

Synthetic Application of Data Envelopment Analysis and Balanced Scorecard for Systems Performance Evaluation: A Review

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ABSTRACT: Some indexes are necessary for performance evaluation of a management system. Balanced scorecard (BSC) is used in order to extraction of these indexes for evaluating the necessary performances in the evaluation process. Utilization of BSC causes to prevent in increasing information and data. Furthermore, all of the important indexes are considered in evaluation performance. Data envelopment analysis (DEA) is applied for evaluating the system performance. It is a non-parametric method based on linear programming. This method uses multiple inputs and outputs indexes. Synthetic application of BSC-DEA causes the weak points of each method is enveloped using strong points of another one. In the other hand a systematic relation between the methods can be created. In this paper, the BSC-DEA techniques are considered in order to improve the systems performance, synthetic application of BSC and DEA are considered and reviewed.

Keywords: Balanced Scorecard, Data envelopment analysis, Performance measurement

INTRODUCTION

In management system, performance evaluation can be provided the important information and data for improvement of manager decision in order to evaluation the performance, progress exhibitions, promoting of motivation and problem detection. (Flex, 2003) in order to improvement of management system effect, the evaluation of its performance is necessary (Azzota, 2009). One of the most famous models for performance evaluating model is balanced scorecard. It is proposed by Kaplan and Norton in 1992. This model proposed to use a series of balanced indexes in order to evaluate each organization performance. This causes that managers have a global view from four important organic aspects (Wang, 2006). The balanced scorecard consists of financial indexes that show previous action results. Furthermore it completes the indexes by considering other indexes as driver for future financial performance.

Kaplan and Norton believe that with gaining information from these four aspects the incensement and collection data are removed using limitation of indexes. Also managers are forced to concentrate on only limited number of essential and critical indexes. Furthermore, using several aspects prevent from optimization special section.

For achieving to additional value, resources are not sufficient; rather combination and utilization of resources and making interaction between inputs and outputs of organization are very important.

Data envelopment analysis is a method based on linear programming for evaluating the performance. This method without assumption produce function figure, using solution of mathematical models for a set of decision making units and using of related information based on real input and output values create a virtual unit with highest performance and evaluates non-efficient unit with it (Memariani, 2004). The important specification of this method is to measure performance in the case of multiple inputs and multiple outputs (Karimi, 2011). In this paper at first the BSC method is considered and then DEA techniques are described. Furthermore, synthetic application of BSC-DEA for evaluating the system performance is studied and finally the conclusion is presented.

Balanced Scorecard

In the first decade of 1990, Novlan Norton institute a research entitles "measuring of future organization performance" was fulfilled (Lomotte G., 2000) and (Andersen H. V., 2000). David Norton was an administration manager of this institute as a leader and Robert Kaplan was as an academic adviser of this research (Wongrassmee S., 2003). The results of this research were a set of scales that presented a general view of trades. They found out that the companies could not maintain their competitive benefits only by creating and developing of their capital. In the other hand, invisible capitals will be critical factor in success of creating competitive benefit (Sime K. L. et al., 2001).

Balanced scorecard criteria in organization performance consist of four viewpoints: financial performance, customer perspective, internal business perspective, innovation and learning perspective. These viewpoints are related to duties of calculating, finance, marketing and human resources (Wu H. Y. et al., 2009). Kaplan and Norton believed that managers must be attended to performance from different views (Atkinson H., 2006) and (Kaplan R. S., Norton D. P., 2005):

How do customers see us?

What must we excel at?

Can we continue to improve and create value?

How do we look to shareholders?

The balanced scorecard helps to managers for improving of related unit performance using exhibition of level of organization performance.

Balanced scorecard measure is applied in determination of organization station causes that the managers can use these methods for detecting the defects and problems in organization.

It is necessary to apply a definite for measuring the performance. Kaplan and Norton believed that balanced scorecard measure is used as learning, informing and communicating system. It is not applied as a control system (Reisinger H., Cravens K. S., Tell N., 2003) So the balanced scorecard measure keeps companies looking- and moving – forward instead of backward (Kaplan R. S., Norton D. P., 2005) and (Hepworth P., 1998). This is compatible several of managing innovative and various management strains are combined in script samples of these strains are consists of Risk management, time management, novelty, on time production, quality management, value management and etc.

Data Envelopment Analysis

Efficiency is a management concept that has a long history in management science (Witzel M., 2002). Efficiency shows that an organization has used its resources along production respect to optimal performance in a period of time [24]. The most existing studies on the performance evaluation have mounted on a frame of evaluation index system. Anyway the most of these methods used the persons for obtaining the indexes weights. For this reason, the weights of the indexes cannot be measured accurately (Woolson). In order to decrease inaccuracy of index weight increased using opinion of decision maker, data envelopment analysis is used as a nonparametric method for evaluation of management performance. The major property of DEA is to measure the performance in a case of multiple inputs and outputs. Although data envelopment analysis models have been increased but all of the basic models have some major models based on some designer. One of these models is Charnes, Cooper and Roodes (1978). This model is state by CCR abbreviation. In CCR model deficiency is assumed constant return to scale (CRS). Furthermore another model was presented by Banker, Charnes and Cooper named BCC model. BCC model is designed variable return to scale. Constant return to scale means varying in input values result to the same varying in output values. This model is propped when all of the units operate in optimal scale. Various returns to scale means varying in input values result to the less or more varying in output values (Charnes et al., 1978).

Wang and Wang (2007) presented some indexes such as cost, on time deliver, benefit and production time. Since some measured indexes in management system especially cost are not crisp and uncertain indexes is seen in them, utilization uncertainty methods such as fuzzy logic is suitable (Zhu 2009). Rough set theory is another method for evaluating the uncertain systems (Zhu 2009). In this reference with developing a Rough set theory in indexes such as cost, staffs and production flexibility are used for performance evaluation.

Gau and Tanaka (2001) proposed a fuzzy DEA model that extended from fundamental CCR model. The crisp input and output vectors in CCR model become fuzzy vector. In addition, "almost equal", "almost larger than" and "maximizing a fuzzy variable" are introduced to take the place of "equal", "larger than" and "maximizing crisp output", respectively. This model can evaluate the efficiencies of DMUs in more general way, by which the crisp, fuzzy and hybrid inputs and outputs can be handled homogeneously.

Several authors have surveyed the general DEA literature and provide scenarios for DEA methodology development in different time periods from a range of angles. These surveys can be categorized into three types – bibliography listing, qualitative, and quantitative.

Need for integration of BSC with DEA

While we are working with the Balanced Scorecard, we should be able to evaluate the efficiency of an organization. Business performance is usually unclear and vague. Data Envelopment Analysis Method (DEA) can generate the objective performance indicators (Kuang-Hua, 2005).

Therefore, there are four main reasons that indicate the need for BSC for a complementary tool.

One of the challenges in BSC is having the baseline or benchmark which performance is measured against. Evaluation is impossible without a baseline or benchmark. First, a baseline for evaluation should be determined and then we should do the evaluation against the baseline. However baseline and benchmarks are hard to determine and can be ambiguous. Because DEA is based on relative comparison, the DMUs are evaluated against each other. By combining the BSC with DEA we answer important challenge of BSC, namely, the need to determine baseline and benchmark (Eilat et al., 2008).

Furthermore, BSC does not have a mathematical model or weighting scheme. Therefore, it is difficult to make comparisons within and among the organization. As a result, the inefficient use of resource may be unrecognized (Banker et al., 2005, Chien-Ta and Dauw-Song, 2004, Kuang-Hua, 2005). Rickards (Rickards, 2003) argues that 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. The slacks can be used as the organization's inefficiency to solve the recognition of inefficiencies in BSC.

BSC confronts managers with an extraordinarily complex optimization problem because of BSC has complexity and the interrelated indicators. This complexity also rises from the large number of variables. For example big organization should try to track hundreds of measures in BSC (Rickards, 2007). Fletcher and Smith (Fletcher and Smith, 2004) state that BSC lacks a single index for accountability. BSC does not provide one comprehensive index to summarize the interaction between these measured of performance.

Lack of a common scale of measurement causes more complexity. Moreover, in BSC, we may have dimensionless ratios and index number. Luckily, data envelopment analysis (DEA) can help us to deal with this kind of complexity (Rickards, 2007).

DEA can be a helpful tool to deal with all of these problems.

BSC-DEA concept

This paper integrates the balanced scorecard (BSC) and data envelopment analysis (DEA) to make a relational efficiency evaluation model. Although the BSC has some limitations, it can serve as a foundation for achieving resource deployment, improving internal processes, and enhancing the quality of an organization's controlling system with DEA (METTERS, king-METTERS, Pullman, &Walton, 2006; Pock, Westlund&Fahmi, 2004). moreover, some of the limitations of the BSC are diminished when it is combined with DEA. This is because these two tools complement each other and thus can be used together (Eilat et al., 2008; Njafi et al., 2009; Serrano-Cinca, Fuertes-Callen& Mar-Molinero, 2005).

In the integrated DEA-BSC model, the input and output measures are grouped in cards, which are related to BSC's perspectives. The proposed model is based on DEA, which quantifies the qualitative concept embedded in the BSC approach. The contribution of the presented model is both conceptual- the integration.

According to Cooper (Cooper et al. 1999), integrated DEA-BSC model is trying to accomplish:

Achieving strategic objectives(effectiveness goal);

Optimizing the usage of resources to generate desired outputs (efficiency goal)

Balanced between different aspects of the organization (balance goal)

Obtaining Cause and Effect in Perspectives

Najafi and his team workers (Najafi et al., 2009) proposed a similar model. With efficiency decomposition, they identified the inefficient operations. They used six banking banking branch's data for their illustration.

Shafer and Byrd (Shafer and Byrd, 2000) developed a framework for measuring efficiency of organization's investment in information technology. They used over 200 large organization's data in DEA model to show their framework.

Specific DEA models for technology selection in R&D projects were proposed first by (Stewart, 2001). Stewart considered Projects as "mini-organization" in a BSC's perspectives, same as their parent organizations. Using balanced Scorecards for R&D project evaluation have been developed by (Eilat et al., 2008), (Oral et

al.,1991), (Baker and Talluri, 1997) and (Khouja, 1995) since then. Sowlati (Sowlati et al., 2005) also proposed a DEA model for prioritizing IS projects.

Eilat and Golani (Eilat et al., 2008) studied the BSC into DEA model through balance constraints. Different from traditional DEA's weight restriction techniques which restrict the weight flexibility of the individual weights, Eilat and Golani (Eilat et al., 2008) considered "importance" attached to groups of measures. They applied their method to a hierarchical balance structure.

Furthermore, ChangSu-Chao (ChangSu-Chao et al., 2005) had applied DEA into the BSC to measure performance efficiency of hotels in Taiwan and Vietnam. Their results studied efficiency frontier and benchmarking partners of each hotel. They also identified the ideal input amount and the slack of every hotel. Benchmarking is a management technique that is used to improve the performance of an organization. Many companies have engaged in benchmarking practices, and DEA can provide information pertaining to either the most efficient or most inefficient factors influencing the productivity of a company (Mostafa, 2007).

In short, management performance measurement is a complex task since multiple inputs and multiple outputs are involved in the process. The balanced scorecard is one approach to measuring management performance. However, when the efficiencies of multiple performance organizations are being compared quantitatively, DEA is a more appropriate model because DEA enable management to integrate multiple dissimilar inputs and outputs to make simultaneous comparisons (Avkiran, 2002). DEA rests on the economic notion of production technology of transforming inputs into outputs. Its advantage is the ability to deal with a collection of information rather than specific information (Chang & Lo, 2005). Therefore, DEA is viewed as a methodology that provides a valid starting point for specifying balanced performance.

There are four steps for the processes of measurement and performance rating:

The identification of organization (creation of appropriate BSC) is the first step. In this step, organization's strategies are identified by using BSC. Then we design the measurement in every perspective. The measurements should be in balance and with different perspectives.

Efficiency rating is second step. The measurements created by BSC will be divided into two groups of inputs and outputs to be used in DEA model. Then we use DEA Whether in a horizontal evaluation (during the time period) and, or vertical evaluation (in comparison with similar units in the chronological period).

Modification and improvement is the third step. Having the results of DEA, we identify the potential for modification and improvement.

Setting the benchmarks is the final step. DEA determines the measurement goals and places them as benchmarks for the next performance evaluation.

If the organization achieves the determined goals, it will be efficient. In the next periods, the organization's situation is compared with the expected conditions of the previous period. In this comparison, new efficiency goals efficiency goals will be determined (Njafi et al., 2009).

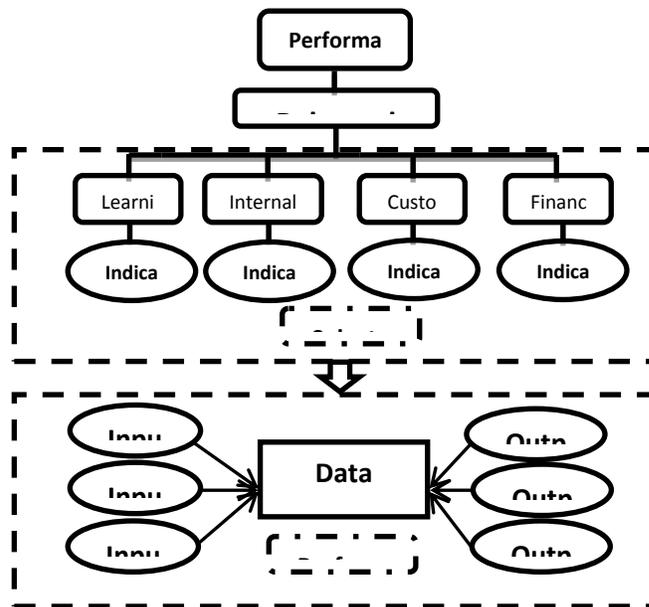


Figure1.BSC-DEA integration model

CONCLUSION

First, this paper has shown that the Balanced Scorecard can be used as a performance management tool for evaluating an organization's efficiency. The four dimensions of the Balanced Scorecard link organization's strategies with indicators, and help management establish an integrated efficiency assessment system for evaluation a system. Second, this paper has shown that the DEA model can be used to generate one single efficiency figure in multi-input a multi-output situations. DEA performs optimization analysis on each individual unit (DMUs) and generates relative efficiency value of each DMU. Through DEA, management will know the overall efficiency indicator and will know the origins of inefficiencies. The DEA model has many benefits. For example, it can accommodate diversified variables of different measuring units. With introducing BSC-DEA model, the reasoning and the theory behind this model is shown. The integrated model has considered a holistic view of an organization like financial and non-financial, short-term and long term. It is helpful for the data DEA uses. The integrated model proposes a new approach to evaluate performance by applying quantitative analysis that combines the measures within each card into a single value. Integrated model also addresses some of the difficulties in existing BSC applications. For example, BSC does not produce a single, comprehensive measure of performance that is because it does not have a mathematical model or a weighting scheme to make comparisons. In addition, the complexity of BSC and the interrelated nature of the BSC indicators is another difficulty that the BSC-DEA integrated model solves.

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