Supply chain performance evaluation with data envelopment analysis and balanced scorecard approach

Morteza Shafiee [a,*], Farhad Hosseinzadeh Lotfi [b], Hilda Saleh [b]

[a] Department of Industrial Management, Shiraz Branch, Islamic Azad University, Shiraz, Iran
[b] Department of Mathematics, Science and Research Branch, Islamic Azad University, Tehran, Iran

ABSTRACT

One of the most complicated decision making problems for managers is the evaluation of supply chain (SC) performance which involves various criteria. Though vast studies have been recorded on supply chain efficiency evaluation via balanced scorecard (BSC) approach, these studies do not focus on the relationships between the four perspectives of BSC approach. The present paper is an attempt focusing on these relationships, especially the returnable ones. To do so, at first, all relationships between the four perspectives of BSC were determined and then the DEMATEL approach was employed to obtain a network structure. This network structure was then used to create a network DEA model. Since it was not possible to calculate the efficiency evaluation score by BSC, the data envelopment analysis (DEA) model was used for such an evaluation. Moreover, after reviewing different tools to evaluate the performance of supply chain, a new approach, relying on network DEA with BSC approach, was generated. Finally, this model was applied in the Iranian food industry to evaluate its supply chains efficiency and the results proved the high efficiency of the model designed. The findings could be used in various evaluation processes in different industries.

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1. Introduction

Market globalization has made supply chain management an interesting topic to be discussed: an efficient supply chain can lead to a range of benefits including reduced cost, increased market share and sales, and sustainable customer relationships [1]. It has also been cited that evaluation of supply chain performance can improve the overall performance of the organization [2]. Efficiency of the supply chain is the result of integration of the performance of all members. As such, managing the overall supply chain efficiency is a challenging task.

In 1900 William Durant-the founder of General Motors-claimed that profit is the outcome of a cost stream that spreads throughout the supply chain, not the result of an accounting exercise. Since then, the principle of identifying profit and controlling cash flow has been used to evaluate organizational performance. Generally, the efficiency of the supply chain, which is usually managed as a series of simple business functions, is measured by taking the ratio of revenue over the total supply chain operational cost. However, since the demands for quick order fulfillment and fast delivery are increasing, new trends have emerged. In addition to the usual financial measures, other specific indicators such as customer satisfaction should be

taken into consideration. The emergence of multiple performance measures has made the efficiency measurement a difficult and sophisticated task. Hence, the means utilized to measure the performance should provide not only the quantitative reasoning, but also the qualitative perspective to remain aligned with the strategic goals of the organization.

Since "performance" and "predetermined parameters", can be defined as "measurement" and "the ability to monitor events and activities in a meaningful way", respectively, performance measurement can be defined as the process of quantifying the effectiveness and efficiency of action [3]. A number of approaches have been mentioned to measure performance. Some of most prominent ones frequently refereed to are: balanced scorecard [4], the performance measurement matrix [5], performance measurement questionnaire [6], criteria for measurement system design [7], and computer aided manufacturing approaches. However, in practice these approaches have suffered some shortcomings including lack of strategic focus, forcing managers to encourage local optimization rather than seeking the continuous improvement and, being incapable of providing adequate information about competitors.

For the application of performance measurement, it is essential that companies' tangible and intangible targets be defined the way that is more appropriate to the requirements and objectives of these targets, and that its strategy is more extensively operationalized, quantified, and linked in a mutually supplementing way [8].

As emphasized by Ghalayini and Noble [9], the literature concerning performance measurement has two phases: in the first phase, which went on until the 1980s, the center of attention was performance measurement based on the financial criteria supplied by the management accounting system. The second phase which started in the late 1980s, and is still proceeding, brought about many changes within performance measurement, and interest in this field has increased tremendously. In the late 1980s, the problems of the traditional way of measuring performance were clearly known and researchers started to discuss introducing new performance measures such as shareholder value, economic profit, customer satisfaction, internal operations performance, and intellectual capital and intangible assets [10]. One of the approaches for this purpose was balanced scorecard (BSC) proposed by Kaplan and Norton [11]. They argued that BSC provides managers with the means they need to navigate future competitive success. It included more non-financial measures derived specifically from the organization's strategy. BSC is one of the most comprehensive and simple performance measurement means which emphasizes both aspects of financial and non-financial, long-term and short-term strategies as well as internal and external business measures.

Several studies have focused on the evaluating performance of supply chain based on BSC [12–17]. The strongest point of BSC is its ability to illustrate the cause and effect relations between strategies and processes through the four BSC's perspectives of financial perspective, customer perspective, internal business process perspective, as well as learning and growth perspective. In other words, the relationships between the four perspectives of BSC are very important for performance evaluation. There have been quite a few studies conducted on these relations [18–27]. These studies determine the efficiency and performance in organizations and R&D projects. In these studies, the researchers do not focus on all possible relationships between the four perspectives of BSC. The fact is that they study these relationships in a simple manner as in their models the learning and growth perspective influences the internal business process perspective, and the internal business process influences the customer perspective, and the customer perspective influences the financial perspective. It must be mentioned that other important relationships between these perspectives may exist. Considering these possible relationships, particularly the returnable ones, is exactly what this paper tries to take into account, based on the network structure for supply chain performance evaluation.

Since it is not possible to determine the efficiency evaluation score by applying BSC, we used the data envelopment analysis model (DEA) to calculate the efficiency score of supply chain performance. DEA is a non-parametric method to analyze efficiency, proposed by Charnes et al. [28] to produce the efficiency frontier based on the concept of Pareto optimum. DEA is also a powerful means in evaluating organizations with multiple inputs and outputs and takes the qualitative and quantitative measures into account. There have been conducted some studies on the combination of DEA and BSC [18–27]. In these studies the classic DEA model of efficiency evaluation has been used and the researchers have not focused on all possible relationships between the four perspectives of BSC. In several studies, the researchers have determined all possible relationships between the four perspectives of BSC [29,30], however, they have not been able to determine the efficiency score for the decision making unit.

To meet the purpose mentioned above, determining the efficiency score for the decision making unit, the present authors created a network structure by determining these relations and then created a new multi stage DEA model for efficiency evaluation of the supply chain.

The proposed model involves all possible relationships between the perspectives, especially the returnable ones. This proposed approach is designed to solve the problems of measuring supply chain performance, in particular:

– The identification of the performance structure in which the parameters and necessary metrics for calculating the performance are identified.
– The identification of the links between the required parameters and the metrics in relation to the achieved objectives.

In general, this paper is organized as follows: first, a brief description of some traditional tools of measuring supply chain performance is given. After that, DEA and Multi stage DEA and their applications and concepts associated with the supply chain are reviewed. This is followed by an explanation of the methodology and multi stage DEA by BSC approach models