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RESEARCH PAPER

Supply Chain Network Performance Measurement and Improvement Using DEA and SCOR Models in Dynamic Conditions

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Abstract

Dynamic systems have always attracted much attention from researchers as a significant part of the various types of systems, and modeling of supply chain processes is considered as one of these due to the nature of its change over time, the volatility of customer demand is considered as one of these problems that have many effects on the system and its costs. In the present study, the SCOR Supply Chain is first modeled with the Dynamic Systems Approach (DSA) under specific parameters. We determine the control parameters of the studied policy using the DEA-SCOR model. We also Improvement the basic five-stage model to investigate models incorporating advanced demand information and evaluate the influence of demand variability on the system performance. Then, the evaluation and ranking of the supply chain network of several distribution companies have been analyzed using the indicators of information sharing, based on the opinion of managers and experts familiar with the subject and by a combination of the data envelopment analysis (DEA)-SCOR and stochastic frontier analysis (SFA). By calculating total efficiency according to DEA-SCOR model in SCOR supply chain supply network of oil products Distribution Companies, Falavarjan Branch and Tehran Office Branch, have the highest performance, and the lowest performance is observed in Lordegan, Shahriar branch. According to the results of the SFA method, Tehran Office Branch and Isfahan Branch had the highest performances, and Shahriyar and Tiran branches had the lowest performances. The performance level calculated using the SFA method is approximately the same as the performance level calculated using the DEA method. The performance calculated by the DEA method is less than that calculated by the SFA method in some cases. The average calculated performance in the DEA method equals 0.80, and the average for the SFA method is 0.82. Given the inadequacy of indicators and the improvement of these indices at each stage, the calculated efficiency in each dynamic period gradually improves, and the average total performance in the dynamic period is 0.90.

Keywords:
Supply Chain Network;
Information Sharing;
Dynamic Performance Evaluation;
SCOR Model Envelopment Analysis;
Uncertainty

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Introduction

Customers' rising demands and the advent of items with limited survival have compelled companies in today's competitive market-place to invest in and reconfigure their logistical infrastructure. Creating new institutions and activities, developments, and increased activities, have led to uncontrollable activity among these changes. At the same time, the activities are needed to organize, monitor, and rank these irregularities. The second thing to keep in mind is that businesses are constantly looking for novel strategies to better their position and govern their company. They are continuously looking for approaches to innovate and discover new alternatives. In this research, we have tried to address the fundamental problems of private companies in implementing strategic management. In interviews with the top managers and experts of Petropars Company, some of the main barriers to the implementation of strategic management were identified [1].

These requirements may be fulfilled by supply chain administration as a comprehensive method to correctly control the movement of resources and commodities and monetary data. [2]. Supply chain efficiency may be measured using various models with some restrictions, including established BSC and SCOR. Still, the frequency of independent metrics that are employed is the initial and most significant constraint to be overcome. Scales, on the other hand, give useful data for making decisions, selecting, exchanging, and implementing various signals for successful execution and definite development plans. Supply chain governance has been demonstrated to be a highly efficient method for providing high products and assistance at the lowest possible expense to the members of the supply network [3].

Monitoring and enhancing the efficiency of supply chain networks is one of the most critical concerns for businesses seeking to obtain competitive opportunities. The Supply Chain Complex, which is supported by more than 650 member organizations (academia and industry) around the world, has expanded the Supply Chain Operations Reference (SCOR) model. The Model (SCOR) is a reference model process that intends to have industry standards capable of managing the next-generation supply chain [3].

This model includes the standard description of management processes or a framework of relationships between standard processes, standard criteria to measure process execution, and managerial activities that produce the best degree of implementation and set up the features and functionality of the software. Recently, Supply chain management has become one of the most essential areas in production management due to the increasing competition in global markets. Supply chain management, as a tool introduced in the early 1990s, involves the planning and management of operations and the production, goods transfer, and distribution to reach the customer, suggesting a way to improve the production environment and make it competitive [3].

A supply chain is a collection of facilities, suppliers, customers, products and inventory control, sales, and distribution methods that connect suppliers to customers and begin with the production of raw materials by suppliers and end with consuming the product by customers. Given that the supply chain plays an important role in the production management process, the supply chain performance measurement is considered an important element of the company's (organization) performance [4]. Quantitative processes, or more specifically, processes used to analyze effectiveness and profitability, are referred to as performance assessment mechanisms. The effectiveness of the distribution network, pertaining to this description, in order to fulfill its particular objectives is characterized as an assessment of the efficacy of the corporation's assets in the entire scope of the distribution network [4].

As a nationwide enterprise, the Iranian oil commodities transportation sector has a significant variety of providers and clients. Extensive and interconnected strategies are required for the nation's oil products distributing business, as well as for establishing a favorable environment by matching local supply levels to consumption, engaging in global commerce, facilitating the importation and exportation of oil commodities from the country, and expanding the range of goods available for sale. Given a dynamic system perspective and in parallel with the network structure, performance is regarded as one of the most essential and crucial management tasks in this vast set of companies based on the SCOR reference model. This parameter may be connected with a variety of competitive benefits for the county's oil commodities business.

Research Background

Supply network management is described as a set of practices aimed at efficiently integrating providers, manufacturers, storage, and customers in order to create and deliver items in the most efficient and timely manner possible. To reduce system expenditures while maintaining a specific degree of services, several measures are exploited [4]. Previously, advertising, transportation, management, manufacturing, and sales firms operated in a distinct distribution network. Several investigations assessed the effectiveness of supply chain individual entities, including Distribution Centers Performance (DC3) [5]. Excellent distribution network management has been demonstrated to be a highly efficient method for providing timely and consistent high-quality products and operations with a minimal cost. Using information technology, the research conducted by Gunasekaran and Ngai (2004) looked at the difficulties that occur while establishing a distribution system as follows: the absence of connection between information technology and the institution's economic plan, the absence of excellent commercial management, weak foundations for information technology facilities, insufficient and inaccurate usage of information technology in online firms, and a failure of suitable understanding concerning the application of information technology [6]. Assessment of Provider Efficiency [7] etc. Nevertheless, each of these separate organizations throughout the distribution network has its own set of interests, which are often in opposition to one another. As a result, there is a requirement for a productivity assessment platform so that the effectiveness of different divisions may be combined and assessed in this context at the same time.

The analysis from four dimensions is considered the goal of developing the SCOR model: assurance of business performance, flexibility/accountability, supply chain cost, and turnover on committed capital. This model can be used in all companies in the industrial and service sector at the tactical and operational levels for the implementation of strategic decisions of the company [8].

The SCOR model includes five main processes: plan, source, make, deliver and return. The model supports hundreds of functional matrices concerning the five useful features: reliability, accountability, flexibility, cost, and asset criteria [9].

In order to develop an effective distribution chain, it is critical to monitor the effectiveness of every connection throughout the network. System expenses may be minimized while service levels are maintained using these methods. The analytic network process (ANP) is one of the multi-criteria decision-making techniques which Mr. Saati introduced as a solution to solve multi-criteria decision-making problems. In fact, it is an extension of the ANP hierarchical programming technique [10].

In addition to providing a standard structure, this model includes a common terminology, identical characteristics, improved methodologies, and a hierarchical arrangement with distinct dimensions. The SCOR model's core hierarchical structure is as follows [11]:

Level 1: Types of Process: Plan, Prohibition, Make, Deliver, and Return is the five processes used to describe scope and material.

Level 2: Process categorizations: The primary procedure categories may be used to describe a distribution network at this arrangement scale.

Level 3: Process functions: This level breaks down procedures into several components, discusses sources and outcomes, defines process effectiveness standards, and determines the ideal operations.

The strategic dimension of supply chains makes it paramount that their performances are measured [12]. One of the most complex decision-making problems of managers is supply assessment. A study has proposed a general framework for evaluating the overall performance of the supply chain, using the BSC and DEA models. In the first stage, supply chain efficiency was measured through a careful literature review and based on a detailed examination of expert theory. In the second stage, they were divided into four BSC approaches. DEMATEL method was used to determine the causal relationships and interactions.

DEA was used to measure the efficiency by BSC. Finally, this model was applied to Iran's food industry to assess the efficiency of its supply chain and prove high-efficiency results [13].

As the first general structure for supply chain planning, effectiveness evaluation, and development, and as the first model that may be applied to design distribution network operations in accordance with company objectives, the SCOR model is widely regarded as a landmark achievement. Compared to earlier models, this model offers a consistent and complete model, and the fact that it is mechanism-based is the primary benefit of effectiveness evaluation. As a result, this process-oriented perspective offers a systematic and organized framework of assessments and standards, giving all distribution network managers a holistic opinion about the distribution system [14].

To fulfill consumer demands and gain a sustainable competitive superiority, distribution network management pertains to integrating administrative divisions within the network and establishing coordinated streams of goods, data, monetary assets, and financial resources to meet customers' needs. The present DEA modelling of inputs/outputs is at a more advanced level because of this rationale (total ideas of sustainability actions and efficiencies). As a result, to provide a more sophisticated and durable strategy, the mixed SEM- and DEA-based PM modelling technique might be used with existing stand-alone PM methods [15].

Supply chain efficiency measurement is an essential factor for industrial units in decision-making. With creating a relationship between the supply chain and the concepts of sustainability and performance assessment in this study, the actual data of the Shoapanjere Company with three sustainability criteria have been considered to propose a new model for the supply chain efficiency measurement. The main idea behind this study is to develop a new method to measure supply chain efficiency, which considers economic and social methods, and environmental aspects. The literature review showed that DEA, as a quantitative method, fits the objective of this study [16].

This research's goal was to examine both the upbeat and downbeat perspectives on efficacy and performance. Instead of merely looking at the upbeat performance across a range of time, our approach additionally takes into account the downbeat performance. Moreover, undesired outputs are considered first and then the overall performance is assessed. In order to classify all DMUs, it is necessary to take into account both the upbeat and downbeat indicators. On the other hand, a good understanding can be obtained by using optimistic and pessimistic indices [17]. We proposed an instance version of the two-stage DEA network CE model. With the suggested model, the proportion of restrictions and parameters may be substantially decreased as well as the number of computing standards needed to do CE calculations [18].

An efficiency measurement model was developed based on the two-stage DEA to measure the common effect of sustainable operation and operational activities on the commercial efficiency of a retail company. A case study on an Indian electronic retail chain has been used to determine the potential and appropriateness of the proposed model. The strength of this case study was the creation of DEA models for an Indian retail company and the provision of an analytical understanding of the conditions under which strategic decisions, at the operational level, successfully support the integration of sustainable operation in SC management. The results show that additional sustainable constraints lead to the operational efficiency of some business and retail chain companies, whereas, in other companies, the integration of sustainable goals reduces business efficiency [19].

DEA's classic series and parallel constructions have been used to simulate the natural gas distribution chain's intricate facilities. The effectiveness of the natural gas distribution was measured using a DEA system, which was established in this research. Monthly data was used to examine Iran's natural gas distribution infrastructure throughout a five-year planning window. Three sub-processes were serially considered: production, transportation, and distribution. Exogenous, undesired, and middle inputs and outputs of final products have also been considered. The related efficiency of all supply chain elements over a 5-year planning horizon and the combination of actual monthly operational data show the overall efficiency. The suggested model of this research's NGSCN ranking and effectiveness and ineffectiveness of manufacturing, transport, and supply phases may be adjusted and applied in different energy delivery networks, including water, petroleum, electricity, and wind [20].

This paper focused on supply chain management's two-level production and distribution planning problem. To overcome this problem, some formulas were proposed to implicitly express production technologies using input-output data observed in production activities and also to encompass the DEA idea. To clarify the validity of these DEA approaches, we compared them with simple formulation with technological coefficients using a numerical example [21].

One of the most challenging obstacles for regulators and SME shareholders is ensuring the long-term viability of SMEs. Previous studies have used DEA to measure the performance of SME groups, using multiple criteria (inputs and outputs) by distinguishing efficient from inefficient SMEs. The improvement measures for each inefficient SME are compared to the best SMEs. To fill this gap, SEM allows for the development of relationships between sustainability performance measurement criteria and subcriteria and identifies improvement measures for each SEM in a zone through a statistical modeling approach.

The proposed framework in this study has been used in two different geographical locations, namely Normandy in France and Midlands in the UK, to show the effectiveness of measuring supply chain performance sustainability using the mixed DEA and SEM approach. Moreover, the sustainability status of the companies in both zones is determined using comparative analyses [22].

A study proposed a new DEA-based approach to investigate the sustainability performance of systems in the presence of inaccurate criteria. To this end, system performance is assessed using fuzzy data from economic, social, and environmental aspects. Then, the overall sustainability is assessed using the total fuzzy composite indices based on DEA. Our proposed approach is also used to measure the sustainability of hospitals. The findings provide informative details about the overall sustainability of hospitals, as well as the strengths and weaknesses of each aspect [23].

This study used scorecards to score each essential operation by investigating achievement in terms of methods, infrastructures, and investments. In addition, this approach is more realistic for obtaining overall supply chain performance scores. For example, fuzzy numbers were considered in the allocation of scores. Another advantage identified by users was that the hierarchical analysis process could be adapted to new decision-making areas or environments by adding and removing new components using the overall structure and computational steps [24].

Some of the most recent studies on supply chain performance measurement with the Supply Chain Reference Model (SCOR) approach, briefly describe the researchers' activities. For the first time, this paper develops a DNDEA version of the free disposal hull (FDH) model in the context of the SCOR framework [25].

This description implies that an SC consists of various interdependent components, each of which attempts to maximize its objective function; actually, we are faced with a problem with various objective functions that need to be satisfied at the same time. Such a problem is called multi-objective optimization with numerous Pareto optimal solutions; thus, the final decision is to establish balance in the entire chain based on all the factors [26].

Some research in the field of supply chain performance evaluation with different techniques and hierarchical, process, and descriptive functions are listed in Table 1.

Table 1. Some research in the field of supply chain performance evaluation with different techniques (1388-1400).

Row	Reference	Title	Technique						Function		
			uncertainty	simulation	DELPHI/ survey	DEA	ANP	AHP	Descriptive	Process	Hierarchical
1	[26]	Performance measurement of inter-organizational information systems in the supply chain						*	*		
2	[27]	A SCOR- based model for supply chain performance measurement: application in the footwear industry				*		*	*	*	
3	[28]	Supplier selection and evaluation in e-commerce enterprises: a data envelopment analysis approach			*	*		*	*	*	
4	[29]	Sustainable performance measurement of Indian retail chain using two-stage network DEA	*			*			*		*
5	[19]	Employing a combination of structural mathematical modeling and knowledge envelopment evaluation, efficiency planning of supplying network durability throughout small and medium-sized firms	*		*				*		
6	[30]	The Roles of Supply Chain Performance Measurement on Manufacturing Firms							*		

In the previous research, only a part of the supply chain has been studied, while in the current research, all supply chain processes have been studied and evaluated, then, the new integrated models of DEA and SCOR in dynamic conditions have been used to select the indicators. We determine the control parameters of the studied policy using the DEA and SCOR model, We also generalize the basic five-stage model to investigate models incorporating advanced demand information and evaluate the influence of demand variability on the system performance [31].

Criteria for the Supply Chain Performance Measurement

Supply chain performance measurement provides feedback and necessary information to managers about supply chain activities in meeting customer expectations and the extent to which strategic goals are realized. For the supply chain, performance measurement in a dynamic company, the strategic, operational, and tactical levels are the first to third priority. Customer dimension was the most important criterion for system measurement in terms of the four dimensions of balanced scorecard assessment [32]. This document provides an example of how to examine the long-term viability of supply networks using a case study approach. As a general rule, under the face of unwanted outcomes, the suggested model may be used to assess SSCM's upbeat and downbeat productivity, usefulness, and total achievement [33].

Several Hong Kong University professors have presented a conceptual model of performance measurement in SCM [34]; a process-oriented approach has been used to describe the supply chain performance in their model. Firstly, this model is based on the analysis of the main and the sub-processes and ultimately determines the weight and importance of performance evaluation indicators from the performance evaluation teams' perspective. In addition to using Multi-Criteria Decision Making (MCDM) models in this model to achieve relative values of performance in the chain, this model is also of utmost importance in terms of comprehensiveness of attitude and application of systemic viewpoint in performance measurement. Regarding the logistics services performance measurement in the supply chain, according to the results of the analysis of the PZB model in the quality assessment, the performance measurement system is presented based on the three main criteria of the methods of doing service, information activities, and objective utility of the equipment [35].

Supply chain networks operate in a dynamic environment with numerous ambiguities regarding consumption, production ratios, and delivery time; thus, supply management is still unknown and not fully understood. One of the objectives of tactical supply chain planning in performing customer orders is to meet customers' demands in terms of delivery, accuracy, and delivery at a given time. A study conducted using an integrated framework based on the SCOR model and customer order decoupling point, using an analytical and simulation model, and based on a numerical example, shows how the proposed method can be used in a decision state. Our results can identify the worst and the critical determinants of planning [36].

Guo and Tanaka (2001) developed a data envelopment analysis model for the supply chain performance measurement. They developed their model by integrating the classical data envelopment analysis model and the rough set theory (RST) and used it for six companies in Western China to represent the model's performance and used indicators such as cost, procurement time, and timely delivery percentage [37]. Liang et al. (2006) identified two barriers to the supply chain measurement and its members in the presence of multiple indicators that determine the performance of the members and the existence of a contradiction between the members of the chain. They showed that the classical data envelopment analysis model cannot measure the performance well, due to intermediate indicators. Therefore, they developed several models in his study based on data envelopment analysis in which intermediate indicators are integrated with performance measurement. They developed their model in two-chain and as a seller-buyer. They considered two different modes; the first is that a chain acts as a leader, and the second chain follows it. In this case, the chain related to the leader member is first evaluated, and then the subsequent chain is evaluated using the results of the leader member. The latter mode is defined as a partnership in which an attempt is made to maximize the joint performance of the two chains, which are considered their average performance. In this case, both supply chains are evaluated simultaneously [38]. Chen et al. (2006) observed a performance game between two chain members based on the definitions of chain performance measurement and games theory. They have shown that there are many equilibrium points for the performance of a set of suppliers and producers according to their performance function. They provided a trading model for analyzing the producer and supplier decision-making process and identified the best performance model strategy [39].

Li and O'Brien presented an integrated decision model for the supply chain performance. They referred to the fact that previous studies were focused more on the cost index in the supply chain; they have tried to focus on four criteria: profit, procurement time performance, quick delivery, and waste removal instead of the cost of their model. Their model measures the supply chain performance in two levels of operation and chains. At the chain level, the objectives related to the criteria are considered for each stage of the supply chain so that the supply chain performance can meet customer service goals and select the best supply chain management strategy. At the operational level, logistic and production activities are optimized under specified goals [40].

Hwang et al. (2008) investigated activities related to sourcing and relevant criteria in the SCOR model. Their research is on the liquid-crystal display (LCD) industry in Taiwan. They used a questionnaire to get empirical information and a regression model to investigate the sourcing process at the second level of the SCOR model and its performance criteria. They concluded that their model could help decision-makers in various industries [41].

Easton et al. (2002) investigated the performance measurement of the purchasing department in the supply chain. Referring to the fact that performance measurement of the purchasing department and comparing it with other purchasing departments is complicated, they concluded that this difficulty was due to the lack of acceptable measurement criteria and appropriate methods for integrating these criteria and providing a general performance. They developed a DEA model for purchasing performance measurement in the petrochemical industry [42]. Kojima et al. considered the supply chain performance measurement in a Just-in-time (JIT) manufacturing environment [43]. Little has been done on network DEA in education, and nobody has the effort to model the whole education supply chain using network DEA [44]. The JIT environment has two types of Kanban systems with stochastic demand and definite process times. They developed an algorithm for accurate performance measurement. Gunasekaran et al. (2004) have pointed out that performance measurement and criteria related to the supply chain have not been considered sufficiently in practical studies. To properly comprehend the relevance of distribution network efficiency monitoring and its standards, they established a suitable structure. They determined the measurement criteria and their importance by developing a questionnaire and sending it to 150 large companies in different industries and in the United Kingdom. Criteria are categorized into four main processes of the main chain as follows: plan, source, produce (make/assembly) and deliver [45].

After the questionnaire was received and the importance of each indicator was determined, they were categorized into three main groups of strategic, technical, and operational management to identify the appropriate managerial level to have the authority and responsibility for each criterion. The strategic level represents the performance of senior management. The technical level deals with resource allocation and performance measurement compared to predetermined goals. In this section, performance measurement provides good feedback from middle management decisions. Accurate data is needed for measurements at the operational level, and these measurements indicate the results of lower-level management decisions.

According to Beamon (1999), the performance measurement system, which considers only one performance criterion, is generally incomplete because it does not consider the interaction between critical components of the supply chain and the significant aspects of strategic organizational goals. He identifies key elements of strategic goals as resource, output, and flexibility, and he emphasized that a performance measurement system should include indicators from these three categories [4]. Beamon concluded that each of these three categories of indicators has critical measurement criteria, and measuring each of the indicators has a significant effect on the other. He has emphasized that any performance measurement system must include at least one category criterion (resources, output, and flexibility), and any requirements chosen should be consistent with organizational strategic goals [4].

Huan et al. (2004) reviewed the SCOR model and pointed out that research at the supply chain level was classified into three categories: operational, design, and strategic. They then introduced the model using the AHP technique and examined the performance of the components of the supply chain [46].

Chan (2003), during a study, divided the criteria for the supply chain measurement into two basic quantitative and qualitative categories. Quantitative indicators include cost and resource utilization, and qualitative indicators include quality, flexibility, vision, trust, and innovation. Then, he expressed the measurement criteria for each of these seven categories and, using the AHP technique, tried to identify the most important indicators for the electronic industry. He also presented suggestions for other sectors [47].

Chan and Qi (2003) tried to apply a systematic approach and developed an efficient model for measuring the overall performance of the supply chain. They have used fuzzy set theory to deal with real-world conditions in measurement processes. This paper proposes a fuzzy network epsilon-based data envelopment analysis for supply chain performance evaluation [48].

Wong and Wong (2007) used a Classical Data Envelopment Analysis (DEA) model for the performance measurement of 22 supply chains. Criteria such as profit, Just-In-Time delivery, and cost were used [49].

Estampe et al. (2013) presented a framework and tried to analyze the performance measurement models of the supply chain. This analysis has been done by specifying each model's specific features and capabilities in various fields. They also have tried to divide the models into seven smaller layers to help managers choose the right model for their needs correctly [50]. Comelli et al. (2008) have presented an approach for production planning assessment in supply chains. They pointed out that the production planning assessment is usually based on physical parameters such as inventory level and demand satisfaction. They concluded that adding financial evaluation to classic models is advantageous. They used an ABC method for cash flow estimation of production planning for the supply chain [51].

An important management tool for maximizing the use of precious assets, ensuring high-quality products and services while remaining competitive in a worldwide marketplace, is effectiveness measures and criteria [52].

Unlike logistic systems and closed-loop supply chains, performance measurement has attracted much attention from academics and researchers [53].

Traditionally, the efficiency of the supply chain has been measured by the amount of revenue on the overall cost of the operations. Customers' increasing and diverse demands, coupled with producers' need to meet quick delivery times, have created a new trend toward massive customization. As a result, the distribution system is frequently thought to be challenging to evaluate.

Stochastic frontier analysis (SFA) is a method used for measuring efficiency by comparing decision-making units to an experimental production frontier made from a data set; Wang also added that the use of several multiple performance measurement methods contributes to a greater challenge and efficiency measurement. Strategic management with numerical and qualitative measures to improve the entire effectiveness of the distribution network is offered to assess both the technological and monetary efficacy of this network [49].

Farrell (1957) introduced a basic definition and computational framework about technical efficiency that led to the development of the efficiency of measuring and boundaries estimation and indicates that although there was significant progress in efficiency analysis over the past decades, there is still no better in this field [54].

More than 3200 documents, comprising publications, conference papers, and textbooks, have been published over the last three decades using the DEA technique to assess and evaluate indicators [45]. However, the application of SFAs in measuring supply efficiency and production in the field of the supply chain is not shared. Ainero, Myozin, and Breivik established SFA, a randomized frontier manufacturing framework.

Balanced Scorecard models are used as a benchmark to optimize the supply chain, and then a linear programming model was developed [55].

Among the approaches dealing with the uncertainty proposed in optimization problems, the robust optimization approach has attracted more attention in recent years, which is mainly due to its efficiency and applicability [56].

Kiyani and Mohammad Jafari (2015), during a study, introduced the hierarchy of evaluation indicators in three levels by considering the criteria of the SCOR model as functional indicators and the six processes of this model as process indicators and also by determining the relevant sub-criteria in each indicator [57].

In the presented model, two macro measurement indicators are defined at the first level; 11 indicators at the second level and 35 sub-criteria at the third level. AHP group technique was used to provide the weight of the indicators and parameters of the model.

The results show that 61.89 % of the weight is related to the results indicators and 38.11 % of the weight is associated with the process indicators. Considering the result and performance indicators compared to the SCOR model that only measures the result indicators, this model is helpful for newly established and emerging companies that are effective in the process of setting up and organizing parts and processes. Therefore, it can be suggested that each manufacturing company, by calculating the amount of comprehensive indicator of its supply chain measurement, while being aware of the existing situation in comparison with its competitors, will provide the appropriate context for improving the qualitative and quantitative level of supply chain and improvement of the relevant organization while aware of the current situation compared with competitors [58]. We utilized path analysis to explore the effect of various supply chain centrality measures on firms' financial performance, investment risk, and market value volatility [59].

Saberizonouziasl and Hasanzadeh (2013) during a study, investigated the supply chain performance measurement of the urban management system of one of the districts of Tehran and ranked the main processes of the SCOR model. The inferential statistics method has been used to test the hypotheses related to the proposed conceptual model, and the final result has determined that considering the planning and high ability of the municipality of Tehran in sourcing and outsourcing of services, the performance, and output of the system, it is not in a desirable situation; thus the necessary solutions are presented accordingly [60]. The Previous study develops a performance measurement model based on a two-stage network data envelopment analysis (DEA) technique for measuring the joint impact of sustainable operations and operational activities on the business performance of a retail firm [29].

This study aims to evaluate how students rank a higher education institute for taking admission, considering the relevant criteria as inputs and outputs; the Data Envelopment Analysis is employed to assess the weights corresponding to each criterion/factor [61].

Bigliardi and Bottani (2010) introduced the BSC model to evaluate the supply chain performance of the food industry [62]. In this regard, first, the key indicators of performance (financial and non-financial indicators) were identified by reviewing the literature. Then, the indicators were modified and adjusted using the Delphi technique and structured in four perspectives of the BSC model [63]. We propose a network data envelopment analysis (NDEA) model to reflect the internal structure of networks in efficiency evaluation [64].

Chia et al. (2009) introduced 15 general criteria for supply chain performance measurement and structured them into four models of the BSC model. They concluded that all of the requirements proposed for supply chain performance measurement are used in performance measurement, but the percentage of use of these criteria is different [65].

New metrics are added to the SCOR model, and a novel SCOR 4.0 model is proposed. The novel performance evaluation model is structured as a three-level hierarchical structure to evaluate the supply chain [66].

Research Methodology

In order to evaluate the supply network effectiveness of the oil commodities transportation sector, this research used data exchanging indicators. Consequently, this investigation is regarded as an applicable study in terms of purposes. Still, in considerations of the information collecting technique, it is designated a research project and descriptive survey.

The opinions of 240 administrators and specialists familiar with supplying network issues in each unit of the Oil Distribution Company were gathered independently for this research (Chaharmahal and Bakhtiari, Kohgiluyeh and Boyer Ahmad, Tehran, Isfahan).

The steps performed in this study are shown in Fig. 1.

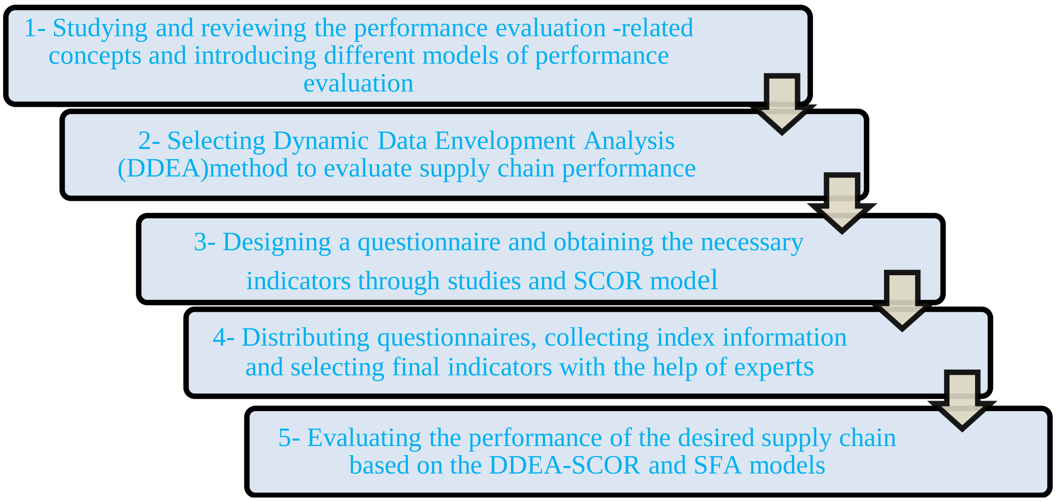

Fig. 1. Study process

The supply chain operations reference model (SCOR) is a management tool used to address, improve, and communicate supply chain management decisions within a company and with suppliers and customers of a company (1). The model describes the business processes required to satisfy a customer's demands.

Dynamic Data Envelopment Analysis (DDEA) deals with efficient analysis of decision-making units in time-dependent situations.

Identifying Effectiveness Assessment Indices in the Distribution Network

In contexts of monetary, customer, organizational procedures, development, and training in a distribution system, the IT indexes are subdivided according to the table below, as follows.

Table 2. Supply Chain Performance Assessment Indices Employing the SCOR Model.

Parameters	Row	Indicators
Designing and Planning	1 input	In the realm of engineering and management, how much is the pricing indicator influenced?
	2 inputs	What is the entire expense of knowledge transmission in the company's development and management?
	3 Outputs	What is the impact of the overall reaction time of supplying networks on engineering and management?
	4 inputs	In terms of designing and management, how long does it take for customers to respond?
Supply and Sourcing	5 Inputs	In terms of distribution and procurement, what is the amount of provider and purchaser engagement in the corporation?
	6 Inputs	How reliable and up-to-date is the firm's data on supplying and procurement practices?
	7 Inputs	Regarding distribution and procurement, what is the appropriate degree of goods excellence for the corporation?
	8 Outputs	In the realm of distribution, how long is the firm's planned distribution period relative to the corporation's soft?
Production and Make	9 inputs	In the realm of engineering and manufacturing, how accurate is inventory documentation?
	10 inputs	What is the state of manufacturing adaptability?
	11 Outputs	In the realm of fabrication and manufacturing, what is the inventory potential?
Send and Deliver	12 Reverse / Inputs	In the realm of transmission and delivery, how much does it cost each unit to ship?
	13 inputs	How much is the transit performance indication in terms of the corporation's transmission and distribution?
	14 Outputs	How reliable is the transportation of commodities to the corporation regarding shipping and distribution?
Returning	15 inputs	In the realm of returns, at what degree is the reliability of the commodities inspected?
	16 Outputs	In the service provision mechanism for a given demand, how much adaptability is regarded?
	17 inputs	The delivery chain's reaction period
	18 Outputs	In the realm of returning, what are the consumer contentment metrics?
	19 Outputs	In the returning sector, how much is the entire expenditure of the corporation?

Solving Method

The conceptual model of SCOR is presented as follows:

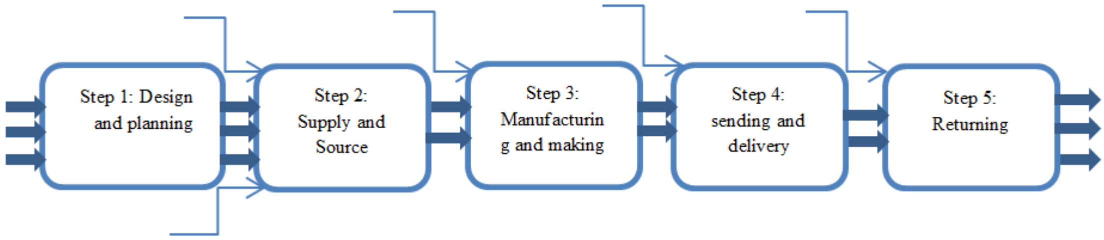

Fig. 2. SCOR conceptual model in a multi-stage system where each stage has input and output performance indicators.

Firstly, the model for the SCOR model performance measurement of data envelopment analysis is developed as follows:

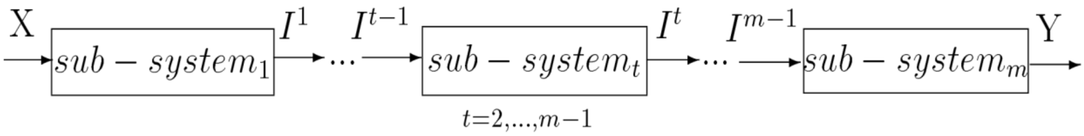

Fig. 3. Network Data Envelopment Analysis for SCOR Measurement.

Performance measurement indicators have been determined according to the steps of the SCOR model. Performance measurement indicators include inputs, outputs, and external factors of the performance measurement model (Table 2).

Determining the units under study

Each DMU should be defined as an entity responsible for the data used and outputs generated. The number of DMUs must be large enough to provide an appropriate degree of freedom. The following *rule of thumb* is common for the significance of the results of the performance measurement (S is the number of outputs, M is the number of data and N is the number of DMUs):

$$S+M \leq N/3 \tag{1}$$

In the model presented in the present study, all previous methods in relation to non-optional variables are covered, and non-optional variables are considered as external factors. In this model, the frontier of efficiency is defined based on optional variables and non-optional variables, but reference units are selected from units that the same external conditions govern them. The desired model is a non-radial model in which inputs and outputs are classified into three categories: input and output and external factors.

θ: Supply Chain Performance
d: Supply Chain Companies
X: First step inputs index
i: Intermediate Indicators
t: the middle stages of the chain
m: the last stage of the chain
k_1: number of output indicators of the first stage
P: number of input indicators of the first stage
k_t: t number of output indicators of the middle phase
k_{t-1}: number of input indicators of middle stage t-1
q, Q: number of output indicators of the last stage
K_{m-1}: number of input indicators of the last stage

v_p: weights of input indicators of the first stage
Z^1_{k1}: weights of the output indicators of the first stage
$z^t k_t$, $z^{t-1} k_{t-1}$: weights of the input and output indicators of the middle stages
zk_{m-1}: The weights of the input indicators of the last stage
u_q: The weights of the last step
W_1: The total weight of the first stage indicators
W_t: The total weight of the t[th] stage indicators
W_m: The total weight of the m[th] stage indicators
θ_d: The performance of the whole supply chain of the company d
θ_{1d}: The performance of the first phase of the supply chain of the company d
θ_{td}: The performance of the middle steps of the supply chain of the company d
θ_{md}: The performance of the last step of the supply chain of the company d
S: The total number of courses studied in dynamic mode
T: Period d in dynamic mode

First, we propose a fractional measurement model according to Chan et al. as follows [57]:

$$Max\theta_d = w_1 \frac{\sum_{k_1=1}^{K_1} z^1_{k_1} i^i_{k_1 d}}{\sum_{p=1}^{P} v_p x_{pd}} + \sum_{t=2}^{m-1} w_t \frac{\sum_{k_t=1}^{K_t} z^t_{k_t} i^t_{k_t d}}{\sum_{k_{t-1}=1}^{K_{t-1}} z^{t-1}_{k_{t-1}} i^{t-1}_{k_{t-1} d} + \sum_{b_{t-1}}^{B_{t-1}} f^{t-1}_{b_{t-1}} e^{t-1}_{b_{t-1}}} + w_m \frac{\sum_{q=1}^{Q} u_q y_{qd}}{\sum_{k_{m-1}=1}^{K_{m-1}} z^{m-1}_{k_{m-1}} i^{m-1}_{k_{m-1} d} + \sum_{b_{m-1}}^{B_{m-1}} f^{m-1}_{b_{m-1}} e^{m-1}_{b_{m-1}}}$$

$$s.t$$

$$\frac{\sum_{k_1=1}^{K_1} z^1_{k_1} i^i_{k_1 j}}{\sum_{p=1}^{P} v_p x_{pj}} \le 1,\ j = 1,2,...,N,$$

$$\frac{\sum_{k_t=1}^{K_t} z^t_{k_t} i^t_{k_t j}}{\sum_{k_{t-1}=1}^{K_{t-1}} z^{t-1}_{k_{t-1}} i^{t-1}_{k_{t-1} d} + \sum_{b_{t-1}}^{B_{t-1}} f^{t-1}_{b_{t-1}} e^{t-1}_{b_{t-1}}} \le 1, t = 2,...,m-1.,\ j = 1,2,...,N$$

$$\frac{\sum_{q=1}^{Q} u_q y_{qj}}{\sum_{k_{m-1}=1}^{K_{m-1}} z^{m-1}_{k_{m-1}} i^{m-1}_{k_{m-1} d} + \sum_{b_{m-1}}^{B_{m-1}} f^{m-1}_{b_{m-1}} e^{m-1}_{b_{m-1}}} \le 1,\ j = 1,2,...,N$$

$$u_q \ge 0, v_p \ge 0, z^t_k \ge 0, \forall q, p, k, t = 1,2,...,m-1. \tag{2}$$

In the objective function, the first and second fractions have been determined for the first and second members of the chain. Similarly, m members have been considered and weight (w) has been attributed to each member. In each fraction, the numerator and denominator represent the member's outputs and input, respectively. The sum of all these inputs and outputs represents the total efficiency of the chain. In each constraint, the output of each fraction should be lower than 1. The efficiency is between 0 and 1. In the above model, weights (w) are replaced with the following items, in which the share of each input of the total inputs is defined in each member. Now, in the above model, we replace the weights w as follows, in which the contribution of each input from the total inputs is defined in each member; therefore, using the findings of Chan et al. [68], we have:

$$\omega_1 = \frac{\sum_{p=1}^{P} V_p X_{pd}}{\sum_{p=1}^{P} V_p X_{pd} + \sum_{k_{t-1}=1}^{K_{t-1}} z_{k_{t-1}}^{t-1} i_{k_{t-1}d}^{t-1} + \sum_{b_{t-1}}^{B_{t-1}} f_{b_{t-1}}^{t-1} e_{b_{t-1}}^{t-1}}$$

$$\omega_t = \frac{\pm \sum_{k_{t-1}=1}^{K_{t-1}} z_{k_{t-1}}^{t-1} i_{k_{t-1}d}^{t-1} + \sum_{b_{t-1}}^{B_{t-1}} f_{b_{t-1}}^{t-1} e_{b_{t-1}}^{t-1}}{\sum_{p=1}^{P} V_p X_{pd} + \sum_{t=1}^{m-1} \left(\sum_{k_{t-1}=1}^{K_{t-1}} z_{k_{t-1}}^{t-1} i_{k_{t-1}d}^{t-1} + \sum_{b_{t-1}}^{B_{t-1}} f_{b_{t-1}}^{t-1} e_{b_{t-1}}^{t-1} \right)} \qquad (t = 2, \dots, m) \tag{3}$$

It is clear that, the sum of all weights w will be equal to 1. By putting the weights in the Model (4), the Model (4) will be achieved:

$$\max \theta_d = \frac{\sum_{t=1}^{m-1} \sum_{k_t=1}^{K_t} Z_{kt}^t I_{k_t d}^t + \sum_{q=1}^{Q} U_q Y_{qd}}{\sum_{p=1}^{P} V_p X_{pd} + \sum_{t=1}^{m-1} \left(\sum_{k_{t-1}=1}^{K_{t-1}} z_{k_{t-1}}^{t-1} i_{k_{t-1}d}^{t-1} + \sum_{b_{t-1}}^{B_{t-1}} f_{b_{t-1}}^{t-1} e_{b_{t-1}}^{t-1} \right)}$$

$$\frac{\sum_{k_1=1}^{K_1} z_{k_1}^1 i_{k_1 j}^i}{\sum_{p=1}^{P} v_p x_{pj}} \le 1, \; j = 1,2,\dots,N,$$

$$\frac{\sum_{k_t=1}^{K_t} z_{k_t}^t i_{k_t j}^t}{\sum_{k_{t-1}=1}^{K_{t-1}} z_{k_{t-1}}^{t-1} i_{k_{t-1}d}^{t-1} + \sum_{b_{t-1}}^{B_{t-1}} f_{b_{t-1}}^{t-1} e_{b_{t-1}}^{t-1}} \le 1, t = 2,\dots,m-1., \; j = 1,2,\dots,N$$

$$\frac{\sum_{q=1}^{Q} u_q y_{qj}}{\sum_{k_{m-1}=1}^{K_{m-1}} z_{k_{m-1}}^{m-1} i_{k_{m-1}d}^{m-1} + \sum_{b_{m-1}}^{B_{m-1}} f_{b_{m-1}}^{m-1} e_{b_{m-1}}^{m-1}} \le 1, \; j = 1,2,\dots,N$$

$$u_q \ge 0, v_p \ge 0, z_k^t \ge 0, \forall q, p, k, t = 1,2,\dots,m-1. \tag{4}$$

As observed, Model (4) is nonlinear; therefore, it can be converted into a linear programming model as follows:

$$h = \frac{1}{\sum_{p=1}^{p} V_p X_{pd} + \sum_{t=1}^{t-1} \sum_{k_t=1}^{m} Z_{k_t}{}^t I_{k_t d}{}^t + \sum_{b_{t-1}}^{B_{t-1}} f_{b_{t-1}}^{t-1} e_{b_{t-1}}^{t-1}}$$

$$\delta_p = hV_p, \varphi_k^t = hZ_k^t, t = 1,\dots,m-1, \mu_q = hU_q \tag{5}$$

By putting equations used in the study conducted by Charles and Cooper, the following linear model can be achieved:

$$
\begin{aligned}
&Max\theta_d = \sum_{q=1}^{Q} \mu_q Y_{qd} + \sum_{t=1}^{m-1}\sum_{k_t=1}^{K_t} \varphi_{k_t}^t I_{k_t d}^t \\
&s.t \sum_{p=1}^{P} \delta_p X_{pd} + \sum_{t=1}^{m-1}\sum_{k_t=1}^{K_t} \varphi_{k_t}^t I_{k_t d}^t = 1, \\
&\sum_{k_1=1}^{K_1} \varphi_{k_1}^1 I_{k_1 j}^1 - \sum_{p=1}^{P} \delta_p X_{pj} \le 0,\ j = 1,\dots,N, \\
&\sum_{k_t=1}^{K_t} \varphi_{k_t}^t I_{k_t j}^t - \sum_{k_{t-1}=1}^{K_{t-1}} \varphi_{k_t-1}^{t-1} I_{k_{t-1} j}^{t-1} \le 0, t = 2,\dots,m-1,\ j = 1,\dots,N, \\
&\sum_{q=1}^{Q} \mu_q Y_{qj} - \sum_{k_m-1=1}^{K_m-1} \varphi_{k_m-1}^{m-1} I_{k_{m-1} j}^{m-1} \le 0,\ j = 1,\dots,N, \\
&\mu_q \ge \varepsilon, \delta_p \ge \varepsilon, \varphi_k^t \ge \varepsilon, \forall k.q, p, t = 1,\dots,m-1.
\end{aligned}
\tag{6}
$$

Model (7) can evaluate the performance of the entire t-member chain in series. In linear programming models, the optimal value of the objective function in the primary and secondary models will be the same; therefore, we will have:

$$
s.t \frac{\sum_{t=1}^{m-1}\sum_{k_t=1}^{K_t} z_{kt}^t i_{k_t d}^t + \sum_{q=1}^{Q} u_q y_{qd}}{\sum_{p=1}^{P} v_p x_{pd} + \sum_{t=1}^{m-1}\sum_{k_t=1}^{K_t} z_{k_t}^t i_{k_t d}^t} = \theta_d^* \tag{7}
$$

Now, the efficiency of each member can be calculated by considering the efficiency of the entire chain as follows:

$$
Max\theta_{1d} = \frac{\sum_{k_1=1}^{K_1} Z_{k1}^1 I_{k_1 d}^1}{\sum_{p=1}^{P} v_p x_{pd}}
$$

$$
\frac{\sum_{k_1=1}^{K_1} z_{k_1}^1 i_{k_1 j}^1}{\sum_{p=1}^{P} v_p x_{pj}} \le 1.\ j = 1,\dots,N.
$$

$$
\frac{\sum_{k_t=1}^{K_t} z_{kt}^t i_{ktj}^t}{\sum_{k_{t-1}=1}^{K_t-1} z_{k_t-1}^{t-1} i_{k_{t-1} j}^{t-1}} \le 1, t = 2,\dots,m-1,\ j = 1,\dots,N
$$

$$\frac{\sum_{q=1}^{Q} U_q Y_{qj}}{\sum_{k_{m-1}=1}^{K_{m-1}} Z_{k_{m-1}}^{m-1} I_{k_{m-1}j}^{m-1}} \le 1, \qquad \mathrm{j} = 1,2,...,\mathrm{N},$$

$$\mathrm{U}_q \ge 0, \quad V_p \ge 0, \quad Z_k^t \ge 0, \quad \forall q, p, k, \; t = 1,...,m-1 \tag{8}$$

The performance of the first member of the chain can be obtained by the Model (9). Given that the model is a non-linear programming model, it can be achieved by using a transformation to a linear programming problem for evaluating the performance of the first member of the chain so that we will have:

$$\max \quad \theta_{1d} = \sum_{k_1=1}^{K_1} \varphi_{k_1}^1 I_{k_1 d}^1$$

$$s.t \sum_{\mathrm{p}=1}^{\mathrm{p}} \delta_p X_{pd} = 1,$$

$$\sum_{k_1=1}^{K_1} \varphi_{k_1}^1 I_{k_1 d}^1 - \sum_{p=1}^{P} \delta_p X_{pj} \le 0, \qquad j = 1,2,...,\mathrm{N},$$

$$\sum_{k_t=1}^{K_t} \varphi_{k_t}^t I_{k_t j}^t - \sum_{k_{t-1}=1}^{K_{t-1}} \varphi_{k_{t-1}}^{t-1} I_{k_{t-1} j}^{t-1} \le 0, \quad t = 2,...,m-1 \quad j = 1,2,...,N,$$

$$\sum_{q=1}^{Q} \mu_q Y_{qj} - \sum_{k_{m-1}=1}^{K_{m-1}} \varphi_{k_{m-1}}^{m-1} I_{k_{m-1} j}^{m-1} \le 0, \qquad j = 1,2,...,N,$$

$$\sum_{q=1}^{Q} \mu_q Y_{qd} + (1-\theta_d^*)\left[\sum_{t=1}^{m-1}\sum_{k_t=1}^{K_t} \varphi_{k_t}^t I_{k_t d}^t\right] = \theta_d^*,$$

$$\mu_q \ge \varepsilon, \quad \delta_p \ge \varepsilon, \quad \varphi_k^t \ge \varepsilon, \quad \forall k, q, p, \quad t = 1,2,...,m-1. \tag{9}$$

As stated, also for middle members of the chain, (t = 2, m-1), the calculation method for performance measurement can be calculated as follows:

$$\max \quad \theta_{td} = \sum_{k_t=1}^{K_t} \varphi_{k_t}^t I_{k_t d}^t$$

$$\sum_{\mathrm{K}_{t-1}=1}^{\mathrm{K}_{t-1}} \mathrm{Q}_{\mathrm{K}_{t-1}}^{t-1} \mathrm{I}_{\mathrm{K}_{t-1}\mathrm{d}}^{t-1} = 1,$$

$$\sum_{k_1=1}^{K_1} \varphi_{k_1}^1 I_{k_1 j}^1 - \sum_{p=1}^{P} \delta_p X_{pj} \le 0, \qquad j = 1,2,...,\mathrm{N},$$

$$\sum_{k_t=1}^{K_t} \varphi_{k_t}^t I_{k_t j}^t - \sum_{k_{t-1}=1}^{K_{t-1}} \varphi_{k_{t-1}}^{t-1} I_{k_{t-1} j}^{t-1} \le 0, \quad t = 2,...,m-1 \quad j = 1,2,...,N,$$

$$\sum_{q=1}^{Q} \mu_q Y_{qj} - \sum_{k_{m-1}=1}^{K_{m-1}} \varphi_{k_{m-1}}^{m-1} I_{k_{m-1} j}^{m-1} \le 0, \qquad j = 1,2,...,N,$$

$$\sum_{q=1}^{Q} \mu_q Y_{qd} + (1-\theta_d^*)\left[\sum_{t=1}^{m-1}\sum_{k_t=1}^{K_t} \varphi_{k_t}^t I_{k_t d}^t\right] - \theta_d^* \sum_{p=1}^{P} \delta_p X_{pd} = 0,$$

$$\mu_q \ge \varepsilon, \quad \delta_p \ge \varepsilon, \quad \varphi_k^t \ge \varepsilon, \quad \forall k, q, p, \quad t = 1,2,...,m-1. \tag{10}$$

Finally, the efficiency of the last step of the supply chain subsystem is calculated as follows:

$$\max \quad \theta_{md} = \sum_{q=1}^{Q} \mu_q Y_{qd}$$
$$\sum_{K_{m-1}=1}^{K_{m-1}} Q_{K_{m-1}}^{m-1} I_{K_{m-1}d}^{m-1} = 1,$$
$$\sum_{k_1=1}^{K_1} \varphi_{k_1}^1 I_{k_1 j}^1 - \sum_{p=1}^{P} \delta_p X_{pj} \le 0, \qquad j = 1,2,\ldots,\mathrm{N},$$
$$\sum_{k_t=1}^{K_t} \varphi_{k_t}^t I_{k_t j}^t - \sum_{k_{t-1}=1}^{K_{t-1}} \varphi_{k_{t-1}}^{t-1} I_{k_{t-1} j}^{t-1} \le 0, \quad t = 2,\ldots,m-1 \quad j = 1,2,\ldots,N,$$
$$\sum_{q=1}^{Q} \mu_q Y_{qj} - \sum_{k_{m-1}=1}^{K_{m-1}} \varphi_{k_{m-1}}^{m-1} I_{k_{m-1} j}^{m-1} \le 0, \qquad j = 1,2,\ldots,N,$$
$$\sum_{q=1}^{Q} \mu_q Y_{qd} + (1-\theta_d^*)\left[\sum_{t=1}^{m-1}\sum_{k_t=1}^{K_t} \varphi_{k_t}^t I_{k_t d}^t\right] - \theta_d^* \sum_{p=1}^{P} \delta_p X_{pd} = 0,$$
$$\mu_q \ge \varepsilon, \quad \delta_p \ge \varepsilon, \quad \varphi_k^t \ge \varepsilon, \quad \forall k,q,p, \quad t = 1,2,\ldots,m-1. \tag{11}$$

Dynamic Model of Supply Chain

The performance of the entire t-member chain in series can be measured using model (6). Now, the above model has been rewritten periodically with the definition of the index s as the index of the period, which varies between 1 and T [68]; in this study, the data of the problem is considered seasonally.

$$Max\theta_d = \sum_{s=1}^{T}\sum_{q=1}^{Q} \mu_q Y_{qds} + \sum_{t=1}^{m-1}\sum_{k_t=1}^{K_t} \varphi_{k_t}^t I_{k_t d}^{ts}$$
$$s.t \sum_{p=1}^{P} \delta_p X_{pds} + \sum_{t=1}^{m-1}\sum_{k_t=1}^{K_t} \varphi_{k_t}^t I_{k_t d}^{ts} = 1, \forall s = 1,2,\ldots,T$$
$$\sum_{k_1=1}^{K_1} \varphi_{k_1}^1 I_{k_1 j}^{1s} - \sum_{p=1}^{P} \delta_p X_{pjs} \le 0, \; j = 1,\ldots,N, s = 1,2,\ldots,T$$
$$\sum_{k_t=1}^{K_t} \varphi_{k_t}^t I_{k_t j}^{ts} - \sum_{k_{t-1}=1}^{K_{t-1}} \varphi_{k_t-1}^{t-1} I_{k_{t-1} j}^{t-1,s} \le 0, t = 2,\ldots,m-1, \; j = 1,\ldots,N, s = 1,2,\ldots,T$$
$$\sum_{q=1}^{Q} \mu_q Y_{qjs} - \sum_{k_m-1=1}^{K_m-1} \varphi_{k_m-1}^{m-1} I_{k_{m-1} j}^{m-1,s} \le 0, \; j = 1,\ldots,N, s = 1,2,\ldots,T$$
$$\mu_q \ge \varepsilon, \delta_p \ge \varepsilon, \varphi_k^t \ge \varepsilon, \forall k.q, p, t = 1,\ldots,m-1. \tag{12}$$

Now, the efficiency of each member can be calculated by considering the efficiency of the entire chain as follows:

$$Max\theta_{1d} = \frac{\sum_{s=1}^{T}(\sum_{k_1=1}^{K_1} Z_{k1}^{1s} I_{k_1 d}^{1s})}{\sum_{s=1}^{T}(\sum_{p=1}^{P} v_{ps} x_{pds})}$$

$$s.t \frac{\sum_{t=1}^{m-1}\sum_{k_t=1}^{K_t} z_{kt}^{ts} i_{k_t d}^{ts} + \sum_{q=1}^{Q} u_{qs} y_{qds}}{\sum_{p=1}^{P} v_{ps} x_{pds} + \sum_{t=1}^{m-1}\sum_{k_t=1}^{K_t} z_{k_t}^{ts} i_{k_t d}^{ts}} = \theta_d^*, s = 1,2,...,T$$

$$\frac{\sum_{k_1=1}^{K_1} z_{k_1}^{1s} i_{k_1 j}^{1s}}{\sum_{p=1}^{P} v_{ps} x_{pjs}} \leq 1. j = 1,..., N, s = 1,2,...,T$$

$$\frac{\sum_{k_t=1}^{K_t} z_{kt}^{ts} i_{ktj}^{ts}}{\sum_{k_{t-1}=1}^{K_t -1} z_{k_t -1}^{t-1,s} i_{k_{t-1} j}^{t-1,s}} \leq 1, t = 2,..., m-1, j = 1,..., N, s = 1,2,...,T$$

$$\frac{\sum_{q=1}^{Q} U_{qs} Y_{qjs}}{\sum_{k_{m-1}=1}^{K_{m-1}} Z_{k_{m-1}}^{m-1,s} I_{k_{m-1},j}^{m-1,s}}, j = 1,2,..., N, s = 1,2,...,T$$

$$U_{qs} \geq 0, V_{ps} \geq 0, Z_k^{ts} \geq 0, \forall q, p, k, t, s \tag{13}$$

Model (14) can calculate the efficiency of the first member of the chain. Given that the model is a non-linear programming model, a linear programming problem for measuring the performance of the first member of the chain can be achieved by using transformations so that we will have:

$$\max \theta_{1d} = \sum_{k_t=1}^{K_t}\sum_{s=1}^{T}(\varphi_{k_t}^1 I_{k,d}^{1s})$$

S.t.

$$\sum_{p=1}^{P}\sum_{s=1}^{T} \delta_p X_{pds} = 1$$

$$\sum_{k_t}^{K_t} \varphi_{k_t}^1 I_{k,d}^{1s} - \sum_{p=1}^{P} \delta_p X_{pjs} \leq 0, j = 1,2,..., N, s = 1,2,...,T$$

$$\sum_{k_t=1}^{K_t} \varphi_{k_t}^t I_{k,j}^{ts} - \sum_{k_{t-1}=1}^{K_{t-1}} \varphi_{k_{t-1}}^{t-1} I_{k_{t-1},j}^{t-1,s} \leq 0, t = 1,2,..., m-1, s = 1,2,...,T$$

$$\sum_{q=1}^{Q}\mu_q Y_{qjs}-\sum_{k_{mt-1}=1}^{K_{mt-1}}\varphi_{k_{m-1}}^{m-1}I_{k_{m-1},j}^{m-1,s}\leq 0,,s=1,2,...,T$$
$$\sum_{q=1}^{Q}\sum_{s=1}^{T}\ \mu_q Y_{qjs}+(1-\theta_d^*)[\sum_{s=1}^{T}(\sum_{t=1}^{m-1}(\sum_{k_{mt-1}=1}^{K_{mt-1}}\varphi_{k_t}^{t}I_{k_t,d}^{t,s}))]=\theta_d^*$$
$$\mu_q\geq\varepsilon,\quad \delta_p\geq\varepsilon,\quad \varphi_k^t\geq\varepsilon,\quad \forall k,q,p,\quad t=1,2,...,m-1. \tag{14}$$

Also, the average productivity of the subsystems (t = 2, m-1) of the supply chain can be calculated as follows:

$$\max\theta_{td}=\sum_{k_t=1}^{K_t}\sum_{s=1}^{T}(\varphi_{k_t}^{t}I_{k,d}^{ts})$$

S.t.

$$\sum_{k_{t-1}=1}^{K_{t-1}}\sum_{s=1}^{T}\ \varphi_{k_{t-1}}^{t-1}I_{k_{t-1},d}^{t-1,s}=1$$
$$\sum_{k_t}^{K_t}\varphi_{k_t}^{1}I_{k,j}^{1s}-\sum_{p=1}^{P}\delta_p X_{pjs}\leq 0,\ j=1,2,...,N,s=1,2,...,T$$
$$\sum_{k_t=1}^{K_t}\varphi_{k_t}^{t}I_{k,j}^{ts}-\sum_{k_{t-1}=1}^{K_{t-1}}\varphi_{k_{t-1}}^{t-1}I_{k_{t-1},j}^{t-1,s}\leq 0,t=1,2,...,m-1,s=1,2,...,T$$
$$\sum_{q=1}^{Q}\mu_q Y_{qjs}-\sum_{k_{mt-1}=1}^{K_{mt-1}}\varphi_{k_{m-1}}^{m-1}I_{k_{m-1},j}^{m-1,s}\leq 0,,s=1,2,...,T$$
$$\sum_{q=1}^{Q}\sum_{s=1}^{T}\ \mu_q Y_{qds}+(1-\theta_d^*)[\sum_{s=1}^{T}(\sum_{t=1}^{m-1}(\sum_{k_{t-1}=1}^{K_{t-1}}\varphi_{k_t}^{t}I_{k_t,d}^{t,s}))]-\theta_d^*\sum_{p=1}^{P}\sum_{s=1}^{T}\ \delta_p X_{pds}=0$$
$$\mu_q\geq\varepsilon,\quad \delta_p\geq\varepsilon,\quad \varphi_k^t\geq\varepsilon,\quad \forall k,q,p,\quad t=1,2,...,m-1. \tag{15}$$

Finally, the efficiency of the last step of the supply chain's subsystem is calculated as follows:

$$\max\theta_{md}=\sum_{k_t=1}^{K_t}\sum_{s=1}^{T}(\mu_q Y_{qds})$$

S,t.

$$\sum_{k_{m-1}=1}^{K_{m-1}}\sum_{s=1}^{T}\ \varphi_{k_{m-1}}^{m-1}I_{k_{m-1},d}^{m-1,s}=1$$
$$\sum_{k_t}^{K_t}\varphi_{k_t}^{1}I_{k,j}^{1s}-\sum_{p=1}^{P}\delta_p X_{pjs}\leq 0,\ j=1,2,...,N,s=1,2,...,T$$
$$\sum_{k_t=1}^{K_t}\varphi_{k_t}^{t}I_{k,j}^{ts}-\sum_{k_{t-1}=1}^{K_{t-1}}\varphi_{k_{t-1}}^{t-1}I_{k_{t-1},j}^{t-1,s}\leq 0,t=2,...,m-1,s=1,2,...,T$$
$$\sum_{q=1}^{Q}\mu_q Y_{qjs}-\sum_{k_{mt-1}=1}^{K_{mt-1}}\varphi_{k_{m-1}}^{m-1}I_{k_{m-1},j}^{m-1,s}\leq 0,,s=1,2,...,T$$

$$\sum_{q=1}^{Q}\sum_{s=1}^{T} \mu_q Y_{qds} + (1-\theta_d^*)[\sum_{s=1}^{T}(\sum_{t=1}^{m-1}(\sum_{k_{t-1}=1}^{K_{t-1}} \varphi_{k_t}^t I_{k_t,d}^{t,s}))] - \theta_d^* \sum_{p=1}^{P}\sum_{s=1}^{T} \delta_p X_{pds} = 0$$
$$\mu_q \geq \varepsilon, \quad \delta_p \geq \varepsilon, \quad \varphi_k^t \geq \varepsilon, \quad \forall k, q, p, \quad t = 1, 2, ..., m-1. \tag{16}$$

Case Study

The performance measurement method at the Oil Products Distribution Company is implemented in this section.

National Iranian Petroleum Products Distribution Company (N.I.O.P.D.C), with a 90-year history in supplying and distributing petroleum products, was established in 1928. NIOPDC, with more than 6243 permanent staff and about 10,000 fixed-term staff and the following facilities and infrastructure, is responsible for providing management and oversight of the daily distribution of more than 240 million liters of petroleum products in the country: 37 zones; 232 districts; 3,742 petroleum product supply stations; 2,312 CNG-stations; 50 aircraft refilling centers; 13,000 tanker trailers to transport the petroleum products and LPG; 8 tanker ships and floats; facilities with the capacity of 12.7 billion liters for storing major petroleum products. This paper investigated the NIOPDCs in four regions (Chaharmahal-and-Bakhtiari Province, Kohgiluyeh and Boyer-Ahmad Province, Isfahan, and Tehran), which are comprised of 40 sectors in the following DMU order:

Distribution of studied oil products: (Chaharmahal-and-Bakhtiari: DMU1 - Tehran headquarters: DMU2- Kohgiluyeh and Boyerahmad Headquarters: DMU3- Isfahan Headquarters: DMU4- Lordejan: DMU5- Borujen: DMU6- Shahrekord: DMU7- Yasuj: DMU8- Gachsaran: DMU9 - Dehdasht: DMU10- Isfahan: DMU11- Kashan: DMU12- Fereydoun City: DMU13- Khomeinishahr: DMU14- Najaf Abad: DMU15- Shahinshahr: DMU16- Shahreza: DMU17- Khorasgan: DMU18- Fouladshahr: DMU19- Mobarakeh: DMU20- Baharestan: DMU21- Zarinshahr: DMU22- Tiran: DMU23- Golpayegan: DMU24- Falavarjan: DMU25- Aran and Bidgol: DMU26- Tehran: DMU27- Nasimshahr: DMU28- Golestan: DMU29- Ghods: DMU30- Melard: DMU31- Varamin: DMU32 - Shahriar: DMU33- Pakdasht: DMU34 - Ray: DMU35 - Robat Karim: DMU36 - Pardis: DMU37 - Andisheh: DMU38 - Gharchak: DMU39 - Islamshahr: DMU40)

At First, a questionnaire was designed based on the indices in Table 3 and distributed among the managers and experts in these companies. These 290 individuals were managers with not only information knowledge but also strategy development knowledge, and thus they were competent to respond to the questionnaire in a specialized fashion.

Library research and field research in the form of interviews and questionnaires are among the two main methods used to gather data in the present study. The usage of components like questionnaire structure and intelligible phrases in the original construction of questions helps to ensure the questionnaire's reliability. Reliability was increased by consulting with managers, advisors, and specialists following the questionnaires that had been constructed. To assess the questionnaire's validity, the Cronbach's alpha coefficient one assessment has been implemented. The questionnaire's alpha is 0.754, which indicates that it has a reasonable standard of validity.

Firstly, according to the questionnaire (Table 2), the issue of information-sharing study related to supply chain performance measurement was investigated using the SFA and SCOR models at the oil products distribution company. The following results are obtained after entering input and output indices in the GAMS program (According to mathematical models).

DEA model results

Initially, a questionnaire was prepared and delivered to 1200 instances of administrators and specialists (quality control sector –scheduling portion –stockroom department – assessment part – management section – CNG section) of these organizations based on the criteria in Table 2. Only the corporation's 1200 top administrators, each well-versed in the organization's prolonged strategic goals, can provide thoughtful responses to the questionnaire. Thus, considering inputs and outputs, we take the median of these qualitative figures in Table 3.

Table 3. Average Quality Kits of completed questionnaires of oil distribution companies.

	Input stage 1	Input stage 1	Output stage 1	Input stage 1	Output stage 1	Input stage 2	Output stage 2	Output stage 2	Input stage 3	Output stage 3	Output stage 3	Input stage 4	Input stage 4	Output stage 4	Input stage 5	Output stage 5	Output stage 5	Output stage 5	Output stage 5
DMU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	5	2	4	4	4	4	3	3	4	4	4	4	3	5	5	4	3	4	2
2	5	4	4	4	5	4	5	5	4	5	5	4	5	4	4	3	4	4	4
3	3	3	3	4	2	2	3	4	2	2	2	3	4	3	3	3	4	4	3
4	5	4	4	4	4	5	4	3	3	3	2	5	4	3	4	5	5	4	4
5	5	4	4	4	4	4	3	4	3	4	3	3	4	4	3	3	4	4	4
6	5	4	4	3	4	4	4	2	4	4	3	4	4	4	4	4	4	4	4
7	5	3	4	3	4	3	4	2	5	3	4	4	4	3	4	4	4	5	2
8	4	4	4	4	3	4	4	3	4	4	3	3	4	4	5	4	5	3	4
9	4	4	2	4	2	2	4	4	3	3	4	4	4	4	5	4	3	4	4
10	4	3	4	3	5	4	4	3	2	3	4	3	4	4	5	5	3	3	3
11	1	3	3	4	3	4	3	3	3	4	4	3	4	4	4	4	3	3	3
12	4	4	3	4	4	4	4	3	4	3	2	3	4	4	3	3	3	4	4
13	4	3	4	4	3	4	4	4	4	4	4	3	3	4	4	4	4	3	3
14	5	3	5	4	4	3	4	2	4	4	4	3	2	5	3	4	5	3	3
15	5	3	5	5	4		4	3	4	3	4		3	4	5	2	2	4	3
16	5	3	5	4	4	4	4	5	4	2	4	3	5	3	4	4	3	4	3
17	3	4	3	3	4	4	4	3	3	4	2	3	3	4	4	3	3	2	4
18	4	4	4	4	4	4	4	2	4	4	3	3	3	2	4	4	3	2	4
19	5	5	4	4	4	4	3	3	4	4	4	3	3	5	3	3	3	5	5
20	4	3	4	3	4	4	4	4	3	4	3		3	5	4	4	3	3	3
21	4	3	4	5	2	4	3	3	4	3	3	3	3	5	4	4	2	3	3
22	4	3	3	5	3	4	4	3	3	3	4	3	4	3	3	4	5	3	2
23	4	3	5	4	3	5	2	3	2	2	4	3	2	4	4	3	5	2	3
24	4	4	5	5	4	4	4	3	4	3	3	4	2	3	3	4	3	5	4
25	4	2	5	4	2	4	4	4	5	5	4	3	5	5	3	3	5	4	2
26	5	4	4	5	3	4	2	3	4	4	3	5	3	4	4	3	4	4	4
27	4	3	3	2	2	4	4	2	3	3	4	3	3	4	4	4	4	4	3
28	4	2	4	3	4	5	5	3	4	4	3	4	3	4	4	3	5	4	2
29	4	4	5	5	3	4	3	2	4	3	4	3	3	4	4	4	4	4	4
30	4	3	4	5	4	4	3	3	4	3	3	3	4	4	4	4	3	4	3
31	3	2	4	4	3	5	3	4	4	2	3	4	3	4	4	3	3	5	2
32	3	3	5	4	4	4	4	3	3	4	3	3	3	5	4	4	3	4	3
33	3	3	4	3	2	4	3	3	4	4	4	3	4	3	4	3	3	4	3
34	4	3	4	4	4	4	4	3	4	4	3	3	3	4	4	4	3	4	3
35	3	2	5	3	4	4	5	3	4	4	2	3	3	4	4	4	5	4	2
36	3	4	4	4	5	4	4	3	4	4	3	4	3	4	3	3	4	4	4
37	4	3	5	4	4	4	4	4	4	3	3	4	3	4	3	4	3	4	3
38	5	4	5	3	4	3	3	5	4	4	4	4	3	5	5	3	5	4	5
39	5	3	4	4	2	4	4	4	3	4	3	3	3	4	3	4	3	5	3
40	3	4	3	4	3	3	4	3	3	3	3	3	3	3		3	3	4	4

Table 4. Calculation of Supply Chain Performance of Oil Products Distribution Companies by Using the DEA-SCOR Model.

Performance Total	Performance fifth stage	Performance fourth stage	Performance third stage	Performance second stage	Performance first stage	Decision making unit
0.872	0.752	0.995	0.962	0.929	1	DMU_1
0.893	1	0.799	0.957	1	0.847	DMU_2
0.822	0.766	0.935	1	1	0.831	DMU_3
0.888	1	0.846	0.958	0.913	1	DMU_4
0.811	0.752	0.928	1	0.944	0.84	DMU_5
0.858	0.827	0.814	1	0.951	1	DMU_6
0.869	0.851	0.889	0.98	0.827	0.937	DMU_7
0.879	0.8	1	0.913	0.943	1	DMU_8
0.84	0.708	0.972	1	0.928	0.859	DMU_9
0.858	0.731	0.942	0.945	1	1	DMU_{10}
0.876	0.745	0.949	1	0.915	1	DMU_{11}
0.855	0.827	0.912	0.908	1	0.989	DMU_{12}
0.867	0.745	0.992	0.913	0.897	1	DMU_{13}
0.867	0.763	0.979	0.974	0.919	1	DMU_{14}
0.872	0.736	1	0.811	1	1	DMU_{15}
0.855	0.785	0.871	1	0.933	0.976	DMU_{16}
0.852	0.809	0.852	0.987	0.917	0.989	DMU_{17}
0.88	0.806	0.859	0.975	0.924	1	DMU_{18}
0.848	0.841	0.82	1	0.911	0.917	DMU_{19}
0.841	0.683	1	0.929	0.905	0.958	DMU_{20}
0.848	0.644	1	0.947	0.897	0.953	DMU_{21}
0.869	1	0.847	1	1	1	DMU_{22}
0.833	0.764	1	0.889	1	1	DMU_{23}
0.854	0.834	0.809	0.939	0.86	0.999	DMU_{24}
0.895	1	0.881	0.971	0.982	1	DMU_{25}
0.87	0.785	0.872	0.912	1	1	DMU_{26}
0.868	0.825	0.949	0.892	0.951	1	DMU_{27}
0.861	0.733	0.999	0.992	0.865	1	DMU_{28}
0.869	0.899	0.81	0.915	0.88	1	DMU_{29}
0.87	0.825	1	1	0.816	1	DMU_{30}
0.866	0.825	0.877	0.97	0.884	0.988	DMU_{31}
0.852	0.785	0.921	1	0.935	1	DMU_{32}
0.817	0.843	0.936	0.989	1	0.773	DMU_{33}
0.844	0.79	0.986	0.899	0.952	0.941	DMU_{34}
0.858	0.825	1	0.931	0.814	1	DMU_{35}
0.851	0.756	1	0.959	0.988	0.967	DMU_{36}
0.866	0.783	0.993	0.959	0.889	1	DMU_{37}
0.87	0.913	1	0.94	0.879	1	DMU_{38}
0.849	0.759	0.991	0.962	0.866	0.959	DMU_{39}
0.887	0.952	0.866	1	0.962	1	DMU_{40}

As shown in Table 4 and Fig. 4, in terms of the performance of the whole supply chain, the oil products distribution companies in Falavarjan, Tehran had the highest performance, and oil products distribution companies in Lordegan, Shahriyar had the lowest performance among 40 oil companies.

Table 5. Calculation of Supply Chain Performance of Oil Distribution Companies Using the DDEA-SCOR Dynamic Model.

Performance total	Performance winter season	Performance autumn season	Performance summer season	Performance spring season	Decision-making unit
0.905	0.876	0.81	0.822	0.801	DMU_1
0.92	0.832	0.854	0.817	0.798	DMU_2
0.869	0.818	0.789	0.849	0.828	DMU_3
0.932	0.83	0.802	0.841	0.811	DMU_4
0.874	0.785	0.739	0.827	0.806	DMU_5
0.888	0.811	0.837	0.834	0.815	DMU_6
0.892	0.792	0.816	0.811	0.787	DMU_7
0.915	0.828	0.826	0.86	0.84	DMU_8
0.879	0.8	0.815	0.798	0.774	DMU_9
0.887	0.852	0.814	0.837	0.815	DMU_{10}
0.903	0.851	0.845	0.859	0.842	DMU_{11}
0.897	0.787	0.814	0.78	0.754	DMU_{12}
0.89	0.809	0.743	0.792	0.764	DMU_{13}
0.892	0.835	0.805	0.821	0.802	DMU_{14}
0.89	0.841	0.844	0.858	0.842	DMU_{15}
0.893	0.787	0.793	0.799	0.781	DMU_{16}
0.88	0.8	0.779	0.788	0.767	DMU_{17}
0.916	0.803	0.816	0.859	0.838	DMU_{18}
0.878	0.787	0.808	0.808	0.789	DMU_{19}
0.885	0.857	0.833	0.824	0.809	DMU_{20}
0.89	0.788	0.849	0.832	0.816	DMU_{21}
0.893	0.844	0.861	0.858	0.843	DMU_{22}
0.878	0.856	0.838	0.809	0.78	DMU_{23}
0.887	0.802	0.817	0.812	0.792	DMU_{24}
0.918	0.83	0.831	0.839	0.819	DMU_{25}
0.897	0.812	0.842	0.855	0.831	DMU_{26}
0.888	0.876	0.871	0.833	0.815	DMU_{27}
0.88	0.839	0.859	0.854	0.838	DMU_{28}
0.888	0.77	0.848	0.839	0.821	DMU_{29}
0.895	0.836	0.822	0.881	0.865	DMU_{30}
0.891	0.835	0.809	0.815	0.794	DMU_{31}
0.882	0.807	0.799	0.79	0.764	DMU_{32}
0.872	0.841	0.855	0.847	0.83	DMU_{33}
0.887	0.839	0.829	0.837	0.821	DMU_{34}
0.885	0.8	0.804	0.813	0.794	DMU_{35}
0.881	0.823	0.807	0.805	0.785	DMU_{36}
0.899	0.793	0.789	0.834	0.818	DMU_{37}
0.885	0.842	0.794	0.809	0.786	DMU_{38}
0.902	0.818	0.84	0.816	0.794	DMU_{39}
0.912	0.861	0.853	0.841	0.824	DMU_{40}

As shown in Table 5, in terms of the dynamic evaluation performance, the oil products distribution companies of Ghods and Zarin Shahr in the spring, Quds and Yasuj in the summer, Tehran and Zarrin Shahr in the autumn, and Chaharmahal-and-Bakhtiari and Tehran in the winter had the highest efficiency. Oil products distribution companies of Kashan, Shahreza, Lordegan, and Golestan, respectively, had the lowest efficiency among 40 oil products companies in each seasonal period.

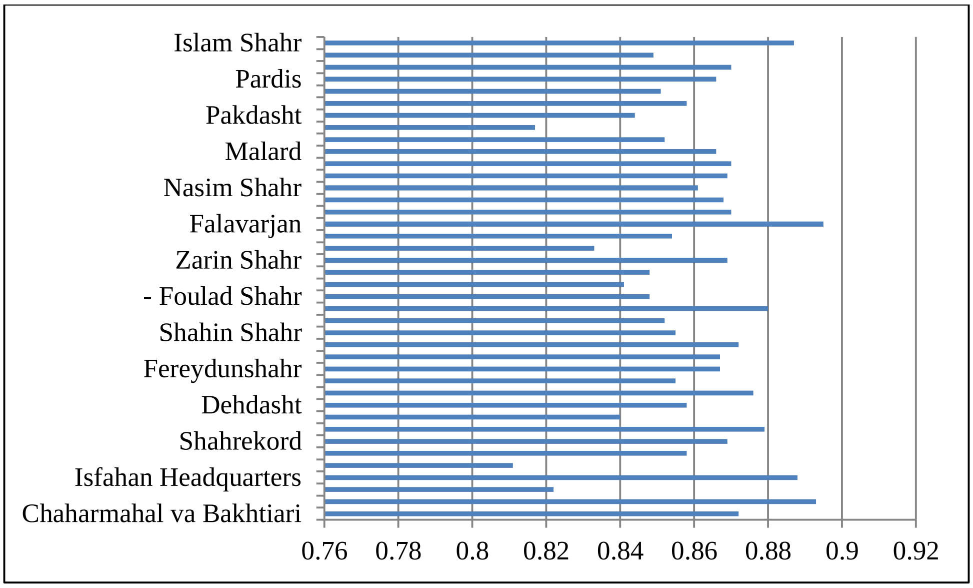

Fig. 4. The SCOR model's overall effectiveness with DEA.

SFA method

The curve also shows the production or frontier functions needed to measure performance. The data envelopment analysis method uses linear programming, while the stochastic frontier analysis method uses econometric models.

Given that the frontier function is never available practically, Farrell suggested that the frontier function be estimated by sample data (firms).

Be reminded that the frontier production function (in short, the production function) is defined as maximum products that can be produced from a set of production agents; that is, it is referred to as a frontier or partial function.

The basic structure of the stochastic frontier production function model is as follows:

$$Y = \beta' X + V - U \quad (17)$$

So that,

$V \sim N(0, Q_V^2)$,

$U = /U/ \qquad U \sim N(0, Q_U^2)$

V: Stochastic component

U: The effects of inefficiency

Y: The product of the firm

X: Vector of inputs

β: Vector of parameters

The difference between the two terms (V-U) is non-symmetric and abnormal, and the degree of non-symmetry depends on the value of $\lambda = Q_U / Qv$. If $\lambda = 0$, the normal regression function is converted to the normal distribution of the stochastic term.

The deviation of observed points from the frontier production function depends on the two sections of U and V, which are different in nature. V is a stochastic term, and U is an inefficiency term.

The recent function indicates the stochastic frontier function, and this method is called the stochastic frontier analysis (SFA). The economic logic of the separation of U and V is that these two terms are different with various properties.

Two economics groups added the above production function to the economic literature simultaneously and on two continents (MV and ALS).

Jondrow et al. and Kalirajan and Felin [69,70], independently investigated the random model proposed by Eugenor, Lovell and Schmidt, Meosen, and Brock to predict the random variable Ui under the assumption that Ui + Vi is known. The best prediction of an unknown random variable (U) with a known combined value of random variables Ui + Vi is the prediction of the conditional Ui conditional expectation Ui provided Ui + Vi. Following the formulation of Kalirajan and Felin, where Ui has a half-normal distribution, the specific technical efficiency of each firm is estimated by the following formula:

$$E(U_i|V_i + U_I) = -\frac{\sigma_u\sigma_v}{\sigma}\left[\frac{f(0)}{1-F(0)} - \frac{V_i+U_i}{\sigma}\sqrt{\frac{r}{1-r}}\right] \quad (18)$$

where, f (0) and F (0) are standard and distribution normal density functions:

$$\frac{V_i+U_i}{\sigma}\sqrt{\frac{r}{1-r}} \quad \text{و} \quad r = \frac{\sigma_u^2}{\sigma^2} \quad \text{و} \quad \sigma^2 = \sigma_u^2 + \sigma_v^2 \quad (19)$$

However, it can be said that Vi + Ui has only incomplete information about Ui, then Vi + Ui has inherent variability.

V is a stochastic term and explains the factors beyond the manufacturer's control, such as favorable and unfavorable external events (such as luck, weather, and machine performance) as well as measurement-related errors in statistics and non-key variables which are removed from the model. The non-key variables that are removed from the model are all contained in V. This random variable (V) has a normal distribution and is independent of U:

$V \sim N(0, \sigma_v^2)$

This assumption is confirmed due to the random nature of V and the central limit theorem (i.e., the disruption term of the sum of the various effects is independent of them).

On the other hand, U represents inefficiency and represents problems that include inefficiencies in production, such as skills, effort or lack of effort of management and staff, the firm's unique information and information constraints, and so on.

The economic interpretation of U that defines inefficiency is consistent with Farrell's definition. Given that the efficiency cannot exceed 1, U must contain one-way values.

There are many one-way distributions, among which half-normal distribution can be considered. The choice of the type of distribution for U is of utmost importance because at that time the model can be estimated by the maximum likelihood (ML) method in one step based on the distribution assumptions V and U. The maximum likelihood method is preferable. After all, effective limit estimation is provided using this method for the parameter coefficients (β).

The model presented as an equation at the beginning of the discussion is called the stochastic frontier production function because different values of the product can be classified by the random variable exp (Xi β + Vi). Random error (Vi) can be positive or negative. In this chart, the stochastic frontier curve is drawn randomly with the assumption of the descending yield versus the scale, the horizontal axis is considered the vector of inputs, and the product vector is considered in the vertical axis.

This chart shows observations related to the factors of production and product for two firms i and j. The i-th firm produces the product Yi using the production factors Xi. The value of the factor of production and product by X is shown above the Xi value. The value of the stochastic frontier product $Y_j \cong exp(X_i\beta + V_i)$ is below the production function curve due to the negative stochastic error.

It should be noted that the stochastic frontier products Yj, Yi are invisible due to the non-visibility of Vj, Vi. If the stochastic errors are larger than the effects of inefficiencies, then the observed product will be above the frontier production function, that is:

If $V_i > U_i$ Then $Y_i > exp(X_i\beta)$ (20)

The known term of the stochastic frontier model [exp (Xi β)] is smaller than the stochastic frontier product. Using econometric techniques, the stochastic component (Vi) and the technical inefficiency component (Ui) can be estimated, and the hypotheses can be tested about these components. The frontier values are obtained for (V -U) by estimating the model. In the early years of the model introduction, the separation of the inefficiency (U) and the stochastic (V) terms in the compound error (V -U) was impossible.

Therefore, only the average performance of all firms is estimated in the early estimation techniques. It should be noted that, from the policy perspective, it is essential to measure performance for each sample firm; therefore, in the early years, it was not overly welcomed until calculating and measuring the inefficiency of manufacturing and service firms was done in practice by presenting an innovative solution in 1982. Thus a significant change occurred in the calculation of the efficiency and the estimation of frontier functions [69].

It was suggested that U could be predicted by U-conditional expectation in terms of the value of the random variable ε = V -U. The expected value of this conditional distribution can be extracted as an estimate of U:

$$E\ (U|\varepsilon = V - U) = \sigma\lambda/(1 + \lambda 2)\ [\phi(\varepsilon\lambda/\sigma)/\{1 - \phi\ (\varepsilon\lambda/\sigma)\} - \varepsilon\lambda/\sigma] \quad (21)$$

Given that variations associated with the U-distribution provided V-U are independent of the number of firms (N), therefore, these estimates cannot be consistent with U ultimately. But when definitive data is used for analysis, there is no better solution.

Stochastic frontier function analysis is also called the parametric method because a specific shape of the frontier function should be considered to estimate the function's parameters (β). Commonly used forms include Cobb-Douglas and Translog frontier models [63].

To implement this method, the coefficients of variables are estimated using the maximum likelihood method, and then the efficiency of the units under consideration has been calculated.

Table 6. The results of estimation of the parameters of the frontier production function by maximum likelihood method.

Variable	Parameter	Standard deviation	The statistics-t
y-intercept	0.643	5.100	3.099
Effect of sales index in the field of design and planning	0.430	0.569	2.67
Effect of the total cost of information transfer in the field of design and planning of the company	2.119	1.189	4.35
Effect of total response time in the supply chain in the design and planning field	-1.033	0.494	2.63
Effect of customer response time on design and planning	0.201	4	2.94
Effect of the level of supplier and buyer participation in the company in the field of supply and sourcing	-425	0.197	3.89
Effects of data precision and punctuality throughout the supplying and source industries	-0.148	0.475	3.02
The impact of a corporation's ability to provide and source high-quality items on the distribution chain	-1.268	0.560	2.99
In the realm of supplying and procurement, the firm's targeted delivery time is relative to the business soft.	-0.384	0.527	12.70
The influence of precision on inventories data in the production and engineering industries	0.118	0.300	10.43
Effect of flexibility on the amount of production in the field of making and manufacturing	0.724	0.400	2.41
Inventory capacity's impact on fabrication and processing	0.189	0.391	2.96

Variable	Parameter	Standard deviation	The statistics-t
The impact of per-unit transportation expenses in the sector of transmission and distribution	0.080	0.944	9.84
Effect of the indicator of transportation efficiency in the field of delivery and sending	0.257	0.607	4.37
The impact of a firm's dependability on the distribution and dispatching of products	-0.842	0.533	4.47
The level of checking goods in the field of returning	0.682	0.313	2.68
Flexibility in the system of service delivery to specific needs in the returning field	0.272	0.601	7.54
Response time in the supply chain	0.241	0.316	6.62
The rate of considering the customer satisfaction indices in the company's returning field	0.331	0.259	3.64
The total cost of the system in the field of returning	-1.486	0.992	9.20
Variance parameters	0.29	0.498	3.76
The variance of the inefficiency component and random components	0.999	0.0002	11.03
The maximum likelihood test statistic	83.6		
Log-Likelihood Function	-9.052		

As shown in Table 6 (Statistics-t values), all estimated coefficients are significant at the level of 0.05. Now, according to estimated coefficients, the efficiency of each unit under study is calculated (Table 7).

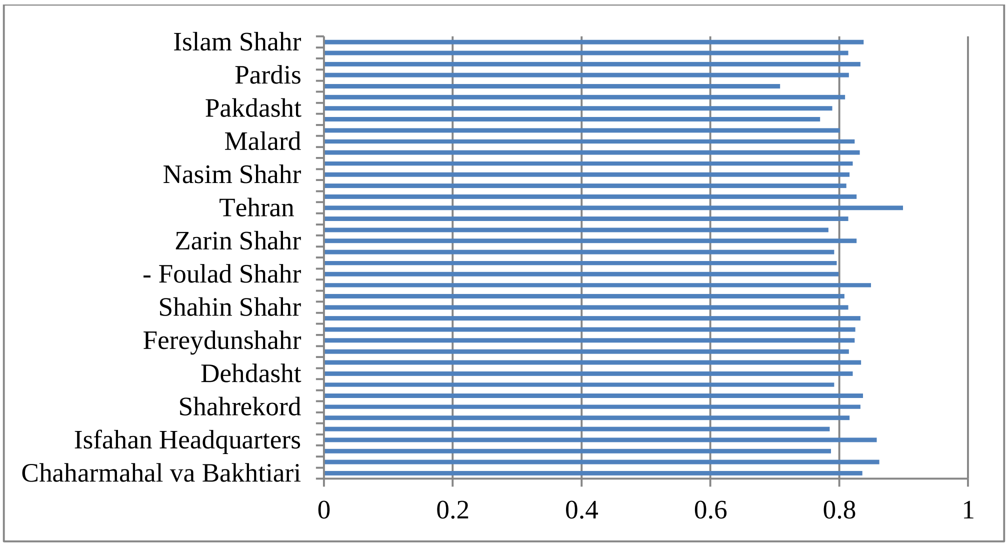

Fig. 5. Performance Measurement by SFA Method.

The results of the performance measurement by the Stochastic Frontier Analysis (SFA) method are shown in Table 7 and Fig. 5.

Table 7. Ranking the units under study in terms of performance using a stochastic frontier model.

Ranking	**Performance total**	**Decision making unit**
1	0.849	DMU27
2	0.847	DMU31
3	0.839	DMU4
4	0.837	DMU10
5	0.835	DMU12
6	0.828	DMU13
7	0.827	DMU16
8	0.826	DMU26
9	0.824	DMU40
10	0.819	DMU3
11	0.818	DMU6
12	0.817	DMU8
13	0.817	DMU9
14	0.816	DMU15
15	0.815	DMU18
16	0.815	DMU21
17	0.814	DMU22
18	0.813	DMU23
19	0.813	DMU28
20	0.812	DMU33
21	0.812	DMU37
22	0.811	DMU39
23	0.809	DMU1
24	0.808	DMU11
25	0.806	DMU14
26	0.806	DMU20
27	0.805	DMU24
28	0.804	DMU25
29	0.803	DMU30
30	0.801	DMU38
31	0.799	DMU2
32	0.798	DMU19
33	0.798	DMU29
34	0.797	DMU32
35	0.796	DMU35
36	0.789	DMU5
37	0.787	DMU7
38	0.785	DMU34
39	0.779	DMU17
40	0.774	DMU36

As shown in this figure, according to the results of the SFA method, Tehran's oil products distribution has the highest performance, and the distribution of Rabat Karim oil products has the lowest performance. As shown in Fig. 6, the performance is calculated by the DEA method and the SFA method.

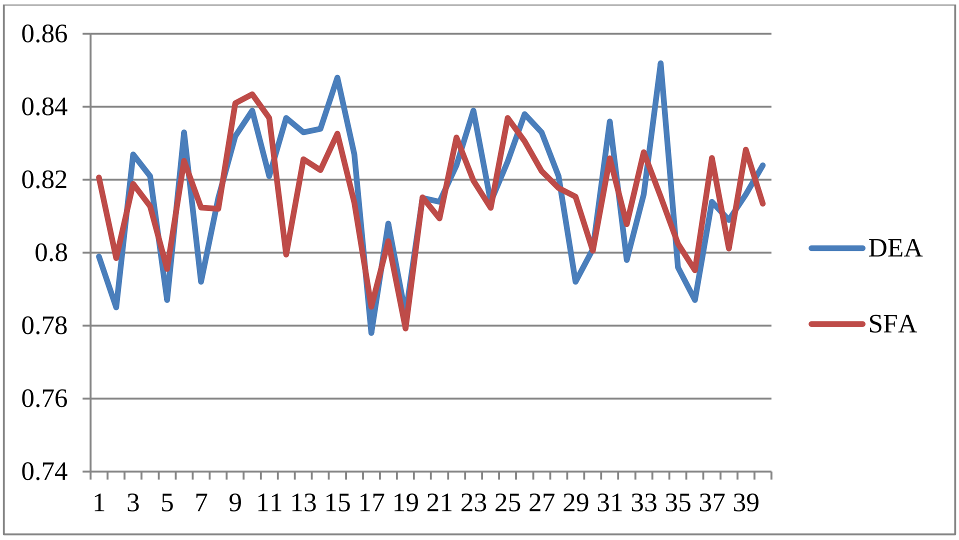

Fig. 6. Comparison of DEA and SFA results.

Sensitivity analysis

Sensitivity analysis is one part of linear programming. Sensitivity analysis is based on two theories; first principle: when variables change linearly, the state variables should be linear parameter-dependent. Second principle: when a parameter changes, the other model parameters should not consequently affect the state variables. These hypotheses are true until the problem variables are changed at a low level. The real efficiency of the first stage (design and programming) of the distribution of petroleum products in Chaharmahal-and-Bakhtiari province and Tehran headquarters in sale indicator is 1 and 0.84. The total real efficiency is 0.87, respectively. As the input value reaches its maximum value in the design and programming stage, the efficiency rate increases. As the input value decreases to its minimum value, the efficiency rate reduces. For example, if the input value increases at the design and programming stage, the efficiency of the distribution of petroleum products in Chaharmahal-and-Bakhtiari province and Tehran headquarters is obtained to be 0.98 and 0.82, and the total efficiency is obtained to be 0.85 and 0.88, respectively, but by decreasing the input value at the design and programming stage, the efficiency in the design and programming stage is obtained to be 1 and 0.87, and the total efficiency is obtained to be 0.90 and 0.91.

By deleting the customer response time indicator in the design and programming stage, we will observe the chain's efficiency at this stage and the total efficiency decrease. Generally, when our input value at each stage reaches its maximum value, the efficiency value approaches the maximum value, i.e., 1. If the input value surpasses the minimum value, the efficiency reduces in the same proportion.

Discussion

There are different techniques and models to calculate the efficiency of the distribution network. In the present study, the SCOR DEA- and SFA models have been used.

Numerous scholars think of "dynamic capacities" as a procedure relating to an institution's capacity to modify its resource shape in response to more effective alterations in its area of operation. Academic resources have recently grown concerned with dynamic competences and supplying network management. As with dynamic competences, data on supplying network management may be found in resources. By combining dynamic competences with distribution chain administration, it is feasible to develop a more adaptable and dynamic business that can simply and rapidly adjust to emerging industry patterns and avoid commercial instability.

Competitive opportunity will be created for the firm among other market players in this situation.

Previous studies have investigated only a part of the supply chain. The present study has investigated and assessed all supply chain processes and then used new mixed models of DEA and SCOR under dynamic conditions.

Such techniques as SCOR and DEA cannot be proposed as alternatives Rather, their mixed-use seems necessary in the performance assessment structure. In other words, a systematic relationship can be found between these two models, where one of them is used to complete and cover the weaknesses of the other model. As a result, proper use and combination can be an essential issue in supply chain performance.

The real efficiency of the first stage of distribution of petroleum products in Chaharmahal-and-Bakhtiari province and the Tehran headquarters is 1.00 and 0.84, respectively, and the real total efficiency is 0.87 and 0.89. By increasing the number of input to its maximum value in the design and planning stage, the amount of efficiency increases, and by decreasing the number of input to its minimum, the amount of efficiency decreases.

For example, by increasing the amount of input in the design and planning stage to the lowest possible value, the distribution efficiency of petroleum products in Chaharmahal-and-Bakhtiari province and Tehran headquarters was obtained 0.98 and 0.82 and the total efficiency was 0.85 and 0.88. By decreasing the amount of input in the design and planning stage to the most possible value, the efficiency in the design and planning stage was obtained 1.00 and 0.87 and the total efficiency was 0.90 and 0.91. 91 for these provinces, respectively.

Conclusion

In this study, SCOR and DEA were used as a reference for designing performance assessment indices and an instrument for performance assessment, respectively.

The measurement indicators are considered through the supply chain reference model to measure the supply chain performance so that different approaches to performance indicators are considered, and the views of experts from these companies are selected for the case study in the oil products distribution industry are used. Moreover, a questionnaire was developed in a specific form and based on the SCOR model, and the opinions of relevant experts have been considered in the selection and formulation of measurement indices.

In this method, the indicators are classified into two categories of input and output factors. Input indicators include indicators (including sales volume, the total cost of data transfer, shipping cost, etc.) and output indicators called flexibility (including product flexibility and delivery flexibility), financial indicators (including sales volume and net profit), and service level indicator (including order completion rate and just-in-time delivery rate).

From the perspective of the performance of the entire supply chain, the oil products distribution companies in Isfahan, Tehran, and Baharestan had the highest performance, and oil products distribution companies of Robat Karim, Mobarakeh, had the lowest performance among 40 oil products companies.

As shown in Fig. 6, the performance calculated by the DEA method and the SFA method is complementary, and a very high correlation (0.070) is observed between these two methods. The average calculated performance by the DEA method is equal to 0.80, and the average for the SFA method equals 0.82.

The performance calculated by the DDEA method is more than the DEA method due to the control and improvement of the supply chain indicators in each period and the average calculated performance in the static method is 0.85 and in the dynamic method is 0.90; thus, the companies have better performance under the dynamic conditions, and in general, this has led to a 5% improvement in the performance of the entire supply chain. This increase is significant due to the very high turnover of oil products distribution companies.

The level of information technology capabilities of the industry, to share suitable information consistent with environmental and technological changes and appropriate planning, has taken important essential steps to investigate and identify the critical needs of customers and eliminate them. Finally, the incentive of the chain's members has been increased by considering their benefits; in this way, the coordination and cooperation among the existing organizations in the supply chain can be improved, and the profitability of the entire supply chain can be increased.

References

[1] D.M. Janaki, A. Mirzazadeh and M.M. Janaki, "Reducing barriers to the implementation of strategic management by providing improved strategies: using fuzzy QFD applied to Petropars Company", *International Journal of Industrial and Systems Engineering*, vol. 31, no. 4, pp. 535-557, 2019.

[2] D. Janaki, H. Izadbakhsh and S. Hatefi, "The evaluation of supply chain performance in the Oil Products Distribution Company, using information technology indicators and fuzzy TOPSIS technique," *Management Science Letters*, vol. 8, no. 8, pp. 835-848, 2018.

[3] W. Piotrowicz and R. Cuthbertson, "Performance measurement and metrics in supply chains: an exploratory study," *International Journal of Productivity and Performance Management*, vol. 64, no. 8, pp. 1068-1091, 2015.

[4] B.M. Beamon, "Measuring supply chain performance", *International Journal of Operations & Production Management*, vol. 19, no. 3, pp. 275-292, 1999.

[5] A. Ross and C. Droge, "An integrated benchmarking approach to distribution center performance using DEA modelling", *Journal of Operations Management*, vol. 20, no. 1, pp. 19-32, 2002.

[6] A. Gunasekaran and E.W. Ngai, "Information systems in supply chain integration and management", *European journal of operational research*, vol. 159, no. 2, pp. 269-295, 2004.

[7] S. Talluri, R. Narasimhan and A. Nair, "Vendor performance with supply risk: A chance-constrained DEA approach", *International Journal of Production Economics*, vol. 100, no. 2, pp. 212-222, 2006.

[8] W.W. Wu, "Choosing knowledge management strategies by using a combined ANP and DEMATEL approach", *Expert systems with applications*, vol. 35, no. 3, pp. 828-835, 2008.

[9] A. Theeranuphattana and J.C. Tang, "A conceptual model of performance measurement for supply chains: alternative considerations", *Journal of Manufacturing Technology Management*, vol. 19, no. 1, pp. 125-148. 2008.

[10] W.H. Tsai, and W.C. Chou, "Selecting management systems for sustainable development in SMEs: A novel hybrid model based on DEMATEL, ANP, and ZOGP", *Expert systems with applications*, vol. 36, no. 2, pp. 1444-1458, 2009.

[11] F.B. Georgise, K.D. Thoben and M. Seifert, "Adapting the SCOR model to suit the different scenarios: a literature review & research agenda", *International Journal of Business and Management*, vol. 7, no. 6, p. 2, 2012.

[12] D. Estampe, S. Lamouri, J.L. Paris and S. Brahim-Djelloul, "A framework for analysing supply chain performance evaluation models", *International Journal of Production Economics*, vol. 142, no. 2, pp. 247-258, 2013.

[13] M. Shafiee, F. Hosseinzadeh Lotfi, H. Saleh, "Supply Chain Performance Evaluation with Data Envelopment Analysis and Balanced Scorecard Approach", *Applied mathematical modelling*, vol. 38, no. 21-22, pp. 5092-5112, 2014.

[14] E.N. Ntabe, L. LeBel, A.D. "Munson and L.A. Santa-Eulalia, A systematic literature review of the supply chain operations reference (SCOR) model application with special attention to environmental issues", *International Journal of Production Economics*, vol. 169, pp. 310-332, 2015.

[15] P.K. Dey, G.L. Yang, C. Malesios, D. De, and K. Evangelinos, "Performance management of supply chain sustainability in small and medium-sized enterprises using a combined

structural equation modelling and data envelopment analysis," *Computational Economics*, pp. 1-41, 2019.
[16] A. Karimi, S. Jafarzadeh-Ghoushchi, & M.A.Mohtadi-Bonab,"Presenting a new model for performance measurement of the sustainable supply chain of Shoa Panjereh Company in different provinces of Iran (case study)", *International Journal of System Assurance Engineering and Management*, vol. 11, no. 2, pp. 140-154, 2020.
[17] T. Samavati, T. Badiezadeh, R. Farzipoor Saen, "Developing Double Frontier Version of Dynamic Network DEA Model: Assessing Sustainability of Supply Chains", *Decision Sciences*, vol. 51, no. 3, pp. 1-26, 2020.
[18] R. Mousavizadeh, M. Navabakhsh and A. Hafezalkotob, "Cost-efficiency measurement for two-stage DEA network using game approach: an application to electrical network in Iran," *Sādhanā*, vol. 45, no. 1, pp. 1-14, 2020.
[19] N. Pachar, J.D. Darbari, K. Govindan, and P.C. Jha, "Sustainable performance measurement of Indian retail chain using two-stage network DEA", *Annals of Operations Research*, pp. 1-39, 2021.
[20] J.-Sharahi, S., Khalili-Damghani, K., Abtahi, AR. et al, "A new network data envelopment analysis models to measure the efficiency of natural gas supply chain", *Operational Research*, vol. 21, pp. 1461-1486, 2021.
[21] I. Nishizaki, T. Hayashida, S. Sekizaki, J. Okabe, "Data envelopment analysis approaches for two-level production and distribution planning problems", European Journal of Operational Research, In Press, 2021.
[22] P.K. Dey, G.L. Yang, C. Malesios, D. De, and K. Evangelinos, "Performance management of supply chain sustainability in small and medium-sized enterprises using a combined structural equation modelling and data envelopment analysis", *Computational Economics*, vol. 58, no. 3, pp. 573-613, 2021.
[23] Y.T. İç, and M. Yurdakul, "Development of a new trapezoidal fuzzy AHP-TOPSIS hybrid approach for manufacturing firm performance measurement", *Granular Computing*, vol. 6, no. 5, pp. 915–929, 2021.
[24] M. Jahani Sayyad Noveiri, S.Kordrostami, "Sustainability assessment using a fuzzy DEA aggregation approach: a healthcare application", *Soft Computing*, 25, vol. 25, pp. 10829–10849, 2021.
[25] F. Ebrahimi, R.F. Saen and B. Karimi, "Assessing the sustainability of supply chains by dynamic network data envelopment analysis: a SCOR-based framework," *Environmental Science and Pollution Research*, pp. 1-29, 2021.
[26] Y.H. Liang, "Performance measurement of interorganizational information systems in the supply chain" *International Journal of Production Research*, vol. 53, no. 18, pp. 5484-5499, 2015.
[27] M.A. Sellitto, G.M. Pereira, M. Borchardt, R.I. da Silva, and C.V. Viegas, "A SCOR-based model for supply chain performance measurement: application in the footwear industry", *International Journal of Production Research*, vol. 53, no. 16, pp. 4917-4926, 2015.
[28] S. Pratap, Y. Daultani, A. Dwivedi, and F. Zhou, "Supplier selection and evaluation in e-commerce enterprises: a data envelopment analysis approach", *Benchmarking An International Journal*, vol. ahead-of-print, no. ahead-of-print, 2021.
[29] N. Pachar, J.D. Darbari, K. Govindan and P.C. Jha, "Sustainable performance measurement of Indian retail chain using two-stage network DEA", *Annals of Operations Research*, pp. 1-39, 2021.
[30] A.W.W. Dametew, F. Ebinger, and B. Beshah, "The Roles of Supply Chain Performance Measurement on Manufacturing Firms", *Global Journal of Technology & Optimization*, vol. 9, no. 1, pp. 1-9, 2018.
[31] M. Saeedi Mehrabad, A. Aazami, A. Goli, "A location-allocation model in the multi-level supply chain with multi-objective evolutionary approach", *Journal of Industrial and Systems Engineering*, vol. 10, no. 3, pp. 140-160, 2017.
[32] R.D. Banker, H. Chang and W.W. Cooper, "A simulation study of DEA and parametric frontier models in the presence of heteroscedasticity", *European Journal of Operational Research*, vol. 153, no. 3, pp. 624-640, 2004.

[33] T. Samavati, T. Badiezadeh and R.F. Saen, "Developing double frontier version of dynamic network DEA model: Assessing sustainability of supply chains," *Decision Sciences*, vol. 51, no. 3, pp. 804-829, 2020.

[34] F.T.S. Chan and H.J. Qi, "Feasibility of performance measurement system for supply chain: a process- based approach and measures", *Integrated manufacturing systems*, vol. 14, no. 3, pp. 179-190, 2003.

[35] C. Rafele, "Logistic service measurement: a reference framework", *Journal of manufacturing technology management*, vol. 15, no. 3, pp. 280-290, 2004.

[36] U. Okongwu, M. Lauras, J. François and J.C. Deschamps, "Impact of the integration of tactical supply chain planning determinants on performance", *Journal of Manufacturing Systems*, vol. 38, pp.181-194, 2016.

[37] P. Guo and H. Tanaka, "Fuzzy DEA: a perceptual evaluation method", *Fuzzy sets and systems*, vol. 119, no. 1, pp. 149-160, 2001.

[38] L. Liang, F. Yang, W.D. Cook and J. Zhu, "DEA models for supply chain efficiency evaluation," *Annals of operations research*, vol. 145, no. 1, pp. 35-49, 2006.

[39] Y. Chen, L. Liang and F. Yang, "A DEA game model approach to supply chain efficiency," *Annals of Operations Research*, vol. 145, no. 1, pp. 5-13, 2006.

[40] D. Li, and C. O'Brien, "Integrated decision modelling of supply chain efficiency," *International Journal of Production Economics*, vol. 59, no. 1-3, pp. 147-157, 1999.

[41] Y.D. Hwang, Y.C. Lin and J. Lyu Jr, "The performance evaluation of SCOR sourcing process—The case study of Taiwan's TFT-LCD industry," *International journal of production economics*, vol. 115, no. 2, pp. 411-423, 2008.

[42] L. Easton, D.J. Murphy and J.N. Pearson, "Purchasing performance evaluation: with data envelopment analysis," *European Journal of Purchasing & Supply Management*, vol. 8, no. 3, pp. 123-134, 2002.

[43] M. Kojima, K. Nakashima and K. Ohno, "Performance evaluation of SCM in JIT environment," *International Journal of Production Economics*, vol. 115, no. 2, pp. 439-443, 2008.

[44] S. Ramzi, "Modeling the Education Supply Chain with Network DEA Model: The Case of Tunisia", *Journal of Quantitative Economics*, vol. 17, no. 3, pp. 525-540, 2019.

[45] A. Gunasekaran, C. Patel and R.E. McGaughey, "A framework for supply chain performance measurement," *International journal of production economics*, vol. 87, no. 3, pp. 333-347, 2004.

[46] S.H. Huan, S.K. Sheoran and G. Wang, "A review and analysis of supply chain operations reference (SCOR) model," *Supply chain management*, vol. 9, no. 1, pp. 23-29, 2004.

[47] F.T. Chan, "Performance measurement in a supply chain," *The international journal of advanced manufacturing technology*, vol. 21, no. 7, pp. 534-548, 2003.

[48] F.T. Chan and H.J. Qi, "An innovative performance measurement method for supply chain management," *Supply chain management*, vol. 8, no. 3, pp. 209-223, 2003.

[49] W.P. Wong and K.Y. Wong, "Supply chain performance measurement system using DEA modeling," *Industrial management & data systems*, vol. 107, no. 3, pp. 361-381, 2007.

[50] D. Estampe, S. Lamouri, J.L. Paris and S. Brahim-Djelloul, "A framework for analysing supply chain performance evaluation models," *International Journal of Production Economics*, vol. 142, no. 2, pp. 247-258, 2013.

[51] M. Comelli, P. Féniès and N. Tchernev, "A combined financial and physical flows evaluation for logistic process and tactical production planning: Application in a company supply chain," *International journal of production economics*, vol. 112, no. 1, pp. 77-95, 2008.

[52] A. Gunasekaran and E.W. Ngai, "Modeling and analysis of build-to-order supply chains," *European Journal of Operational Research*, vol. 195, no. 2, pp. 319-334, 2009.

[53] K. Govindan, H. Soleimani and D. Kannan, "Reverse logistics and closed-loop supply chain: A comprehensive review to explore the future," *European journal of operational research*, vol. 240, no. 3, pp. 603-626, 2015.

[54] M.J. Farrell, "The measurement of productive efficiency," *Journal of the Royal Statistical Society: Series A (General)*, vol. 120, no. 3, pp. 253-281, 1957.

[55] R. Jagadesh, "Performance Assessment of Global Supply Chains and Moving Towards Optimization of Efforts and Challenges," *International Journal of Recent Advances in Organizational Behaviour and Decision Sciences*, vol. 1, no. 3, pp. 1-17, 2015.

[56] A.K. Sangaiah, E.B. Tirkolaee,A. Goli, S. Dehnavi-Arani, "Robust optimization and mixed-integer linear programming model for LNG supply chain planning problem", *Soft computing,* vol. 24, no. 1, pp. 7885–7905, 2020.

[57] J. Kiyani and M. Mohammad Jafari., "Designing the Overall Performance Index of Supply Chain A Production Workshop Based on the Supply Chain Operations Reference Model and Analytical Hierarchy Model," *2th International Management Conference and Industrial Engineering*, Tehran, Iran, 2015.

[58] S.D. Aydın, S.H. Eryuruk and F. Kalaoğlu, "Evaluation of the performance attributes of retailers using the scor model and AHP: a case study in the Turkish clothing industry," *Fibres & Textiles in Eastern Europe*, vol. 22, no. 5, pp. 14-19, 2014.

[59] K.M. Lavassani and B. Movahedi, "Firm-Level Analysis of Global Supply Chain Network: Role of Centrality on Firm's Performance," *International Journal of Global Business and Competitiveness*, pp. 1-18, 2021.

[60] R. Saberizonouziasl, and T. Hasanzadeh, "Supply Chain Performance Evaluation of Urban Management Based on 137 of a Tehran Municipality Model SCOR," *2th National Conference on Applied Research in Civil Engineering, Architecture and Urban Management*, 2013.

[61] Y. Daultani, A. Dwivedi, and S. Pratap, "Benchmarking higher education institutes using data envelopment analysis: capturing perceptions of prospective engineering students", *OPSEARCH*, pp. 1-17, 2021.

[62] B. Bigliardi and E. Bottani, "Performance measurement in the food supply chain: a balanced scorecard approach", *Facilities*, vol. 28, no. 5/6, pp. 249-260, 2010.

[63] C. Bai, J. Sarkis, X. Wei and L. Koh, "Evaluating ecological sustainable performance measures for supply chain management", *Supply Chain Management*, vol. 17, no. 1, pp. 78-92, 2012.

[64] J. Gerami, R.K. Mavi, R.F. Saen and N.K. Mavi, "A novel network DEA-R model for evaluating hospital services supply chain performance", *Annals of Operations Research*, pp. 1-26, 2020.

[65] A. Chia, M. Goh and S.H. Hum, "Performance measurement in supply chain entities: balanced scorecard perspective", *Benchmarking: An International Journal*, vol. 16, no. 5, pp. 605-620, 2009.

[66] E. Ayyildiz, and A.T. Gumus, "Interval-valued Pythagorean fuzzy AHP method-based supply chain performance evaluation by a new extension of SCOR model: SCOR 4.0", *Complex & Intelligent Systems*, vol. 7, no. 1, pp. 559-576, 2021.

[67] F.T. Chan, A. Nayak, R. Raj, A.Y.L. Chong and T. Manoj, "An innovative supply chain performance measurement system incorporating research and development (R&D) and marketing policy", *Computers & Industrial Engineering*, vol. 69, pp. 64-70, 2014.

[68] C. Kao, "Dynamic data envelopment analysis: A relational analysis," *European Journal of Operational Research*, vol. 227, no. 2, pp. 325-330, 2013.

[69] J. Jondrow, C.K. Lovell, I.S. Materov and P. Schmidt, "On the estimation of technical inefficiency in the stochastic frontier production function model", *Journal of econometrics*, vol. 19, no. 2-3, pp. 233-238, 1982.

[70] K. Kalirajan, "On Measuring Absolute Technical and Allocative Efficiencies", *Sankhyā: The Indian Journal of Statistics, Series B*, 47, no. 3, pp. 385–400, 1985.