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Evaluating and Selecting Suppliers in the Setareh Flour Milling Company Supply Chain Using Clustering Techniques

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Abstract

One of the most important factors in survival of an organization in today's competitive environment is to reduce production costs. Choosing the right suppliers can help us reduce these costs. The selection and assessment of suppliers is a multi-criteria decision-making process, in which quantitative and qualitative criteria are presented in this assessment, our goal in this article is to first compile all the criteria that organizations are conducting in evaluating and The best choice is to help, and in the future, an algorithm that determines the number of clusters of suppliers and then supplies the suppliers in their clusters, in the end is a case study in which to evaluate and select the supply The Setareh flour milling company will review the payment.

Keywords: Supply chain, Data mining, Clustering Technique.

1 | Introduction

In today's global markets, companies are not exclusive brand names that can operate independently. It is also an important part of a supply chain. In this case, the ultimate success of a company depends on its managerial ability to integrate and coordinate a complex network of business relationships among supply chain members [1]. The ultimate goal of these companies is to manage their suppliers across the supply chain, deliver faster, reduce production latencies, reduce costs, and increase quality [2]. In the last decade, supply chain management has been a challenge for most companies, and the need to achieve a global competitive edge in the supply chain has substantially increased [3]. In most industries, the cost of raw materials and components constitutes the main cost of a product, therefore, the purchasing department can play a key role in the efficiency and effectiveness of an organization, because it directly affects cost, profitability and Flexibility of

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a company [4]. In addition, since suppliers have already had a major impact on the success or failure of a company, which was previously considered as a pure tactical tool, it is now also a strategic task Is known [5]. Supply Chain Management A system consisting of three main components, focusing on obtaining raw materials for production, focusing on converting raw materials into finished products, and focusing on distributing these products to customers through distributors, warehouses And sellers. Today, supply chain management and supply chain selection process are of considerable importance in business management. During the 1990s, many manufacturers sought to work with their suppliers in order to enhance their performance management and competition [6] and [7]. The flow of materials in the supply chain is shown in *Fig. 1*.

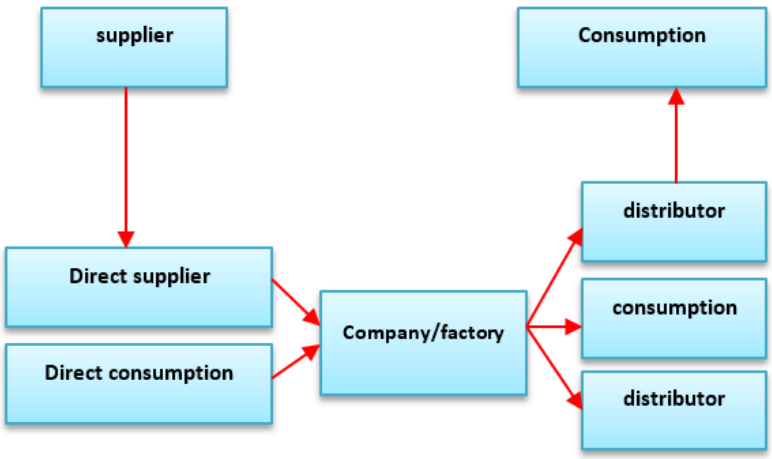

Fig. 1. Flow of woods and materials throughout of the supply chain.

Purchasing performance is increasingly seen as a strategic issue in organizations. The buyer-supplier relationships in the manufacturing companies attract a lot of attention. In other words, when a provider of a part of the supply chain is well managed, this relationship will have a lasting effect in competition from the entire supply chain. Therefore, the supplier selection problem has become one of the most important issues for creating an effective supply chain system. The general aim of the supplier selection process is to reduce the purchase risk, maximize the buyer's overall value, and establish a proximity and long-term relationship between buyers and suppliers [8]. In the supply chain, coordination between the manufacturer and the suppliers is typically a major and important link in the distribution channel. Many models have been developed to decide supplier choices based on relatively simple perceptions of the decision-making process [9] and [10]. Many of the existing decision-making models have considered quantitative criteria for choosing suppliers, however, there are several factors that are not effective in the decision-making process, such as incomplete information, additional qualitative criteria. With respect to the above, it can be concluded that some of the features are valuable in solving the decision-making problem of selecting suppliers [2], [9], [11]. Finding the best way to evaluate and select suppliers is difficult and companies use a variety of methods to deal with it. Therefore, the most important issue in choosing suppliers is to develop a suitable method for selecting suppliers. It is suitable. Basically, the choice of supplier in a supply chain system is a multiple decision criterion [12].

The remainder of the sections is that, in Section 2, a background to the studies carried out in this area will be presented, Section 3 discusses our contribution to this article, and Section 4 lists the criteria for we will select suppliers as a model. In Section 5, we will outline the proposed algorithm. In Section 6, the steps and method of evaluating suppliers will be discussed using the clustering and case study methodology, and Section 7 will be related to the conclusions and the work to be done in the future, Should be.

2 | Literature Review

In general, many quantitative and qualitative factors, such as quality, price, flexibility and delivery performance, should be considered to determine the appropriate suppliers. Chen et al. [12] used linguistic values to evaluate ranking and weight of factors, then they expressed the linguistic ranking as fuzzy numbers. Subsequently, they used a fuzzy multi-criteria hierarchical decision-making model to address supply chain selection issues. According to the concept of TOPSIS, a proximity coefficient is defined for the ranking of suppliers. This paper shows that the proposed model is well used as the decision maker to select the appropriate supplier. Choosing a supplier as one of the most important components of supply chain management is usually a multi-criteria decision-making problem. In order to cope with multiple criteria and inherent uncertainty in supplier selection, in his article, the method of fuzzy analysis process, which first identified the best suppliers, taking into account the effects of interdependence among the selection criteria, and It then examines the uncertain and contradictory judgments and then uses fuzzy multi-objective linear programming to integrate the best suppliers in order to optimize the allocation under fuzzy conditions [13].

Association laws are one of the broadest data mining techniques that search data sets to find the best rules for data and their relationship. Often, there will be thousands of potential suppliers, and finding subsets of suppliers will be a complex process. lin et al. [14] proposed a proposed methodology, which includes the developed algorithm of association rules to find key suppliers. The results show that the method is effective and executable. Ferreira and Borenstein [15] introduced a new approach based on the integration of fuzzy logic and fuzzy logic for ranking and evaluation of suppliers, using linguistic variables for ranking and weighting criteria, and from possible learning in the choice of supply It utilizes Bayesian learning. Bruno et al. [16] used the Analytical Hierarchy Process (AHP) method to evaluate suppliers. AHP is one of the most prominent methods used to address this problem. Lasch and Janker [17] A supplier ranking system that uses an analysis of the primary and primary components of the ranking, then ranked and ranked potential suppliers according to each category. Huang and Keskar [18] is used as a useful source for reviewing literature to select suppliers through analytical hierarchical planning and other ranking methodologies. Kagnicioglu [19] presented a fuzzy model for the supplier-choice problem, in which both objectives and fuzzy propositions are present. Morlacchi et al. [20] is a model that uses the theory of fuzzy sets with AHP using integer integer programming to reduce the number of suppliers. The AHP model integrated in the optimal architecture distinguishes features for this model [21]. Kumar et al. [22] used fuzzy utopian planning to solve the supplier choice problem with multiple goals and fuzzy parameters. They used real world data to demonstrate the effectiveness of the proposed model.

3 | Contribution

When the need to decide on the choice of a supplier is necessary, organizations generally formulate and develop a set of evaluation criteria. Purchasing managers in each organization use all the available features to evaluate suppliers' performance. Meanwhile, the main issue is the choice of criteria for evaluating suppliers. In this paper, we try to provide the criteria needed to select suppliers in a general way in the form of a model to be used by all organizations.

Preprocessing is one of the most important tasks in data mining. In this paper, we use the PCA (Principal Component Analysis) technique, one of the techniques of diminishing later, in the preprocessing section, so that the dimension of the data Let's lower One of the important issues that most of the data mining clustering techniques face is determining the number of clusters, in this paper, we use the subtractive clustering algorithm to achieve this, and then , We perform clustering with the K-Means algorithm and divide suppliers into different parts, then analyze each sector and, as a result, the most suitable part that includes the best suppliers We will choose.

4 | Provide a model of supplier's assessment criteria

For this division, we have tried to use expert business people to achieve acceptable results. Given the shape from top to bottom, the importance of the criteria decreases. Categorized criteria can be used by other suppliers other than the Setareh flour milling company to evaluate suppliers. According to the classification, it can be concluded that this model can help us to select appropriate criteria for evaluation. In general and in the form of a model.

Fig. 2. Evaluation criteria of suppliers.

5 | Proposed Algorithm

In this section we will describe the proposed algorithm for Subtractive K-Means. This algorithm consists of two main parts of the subtractive algorithm and the K-Means algorithm. *Fig. 3* shows the implementation process for this algorithm. The steps of the proposed algorithm will be implemented in this way; the first step for each data is considered to be a rating and score, which is calculated by the total distance of the other data from each of the data. The lower the total distance, the higher the score is assigned to the data. The second step, the data that has the highest score, is considered as the center of the cluster. In the third step, all the data points that are adjacent to the center of that cluster are deleted, which can be considered as a constant impact ray for this section and remove any data in which the radius is affected. In Step 4, if after deleting the data that is affected by the radius, the data will remain in Step 1, otherwise, go to Step 5 and calculate the number of centers of clusters and consider it as K. We get The first five steps are related to the subtractive algorithm. In Step 6, we select the point K as the cluster centers and define the cost function for the algorithm. This cost function sets the minimum distance of each of the data from the cluster centers, since we seek to

minimize it, therefore classifying the clustering problem as a minimization problem. The clustering cost function is represented in *Eq. (1)*.

$$\text{Min} \sum_{i=1}^{n} d_i = \text{Min} \sum_{i=1}^{\infty} \text{Min} \left\| x_i - c_j \right\|. \quad (1)$$

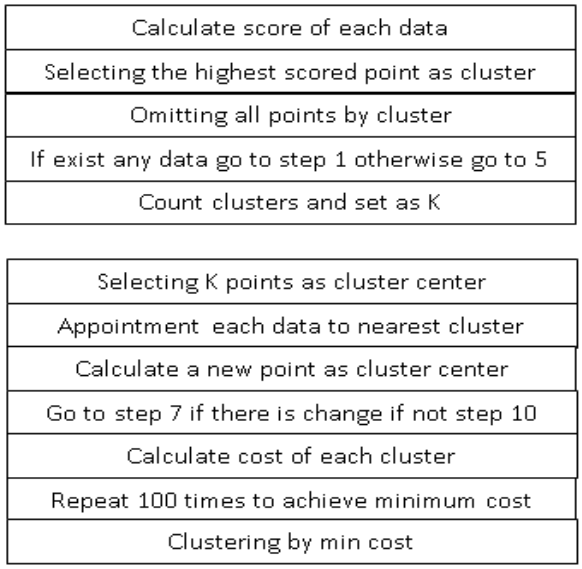

Fig. 3. The process of implementing proposed algorithm.

In Step 7, we assign each sample of the data that has the smallest distance to the centers of the clusters in that cluster; in step 8 we update the cluster centers for all clusters and add a new point as the center of the cluster is considered for each cluster. In Step 9, if a change occurs in the cluster centers, enter into Step 7, otherwise we go to Step 10. In Step 10, we obtain the value of the cost function for clustering. Since cluster centers are randomly selected, they influence the clustering process and therefore the value of the cost function, and since we seek the best clustering, clustering is 100 times or more We make sure that the best cost function is obtained to achieve the value of the cost function that is better represented by clustering and then proceed to the clustering results based on the values obtained from that clustering. We analyze the clusters. Assess suppliers using clustering

Clustering is one of the most important data mining tools. Today, clustering has been able to showcase its value as a uncontrolled learning method in many applications. Clustering involves finding a structure within a collection of unlabeled data. A cluster is referred to as a collection of data so that data is split into clusters that minimizes the similarity between the data within each cluster and the similarity between the data within the different clusters. In the classification of each data, a given class (class) is assigned in advance, but in the clustering, there is no information about the existing classes within the data, in other words, the clusters are extracted from the data. Time clustering will provide useful results to use good form data. In this section, we will discuss the steps to be taken in order to evaluate suppliers. The steps in this section are presented as a model in *Fig. 4*.

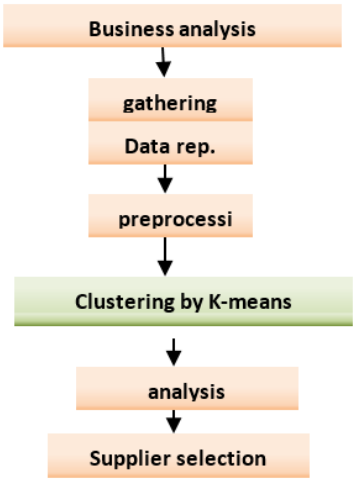

Fig. 4. Supplier assessment processes by clustering.

6.1 | Business Analysis and Suppliers

In the first step of evaluating suppliers, we must get acquainted with the business concepts that we carry out the assessment of the suppliers around, familiar with the proper value metrics that are used to segment and segment the suppliers. We get With regard to the business we are looking at, we will determine which market is one of the markets for full competition, exclusive competition and absolute monopoly, and with this in mind, we can obtain a better understanding of the type of suppliers that we have It will help in evaluating and choosing a better supplier.

6.2 | Aggregated and Described

After the business analysis, the information necessary to evaluate the suppliers will be obtained as usable and specific data. In some businesses, depending on the type of data used, these data can be collected from the data bases of the organization itself, and other items can be excluded from the questionnaire. The success of projects depends on the breadth and quality of existing data. In this section, where we will use the data mining clustering technique, the more available data will include more samples from suppliers, clustering will be implemented more satisfactorily. The data collection method was implemented through a survey form as well as the company's database on the 50 suppliers of raw materials from the Setareh flour milling company. Setareh flour milling company is a manufacturing company specializing in the production of electronic kits, which started its business in the field since 1375, and its working process includes CNC drilling, cutting and cutting, CNC cutting, electroplating, printing of parts, protective printing And hot air. The questionnaire uses the supplier assessment criteria discussed in the previous section.

6.3 | Data Preprocessing

Preprocessing or preparing data is the most important and time-consuming step in data mining projects. Approximately 60 to 90 percent of the time for a data mining project is spent on this stage, and 75 to 90 percent of the success of data mining projects depends on it. The processes that are performed in the preprocessing are aggregation, sampling, diminishing the dimension, selecting the subset of features, creating features and data transformations. According to the type of application that the data mining operation has to be performed, different techniques are used for each of these actions [24].

In this part of the process of data conversion and data reduction we use. When dealing with real data, encountering lost values is not a new issue. As we encounter this problem in the dataset, some other methods can be used to resolve this issue. In this study, the most repeated method is used so that if there is a missing value, this value is replaced with the maximum value in which the repeat field is replaced. After solving the

problem of missing values for implementation, we need to convert the data so that we convert the values of the fields to numeric values. Since the supplier's evaluation criteria are not equally important to the company, so, with the expert's opinion, for the quality criteria, production capacity, after-sales service, the fit of the price and timely delivery of factor 2, and for the remaining items, the coefficient 1 Because of the large size of the supplier's fields to display the output and clustering to reduce after dimensional reduction techniques such as PCA, we use dimensions from 22 to 3 dimensions and we can get the clustering results as More concrete.

7 | Clustering suppliers using the proposed algorithm

According to Section 5, which describes the proposed algorithm, we will conduct clustering. After preprocessing the data and entering the data as the input of the proposed algorithm and considering the impact radius of 0.5, at the beginning of the operation, the subtractive algorithm chooses the eight cluster centers shown in *Table 1* of its coordinates. Therefore, the optimal number of clusters or K is required to continue the K-Means algorithm.

Table 1. The coordinates of cluster centers derived by subtractive algorithm.

Cluster no.	x	y	z
Cluster 1	3.3266	-1.2497	-1.3205
Cluster 2	-1.1213	-1.9613	-0.1659
Cluster 3	-3.6321	3.6861	-0.3774
Cluster 4	3.2238	2.1946	1.9954
Cluster 5	1.2611	1.5055	-1.4298
Cluster 6	-3.4476	-2.3683	0.1943
Cluster 7	0.2874	-1.2894	2.9593
Cluster 8	-1.5965	.07491	1.0546

In the next step, the K-Means algorithm is applied to the dataset derived from the PCA. *Fig. 5* shows the clustering results from the proposed algorithm. In Fig. 5, the proposed algorithm clustered the existing dataset optimally into 8 clusters, which can be seen as 8 different states. As stated above, the proposed algorithm is executed in such a way that the distance between the total data and the centers of its clusters is the lowest possible. It should also be noted that in the continuing run, we do not use the coordinates obtained in Table 1, we will only use the number of cluster centers that have 8 clusters as the number of clusters or K to continue the work.

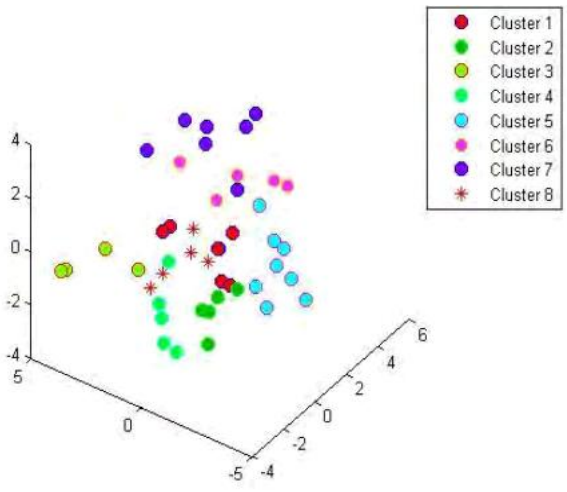

Fig. 5. Clustered results of the proposed algorithm.

8|Division Analysis and Selection of the Best Supplier

After dividing suppliers and placing suppliers in separate sectors, we must analyze each sector in order to better understand the suppliers and then select the best suppliers. By choosing the proposed algorithm for customer clustering, we get 8 clusters that separate each cluster or segment into fields, details of each cluster can be found in *Table 2*. To analyze suppliers, a set should divide them into categories that are different in some common characteristics and in some of their properties, as shown in *Table 2*, we propose the proposed clustering algorithm for this segmentation have given.

According to *Table 2* and criteria for customer clustering and identifying the priorities of clustering criteria for the company, it can be concluded which cluster is selected as the best cluster. As output, it is possible to quantify each of the values of the clusters, after which the specific coefficient chosen by the expert is assigned to each clustering criterion, and finally, the average of each cluster is calculated and consider each cluster with a higher average as the best cluster.

The company assigns a coefficient of 2 for the quality criteria, capacity, production capacity, after sales service, fits the price and timely delivery, as shown in the table in red, coefficient 2, and for the remaining items, coefficient 1. *Table 3* shows the comparison of clusters as stated.

According to *Table 3*, the cluster 7 has the highest average among the remaining clusters, so it will be selected as the best cluster, so suppliers of this cluster, namely suppliers 10, 19, 27, 33, 40, 42, and 48 the title will be chosen as the best suppliers.

Among these suppliers, one of them can be selected using other methods. The goal of clustering in this article is to achieve the desired cluster from better suppliers.

9|Conclusion

The segmentation of suppliers is a process by which parts of the suppliers that meet their requirements and specifications are the same. Segmenting suppliers can accelerate the decision to participate. In this research in

First, we will compile the criteria that help organizations to perform better evaluation and selection, and we will use the proposed algorithm to cluster and select the best suppliers. Basically, the supplier choice problem in the supply chain system is the multiple decision criteria that the clustering technique yields the best result, which is the choice of the best suppliers. The clustering of suppliers can be compared using other algorithms. Also, using indicators such as the Davis Boulder index, the number of clusters can be determined and clustered for that.

Table 2. Details of each cluster using the proposed algorithm.

8	7	6	5	4	3	2	1	cluster
5	7	5	10	5	6	5	7	Supplier numbers
Low	Good	Good	Low	Medium	Medium	Medium	Good	Environmental standards
Good	Much	Good	Medium	Good	Low	Low	Low	Company flexibility
Good	Good	Good	Good	Good	Medium	Good	Good	Personnel numbers
Good	Good	Good	Medium	Low	Good	Medium	Medium	Organizational structure
Good	Much	Much	Good	Medium	Good	Good	Medium	The willingness of suppliers to trade
Medium	Much	Much	Much	Good	Medium	Medium	Good	The supplier's speed in development and growth
Good	Good	Good	Good	Good	Good	Good	Good	Continuous improvement
Good	Good	Good	Much	Medium	Low	Good	Medium	Future production capacity
Good	Much	Good	Much	Medium	Medium	Medium	Medium	Production facilities
Good	Good	Good	Good	Good	Medium	Good	Medium	Asset management
Much	Good	Much	Much	Medium	Low	Medium	Good	Financial circumstances
Low	Good	Good	Good	Medium	Low	Good	Good	Quality
Medium	Medium	Much	Much	Medium	Low	Medium	Medium	Production capacity

Table 2. Continued.

Much	Much	Good	Medium	Good	Medium	Medium	Medium	Brand reputation
Much	Medium	Much	Medium	Medium	Low	Medium	Medium	Long term relationships
Much	Medium	Much	Medium	Medium	Low	Medium	Medium	Historical records
Much	Medium	Good	Much	Medium	Medium	Medium	Low	Technical capability
Much	Much	Medium	Medium	Medium	Much	Low	Medium	Services
Medium	Much	Good	Good	Low	Medium	Low	Medium	Price
Medium	Good	Good	Good	Good	Medium	Low	Medium	Competitive situation
Much	Much	Medium	Much	Low	Medium	Low	Medium	location
Much	Much	Low	Medium	Medium	Medium	Low	Good	Delivery

Table 3. Comparison of clusters.

8	7	6	5	4	3	2	1	cluster
3.54	4.04	3.68	3.54	2.59	2.36	2.36	2.77	Average weight of clusters

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Data Availability

The data used in this study were collected from the internal database and supplier records of Setareh Flour Milling Company. Due to privacy and confidentiality agreements, the dataset is not publicly available. However, specific information may be shared by the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this paper.

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