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The Proposal of an Innovative Integrated BSC – DEA Model

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Abstract

Data envelopment analysis has been one of the most significant management tools for measuring efficiency. On the other side, the balanced scorecard has been one of the best-known performance management tools. Several foreign studies deal with innovative approaches to a modification of the balanced scorecard and data envelopment analysis methods, frequently by the designing of new models in combination with other methods. However, there are very few studies that examine integration of these two methods and compare the obtained results. In this paper, we combine the BSC with the DEA method to obtain comprehensive performance and efficiency management system for industrial companies and their processes.

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Keywords: Balanced scorecard, Data envelopment analysis, integration, integrated BSC-DEA model;

1. Introduction

In today´s competitive business environment, characterized by the scarcity of resources, performance measurement and management assumes a crucial role and companies try to improve their efficiency and performance in order to succeed in a this global competition.

The Balanced Scorecard, developed by Kaplan and Norton, is one of the best-known of performance assessment frameworks. Developed from the strategy of the company, this framework includes indicators related to four perspectives: financial, customers, internal processes, learning and growth. The newest 4th Generation BSC incorporates also social and environmental impact (external perspective) without destroying the cause and effect model across the original BSC perspectives. Data Envelopment Analysis is a non-parametric technique for

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evaluating the performance of Decision Making Units (DMUs). In recent years we have seen the widespread application of DEA in several fields, such as health care, education, manufacturing, retailing, banking, etc. Despite the popularity of the DEA and the BSC approach, there have been very few studies that have been proposed their integration for extended performance assessment.

2. Balanced Scorecard

Balanced Scorecard (BSC) is one of the most modern tools that meet the criteria established for the strategic concept of company performance evaluation. His persuasiveness, flexible design, and general application have been appreciated by the corporate experience within the meaning of increasing demand for this system of strategy implementation, the development of which is currently classified into four generations.

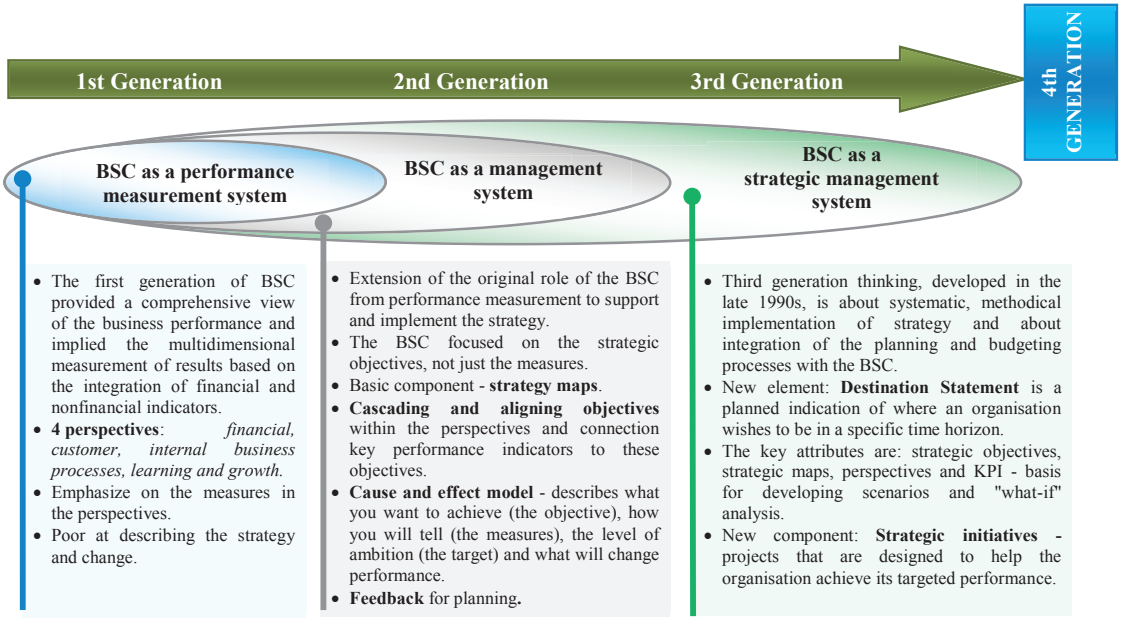

Fig. 1. Development of Balanced Scorecard Source: Karabašová (2010)

The newest 4th Generation Balanced Scorecard is now a sophisticated approach for systematically and continuously learning from your strategy, for socialising behavioural change and creating rich informed discussions about performance, within and beyond the organisation. They include an external perspective, which incorporates social and environmental impact. Environmental impact is added as an external perspective alongside the financial perspective. Social impact can be added above the customer perspective. This represents the wider impact on society or the community than is represented by the customer perspective.

Due to implementation of the Balanced Scorecard company receives very quality and clear view of the company as a whole, about achieving strategic objectives, functioning of processes and causes of fluctuations in their performance and success.

3. Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a relatively new “data oriented” approach, for evaluating the efficiency of Decision Making Units (DMUs), which converts multiple inputs into multiple outputs. DEA used to measure technical efficiency. Being technically efficient means to minimize inputs at a given level of outputs, or maximize outputs at a given level of inputs.

Efficiency, in the economic sense is defined as: Efficiency = Output/ Input.

The measurement of efficiency in production units and the identification of sources of their inefficiency is a precondition to improve the performance of any productive unit in a competitive environment.

Suppose that we have n DMUs {DMU_j, j = 1, 2,...,n }, which produce s outputs y_{rj} : r =1,2,....s, j = 1, 2,...,n by consuming m inputs x_{ij} : i = 1,2,....m, j = 1, 2,...,n.

Relative efficiency is defined as the ratio of total weighted outputs to the total weighted inputs.

The q-th line – i.e. x_{iq} and y_{rq} – shows quantified inputs/ outputs of unit DMU_q. The efficiency rate of such a unit can then be generally expressed as, Vincová, K. (2005):

$$\theta q = \textit{Weighted sum of Outputs/ Weighted sum of Inputs} = \frac{\sum_{r=1}^{s} u_r y_{rq}}{\sum_{i=1}^{m} v_i x_{iq}} \quad (1)$$

where:

v_i , i = 1, 2, …, m, are weights assigned to i-th input,

u_r, r = 1, 2, …, s, are weights assigned to r-th output.

DEA model derive input and output weights by means of an optimising calculation. Based on that, units can be classified into efficient and inefficient. In inefficient units, they tell us target values of inputs and outputs which would lead to efficiency.

In DEA model, we evaluate n productive units, DMUs, where each DMU takes m different inputs to produce s different outputs. The essence of DEA models in measuring the efficiency of productive unit DMU_q lies in maximising its efficiency rate. However, subject to the condition that the efficiency rate of any other units in the population must not be greater than 1. To estimate the DEA efficiency of DMU_q, we use the following original DEA model, Vincová (2005):

Maximize θ_q

Subject to:

$$\sum_{j=1}^{n} x_{ij}\lambda_j \le x_{iq} \qquad i = 1,2,....m \quad (2)$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j \ge \theta y_{jq} \qquad r = 1,2,....s \quad (3)$$

$$\sum_{j=1}^{n} \lambda_j = 1 \quad (4)$$

$$\lambda_j \ge 0 \qquad j = 1,2,....n \quad (5)$$

y_{rq} is the amount of *output r* generated by *unit q* and x_{iq} is the amount of *input i* used by *unit q*; λ_j is the intensity variable for DMU_j.

The score θ obtained from the solution to this linear programming problem is the maximum rate of proportional expansion in all outputs of DMU_q, without decreasing its inputs. The efficiency rate of DMU_q can be obtained by calculating 1/ θ Zhu (2009).

4. The integration of Data Envelopment Analysis and Balanced Scorecard

Several authors in the world have tried to combine BSC and DEA in the theoretical and the abstract level. Their research deals with the application of these methods in various areas, as selected type of industry, projects, IT, financial institutions, hotels, education, etc. not with the specific issue of industrial company.

One of the recent works dedicated to the integration of BSC and DEA model is written by Swedish author Niknazara (2011). He proposed a methodology for identifying the impact of IT investment and the importance of activities related to IT business efficiency using BSC - DEA model, and discussed the results got by using this model.

Despite the popularity of BSC and DEA approaches, there are only very few studies that examine their integration due to better evaluation of the performance and efficiency of industrial enterprises and their processes.

Due to the planned establishment of a systematic relationship between these two methods, it must first gather their significant differences (Table 1).

Table 1. Proposed differences between DEA and BSC method – outputs of deep analysis

Characteristics	BSC	DEA
Way of comparison	Comparison with an ideal virtual unit	Proportional comparison of the same units
View - rating	multiple view - perspectives	input/ output
Mathematical ranking	weak	strong
Application	performance evaluation	technical efficiency
Accuracy of measurement	unclear	high
Presentation of opportunities for improvement	weak	high
Variety of suitable results	does not support	has
Future view	has	does not have
Relationship to business strategy	has	does not have

Furthermore, BSC does not have a mathematical model or a weighting scheme. Therefore, it is difficult to make comparisons within and among the companies. As a result, the inefficient use of resources may be unrecognized. So, DEA is suitable for measuring the efficiency based on of the BSC indicators. The efficiency frontier of DEA can be used to calculate the efficiency of DMUs.

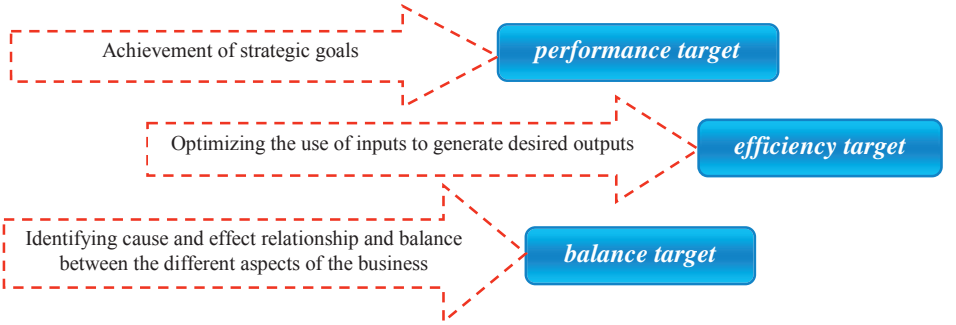

Fig. 2. Objectives of BSC - DEA integration

Based on current theoretical information and analysis it can be stated that the BSC, as a tool for the evaluating of business performance, connects strategy with KPI, but in efficiency measuring and managing has certain shortcomings. The premise is that the integration of BSC and DEA methods could fill these gaps and generate relative value of efficiency for each reporting process, respectively business activities as a whole.

Integration of management method BSC and economic - mathematical method DEA brings a new model that uses the BSC as a comprehensive framework for defining the evaluation criteria (KPI) and the DEA as a method for ranking the efficiency of business processes, based on the input and output parameters - values of selected KPI. The innovative integration of principles and advantages of both methods has three basic objectives (Fig. 2).

The process and use of the integration of BSC and DEA methods, illustrated by the following figure (Fig. 3), may improve the overall explanatory ability of both methods.

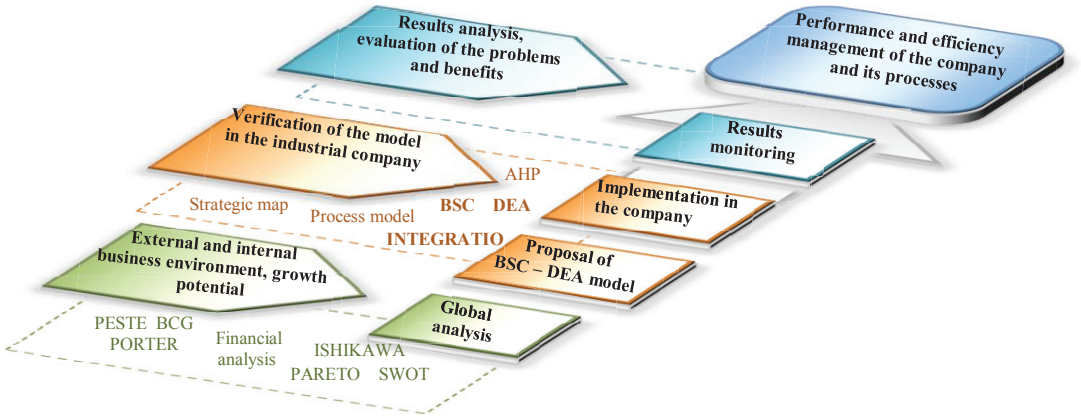

Fig. 3. Process of the BSC - DEA integration

Performance and effectiveness management of business processes is in proposed BSC-DEA model for industrial companies ensure by:

- **the implementation of BSC** company receives very good and clear view of the company as a whole, as fulfilling its strategic objectives, how the processes are working and what causes variations in their performance and success,
- **the applying the principles of DEA** method is measured the effectiveness of the company and its core processes, based on KPIs analysed using the BSC.

5. Conclusion

There are two main types of data collection: quantitative and qualitative. The aim with a quantitative approach is to study relationships between different concepts or to investigate the distribution of earlier defined phenomenon. The qualitative approach investigates variations, structures, and processes for the phenomenon that is not quite known. Integrated BSC-DEA model uses both types - qualitative and quantitative. In the first step, BSC considers all aspects of a company with a holistic view. As BSC categories and tries to understand the reality of company in social and human experiences, beside the financial matters, so we can consider it as a qualitative approach. In the second step, nonparametric frontier method of data envelopment analysis is employed to measure technical efficiency scores of company. DEA uses quantitative data and produce quantitative results so we can regard it as a quantitative approach. In a simple word, BSC has qualitative approach and DEA has quantitative approach. Therefore, proposed integrated BSC-DEA model has both of these approaches and creates a new conceptual framework for monitoring performance of an industrial company and efficiency of its processes and serve managers to make the right decisions at all levels of management.

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