The Evaluation of Automotive and Spare Parts Companies by Balanced Scored Card Approach and Data Envelopment Analysis

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ABSTRACT: With the increasing competitiveness in the demand and supply realm, companies need indices and models for evaluating their performance. Emergence of these needs and lack of efficiency in old evaluating systems, create novel evaluating model. Outdated evaluating models which are generally based on financial indices, have lots of problems. For eliminating these problems, there had been developed different models in the early 90s. These models can be classified into two groups: models based on self-evaluation such as: MBNQA 1987 and EFQM 1991, and models based on measuring approach and business process enhancement such as: EPM1993, CMM 1980 and BSC 1992. Among these the two EFQM and BSC models were the most successful and accepted by most of the companies to be applied. BSC model is one of the most functional models to evaluate the performance. However it suffers from some drawbacks and restrictions. Lack of a pattern and a baseline to evaluate can be considered as one of this model's problem. To overcome these drawbacks we tried to provide a combined model of BSC and DEN.

Keywords: automotive and spare parts industry, balanced score card, data envelop analysis, performance evaluation

INTRODUCTION

In the competitive atmosphere today, globalization has dimmed the economic boundaries between countries and affected their industries (EmamiMeibody, 1379). In such a situation the increasing pressure of stakeholders (shareholders, customers, employees and society) and their expectations of companies force the companies to apply innovative management systems based on stakeholders’ benefits. The world is changing today with an incredible speed and the variety of changes has profound impact on societies. The economic progression, industries' development and markets' growth are dependent on efficient management. To point out the progression elements of competitiveness and survival of companies in a worldwide level, we can name “the long-term planning”, “appropriate specification of targets”, “researches”, “innovation and creativity in companies”, “production quality and services”, “technology management”, “educating and monitoring” and “continuous performance evaluation”.
Monitoring and evaluating has been introduced since the classic theories were proposed. In the other words all the management theories are somehow related to monitoring, controlling and evaluating and considered these factors as the essential responsibilities of management. Therefore “performance evaluation” is not a novel concept, though we have to consider the changing of the attitude related to this concept. On one hand development and expansion of responsibilities in companies has made the “performance evaluation” inevitable, on the other hand profound evolution of knowledge has affected the evaluation mechanism. “Performance evaluation” regards monitoring through a supervision view and seeks to improve the performance. Due to this improvement, it is essential to design the evaluating systems in accordance with organizations’ functions.

“Performance evaluation” increases competitiveness in the industries, provides the appropriate information for investors to invest, informs the companies of their situations and creates the opportunities for companies to develop and progress which results in society’s advancement. According to the importance of “performance evaluation” and its influence on the industries’ evolution, applying the suitable technique to evaluate the performance has become a major concern for managers. Evaluation includes multiple criteria such as rewards, the relation between company’s mission and targets, potential strategic leverages, the probable technical commercial success and so on. After determination of the criteria, they were rated by their weight to verify the degree of emphasis.

Activities in a dynamic atmosphere resulted in inaccessibility of needed information. The lack of information leads to the replacement of opinions and judgments with data, and criteria must be estimated in a qualitative manner. In a situation which estimating the qualitative of criteria is so difficult –similar to return on investment rate-applying qualitative indices is as important as recognition of the market and customer’s satisfaction (Eilat et al, 2008).

Balanced score card includes qualitative criteria and is counted as a recent management innovation introduced by Norton and Caplan as a performance measuring tools in 1992, and as a strategic tool in 1996 and as a model for alignment between organizations’ human resources, information and organizational capitals (Alexandros et al, 2005).

BSC is a management tool consists of a set of criteria which are classified into special groups called card. These criteria are related to four management points of views with the aim of providing a comprehensive business view for high level managers. Cards present a balanced evaluation of company’s performance in the financial, market, strategic and operational realm.

BSC combines the financial and operational criteria and focuses on short and long term targets of the company. Actually most of the companies apply BSC approach to perform management process, clarify the perspectives and strategies, transit and relate the strategic targets and criteria, improve the strategic feedback. (Eilat et al, 2008). Balanced Scored card can conceptualize the strategies of the company and help the managers to connect the control function to company’s strategies through offering the criteria related to strategies as a control and motivation tools. Financial aspect as one of the scored card’s facet causes the financial plans to connect with strategies; it also creates a motivational system based on strategies. (Michalska, 2005).

A major problem in applying the BSC models is determination of baseline and a model which evaluates the company’s performance. Evaluating is impossible without baseline and standard. When a baseline is determined for evaluation, evaluation is applied for model and target. However determining the standards is often difficult and misleading. To solve this problem, Eilat al, have proposed the combined BSC model and data envelopment analysis in 2008. Since DEA is based on relative analysis, decision units are evaluated comparing with each other, thus with the combination of DEA and BSC we overcome one of the obstacle of balance scored cards which is the need of determination of standards and baseline. (Eilatetal, 2008).

Figure (1) shows the relation between balanced score card and envelop analysis approach. It can be seen that sub-criteria of each fourfold aspect of score card are extracted from determined indices for envelop analysis approach. These indices determine the baseline and the pattern for the balanced score card and evaluation.
This paper evaluates the Automotive and Spare Parts Companies by using the combined balanced DEA-BSC approach. The second part of it is specified to the research methodology, reviews previous researches and shows the need of applying DEA-BSC combined technique to evaluate the performance. The third part presents data collecting method and analyzes them and finally the last part provides us with discussion and conclusion of the research.

Figure 1. The relation between BSC and DEA in the combined model (Alirezaei et al, 1384).
RESEARCH METHODOLOGY

Due to the need of standard and baseline determination for applying BSC models for evaluation, using envelop analysis approach is explainable. Envelope analysis is a kind of mathematical planning to measure the relative efficiency of similar units created by Charnes, Cooper, Rhodes based on Farrell’s model. They defined this approach as “envelope analysis as the foundation of modern economics is an applied mathematical planning model for similar data; this is a novel approach for having empirical estimate of weight ratios or for providing the efficient frontierlike production function. (Azar and Gholamrezaei, 1385).

Data envelope analysis is a classic none-parametric technique and is based on mathematical planning used for comparison of efficiency evaluation of similar decision unit sets. There is no need to determine the parametric characteristics (as production function) to gain the efficiency score. This can be regarded as a considerable advantage. (Siriopoulos and Tziogkidis, 2010).

DEA approach allows each decision making unit to choose weight for inputs and outputs to provide the best understanding.

Each DMU is considered by its turn, the best weight is chosen for it and then the performance of all the other DMUs is evaluated by these weights. As a result another set of related performance indices is achieved through using the most favorable weights for other units. This method identifies the DMUs with the best relative performance and poor performance. (Azar and Safari, 1383).

Since the survival of a company is related to its performance, evaluating the performance is important because it monitors the system’s performance and shows the applied strategies by the company. Today managers want better use of their resources, therefore in this changing world, the existence of a model which can provide the feedback to enhance the performance of different parts of the companies and achieve a tool to fulfill this need seems natural. Automotive companies must try to apply an appropriate model to maximize the efficiency of their efforts.

The below model is used to evaluate the different companies in this industry. To design this model first we determine the decision making units which we want to evaluate their efficiency and then according to characteristics of decision making units and the proposed dimensions in balanced score card we determine and choose the inputs and outputs of each DMU. With the collected data related to the amount of inputs and outputs of each DMU, we formulize the evaluating efficiency model based on one of the basic DEA models. After solving each model, for any DMU, the efficiency score is achieved. Then we analyze the efficiency of DMUs based on the achieved results of solving each model.

The model used in this study, is a developed model of basic DEA model. There are two below balancing limitation sets added to basic data envelope analysis models which guarantee the balance of determined dimensions in the balanced score card.

\[
(1) \quad L_k \leq \left( \frac{\sum \alpha_i y_{i0}}{\sum \alpha_i y_{i0}} \right) \leq U_k ; \forall k
\]

\[
(2) \quad \sum_{k=1}^{K} \left( \frac{\sum \alpha_i y_{ij}}{\sum \alpha_i y_{ij}} \right) = 1 ; \forall j
\]

In this model \( O_k \) is the representative of main dimension of balanced scorecard (finance, customer, internal business processes, learning and growth), \( UK \) and \( LK \) are representatives for high and low weight for each dimension of balanced score card respectively, if:

\[
(i) \quad \sum_{k=1}^{K} L_k \leq 1;
\]

\[
(ii) \quad \sum_{k=1}^{K} U_k \geq 1;
\]

\[
(iii) \quad L_k \leq U_k , \forall k ;
\]

\[
(iv) \quad U_k \geq 0, \forall k
\]
As the result the final balanced combined BCC model with BSC comes as follow:

$$\min Z_0 = \sum_{i=1}^{n} x_i y_i + w$$

$$s.t:
\sum_{i=1}^{n} u_{r,j} y_{r,j} = 1$$
$$\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} u_{r,j} y_{r,j} + w \geq 0 \quad (j = 1, 2, \ldots, n)$$
$$L_k \leq \frac{\sum_{r=0}^{\infty} u_{r,j} y_{r,j}}{\sum_{r=0}^{\infty} u_{r,j} y_{r,j}} \leq U_k \quad \forall k$$
$$\sum_{r=0}^{\infty} u_{r,j} y_{r,j} = 1 \quad \forall j$$
$$u_{r,j} y_{r,j} \geq 0 \quad \forall w: Free$$

**Data collecting and analysis**

**Data collecting**

The population under this study consists of some active companies in automotive industry and spare parts. To determine two indices “customer’s satisfaction” and “employees’ satisfaction” we applied sampling method. For the other indices we used documented statistics of the companies. Data are selected by questionnaires. First we distributed questionnaires under the title “the questionnaire for determining the BSC indices and its minimum and maximum dimensions’ weight” among the managers of the companies (5 experts). Figure 2 shows the extracted result of experts’ opinions.

![Figure 2. Criteria of each fourfold aspect of balanced score card](image-url)
Then the other needed information was acquired by standard employees’ satisfaction (JDI) and customer’s satisfaction questionnaire. We asked questions which could help us completing fourfold aspects of balanced score cards and input and output indices of data envelope analysis approach.

**Introduction of the input and output of the model**

In this part, the used inputs and outputs are shown in figure 3.

![Diagram of inputs and outputs of the model](image)

**Table 1.** Applied BCC combined model with BSC performance with sample set of inefficient units

<table>
<thead>
<tr>
<th>Sample Set</th>
<th>Performance Rating</th>
<th>DMU</th>
</tr>
</thead>
<tbody>
<tr>
<td>—</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>—</td>
<td>100%</td>
<td>2</td>
</tr>
<tr>
<td>DMU_i(0.493), DMU_j(0.507)</td>
<td>92.01%</td>
<td>3</td>
</tr>
<tr>
<td>DMU_i(0.739), DMU_j(0.261)</td>
<td>91.8%</td>
<td>4</td>
</tr>
<tr>
<td>—</td>
<td>100%</td>
<td>5</td>
</tr>
</tbody>
</table>

**Creating Virtual Unit**

Finding the best virtual unit out of mixing all the actual units is the fundamental of data envelop analysis. If this virtual unit is better than the considered unit, the considered unit is inefficient. To be better than the considered unit is a situation which the virtual unit has more outputs with the same amount of input comparing with the input amount of actual unit or needs less input with the same amount of output as actual unit has. (Mehregan, 1383).

**Results of Balanced BCC Model combined with BSC**

In this part we show the model applied with variable return to the balanced combined DEA-BSC scale, and the results are shown in table 2. As the result show there is only one company with 100% performance that could maintain the performance and balances among the indices of balanced score cards. In this model, the fifth unit with
the performance of 72.30% has the least score while it had the performance of 100% in the variable return to normal scale DEA-BSC model.

Table 2. Results of balanced BCC model combined with BSC

<table>
<thead>
<tr>
<th>Efficiency Rating $\phi^*$</th>
<th>$\phi^*$</th>
<th>DMU</th>
</tr>
</thead>
<tbody>
<tr>
<td>81.31%</td>
<td>1.230</td>
<td>1</td>
</tr>
<tr>
<td>100%</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>86.92%</td>
<td>1.150</td>
<td>3</td>
</tr>
<tr>
<td>79.88%</td>
<td>1.252</td>
<td>4</td>
</tr>
<tr>
<td>72.30%</td>
<td>1.383</td>
<td>5</td>
</tr>
</tbody>
</table>

**CONCLUSION AND RECOMMENDATIONS**

The results of the applied model in this paper achieved through combined DEA_BSC model, Balanced Combined model DEA-BSC are shown in the table below:

Table 3. The comparative result of normal BCC model and balanced combined BSC model

<table>
<thead>
<tr>
<th>balanced combined BSC model/DEA-BSC</th>
<th>normal BCC model/DEA-BSC</th>
<th>DMU</th>
</tr>
</thead>
<tbody>
<tr>
<td>81.31%</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>100%</td>
<td>100%</td>
<td>2</td>
</tr>
<tr>
<td>86.92%</td>
<td>92.01%</td>
<td>3</td>
</tr>
<tr>
<td>79.88%</td>
<td>91.8%</td>
<td>4</td>
</tr>
<tr>
<td>72.30%</td>
<td>100%</td>
<td>5</td>
</tr>
</tbody>
</table>

Data envelop analysis model, divides the study units into “functional units” and “inefficient units”. The inefficient units have the ability to be rated when they make scores of functionality, but the units with the functional score equal with 1 are not ratable through classic data envelop analysis models, therefore we used cross-efficiency rating model to rate the functional units.

**Applying The Cross-Efficiency Rating Model**

One of the approach to rate the functional units is applying cross-efficiency rating model. This approach has a strong ability to differentiate the functional units. Functionality is calculated by “balanced sum of outputs” divided to “balanced sum of inputs” in data envelop analysis. Weight choosing in the DEA linear programming is in a way that it allows considered unit to maximize its performance compared to the other units. Efficiency evaluation of each unit with best weight sets calculated by the model is called “simple efficiency”.

According to the applied evaluation process by the balanced combination of balanced score card and data envelop analysis, rating the companies in the automotive industry can be shown as below:

Table 4. Ranking the automotive and spare parts companies

<table>
<thead>
<tr>
<th>Ranking by balanced model BCC-BSC</th>
<th>Ranking by normal model BCC-BSC</th>
<th>DMU</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

One of the most important results of this research is the strong ability to differentiate the designed model for evaluating the companies in automotive industry with using the experts’ opinions related to key aspects of performance and high validation of the model. The other features of this research can be listed as “comparing the evaluation of a company with others”, “determining the correction attitude for indices and their improvement based on scientific results of performance evaluation”, “achieving the strategic targets”, “optimization the use of resources to create the expected outputs” and “achieving balance”.

Although these results are considerably valuable, they suffer from limitations and defects. To make these restrictions smoother, we provide applied and research suggestions. Based on the result of this research, the following recommendations can improve the efficiency of companies in automotive industry.
Applied suggestions

According to the results achieved by solving DEA models, the improvement of efficiency and optimized performance of inefficient unit can be programmed by introducing the sample unit to inefficient unit and executive authorities. The appropriate amount of output and input is exactly determined (in the virtual unit). If the units match the amount of output and input with the determined amount, they can achieve the complete efficiency.

It is suggested to become sure of the relation of targets and strategies with key performance indices, and also the balance of key performance indices in different aspects of the company while planning, because most of the companies were efficient in their normal model DEA_BSC, but couldn’t maintain their efficiency in the balanced model, which resulted to an appropriate performance and increased the efficiency and competitive ability of the company.

According to the achieved results, by investing more on human resources and educating them and using motivational programs, companies can satisfy their human resources. Because experienced people ask questions of the situation to improve the process and the improved process leads to the enhancement of productions which brings about the customers’ satisfaction.

To move towards development the efficiency of the companies must be evaluated continuously with maintaining the balance among all the functional and financial aspect in the determined period.

Research suggestions

The amount of the inputs and outputs of the units may not be equal in different situations; therefore applying fuzzy approach to perceive the real conditions of outputs and inputs is suggested for evaluating the efficiency.

It is suggested that performance evaluation of the companies to be done with the other evaluation models such as EFQM, 360’ feedback and etc.

To compare the efficiency of the DMU in different periods, combined window DEA and BSC approach can be used, therefore the rate of performance changing of each DMU in time can be revealed.

Conducting similar researches with applying the balanced combined DEA-BSC in several companies and industries with different inputs and outputs is recommended. But the companies’ specifications should be regarded. We hope that managers in different companies can enjoy the benefit of applying the Balanced Score Cards, and have the best comparison in their administrative units with using combined approaches and achieve prosperous results.

REFERENCES