J. Fuzzy. Ext. Appl

**Journal of Fuzzy Extension & Applications**

**www.journal-fea.com**

# Precise Services and Supply Chain Prioritization in Manufacturing Companies Using Cost Analysis Provided in a Fuzzy Environment

***Alireza Marzband****

*Ayandegan Institute of Higher Education, Tonekabon, Iran.*

**PAPER INFO**

**Chronicle:**
*Received: 14 October 2019*
*Revised: 19 January 2020*
*Accepted: 03 February 2020*

**Keywords:**
*Supply Chain Management.*
*Data Envelopment Analysis.*
*Supply Chain Efficiency.*

**ABSTRACT**

In recent years, management and, consequently, supply chain performance measurement, has attracted the attention of a large number of managers and researchers in the field of production and operations management. In parallel with the evolution of organizations from a single approach to a network and supply chain approach, performance measurement systems have also changed and moved towards network and supply chain performance measurement. Therefore, in order to face the storm of great change and transformation and not give in to the wave of competitive aggression, organizations have long had one thing in common, and that is to focus approaches and focus efforts towards achieving results. Results that lead to a competitive advantage and are more effective and decisive in the performance indicators of the organization, including earning more. In this study, in order to identify and prioritize the factors affecting the supply chain in manufacturing companies, using indicators such as cost, timely delivery and procurement time to evaluate the supply chain efficiency is considered. And performance evaluation was performed at the manufacturer level. Therefore, in order to evaluate the performance of the supply chain using the AHP integration approach and the DEA method approach in the fuzzy environment, the suppliers and suppliers of the manufacturing company were evaluated and ranked in terms of performance.

## 1. Introduction

In recent years, management and, consequently, supply chain performance measurement, has attracted the attention of a large number of managers and researchers in the field of production and operations management [1]. In parallel with the evolution of organizations from a single approach to network approach and supply chain, performance measurement systems have also changed and moved towards measuring network performance and supply chain [2]. This attitude is rooted in the thinking of a system in which the efficiency of any production system does not depend only on the optimal functioning of a subsystem, and all subsystems must work diligently to achieve the pre-drawn goals [1]. Supply chain management is one of the components of competitive strategies for organizational productivity and profitability. Managers in many industries, especially those in the manufacturing sector, try to better

* Corresponding author
E-mail address: marzband.omidico@gmail.com
DOI: 10.22105/jfea.2020.248187.1006

manage the supply chain and evaluate its performance [3]. Therefore, it is important to evaluate and track the performance of its supply chain because several organizations are involved in this chain [4]. Many critical and complex barriers may distract current performance measurement systems from providing significant assistance to improve and expand supply chain management. Due to this inherent complexity, it is necessary to select the appropriate criteria for evaluating the performance of the supply chain [5]. In this chapter, while presenting the problem statement, the topics related to the necessity of conducting research, the theoretical framework of research (model and definition of variables), research objectives, research questions, research scope and limitations are also described. To deal with the storm of change and massive transformation and not to give in to the wave of competitive aggression, organizations have long had one thing in common, and that is to focus approaches and focus all efforts on achieving results; Results that lead to competitive advantage and are more effective and decisive in the performance indicators of the organization, including earning more revenue. Knowing that we are in the age of information and competition between organizations, and every organization to create a new way to transform its organization to surpass its competitors and maintain and gain a competitive advantage. As well as the important role that efficiency plays in the development of societies; examining all its dimensions, especially in the form of mathematical analysis, as a criterion for measuring performance is inevitable [6]. Manufacturing organizations need a high degree of flexibility in order to maintain a competitive advantage as well as to operate in an ever-changing dynamic environment. The success of organizations depends on their ability to deliver outputs. Optimal presentation of products according to criteria such as cost, quality, performance, delivery, flexibility and innovation depends on the ability of the organization to manage the flow of materials, information, etc. inside and outside the organization [7]. Supply chain evaluation is done using different methods. Data envelopment analysis as a non-parametric method is based on linear programming technique and compares the efficiency of different units. Wen et al. [8] provide evidence and reasons that data envelopment analysis is a good way to manage supply chain. Data envelopment analysis can have multi-cell inputs and outputs and uses quantitative and qualitative indicators [8]. Data envelopment analysis is a method to evaluate the performance of organizations in the private and public sectors. The reason for using data analysis as a way to evaluate performance is the complex nature of the relationships between multiple inputs and outputs in activities [9].

In this paper, indicators such as cost, timely delivery and procurement time are considered to evaluate the efficiency of the supply chain and performance evaluation is done at the manufacturer level, while usually looking at the supply chain as a system and overview. This means that performance appraisal indicators are measured for the manufacturer (second level of the chain) and in relation to the supplier and the customer, and the overall supply chain is maintained. Therefore, in this study, we seek to answer the question, how to identify and prioritize the factors affecting the supply chain in manufacturing companies using Data Envelopment Analysis (DEA) in a fuzzy environment? The analytical models proposed to evaluate supply chain efficiency include a variety of techniques, from simple rhythmic scoring methods to complex mathematical scheduling, and from definitive evaluation models to models under uncertainty conditions. Recently, various methods have been proposed to address the issue of supply chain efficiency assessment. 16 categories of these methods are presented by Estampe et al. [10]. To evaluate the efficiency of the supply chain, various indicators are measured in categories such as cost, time, profit, level of service and. Thomas and Griffin [11] equated transportation with more than half the cost of a supply chain and used it for evaluation.

Lee and Billington [12] consider the level of customer satisfaction in companies with customers from all over the world as an important factor and point out that the strategies adopted will not be very costly in order to achieve customer satisfaction. Most existing studies are based on evaluating the supply chain efficiency of a comprehensive evaluation index system. However, most of these methods use the individuals themselves to calculate the weight of the indicators in the evaluation process. Due to personal opinions, the weight of the indicators cannot be measured accurately [13].

To reduce the inaccuracy of the index weight, which is increased by the decision maker's personal opinion, data envelopment analysis is used as a non-parametric method to evaluate supply chain efficiency. The main feature of overlay analysis is that it can measure performance when there are multiple inputs and outputs. Wang and Wang [14] presented a data envelopment analysis model using indicators such as cost, on-time delivery, profit, and production time cycle. Given that some of the indicators measured in the supply chain, especially costs are not definitive and indices of uncertainty are seen in them, the use of uncertainty methods such as fuzzy logic seems appropriate [15]. Until now, uncertainty methods have rarely been used to evaluate the supply chain [14]. The methods of uncertainty used can be referred to uneven sets [15]. In this reference, by developing a rugged set of indicators such as cost, number of employees, production flexibility and level of service have been used to evaluate efficiency. In this research, fuzzy data envelopment analysis is used to evaluate the efficiency of supply chains, which has not been used in previous research. In this paper, the supply chain is considered as a whole and a system that the inputs and outputs of the fuzzy data envelopment analysis model are the same as the manual inputs and outputs of the supply chain. Evaluation indicators are measured at the manufacturer level and to maintain the integrity of the supply chain, the indicators are measured for the manufacturer and by maintaining its relationship with suppliers and customers. In this paper, the cost index is considered fuzzy due to the uncertainty present during the measurement. To deal with the uncertainty environment created by the cost index area, fuzzy set theory is used as a method to deal with uncertainty environments. Considering that no conceptual model is presented in this research, then there is no hypothesis in this research, but the assumptions for conducting the research are as follows:

- Information received from suppliers is fuzzy uncertainty.
- Suppliers are evaluated in the company's supply chain list and are accepted in the initial and technical evaluation.

Saleh and Shafiei [16], in a study entitled "Performance evaluation using envelopment analysis of three-level data" state that, attention to organizational performance evaluation in recent years has led to the development of several frameworks and methodologies, each of which has provided a wide range of benefits. One of the appropriate methods in calculating the efficiency of data envelopment analysis is that despite some limitations, it is a powerful methodology that allows managers to determine the efficiency of the organization under their management compared to other units. In the real world, we encounter different situations that follow a hierarchical structure with decentralized decisions. In this research, the efficiency of supply chains that have a hierarchical structure will be evaluated and a three-level model of data envelopment analysis will be presented by selecting appropriate indicators.

Koushki and Mashayekhi Nezamabadi [17], in a study entitled "A method of network data envelopment analysis to evaluate supply chains and its application in pharmacy" state that, data envelopment analysis is a non-parametric technique based on mathematical programming to evaluate the performance of heterogeneous decision-making units. Many units have a multi-stage structure in which the output of one stage is the input of the next stage. A supply chain, which includes several members such as supplier and manufacturer, has a multi-step process. In this paper, for the first time, network methods for achieving maximum productivity in supply chains, which are considered as a multi-stage system, are introduced. Such a view provides management concepts to improve the efficiency of the supply chain as well as the productivity of each member.

Mousavi and Ahmadzadeh [18], in a study entitled "Study and evaluation of supply chain efficiency using data envelopment analysis (Case study: Amol paper companies)" state that, rapid progress and development, rapid environmental changes, and awareness of new developments and approaches to achieve efficiency and effectiveness in organizations have become essential. In recent years, supply chain management and performance evaluation has received more attention in the business administration of organizations. In this study, the operational performance of seven supply chains operating in the same industry and having different key companies and relatively similar suppliers and distributors has been evaluated using data envelopment analysis method. In order to evaluate the supply chain in this research, indicators such as direct costs, manpower, and depreciation have been considered.

Hosseinzadeh Seljooghi and Rahimi [19], in a study entitled "Evaluation of efficiency and efficiency at the scale of the supply chain of the Iranian resin industry with the model of definitive and fuzzy data envelopment analysis" state, the fuzzy DEA model is used based on the cut-off approach to measure efficiency and determine the supply chain scale efficiency. The proposed ideas have been used to evaluate the efficiency and efficiency of the supply chain scale of 27 resin production companies. In evaluating with definitive data, 6 companies are network efficient; while in the case of fuzzy data, three companies are network efficient. These companies have managed and coordinated the flow of materials between several organizations and within the organization in the most optimal way and with regard to environmental issues.

Samuelinko stated in 2013 that the competitive nature of the business environment requires the awareness of productivity-based organizations of the relative level of effectiveness and efficiency of their competitors. This indicates, firstly, the need for an effective mechanism that allows the discovery of appropriate productivity models to improve overall organizational performance, and secondly, the need for a feedback mechanism that allows the evaluation of different productivity models to select the most appropriate model. In this article, we focus on organizations that consider the state of the internal organizational environment (for example, likely to represent a resource-oriented perspective) and external (for example, likely to represent a positioning perspective) in formulating their strategies. We propose and test a DEA-based Decision Support System (DSS) that aims to evaluate and manage the relative performance of such organizations [20].

Singh stated in 2014 that manpower in an organization is an important and fundamental asset. Qualified personnel have unique academic and managerial abilities in specific disciplines and individual capabilities that can perform many of the different marketing and research tasks required in any organization because they are, in fact, the creditors of the organization's performance. They forgive. Therefore, designing rational methods for assessing the capability of personnel during employment is crucial. The methods that are commonly used for decision making in identifying functional characteristics, including their heavy tasks, include methods such as Delphi and decision matrix, Hierarchical Analysis Process (AHP), and so on. The AHP method converts experts' qualitative theory into quantitative values and creates a decision matrix. In this paper, in this study, the Data Push Analysis method is investigated to establish the internal weights of alternative methods by comparing two-by-two comparison matrices in AHP for a three-property system to measure personnel performance at levels. Login to the management hierarchy is used. Several expert judgments have been made to determine the weight of the features. In conclusion, the SUPER EFFICIENCY DEA (or DEA-AHP combination method) is proposed in this paper as an alternative to traditional weight derivation methods in AHP [21].

Comelli et al. [22] have proposed an approach for evaluating production planning in supply chains. They noted that production planning evaluations are usually based on physical parameters such as inventory level and demand satisfaction. They found it useful to add financial valuation to classical models. They applied an ABC method to estimate the cash flow of supply chain production planning.

In 2016, Lim stated that supplier selection is an important issue that supply chain managers have faced for many years. Choosing the right suppliers is no longer as easy as choosing (based on the price) they offer. There are many quantitative and qualitative criteria that must be considered. Therefore, there is an urgent need for an approach that can meet these criteria. In addition, as supply chains become increasingly important today, it is important to consider the risks of inadequate supply in evaluating suppliers. This research presents an approach that focuses mainly on data envelopment analysis to analyze and compare the relative performance of suppliers. Because data envelopment analysis can only cover quantitative features, the Analytic Hierarchy Process (AHP) is used to aid qualitative analysis. Risks are also considered in the evaluation of suppliers. The purpose of the proposed approach is to provide a comprehensive approach to addressing the issue of supplier selection [23].

Liang et al. [24] identified two barriers to supply chain evaluation and its members in the form of multiple indicators that determine member performance and the existence of conflict between chain members. They showed that the classical DEA model could not perform as well as the mosque due to the presence of intermediate indicators, so in their research they have developed several DEA-based models in which intermediate indicators are integrated in performance evaluation. They developed their model as a two-chain, seller-buyer model. They considered two different modes. The first mode is that one chain acts as the leader and the second chain follows it. The leader is evaluated using member results. The second case is in the form of a partnership in which an attempt is made to maximize the joint efficiency of the two chains, which is considered as their average efficiency. In this case, both supply chains are evaluated simultaneously.

In his research, Chen [25] divided supply chain evaluation criteria into two main categories: quantitative and qualitative. Quantitative indicators include cost and resource use, and qualitative indicators include quality, flexibility, visibility, trust and innovation. He then states the measurement criteria for each of these seven categories of indicators and then uses the AHP technique to identify the most important indicators for the electronics industry. He also made suggestions for other industries.

Easton et al. [26] evaluated the evaluation of purchasing sector efficiency in the supply chain. They pointed out that it is very difficult to measure the efficiency of the procurement department and compare that efficiency with other departments of procurement, and attributed this difficulty to the lack of acceptable measurement criteria and appropriate methods to integrate these criteria and provide an overall efficiency. They developed a DEA model to evaluate purchasing efficiency in the petrochemical industry.

## 2. Methodology

In this study, according to the parts intended to provide an efficient supply chain, first, according to the conditions governing the production of these parts, all suppliers in this field are identified and we put one of the basic and serious principles in the list of suppliers with contract priority. In the supply of these parts, the reduction of risk arises from the selection of the supplier, which in the event of a mistake will incur irreparable losses, which will lead to the failure of the project. In order to conclude a contract for the supply of these parts, it is necessary to prove the efficiency of the supplier in the first stage and to be ranked according to the rank in which they are placed in the next step. In order to evaluate the efficiency of suppliers, it is necessary to measure the input to output ratio of each supplier, and for this issue, according to the main source of this research, the Super Efficiency DEA method has been used. Therefore, it can be said that this research is applied based on the purpose and descriptive-survey based on the nature and method of research. The data collected to solve the research model are related to the years 2019-2020. In the present study, two library and field methods have been used to collect information. In order to collect information in this research, first the documentary method will be used. In order to study and obtain more information in order to know more precisely the subject of research and use the findings of research in this field, the researcher to study and study academic dissertations, foreign and Iranian books, Persian and English journals and textbooks Some professors pay. This research is in the field of measuring the efficiency of supply chains of a manufacturing company and examines the separation of efficient and inefficient chains, determining the appropriate pattern for inefficient units, as well as how to allocate resources optimally. The present study is conducted to investigate the efficiency of supply chains in manufacturing and industrial companies.

### *2.1. Identify Supplier Evaluation Indicators*

In the first step of the research, after reviewing and identifying the suppliers, the first phase of the evaluation begins by selecting appropriate indicators for evaluation. In this section, after reviewing the written scientific texts, the evaluation indicators were identified as *Table 1*.

***Table 1.*** *Supplier survey indicators.*

| Row | Description of the index |
|---|---|
| **1** | *Price product* |
| **2** | *Place of delivery* |
| **3** | *Quality systems certifications* |
| **4** | *After sales service indicators* |
| **5** | *Customization capability* |
| **6** | *Product quality* |
| **7** | *Ability to reduce costs* |
| **8** | *Packing* |

In this study, the verbal variables to determine the importance of the indicators are fuzzified according to the triangular fuzzy numbers in *Table 2* and *Fig. 1*.

***Table 2.*** *Fuzzification of verbal variables in Delphi technique.*

| Verbal Variables | Triangular Fuzzy Numbers |
|---|---|
| *Very little importance* | *(0.25,0,0)* |
| *Low importance* | *(0.5,0.25,0)* |
| *Medium importance* | *(0.75,0.5,0.25)* |
| *Important* | *(1,0.75,0.5)* |
| *Very important* | *(1,1,0.75)* |

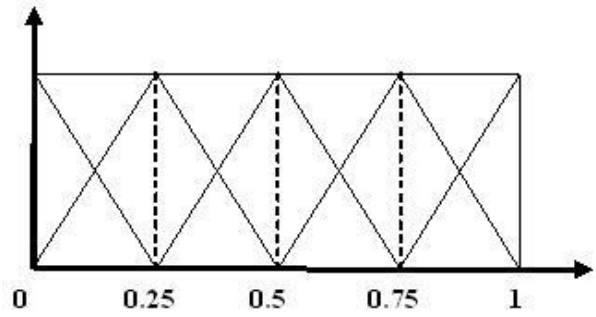


***Fig. 1.*** *Triangular fuzzy numbers.*

## 3. Findings

### *3.1. Introducing the Company's Suppliers*

According to the scope of work of the manufacturing company and also the studies carried out in accordance with the executive instructions of the company, 10 suppliers have been selected as the final candidate supply chain for evaluation and transfer of supply of parts. Suppliers are as follows:

- Sepehr Ryan Sanhat Company (Symbol: A).
- Cheese Company (symbol: B).
- Parsian Sazeh Sepahan Company (Symbol: C).
- Techno Sanat Company (symbol: D).
- Peyman Sanat Company (Symbol: E).
- Tractor Manufacturing Company (Symbol: F).
- Ataco Company (Symbol: G).
- Sarco Company (symbol: H).
- Beshl Motor Company (Symbol: I).
- Iran Casting Company (Symbol: K).

### *3.2. Introducing the Experts of the Research*

In this research, in order to evaluate the indicators and select them, using the opinion of the company's experts, the specifications of the experts are as *Table 3*.

***Table 3.*** *The Specifications of the experts.*

| Row | Side | Work Experience | Education | Age |
|---|---|---|---|---|
| **1** | *plan and program manager* | *18 years* | *MA* | *54 years* |
| **2** | *Supply management* | *20 years* | *Bachelor* | *48 years* |
| **3** | *Procurement manager* | *10 years* | *Bachelor* | *38 years* |
| **4** | *Quality assurance management* | *20 years* | *Bachelor* | *48 years* |
| **5** | *Market research and development management* | *10 years* | *Doctorate* | *35 years* |
| **6** | *Engineering management* | *23 years* | *Bachelor* | *45 years* |
| **7** | *Laboratory management* | *20 years* | *MA* | *55 years* |

### 3.3. Identification, Refining and Screening of Input and Output Indicators with Fuzzy Technique

First, based on the research literature and specialized interviews, a set of input and output indicators of DMUs has been identified. Fuzzy technique was used for screening and final confirmation of the indicators. The indicators are symbolized in *Table 4*.

***Table 4.*** *Symbolization of indicators.*

| Symbol | Description of the Index |
|---|---|
| **i1** | *price product* |
| **i2** | *Place of delivery* |
| **i3** | *Quality systems certifications* |
| **i4** | *After sales service indicators* |
| **i5** | *Customization capability* |
| **O1** | *Product quality* |
| **O2** | *Ability to reduce costs* |
| **O3** | *Packing* |

The views of seven experts to measure the importance of the indicators related to each of the input and output indicators are as *Table 5*.

***Table 5.*** *Experts' views about each indicator.*

| Symbol | Expert 1 | Expert 2 | Expert 3 | Expert 4 | Expert 5 | Expert 6 | Expert 7 |
|---|---|---|---|---|---|---|---|
| **i1** | *very much* | *much* | *much* | *very much* | *medium* | *medium* | *medium* |
| **i2** | *very much* | *medium* | *medium* | *very much* | *much* | *very much* | *much* |
| **i3** | *very much* | *very much* | *much* | *very much* | *much* | *much* | *much* |
| **i4** | *very much* | *very much* | *medium* | *very much* | *much* | *medium* | *much* |
| **i5** | *much* | *very much* | *medium* | *much* | *very much* | *medium* | *very much* |
| **O1** | *medium* | *medium* | *medium* | *medium* | *very much* | *much* | *very much* |
| **O2** | *much* | *very much* | *much* | *much* | *very much* | *much* | *very much* |
| **O3** | *very much* | *much* | *medium* | *very much* | *very much* | *much* | *very much* |

The collected data are fuzzy evaluated according to the *Table 5*. The fuzzy values of the experts' point of view are shown in *Table 6*.

***Table 6.*** *Fuzzified values of the seven experts' views about each indicator.*

| **Symbol** | **Expert 1** | | | **Expert 2** | | | **Expert 3** | | | **Expert 4** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **i1** | *1* | *1* | *0.75* | *1* | *0.75* | *0.5* | *1* | *0.75* | *0.5* | *1* | *1* | *0.75* |
| **i2** | *1* | *1* | *0.75* | *0.75* | *0.5* | *0.25* | *0.75* | *0.5* | *0.25* | *1* | *1* | *0.75* |
| **i3** | *1* | *1* | *0.75* | *1* | *1* | *0.75* | *1* | *0.75* | *0.5* | *1* | *1* | *0.75* |
| **i4** | *1* | *1* | *0.75* | *1* | *1* | *0.75* | *0.75* | *0.5* | *0.25* | *1* | *1* | *0.75* |
| **i5** | *1* | *0.75* | *0.5* | *1* | *1* | *0.75* | *0.75* | *0.5* | *0.25* | *1* | *0.75* | *0.5* |
| **O1** | *1* | *0.75* | *0.5* | *1* | *1* | *0.75* | *0.75* | *0.5* | *0.25* | *1* | *0.75* | *0.5* |
| **O2** | *1* | *1* | *0.75* | *1* | *0.75* | *0.5* | *1* | *0.75* | *0.5* | *1* | *1* | *0.75* |
| **O3** | *0.75* | *0.5* | *0.25* | *1* | *0.75* | *0.5* | *0.75* | *0.5* | *0.25* | *0.75* | *0.5* | *0.25* |

*Continue of table 6*

| **Symbol** | **Expert 5** | | | **Expert 6** | | | **Expert 7** | | |
|---|---|---|---|---|---|---|---|---|---|
| **i1** | *0.75* | *0.5* | *0.25* | *0.75* | *0.5* | *0.25* | *0.75* | *0.5* | *0.25* |
| **i2** | *1* | *0.75* | *0.5* | *1* | *1* | *0.75* | *1* | *0.75* | *0.5* |
| **i3** | *1* | *0.75* | *0.5* | *1* | *0.75* | *0.5* | *1* | *0.75* | *0.5* |
| **i4** | *1* | *0.75* | *0.5* | *0.75* | *0.5* | *0.25* | *1* | *0.75* | *0.5* |
| **i5** | *1* | *1* | *0.75* | *0.75* | *0.5* | *0.25* | *1* | *1* | *0.75* |
| **O1** | *1* | *1* | *0.75* | *1* | *0.75* | *0.5* | *1* | *1* | *0.75* |
| **O2** | *1* | *1* | *0.75* | *1* | *1* | *0.75* | *1* | *1* | *0.75* |
| **O3** | *1* | *0.75* | *0.5* | *1* | *0.75* | *0.5* | *1* | *0.75* | *0.5* |

In the next step, the fuzzy average of expert opinions is calculated. In the following work is used to defuzzificate and determine the importance of input and output indicators. The fuzzy mean and the definite value of the values related to the indicators are shown in *Table 7*. Since the definite value of all values is greater than 0.5, all indices are confirmed.

***Table 7.*** *The fuzzy average of experts' opinions and the definite amounts of the indicators' values.*

| **Symbol** | **Description of the index** | **Fuzzy average** | **Definite amount** |
|---|---|---|---|
| **i1** | *Price product* | *(0.46,0.71,0.89)* | *0.70* |
| **i2** | *Place of delivery* | *(0.54.0.79.0.93)* | *0.77* |
| **i3** | *Quality systems certifications* | *(0.61,0.86,1)* | *0.84* |
| **i4** | *After sales service indicators* | *(0.54.0.79.0.93)* | *0.77* |
| **i5** | *Customization capability* | *(0.54.0.79.0.93)* | *0.77* |
| **O1** | *Product quality* | *(0.57,0.82,0.96)* | *0.80* |
| **O2** | *Ability to reduce costs* | *(0.68,0.93,1)* | *0.90* |
| **O3** | *Packing* | *(0.39,0.64,0.89)* | *0.64* |

### *3.4. Pairewise Comparison of Suppliers Based on Input and Output Indicators*

In this step, according to the identification of input and output indicators of each supplier, we prioritize suppliers using pairwise comparison based on each indicator.

#### *3.4.1. Prioritization of suppliers based on product quality index*

According to the identified quality index, by forming a pairwise comparison matrix by 7 experts, the matrix shown in *Table 8* was formed.

*Table 8.* *Prioritization of suppliers based on product quality index.*

| | A | B | C | D | E | F | G | H | I | j |
|---|---|---|---|---|---|---|---|---|---|---|
| **A** | 1.00 | 2.50 | 0.75 | 1.33 | 0.40 | 0.40 | 0.75 | 0.75 | 6.00 | 0.40 |
| **B** | 0.40 | 1.00 | 0.17 | 1.33 | 2.50 | 1.33 | 0.40 | 1.33 | 0.75 | 0.40 |
| **C** | 1.33 | 6.00 | 1.00 | 0.40 | 0.75 | 1.33 | 2.50 | 6.00 | 1.33 | 0.40 |
| **D** | 0.75 | 0.75 | 2.50 | 1.00 | 0.40 | 2.50 | 0.75 | 0.75 | 1.33 | 0.17 |
| **E** | 2.50 | 0.40 | 1.33 | 2.50 | 1.00 | 0.40 | 0.17 | 6.00 | 0.75 | 0.75 |
| **F** | 2.50 | 0.75 | 0.75 | 0.40 | 2.50 | 1.00 | 0.17 | 0.40 | 1.33 | 1.33 |
| **G** | 1.33 | 2.50 | 0.40 | 1.33 | 6.00 | 6.00 | 1.00 | 0.75 | 0.75 | 2.50 |
| **H** | 1.33 | 0.75 | 0.17 | 1.33 | 0.17 | 2.50 | 1.33 | 1.00 | 0.75 | 2.50 |
| **I** | 0.17 | 1.33 | 0.75 | 0.75 | 1.33 | 0.75 | 1.33 | 1.33 | 1.00 | 0.40 |
| **j** | 2.50 | 2.50 | 2.50 | 6.00 | 1.33 | 0.75 | 0.40 | 0.40 | 2.50 | 1.00 |

*Table 9.* *Ranking of suppliers based on the product quality index.*

| A | B | C | D | E | F | G | H | I | j |
|---|---|---|---|---|---|---|---|---|---|
| 0.940241 | 0.737199 | 1.383006 | 0.840422 | 0.971642 | 0.835959 | 1.568282 | 0.863876 | 0.785027 | 1.436823 |

### *3.4.2. Prioritization of suppliers based on cost reduction capability index*

According to the cost reduction capability index, by forming a pair comparison matrix by 7 experts, the matrix shown in *Table 10* was formed.

*Table 10.* *Prioritization of suppliers based on cost reduction capability index.*

| | A | B | C | D | E | F | G | H | I | j |
|---|---|---|---|---|---|---|---|---|---|---|
| **A** | 1.00 | 0.75 | 1.33 | 0.17 | 2.50 | 1.33 | 0.40 | 0.40 | 1.33 | 0.75 |
| **B** | 1.33 | 1.00 | 0.40 | 0.75 | 0.17 | 2.50 | 1.33 | 6.00 | 1.33 | 0.40 |
| **C** | 0.75 | 2.50 | 1.00 | 0.75 | 2.50 | 0.75 | 0.75 | 1.33 | 2.50 | 2.50 |
| **D** | 6.00 | 1.33 | 1.33 | 1.00 | 0.75 | 1.33 | 1.33 | 1.33 | 1.33 | 2.50 |
| **E** | 0.40 | 6.00 | 0.40 | 1.33 | 1.00 | 0.40 | 2.50 | 6.00 | 1.33 | 1.33 |
| **F** | 0.75 | 0.40 | 1.33 | 0.75 | 2.50 | 1.00 | 0.75 | 1.33 | 2.50 | 2.50 |
| **G** | 2.50 | 0.75 | 1.33 | 0.75 | 0.40 | 1.33 | 1.00 | 6.00 | 1.33 | 2.50 |
| **H** | 2.50 | 0.17 | 0.75 | 0.75 | 0.17 | 0.75 | 0.17 | 1.00 | 2.50 | 2.50 |
| **I** | 0.75 | 0.75 | 0.40 | 0.75 | 0.75 | 0.40 | 0.75 | 0.40 | 1.00 | 0.75 |
| **j** | 1.33 | 2.50 | 0.40 | 0.40 | 0.75 | 0.40 | 0.40 | 0.40 | 1.33 | 1.00 |

***Table 11.*** *Ranking of suppliers based on cost reduction capability index.*

| A | B | C | D | E | F | G | H | I | j |
|---|---|---|---|---|---|---|---|---|---|
| *0.785027* | *0.966482* | *1.32341* | *1.513835* | *1.298745* | *1.167063* | *1.349283* | *0.705432* | *0.639226* | *0.713375* |

### *3.4.3. Prioritization of suppliers based on the packaging index*

According to the packing index, by forming a pairwise comparison matrix by 7 experts, the matrix shown in *Table 12* was formed.

***Table 12.*** *Prioritization of suppliers based on packing index.*

| | A | B | C | D | E | F | G | H | I | j |
|---|---|---|---|---|---|---|---|---|---|---|
| **A** | *1.00* | *0.40* | *1.33* | *0.17* | *1.33* | *0.75* | *2.50* | *0.40* | *0.75* | *6.00* |
| **B** | *2.50* | *1.00* | *0.40* | *1.33* | *0.75* | *1.33* | *1.33* | *0.40* | *2.50* | *2.50* |
| **C** | *0.75* | *2.50* | *1.00* | *0.75* | *1.33* | *1.33* | *2.50* | *2.50* | *6.00* | *0.75* |
| **D** | *6.00* | *0.75* | *1.33* | *1.00* | *0.75* | *1.33* | *1.33* | *1.33* | *1.33* | *2.50* |
| **E** | *0.75* | *1.33* | *0.75* | *1.33* | *1.00* | *2.50* | *1.33* | *1.33* | *0.40* | *0.17* |
| **F** | *1.33* | *0.75* | *0.75* | *0.75* | *0.40* | *1.00* | *0.75* | *1.33* | *2.50* | *2.50* |
| **G** | *0.40* | *0.75* | *0.40* | *0.75* | *0.75* | *1.33* | *1.00* | *0.17* | *0.75* | *0.40* |
| **H** | *2.50* | *2.50* | *0.40* | *0.75* | *0.75* | *0.75* | *6.00* | *1.00* | *0.75* | *0.75* |
| **I** | *1.33* | *0.40* | *0.17* | *0.75* | *2.50* | *0.40* | *1.33* | *1.33* | *1.00* | *1.33* |
| **j** | *0.17* | *0.40* | *1.33* | *0.40* | *6.00* | *0.40* | *2.50* | *1.33* | *0.75* | *1.00* |

***Table 13.*** *Ranking of suppliers based on the packaging index.*

| A | B | C | D | E | F | G | H | I | j |
|---|---|---|---|---|---|---|---|---|---|
| *0.912444* | *1.160865* | *1.530042* | *1.429193* | *0.885467* | *1.03468* | *0.582534* | *1.135376* | *0.83152* | *0.856852* |

### *3.4.4. Prioritization of suppliers based on product price index*

According to the input indices identified for each supplier, based on the price index of the pairwise comparison by 7 experts, the matrix shown in *Table 14* was formed.

**Table 14.** *Prioritization of suppliers based on product price index.*

| | A | B | C | D | E | F | G | H | I | G |
|---|---|---|---|---|---|---|---|---|---|---|
| **A** | *1.00* | *0.40* | *1.33* | *1.33* | *0.17* | *2.50* | *2.50* | *1.33* | *1.33* | *0.40* |
| **B** | *2.50* | *1.00* | *0.75* | *0.75* | *2.50* | *0.75* | *1.33* | *6.00* | *2.50* | *2.50* |
| **C** | *0.75* | *1.33* | *1.00* | *2.50* | *0.75* | *1.33* | *0.17* | *1.33* | *1.33* | *0.75* |
| **D** | *0.75* | *1.33* | *0.40* | *1.00* | *2.50* | *0.40* | *0.40* | *6.00* | *2.50* | *2.50* |
| **E** | *6.00* | *0.40* | *1.33* | *0.40* | *1.00* | *0.75* | *1.33* | *1.33* | *1.33* | *1.33* |
| **F** | *0.40* | *1.33* | *0.75* | *2.50* | *1.33* | *1.00* | *2.50* | *2.50* | *1.33* | *1.33* |
| **G** | *0.40* | *0.75* | *6.00* | *2.50* | *0.75* | *0.40* | *1.00* | *6.00* | *2.50* | *1.33* |
| **H** | *0.75* | *0.17* | *0.75* | *0.17* | *0.75* | *0.40* | *0.17* | *1.00* | *2.50* | *1.33* |
| **I** | *0.75* | *0.40* | *0.75* | *0.40* | *0.75* | *0.75* | *0.40* | *0.40* | *1.00* | *2.50* |
| **j** | *2.50* | *0.40* | *1.33* | *0.40* | *0.75* | *0.75* | *0.75* | *0.75* | *0.40* | *1.00* |

**Table 15.** *Ranking of suppliers based on the product price Index.*

| A | B | C | D | E | F | G | H | I | j |
|---|---|---|---|---|---|---|---|---|---|
| *0.937908* | *1.629309* | *0.942915* | *1.196231* | *1.117384* | *1.309392* | *1.390389* | *0.551527* | *0.677084* | *0.763713* |

### *3.4.5. Prioritization of suppliers based on the place of delivery index*

**Table 16.** *Prioritization of suppliers based on the place of delivery index.*

| | A | B | C | D | E | F | G | H | I | j |
|---|---|---|---|---|---|---|---|---|---|---|
| **A** | *1.00* | *0.75* | *2.50* | *1.33* | *0.75* | *1.33* | *1.33* | *2.50* | *6.00* | *1.33* |
| **B** | *1.33* | *1.00* | *2.50* | *1.33* | *2.50* | *2.50* | *1.33* | *0.17* | *1.33* | *0.75* |
| **C** | *0.40* | *0.40* | *1.00* | *0.75* | *1.33* | *2.50* | *1.33* | *6.00* | *1.33* | *2.50* |
| **D** | *0.75* | *0.75* | *1.33* | *1.00* | *1.33* | *1.33* | *1.33* | *6.00* | *0.40* | *2.50* |
| **E** | *1.33* | *0.40* | *0.75* | *0.75* | *1.00* | *0.75* | *0.40* | *0.40* | *0.75* | *6.00* |
| **F** | *0.75* | *0.40* | *0.40* | *0.75* | *1.33* | *1.00* | *0.50* | *0.75* | *0.75* | *2.50* |
| **G** | *0.75* | *0.75* | *0.75* | *0.75* | *2.50* | *2.00* | *1.00* | *6.00* | *0.75* | *1.33* |
| **H** | *0.40* | *6.00* | *0.17* | *0.17* | *2.50* | *1.33* | *0.17* | *1.00* | *2.50* | *1.33* |
| **I** | *0.17* | *0.75* | *0.75* | *2.50* | *1.33* | *1.33* | *1.33* | *0.40* | *1.00* | *1.33* |
| **j** | *0.75* | *1.33* | *0.40* | *0.40* | *0.17* | *0.40* | *0.75* | *0.75* | *0.75* | *1.00* |

**Table 17.** *Supplier rating.*

| A | B | C | D | E | F | G | H | I | j |
|---|---|---|---|---|---|---|---|---|---|
| *1.521917* | *1.199633* | *1.267077* | *1.267077* | *0.833588* | *0.780947* | *1.252381* | *0.811244* | *0.885467* | *0.582534* |

### *3.4.6. Prioritization of suppliers based on the quality system certification index*

***Table 18.*** *Prioritization of suppliers based on the quality system certification index.*

| | A | B | C | D | E | F | G | H | I | G |
|---|---|---|---|---|---|---|---|---|---|---|
| **A** | *1.00* | *0.40* | *0.40* | *0.40* | *0.75* | *0.75* | *0.17* | *0.40* | *0.17* | *0.75* |
| **B** | *2.50* | *1.00* | *1.33* | *0.75* | *0.75* | *2.50* | *0.40* | *0.40* | *0.75* | *1.33* |
| **C** | *2.50* | *0.75* | *1.00* | *1.33* | *0.40* | *0.17* | *0.17* | *0.17* | *0.40* | *0.75* |
| **D** | *2.50* | *1.33* | *0.75* | *1.00* | *0.75* | *2.50* | *2.50* | *2.50* | *6.00* | *1.33* |
| **E** | *1.33* | *1.33* | *2.50* | *1.33* | *1.00* | *1.33* | *1.33* | *2.50* | *2.50* | *6.00* |
| **F** | *1.33* | *0.40* | *6.00* | *0.40* | *0.75* | *1.00* | *1.33* | *1.33* | *0.75* | *2.50* |
| **G** | *6.00* | *2.50* | *6.00* | *0.40* | *0.75* | *0.75* | *1.00* | *6.00* | *0.40* | *1.33* |
| **H** | *2.50* | *2.50* | *6.00* | *0.40* | *0.40* | *0.75* | *0.17* | *1.00* | *0.40* | *1.33* |
| **I** | *6.00* | *1.33* | *2.50* | *0.17* | *0.40* | *1.33* | *2.50* | *2.50* | *1.00* | *1.33* |
| **j** | *1.33* | *0.75* | *1.33* | *0.75* | *0.17* | *0.40* | *0.75* | *0.75* | *0.75* | *1.00* |

***Table 19.*** *Supplier rating.*

| A | B | C | D | E | F | G | H | I | j |
|---|---|---|---|---|---|---|---|---|---|
| *0.444337* | *0.971642* | *0.517925* | *1.725803* | *1.818304* | *1.12335* | *1.517601* | *0.912444* | *1.309392* | *0.699696* |

### *3.4.7. Prioritization of suppliers based on after-sales service indicators*

***Table 20.*** *Prioritization of suppliers based on after-sales service indicators.*

| | A | B | C | D | E | F | G | H | I | G |
|---|---|---|---|---|---|---|---|---|---|---|
| **A** | *1.00* | *0.40* | *1.33* | *1.33* | *0.17* | *2.50* | *2.50* | *1.33* | *1.33* | *0.40* |
| **B** | *2.50* | *1.00* | *0.75* | *0.75* | *2.50* | *0.75* | *1.33* | *6.00* | *2.50* | *2.50* |
| **C** | *0.75* | *1.33* | *1.00* | *2.50* | *0.75* | *1.33* | *0.17* | *1.33* | *1.33* | *0.75* |
| **D** | *0.75* | *1.33* | *0.40* | *1.00* | *2.50* | *0.40* | *0.40* | *6.00* | *2.50* | *2.50* |
| **E** | *6.00* | *0.40* | *1.33* | *0.40* | *1.00* | *0.75* | *1.33* | *1.33* | *1.33* | *1.33* |
| **F** | *0.40* | *1.33* | *0.75* | *2.50* | *1.33* | *1.00* | *2.50* | *2.50* | *1.33* | *1.33* |
| **G** | *0.40* | *0.75* | *6.00* | *2.50* | *0.75* | *0.40* | *1.00* | *6.00* | *2.50* | *1.33* |
| **H** | *0.75* | *0.17* | *0.75* | *0.17* | *0.75* | *0.40* | *0.17* | *1.00* | *2.50* | *1.33* |
| **I** | *0.75* | *0.40* | *0.75* | *0.40* | *0.75* | *0.75* | *0.40* | *0.40* | *1.00* | *2.50* |
| **j** | *2.50* | *0.40* | *1.33* | *0.40* | *0.75* | *0.75* | *0.75* | *0.75* | *0.40* | *1.00* |

**Table 21.** *Supplier rating.*

| A | B | C | D | E | F | G | H | I | j |
|---|---|---|---|---|---|---|---|---|---|
| *0.937908* | *1.629309* | *0.942915* | *1.196231* | *1.117384* | *1.309392* | *1.390389* | *0.551527* | *0.677084* | *0.763713* |

### *3.4.8. Prioritization of suppliers based on customization indicators*

**Table 22.** *Prioritization of suppliers based on customization indicators.*

| | A | B | C | D | E | F | G | H | I | j |
|---|---|---|---|---|---|---|---|---|---|---|
| **A** | *1.00* | *0.40* | *1.33* | *0.17* | *1.33* | *0.75* | *2.50* | *0.40* | *0.75* | *6.00* |
| **B** | *2.50* | *1.00* | *0.40* | *1.33* | *0.75* | *1.33* | *1.33* | *0.40* | *2.50* | *2.50* |
| **C** | *0.75* | *2.50* | *1.00* | *0.75* | *1.33* | *1.33* | *2.50* | *2.50* | *6.00* | *0.75* |
| **D** | *6.00* | *0.75* | *1.33* | *1.00* | *0.75* | *1.33* | *1.33* | *1.33* | *1.33* | *2.50* |
| **E** | *0.75* | *1.33* | *0.75* | *1.33* | *1.00* | *2.50* | *1.33* | *1.33* | *0.40* | *0.17* |
| **F** | *1.33* | *0.75* | *0.75* | *0.75* | *0.40* | *1.00* | *0.75* | *1.33* | *2.50* | *2.50* |
| **G** | *0.40* | *0.75* | *0.40* | *0.75* | *0.75* | *1.33* | *1.00* | *0.17* | *0.75* | *0.40* |
| **H** | *2.50* | *2.50* | *0.40* | *0.75* | *0.75* | *0.75* | *6.00* | *1.00* | *0.75* | *0.75* |
| **I** | *1.33* | *0.40* | *0.17* | *0.75* | *2.50* | *0.40* | *1.33* | *1.33* | *1.00* | *1.33* |
| **J** | *0.17* | *0.40* | *1.33* | *0.40* | *6.00* | *0.40* | *2.50* | *1.33* | *0.75* | *1.00* |

**Table 23.** *Supplier rating.*

| A | B | C | D | E | F | G | H | I | j |
|---|---|---|---|---|---|---|---|---|---|
| *0.912444* | *1.160865* | *1.530042* | *1.429193* | *0.885467* | *1.03468* | *0.582534* | *1.135376* | *0.83152* | *0.856852* |

According to the final evaluation of suppliers based on input and output indicators, the final matrix of suppliers based on indicators will be as *Tables (24)-(25)*. Supplier scores based on output indicators.

**Table 24.** *Supplier scores based on output indicators.*

| | Product quality | Reduce costs | Packaging |
|---|---|---|---|
| **A** | *0.94* | *0.79* | *0.91* |
| **B** | *0.74* | *0.97* | *1.16* |
| **C** | *1.38* | *1.32* | *1.53* |
| **D** | *0.84* | *1.51* | *1.43* |
| **E** | *0.97* | *1.30* | *0.89* |
| **F** | *0.84* | *1.17* | *1.03* |
| **G** | *1.57* | *1.35* | *0.58* |
| **H** | *0.86* | *0.71* | *1.14* |
| **I** | *0.79* | *0.64* | *0.83* |
| **j** | *1.44* | *0.71* | *0.86* |

***Table 25.*** *Scores of suppliers based on input indicators.*

| | Price Product | Place of Delivery | Quality Systems | After Sales Service | Customization |
|---|---|---|---|---|---|
| **A** | *0.94* | *1.52* | *0.44* | *0.94* | *0.91* |
| **B** | *1.63* | *1.20* | *0.97* | *1.63* | *1.16* |
| **C** | *0.94* | *1.27* | *0.52* | *0.94* | *1.53* |
| **D** | *1.20* | *1.27* | *1.73* | *1.20* | *1.43* |
| **E** | *1.12* | *0.83* | *1.82* | *1.12* | *0.89* |
| **F** | *1.31* | *0.78* | *1.12* | *1.31* | *1.03* |
| **G** | *1.39* | *1.25* | *1.52* | *1.39* | *0.58* |
| **H** | *0.55* | *0.81* | *0.91* | *0.55* | *1.14* |
| **I** | *0.68* | *0.89* | *1.31* | *0.68* | *0.83* |
| **j** | *0.76* | *0.58* | *0.70* | *0.76* | *0.86* |

## 4. Conclusion

With the increase in the number of suppliers in the supply sector of manufacturing companies, the need to have information about the capabilities, capabilities and executive records of suppliers for companies is felt more than ever. In the meantime, having a procedure and instructions that can evaluate suppliers from several different criteria and angles and can select the best supplier is more important. Therefore, in this study, after initial screening of supplier review indicators, the most important indicators were evaluated and selected. Due to the quality of the evaluation indicators, at first, all suppliers were ranked and weighted based on each index using the AHP method. Then, according to the evaluation, all suppliers were evaluated using the Super Efficiency DEA method, all suppliers, based on which the suppliers were ranked among the efficient suppliers, and an accurate evaluation can be provided in this regard. The results of comparing the manufacturing company supplier chain rankings based on AHP, FAHP, and Super Efficiency DEA methods are as *Table 26*.
According to the points obtained, the ranking of suppliers with the methods introduced is as *Table 27*.

All With the increase in the number of suppliers in the supply sector of manufacturing companies, the need to have information about the capabilities, capabilities and executive records of suppliers for companies is felt more than ever. In the meantime, having a procedure and instructions that can evaluate suppliers from several different criteria and angles and can select the best supplier is more important. Therefore, in this study, after initial screening of supplier review indicators, the most important indicators were evaluated and selected. Due to the quality of the evaluation indicators, at first, all suppliers were ranked and weighted based on each index using the AHP method. Then, according to the evaluation, all suppliers were evaluated using the Super Efficiency DEA method, all suppliers, based on which the suppliers were ranked among the efficient suppliers, and an accurate evaluation can be provided in this regard. The results of comparing the manufacturing company supplier chain rankings based on AHP, FAHP, and Super Efficiency DEA methods are as *Table 26*.

***Table 26.*** *Comparison of supplier chain rankings.*

| Row | Supplier | AHP | FAHP | Super Efficiency DEA |
|---|---|---|---|---|
| **1** | **A** | *4.75* | *0.124* | *0.992* |
| **2** | **B** | *6.59* | *0.11* | *0.969* |
| **3** | **C** | *5.2* | *0.114* | *1.693* |
| **4** | **D** | *6.83* | *0.1* | *0.998* |
| **5** | **E** | *5.78* | *0.093* | *1.187* |
| **6** | **F** | *5.55* | *0.097* | *1.122* |
| **7** | **G** | *6.13* | *0.093* | *1.992* |
| **8** | **H** | *3.96* | *0.098* | *1.273* |
| **9** | **I** | *4.39* | *0.087* | *0.972* |
| **10** | **j** | *3.66* | *0.085* | *2.066* |

According to the points obtained, the ranking of suppliers with the methods introduced is as *Table 27*.

***Table 27.*** *Scores of suppliers ranking.*

| Row | Supplier | AHP | FAHP | Super Efficiency DEA |
|---|---|---|---|---|
| **1** | **A** | *7* | *1* | *8* |
| **2** | **B** | *2* | *3* | *10* |
| **3** | **C** | *6* | *2* | *3* |
| **4** | **D** | *1* | *4* | *7* |
| **5** | **E** | *4* | *7* | *5* |
| **6** | **F** | *5* | *6* | *6* |
| **7** | **G** | *3* | *8* | *2* |
| **8** | **H** | *9* | *5* | *4* |
| **9** | **I** | *8* | *9* | *9* |
| **10** | **j** | *10* | *10* | *1* |

According to the study, AHP and FAHP methods in the ranking of suppliers had closer answers than data envelopment analysis. And according to the computational accuracy of data envelopment analysis methods, which is based on the input and output information of each supplier, so supplier number 10 is declared the best supplier. According to the assessments made in this study, first, key indicators regarding supply risks using the articles [23, 24, 27-29] using selection of experts from seven experts of the company, based on the risks of selecting suppliers, the most appropriate indicators have been identified using fuzzy, which in the meantime, article [23] was accepted with the highest selection of indicators and then we evaluated the suppliers. Due to the very high sensitivity in supply chain development, it is necessary for suppliers to be evaluated and selected based on all strategic indicators of the organization, so to develop this research, the following suggestions are provided:

- It is suggested that the production company form a working group consisting of executive units for accurate evaluation of suppliers and all evaluations be reviewed and selected in a multi-purpose working group.
- It is suggested that the executive instructions of the organization be updated and rewritten in accordance with the context of this research.
- It is recommended to conduct periodic evaluations of suppliers to maintain efficiency.

## References


[1] Asgharizadeh, E., Momeni, M., & Ghasemi, A. (2010). Development of supply chain performance indicators by modeling the European model of quality management (case study: shahrvand chain stores company). *Journal of transformation management, 2*(3), 68-98.

[2] Morgan, Ch. (2007). Supply network performance measurement: future challenges? *The international journal of logistics management, 18* (2), 255-273.

[3] Gunasekaran, A., Patel, C., & Tirtiroglu, E. E. (2004). Performance measures and METRICS in a supply chain environment. *International journal of operations & production management, 21* (1/2), 71-87.

[4] Wen, M., You, C., & Kang, R. (2010). A new ranking method to fuzzy data envelopment analysis. *Computers & mathematics with applications*, *59*(11), 3398-3404.

[5] Burgess, K., Singh, P. J., & Koroglu, R. (2006). Supply chain management: a structured literature review and implications for future research. *International journal of operations & production management, 26*(7), 703-729.

[6] Hedayat Tabatabai, S. A. (2012). *Measuring productivity with a technical and engineering approach*. Defense Industries Educational and Research Institute.

[7] Kadkhodazadeh, H. R., & Morvati Sharifabadi, A. (2013). Supplier selection using fuzzy inference system. *Production and operations management, 7* (2), 113-132.

[8] Wen, M., You, C., & Kang, R. (2014). A new ranking method to fuzzy data envelopment analysis. Computers and mathematics with application, *59,* 3398-3404.

[9] Lee, C., & Wen-Jung, C. (2005). The effects of internal marketing and organizational culture on knowledge management in the information technology industry. *International journal of management*, *22*(4), 661.

[10] Estampe, D., Lamouri, S., Paris, J. L., & Brahim-Djelloul, S. (2013). A framework for analysing supply chain performance evaluation models. *International journal of production economics*, *142*(2), 247-258.

[11] Thomas, D. J., & Griffin, P. M. (1996). Coordinated supply chain management. *European journal of operational research*, *94*(1), 1-15.

[12] Lee, H. L., & Billington, C. (1992). Managing supply chain inventory: pitfalls and opportunities. *Sloan management review*, *33*(3), 65-73.

[13] Wu, D., & Olson, D. L. (2008). Supply chain risk, simulation, and vendor selection. *International journal of production economics*, *114*(2), 646-655.

[14] Wu, D., & Olson, D. L. (2008). Supply chain risk, simulation, and vendor selection. *International journal of production economics*, *114*(2), 646-655.

[15] Xu, J., Li, B., & Wu, D. (2009). Rough data envelopment analysis and its application to supply chain performance evaluation. *International journal of production economics*, *122*(2), 628-638.

[16] Saleh, H., & Shafiee, M. (2017). Performance evaluation using three-level data envelopment analysis. *Paper presented at the first national conference on modern applied research in basic sciences*. Bandar Abbas, Islamic Azad University, Bandar Abbas Branch.

[17] Koushki, F., & Mashayekhi Nezamabadi, E., (2018). A network data envelopment analysis method for evaluating supply chains and its application in pharmacy. *Engineering and quality management, 8*(1), 48-37.

[18] Mousavi, S.M., & Ahmadzadeh, N. (2018). Evaluation and evaluation of supply chain efficiency using data envelopment analysis (case study: Amol paper companies). *7th national conference on accounting and management applications*. Tehran, Asia Gold Communication Group.

[19] Hosseinzadeh Seljuqi, F., & Rahimi, A. (2016). Evaluation of efficiency and efficiency at the scale of supply chain of Iranian resin industries with definitive and fuzzy data envelopment analysis model. *Production and operations management, 10*(1) (18 consecutive), 63-47.

[20] Samoilenko, U. (2013). Aligning supply chain collaboration using analytic hierarchy process. *Omega, 41*(2), 431-440.

[21] Singh, S., & Aggarwal, R. (2014). DEAHP Approach for manpower performance evaluation. *Journal of the operations research society of China, 2*(3), 317-332.

[22] Comelli, M., Fenie, P., & Tchernev, N. (2016). 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, 112,* 77–95.

[23] lim, j. j., & zhang, a. n. (2016). A dea approach for supplier selection with AHP and risk consideration. *2016 IEEE international conference on big data (Big Data).* IEEE. 3749-3758.

[24] Liang, L., Yang, F., Cook, W. D., & Zhu, J. (2017). DEA models for supply chain efficiency evaluation. *Annals of operations research, 145,* 35–49.

[25] Chan, F. T. S. (2017). Performance measurement in a supply chain. *International journal of advanced manufacturing technology, 21,* 534–548.

[26] Easton, L., Murphy, D. J., & Pearson, J. N. (2018). Purchasing performance evaluation: with data envelopment analysis. *European journal of purchasing & supply management*, *8*, 123–134.

[27] Lim, J. J., & Zhang, A. N. (2016, December). A DEA approach for Supplier Selection with AHP and risk consideration. *2016 IEEE international conference on big data (big data)* (pp. 3749-3758). IEEE.

[28] Lim, J. J., & Zhang, A. N. (2016, December). A DEA approach for supplier selection with AHP and risk consideration. *2016 IEEE international conference on big data (big data)* (pp. 3749-3758). IEEE.