BSC is properly designed it is possible to build a cause and effect relationship between the financial

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data and other important factors. BSC model also categorizes important criteria for performance evaluation into key performance indicators. Key performance indicators are correlated items, which are measurable and translate mission statements to clarified objectives (Oakland, 1999).

SAPCO Company is one of the biggest suppliers in the field of spare supplying in Iran. The main mission of SAPCO is to supply the needed raw materials of vehicle industry, especially for Iran Khodro Company in Iran. During the last few years, SAPCO has put tremendous efforts to prepare its strategies and key performance indicators. The most important problem is now to prioritize the factors. Ranking is a kind of multi criteria decision making (MCDM) problem with different criteria and objectives.

Many conventional MCDM techniques are based on the additive idea along with the independence assumption, but each individual criterion is not often independent (Leung et al., 2003). To solve the interactions among elements, the analytic network process (ANP) as a relatively new MCDM method was introduced by Saaty (1996). The ANP is a mathematical theory, which deals with all kinds of dependence systematically (Saaty, 2004). The ANP has already been successfully implemented in many areas (Agarwal & Shankar, 2002; Chung et al., 2005; Coulter & Sarkis, 2005; Kahraman et al., 2006; Karsak et al., 2003; Lee & Kim, 2001; Meade & Presley, 2002; Niemira & Saaty, 2004; Partovi, 2001; Partovi & Corredoira, 2002; Partovi, 2006; Shang et al., 2004; Tesfamariam & Lindberg, 2005; Yurdakul, 2004). However, the treatments of inner dependences in those ANP works may suffer from some issues, which motivate us to use Decision Making Trial and Evaluation Laboratory (DEMATEL) method (Gabus & Fontela, 1972, 1973; Fontela & Gabus, 1976; Hori & Shimizu, 1999).

MCDM techniques such as AHP, ANP, DEMATEL, etc. have been extensively utilized in the performance evaluation and other fields for many years such as high-tech selection problem (Erdogmus et al., 2005), airline safety measurement using a hybrid model (Liou et al., 2007), marketing strategy based on customer behavior for the LCD-TV (Chiu et al., 2006), corporate social responsibility programs choice and costs assessment in the airline industry (Tsai & Hsu, 2008). Tsai and Chou (2009) proposed a novel hybrid MCDM model based on the BSC perspectives for selecting optimal management systems. Performance evaluation can be performed using the cause and effect relationships among various items using DEMATEL. Followed by this, ANP is utilized to get the relative weight of each performance index to establish performance indicators and evaluation model, which helps the performance audition of SAPCO reach the expectation of industry corporations.

The rest of this paper is organized as follow: In Section 2, a literature review is presented, In Section 3, evaluation methods are presented. In Section 4, the findings are illustrated. Finally, according to the findings of this research, conclusions and suggestions are depicted.

2. Literature review

This section discusses the strategic model of strategic planning balanced scored card.

2.1. Balance Scored Card (BSC) Concept

BSC approach is a strategic planning system widely used in business and industry. BSC is actually a management system, which enables organizations to clearly define their objectives and strategies (Olson & Slater, 2002). Kaplan and Norton introduced BSC concept in 1992. This concept was first implemented as a performance evaluation system, especially for 12 companies in USA in 1992. The main objective of BSC was to replace and change the traditional performance evaluation model, which merely concentrated on financial indexes to obtain more complete and effective evaluation of organizational performance in this way by application of this model. Note that financial aspect is still

considered as the most important aspect of organizational performance evaluation in BSC. However, other aspects of traditional model should also be considered, aspects such as customer, internal business processes and employee's growth and learning, so that performance evaluation model can achieve more balance and efficiency compared with past performance. The concept and meaning of the four aspects are as following:

1. **Financial aspect:** This aspect considers how organizations benefit from their strategic activities.
2. **Customer aspect:** This aspect pays attention to the issue that organizations should benefit of their inherent and available resources for the distinction among their competitors.
3. **Internal business process aspect:** All the strategic activities in an organization performed for satisfying stockholder and customer's expectations are investigated in this aspect. General process is started by perception of customer's needs and the operational and sale processes are performed after that.
4. **Growth and learning aspect:** if organizations want to maintain permanent activity and development, they should always rely on constant growth and innovation. Kaplan and Norton have expressed their opinions in this way: "organizations have to emphasize on some principals such as promotion of employee's capabilities and abilities, information system performance, persuasion and etc.". Performance indexes must be unbiased and measurable based on organizational objectives. Index selection plays an important role for investigation of required industry performance, since we can enhance efficiency of manufacturing operations and create a lot of advantages for company by accurate investigation of these indexes. Performance key indexes should be investigated for achievement of strategic objectives in every four aspects of BSC (Wu et al., 2007).

Kaplan and Norton believed BSC includes affecting and influenced relationships among different indexes in selected aspects. Other different researchers similarly expressed experimental evidences in support of causal relationship among different aspects of BSC (Schmidberger et al., 2009).

These relationships point to the dependence among financial and non-financial indexes. A structured BSC method should include mutual relations among various aspects and measuring indexes of these aspects (Wang et al., 2010).

2.2. Key Performance Indicators (KPI)

KPIs represent a set of measures focusing on those aspects of organizational performance, which are critical for the current and future success of the organization. KPIs are rarely new to the organization. They either have not been recognized or were "gathering dust" somewhere unknown to the current management team. From extensive analysis and from discussions with over 1,500 participants in KPI workshops, covering most organization types in the public and private sectors, I define seven KPI characteristics:

1. Nonfinancial measures (not expressed in Dollars, Yen, Pounds, Euros, etc.)
2. Measured frequently (e.g., daily or 24/7)
3. Acted on by the CEO and senior management team
4. Understanding of the measure and the corrective action required by all staff
5. Ties responsibility to the individual or team
6. Significant impact (e.g., affects most of the core critical success factors [CSFs] and more than one BSC perspective)
7. Positive impact (e.g., affects all other performance measures in a positive way) (Parmenter, 2007).

3. Evaluation method

In this section, some essentials of the ANP and the DEMATEL are briefly explained.

3.1. The ANP

The balance scored card and KPI ranking is an MCDM problem since it involves various criteria. There are several MCDM methods developed, such as the elimination and choice translating reality (ELECTRE), the technique for order preference by similarity to ideal solution (TOPSIS), and the analytic hierarchy process (AHP). However, these methods do not deal with the interdependences among elements. For dealing with the interdependences among elements, the ANP as a new MCDM method was proposed by Saaty (1996). Saaty (1999) has demonstrated several kinds of ANP models, such as the Hamburger Model, the Car Purchase BCR model, and the National Missile Defense model. However, from the viewpoint of Kinosita (2003), the ANP may simply be differentiated into two practical kinds of models: the Feedback System model and the Series System model (similar to the AHP model). In the Feedback System model, clusters link one by one in turn as a network system. This kind of model can capture effectively the complex effects of interplay in human society, especially when risk and uncertainty are involved (Saaty, 2003). However, it is usually hard to obviate the possibility of interactions within the criteria cluster. Thus, this paper suggests a modified Feedback System model (Fig. 1) that allows inner dependences within the criteria cluster, in which the looped are signifies the inner dependences.

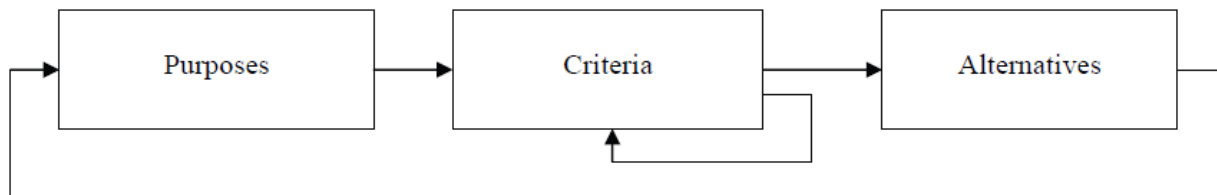


Fig.1. Feedback system model

In order to determine the relative importance between elements, decision makers are asked to respond through a series of pair-wise comparisons. These pair-wise comparisons are based on the Saaty's nine-point scale ranging from 1 (equal) to 9 (extreme). For evaluating the weights of elements, the AHP uses the principal eigenvector of comparison matrix, whereas the ANP employs the limiting process method of the powers of the super-matrix (Sekitani & Takahashi, 2001). For synthesizing overall priorities for the alternatives, it requires adjusting the un-weighted super-matrix to keep it to be column stochastic (Sarkis, 1999). Then, the weighted super-matrix (the adjusted un-weighted super-matrix) can be raised to limit powers to calculate the overall priorities. However, before forming the un-weighted super-matrix, the treatment of inner dependences needs to employ the DEMATEL. The treatment of inner dependences can theoretically use the ANP, but another alternative is to use the DEMATEL.

3.2. The DEMATEL

The Battelle Memorial Institute conducted a DEMATEL method project through its Geneva Research Centre (Gabus & Fontela, 1972, 1973). DEMATEL has become popular in many countries such as Japan since it is a comprehensive technique for creating and analyzing a structural model involving causal relationships among complex factors. The DEMATEL is based on digraphs, which can separate involved factors into cause group and effect group. In order to apply the DEMATEL

smoothly, this paper refines the version used by Fontela and Gabus (1976) and proposes four main steps as below.

Step 1: Generating the direct-relation matrix by measuring the relationship between criteria in four levels: 0 (no influence), 1 (very low influence), 2 (low influence), 3 (very high influence) and 4 (very high influence). Next, experts make sets of the pair-wise comparisons in terms of influence and direction between criteria. Then, as the result of these evaluations, the initial information can be prepared as the direct-relation matrix, which is an $n \times n$ matrix A , in which a_{ij} is denoted as the degree to which the criterion i affects the criterion j .

Step 2: Normalizing the direct-relation matrix. On the base of the direct-relation matrix A , the normalized direct-relation matrix X can be obtained as follows,

$$X = k.A \quad (1)$$

$$k = \frac{1}{\max_{\substack{j=1 \\ 1 \leq i \leq n}} \sum_{i=1}^n a_{ij}}, i, j = 1, \dots, n. \quad (2)$$

Step 3: Attaining the total-relation matrix. Once the normalized direct-relation matrix X is obtained, the total relation matrix T is calculated as follows,

$$T = X(I - X)^{-1}, \quad (3)$$

Where I is identity matrix.

Step 5: Set a threshold value and obtain the network relationship map (NRM). In order to explain the structural relation among the criteria and keep the complexity of the system to a manageable level at the same time, it is necessary to set a threshold value p to filter out some negligible effects in matrix T . Only some criteria, whose effect in matrix T is greater than the threshold value, should be chosen and shown in a network relationship map (NRM) for influence (Tzeng et al., 2007). In this paper, experts decided the threshold value is arithmetic mean of T matrix numbers.

4. Empirical study and discussion

In accordance with the proposed performance evaluation model, this study conducts an empirical analysis gathering the feedbacks of 10 experts from SAPCO. On the basis of the collected professional questionnaires containing performance indices of SAPCO, the performance indices under each BSC perspective based on a Likert scale from one to ten are preserved. Twenty indices are selected from 40 evaluation indices of 4 perspectives. Because these relevant evaluation indices (i.e., KPIs) are summarized on the basis of associated work and consulted by experienced experts, it can have relatively high content validity and face validity Table 1 shows details of our indices.

4.1. Establishment of total influence of BSC perspective

Evaluation criteria are divided to five degrees and numbers from 0 to 4 represent different influential extents. The influential table and diagram are as presented in Table 2.

Table 1

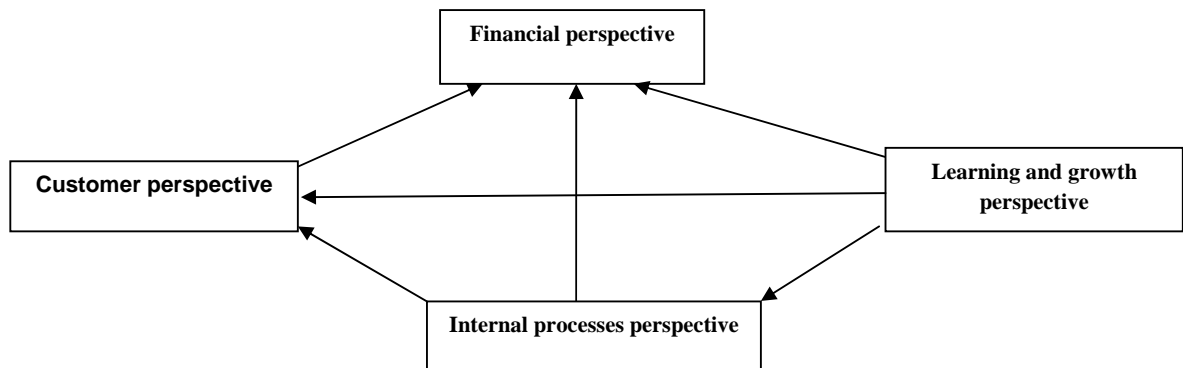
Criteria with a mean of 7.5 and above

Learning and growth(L)	Internal process(P)	Customer (C)	Financial (F)
The average of leaders competencies(L1)	The rate of multi-source spares to total spares(P1)	The rate of satisfied customers(C1)	Total sale(F1)
The percentage of significant electronic exchange of information with Supply chain(L2)	The rate of elimination from package(P2)	Total price of SAMAND LC spares(C2)	Total sale to ISACO(F2)
The rate of employee perception from organization(L3)	The percentage of Suppliers satisfaction(P3)	RANA X12 total spare price(C3)	Dollar volume of direct export(F3)
	Average R&D ability of supply chain in SAPCO(P4)	The return from production line of Iran Khodro (PPM) (C4)	Surplus total sale(F4)
	The average of on-time payment to manufacturer (P5)	The return from after sale services(C5)	The rate of changing in vehicle spare price(F5)
		The rate of production with shortage(C6)	
		Total price of motor spares(C7)	

Table 2

Total-relation matrix with (D + R) and (D-R).

Perspective	D	R	D+R	D-R	Affection
L	4.6459	3.2456	7.6701	1.1789	1
P	4.8916	3.9184	8.81	0.9732	2
C	3.7192	4.4259	8.1451	-0.7067	3
F	3.2005	1.2515	7.8464	-1.4454	4

**Fig. 2.** Casual evaluation structure for SAPCO

D+ R represents the important degree of factors, which means the sum of influence and being influenced degrees. As a result, it could be seen that “Internal process perspective (P)” is more important than the other three perspectives. As for the value of (D-R), the bigger the positive number is, the more effect the factor has on the other factors. It is prone to the factor of cause (cause factor). On the contrary, the bigger the negative number is, the more the factor is influenced by other factors. It is inclined to the factor of effect (effect-factor). Therefore, it is shown in Table 2 that “Internal process perspective (P)” is a central influential perspective; “Learning and growth perspective (L)” is the important cause-factor of affecting other perspectives; “Financial perspective (F)” is an effect-

factor since it is affected the most by other perspectives. This process for key performance indicators is summarized in Table 3.

Table 3
Total-relation matrix with (D + R) and (D-R) for Financial perspective

Financial	R	D	D+R	D-R	Affection
F1	1.4413	1.6616	3.1029	-0.2203	4
F2	1.5418	1.0217	2.5635	0.5201	2
F3	1.1502	0.8862	2.0364	0.264	3
F4	0.9083	2.1611	3.0694	-1.2528	5
F5	1.4024	0.7134	2.1158	0.689	1

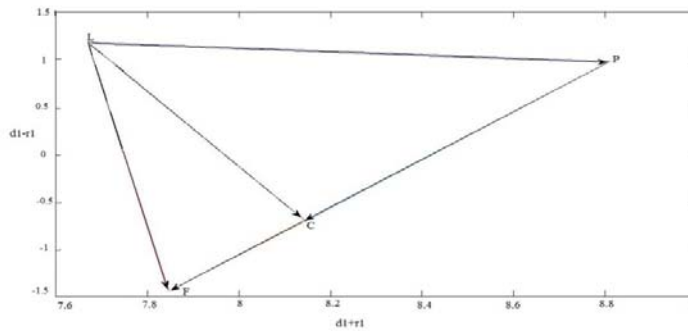


Fig.3.The causal diagram of BSC perspectives for SAPCO

Table 4
Total-relation matrix with (D+ R) and (D-R) for Customer perspective

Customer	R	D	D+ R	D- R	Affection
C1	0.3462	1.1441	1.4903	-0.7979	7
C2	0.4652	0.3574	0.8226	0.1078	4
C3	0.2463	0.3103	0.5566	-0.064	6
C4	0.655	0.2889	0.9439	0.3661	1
C5	0.5043	0.3606	0.8649	0.1437	3
C6	0.3719	0.3852	0.7571	-0.0133	5
C7	0.5488	0.2912	0.84	0.2576	2

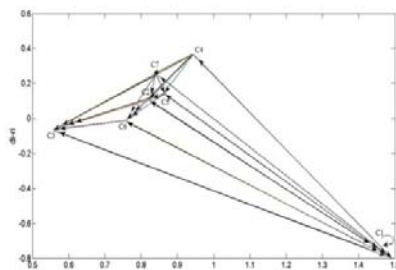


Fig.4.The causal diagram of Customer perspective for SAPCO

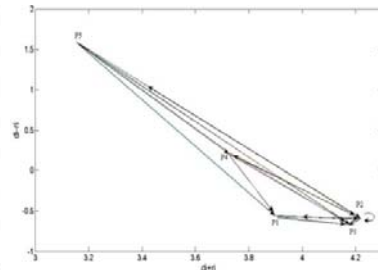


Fig.5.The causal diagram of Process perspective for SAPCO

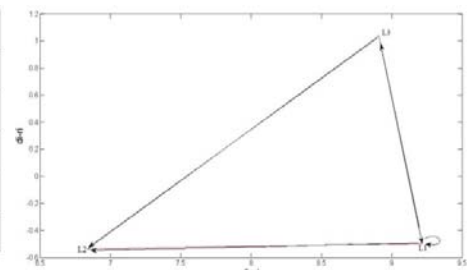


Fig.6.The causal diagram of Learning and growth perspective for SAPCO

Table 5

Total-relation matrix with (D+ R) and (D-R) for Process perspective

Process	R	D	D+ R	D- R	Affection
P1	1.6669	2.235	3.9019	-0.5681	3
P2	1.8131	2.4063	4.2194	-0.5932	4
P3	1.7539	2.426	4.1799	-0.6721	5
P4	1.9775	1.7395	3.717	0.238	2
P5	2.373	0.7785	3.1524	1.5954	1

Table 6

Total-relation matrix with (D+ R) and (D-R) for Learning and growth perspective

Learning and Growth	R	D	D+ R	D- R	Affection
L1	4.3606	4.8572	9.2178	-0.4966	2
L2	3.1488	3.6883	6.8371	-0.5395	3
L3	4.9728	3.9367	8.9095	1.0361	1

Table 7

Final relative weights of key performance indicators

Perspectives and Key performance indicator	Normalized Weight	Limited Supermatrix	Rank
Learning and growth(L)	0.12407	0.0686	4
L1: Employee perception from organization	0.04885	0.02701	8
L2: The percent of significant information exchange with supply chain	0.03801	0.02102	15
L3: The average level of leaders competencies	0.03720	0.02057	16
Internal process(P)	0.21354	0.11807	2
P1: The rate of multi-source spares to total spares	0.04351	0.02406	10
P2: The rate of elimination from surplus package	0.05805	0.03210	4
P3: The percentage of satisfied customers	0.05154	0.02850	7
P4: R&D competency in SAPCO	0.01958	0.01083	19
P5: The average days for manufacturers payment	0.04084	0.022258	13
Customer(C)	0.46282	0.2559	1
C1: The percentage of customers satisfaction	0.06619	0.03660	2
C2: Total price of SAMAND LX	0.1495	0.08276	1
C3: Total price of RANA X12 spare	0.04085	0.02259	12
C4: Return from Iran Khodro production line(PPM)	0.04433	0.02451	9
C5: Return from after sale services(PPM)	0.05174	0.02861	6
C6: Production with shortages rate	0.05813	0.03214	3
C7: Total price of motor spares	0.05188	0.02869	5
Financial(F)	0.19956	0.1134	3
F1: Rial volume of sale	0.04223	0.2335	11
F2: Rial volume of sale to ISACO	0.04868	0.2692	9
F3: The volume of SAPCO disirect export	0.03344	0.1849	18
F4: The rate of total sale	0.03928	0.2172	14
F5: The savings from special suggestions	0.03597	0.1989	17

As Table 7 shows, the customer perspective based on ANP is the most important perspective between four BSC model perspectives. Internal process, Financial and Learning and growth are in the second to fourth position.

5. Conclusion

In this paper, we have developed a set of appropriate key performance indicators according to (BSC) approach for SAPCO using multiple criteria decision making (MCDM) method. We provided key performance indicators through literature reviews and experts' idea in SAPCO, which is one of the biggest vehicle spare suppliers in Iran. The proposed study implemented decision making trial and evaluation laboratory (DEMATEL) and analytic network process (ANP), respectively to measure the casual relationship between the perspectives as well as the relative weights. The results based on ANP method showed that “Customer” was the most influential factor. In addition, internal process, financial and learning and growth were in two to four positions. Three important key performance indicators are also as bellow: Total price of parts, Customer satisfaction and Lack of parts in production.

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