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Applicability of Supplier Selection Using the Electre Method in Food and Beverage Industry

ABSTRACT

The food and beverage industry is now experiencing rapid growth, making it one of the most rapidly expanding industries in the present day. Because of this expansion, the drinks and food industry has encountered a significant challenge pertaining to the process of supplier selection. The implementation of supply chain management has more challenges in comparison to other industries, particularly in the context of food and beverage businesses, which typically rely on a vast array of about 3000 items to facilitate the provision of their services. Nevertheless, empirical research indicates that the advantages of proficient supply chain management within the food and beverage industry are significant and should not be disregarded. Within the scope of this research, the present setting provides an overview of the supplier selection criteria established for food and beverage businesses. It is emphasized that these criteria are subject to potential modifications based on the specific goals of each organization. The evaluation of the Electre technique, which is one of many decision-making approaches, has been conducted to determine its effectiveness in supplier selection within the food and beverage business. This paper aims to elucidate the application phases of the Electre method. The objective of this research is to assess the viability of using the Electre technique as a supplier selection criterion in the context of food and beverage businesses.
Keywords: Food and Beverage Industry, Supplier Selection, Electre Method, Multiple Decision-Making Methods.

1. INTRODUCTION

Today, for businesses to survive in the competitive market, their existing structures must be integrated with the innovations brought by the competitive market. For this reason, businesses are trying to improve their capacity in order to quickly respond to changes in the market. Businesses need to implement a systematic supply chain system to maintain sustainability and keep up with innovations in the market. At this point, supply chain management is a concept that helps businesses both maintain their sustainability and respond quickly to innovations (Özdemir & Doğan, 2010). In general terms, supply chain management is a process integration that includes end users, suppliers, products, services and information within the chain (Gunasekaran & Ngai, 2004). Global Supply Chain Forum, supply chain management; It is defined as an integration that covers the processes of all businesses, from the first supplier to the final consumer, providing products, services and information that create value for customers and other relevant stakeholders (Dehning et al., 2007).

Food and beverage businesses are economic businesses established for profit. For this purpose, food and beverage businesses must plan their activities efficiently. One of the main subheadings of these planning issues is choosing the right supplier. Food and beverage businesses are faced with many suppliers from whom they can obtain the raw materials they want to use the most important issue is to evaluate these suppliers well and to choose the right supplier that will be beneficial for food and beverage businesses because of the evaluation. By choosing the right supplier, food and beverage businesses will be able to extend their lifespan. When making such an important decision, people must act with accurate data. For this purpose, incorporating scientific techniques into decision-making processes will make the results more reliable and ensure that the decision is viewed objectively. For this purpose, the applicability of supplier selection with the electre method in the food and beverage industry which constitutes the problem of the research will be focused on.

2. CONCEPTUAL ANALYSIS

Food and beverage businesses are established to meet the eating and drinking needs of customers; They are businesses that operate under economic, social and rules that meet the expectations of customers in physical, technical, and sociological terms (Bekar & Dönmez, 2004). The main factor that distinguishes food and beverage businesses from other businesses is that the products offered are collected under the roof of a service product. In recent years, food and beverage businesses have continued to develop in line with the needs of consumers. The reasons why food and beverage businesses are developing so rapidly are explained as follows (Doğdubay & Cevizkaya, 2015):

- Time,
- Increase in disposable income,
- Increasing the number of food and beverage businesses,
- The social dimension of meeting the need for eating and drinking outside,
- Differences in lifestyle and changing consumer demographic characteristics,
- Factors such as the increase in travelers have led to a rapid increase in food and beverage businesses.

One of the biggest problems is that rapidly developing food and beverage businesses cannot transform them into a sustainable structure. To ensure the sustainability of food and beverage businesses one of the most important answers to be given is supplier selection (Avcıkurt et al., 2010). Supplier selection is a multi-purpose decision problem that addresses different functions within the business structure and includes many quantitative and qualitative factors in a hierarchical structure (Fedotova and Ferreira, 2010). The aim of supplier selection is to identify potential supplier businesses with the highest qualifications that can continuously and smoothly meet the company's needs at a reasonable price level. The selection process is a general comparison of suppliers using a common set of criteria (Sarjami & Caccetta, 2010).

Food and beverage businesses are organizations based on profitability. The main purpose of such businesses is to maximize profits by ensuring the satisfaction of consumers who prefer the business. In order to achieve this purpose; food and Beverage businesses can only supply low-cost and quality products by choosing the right supplier (Glock, 2008). Choosing the right supplier in food and beverage businesses not only ensures affordable costs in product purchasing but also positively affects the development of competitive advantage (Xia & Wu, 2007). While it affects the competitive advantage, costs and customer satisfaction of food and beverage businesses, it also plays a major role in the continuity of the vital functions of consumers. In light of these data, it is possible to conclude that supplier selection in food and beverage businesses is more complex and requires attention compared to other businesses (Avcıkurt et al., 2010). In this context, the fact that food and beverage businesses include food and beverage production and the use of approximately 3000 different product items to produce these products makes it difficult to control the entire supplied product in terms of supply chain management application (Avcıkurt et al., 2010). Despite this difficulty, the necessity of implementing supply chain management in food and beverage businesses has emerged (Smith & Xiao, 2008).

Food and beverage businesses need to choose the right supplier to maintain their continuity. Choosing the right supplier varies from business to business but is possible with the supplier selection criteria determined by the business. The basic criteria for supplier selection are in addition to price, quality and distribution performance, new criteria such as flexibility, innovation and customer service brought about by developing technology and increasing competition conditions have been added. When different businesses in other sectors are examined; It is seen that they add different criteria to the main criteria due to both the necessity of their sectors and their special conditions. The factors affecting the selection process are as important as the criteria used by businesses in the supplier selection process (Civaroğlu, 2006). When the relevant literature is examined in supplier selection, the evaluation criteria put forward by Dickson are generally used. The most important point for food and beverage businesses is within the framework of the company's supply chain management, it is the ability to effectively apply supplier selection criteria by prioritizing them according to their own business structure (Sarıoğlan, 2011).

The level of use of the supplier selection criteria in food and beverage businesses determined in Figure 1 may vary depending on the production policies of the food and beverage businesses. However, in every food and beverage business, regardless of the determined production policy, if effective success in supplier

selection in the food and beverage sector is to be achieved, the criteria specified in Figure 1 must be used (Şen, 2007).

Today, the effective functioning of supply chain management varies in direct proportion to the resistance of the links forming the sub-chains. The most important link that directly affects the effectiveness of supply chain management is supplier selection and the priority of the criteria used in this selection (Avcıkurt et al., 2010). As mentioned before, it has been mentioned that the answer to the problem that food and beverage businesses must primarily answer is supplier selection. The applicability of supplier selection with the ELECTRE method in food and beverage businesses represents the problematic of your

research. In this context, the electre method will be examined first.

ELECTRE (Elimination Et Choix Traduisant la Realite) method is one of the multi-criteria decision-making methods first introduced by Benayoun in 1966. It was later developed by Roy (1971), Nijkamp and Van Delft (1977) and Voogd (1983). This method is based on making a choice by comparing alternatives according to their preference order (Kuru, 2011). When compared with different concrete decision problems, the concept of "super-rating relationship" emerged and after this concept was introduced, numerous applications related to it were developed. One of the most important of these methods is the ELECTRE method (Roy, 1991).

Figure 1. Supplier Selection Criteria in Food and Beverage Businesses**, Source**: Dickson, 1966; Sarıoğlan & Avcıkurt, 2010

Multi-criteria decision-making techniques it is the process of evaluating a limited or unlimited set of alternatives by taking into account a set of often conflicting criteria that become qualities or objectives depending on the nature of the problem. The methods used for multi-criteria decision-making techniques are classified below.

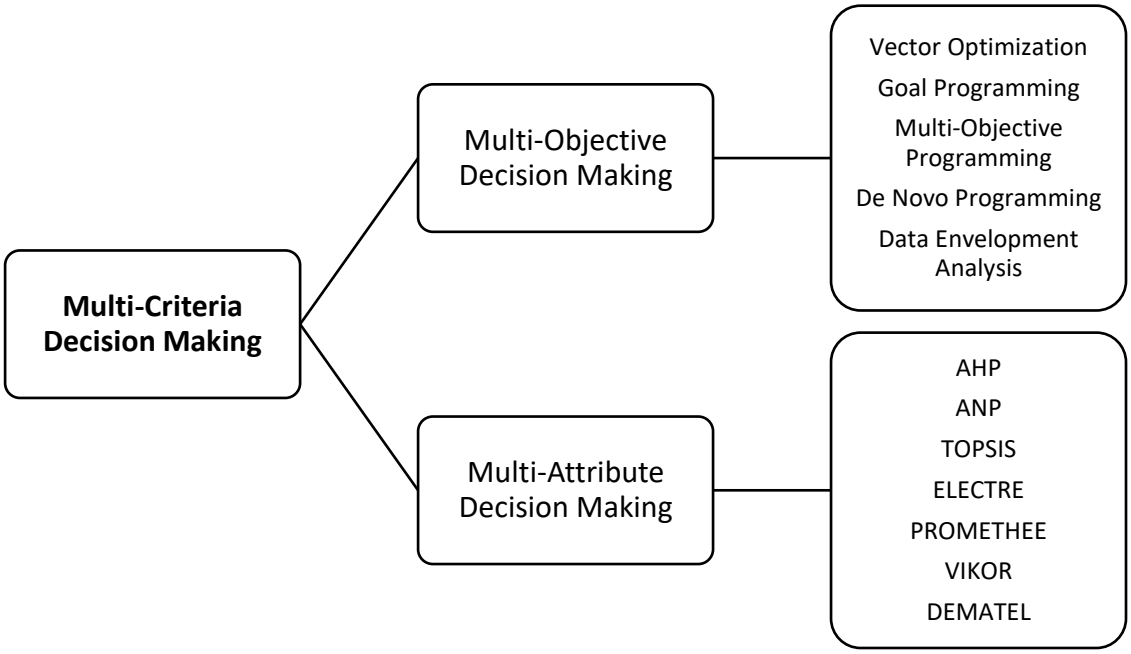

Figure 2. Classification of Multi-Criteria Decision-Making Methods, **Source:** Tzeng & Huang, 2011

The ELECTRE method is a method used to solve results that require selection. There are two basic steps in applying the method (Eryürek & Tanyaş, 2003). These:

- Calculation of compliance and non-compliance indicators because of comparing the options,
- It is the use of superiority relationships between options. As can be seen, in the ELECTRE method, a ranking relationship is basically created, fit and mismatch indices are calculated, and alternatives are selected by creating kernels (Çağıl, 2011).

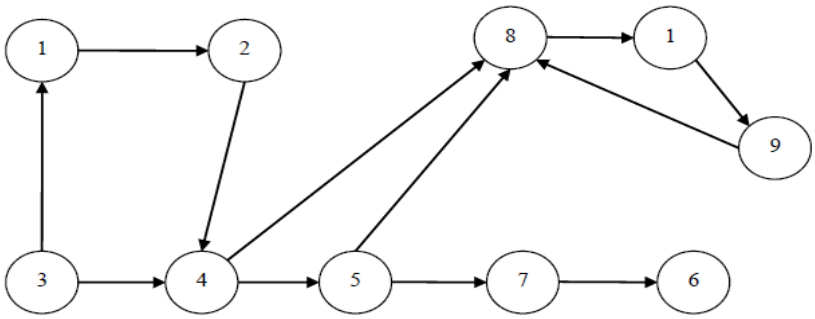

Figure 3. Graphical Representation of Comparisons of Alternatives**, Source**: Çakın, 2013

Each node in Figure 3 shows an alternative, and the arrows used show the dominance of the alternatives relative to each other. The alternative that is the beginning of the arrow means that it is dominant or preferred over the alternative that the arrow points to. As a result of pairwise comparisons of alternatives, the set consisting of alternatives that are superior to all the alternatives they are compared with is called the core set (Çakın, 2013).

When ELECTRE is compared with other multi-criteria decision-making methods, some advantages and disadvantages emerge. In the table below, one of the multi-criteria decision-making methods; the strengths and weaknesses of AHP, TOPSIS, and ELECTRE methods are shown (Özkan, 2007; Kabli, 2009).

Table 1. Strengths and Weaknesses of the Methods

Method	Strong Side	Weakness
AHP	• Judgments can be easily revealed and the formal structure of the problem is clearly established. • Thanks to pairwise comparisons, a large number of detailed inputs are used. • Special issues of many peer-reviewed journals are devoted to AHP and the use of pairwise comparisons in decision making. • Economy, social, politics etc. It is a method that is applied and accepted in a wide area. • The use of the consistency ratio enables the determination of judgments that need to be re-evaluated.	• In difficult decision-making problems, standard assignments are involved in the problem rather than the decision maker. • Failure to make a clear distinction between options and attributes makes it difficult to clearly articulate the perceived problem. • The similarity of the proposed option may depend on whether the analysis includes a non-good option. • The decision maker needs to make many pairwise comparisons.
TOPSIS	• It requires choosing positive ideal and negative ideal solutions as reference points accepted by the decision maker. • The decision maker's goal is not only to increase profit as much as possible, but also to reduce risk as much as possible.	• In cases where different answers are given to the same problem, different methods are used instead of Euclidean distance to measure the distance between alternatives.
ELECTRE	• It has a wide range of usage and application in many practical problems, especially in French societies. • Considering decision maker satisfaction, the method is truly successful. • It can include qualitative and quantitative data together in problem solving. • There is no need for detailed data, which requires high levels of time and manpower resources. • By comparing the alternatives with each other, it examines the superiority relationship of binary preferability among the alternatives.	• It is not possible to investigate the robustness and sensitivity of the method in an automatic and interactive way. • Although threshold values C and D have a significant impact on the final result, they lack operational and psychological meaning. • Since the system does not have to be complete, it is sometimes insufficient to identify many preferred alternatives. • Since the method does not derive scores or weights, the numbers are arguably considered input to a complex algorithm. • It does not calculate the performance values of alternatives. Compares alternatives to each other.

ELECTRE management, one of the multi-criteria decision-making methods, is applied to economic/management problems, database selection, accounting and finance, capital investment, decision support, production, marketing, planning, risk analysis, application evaluations, group decision making, transportation, and weapons. It has areas of use in areas such as control, market selection, public sector, and information selection (Sezer, 2008). ELECTRE can generally list the application steps of the method as follows (Pang et al., 2011):

- Normalization of the decision matrix and creation of a weighted decision matrix,
- Determination of harmony and incompatibility clusters,
- Calculation of fit and mismatch indices,
- Calculation of net compliance and non-compliance indices,
- Ranking the alternatives according to their net compatibility and incompatibility indices.

Considering the above application steps, the operation of the method will be discussed in detail below (Ertuğrul & Karakaşoğlu, 2010; Çağıl, 2011; Tzeng & Huang, 2011; Rouyendegh & Erol, 2012):

Step 1: Creating the Decision Matrix

In the first step of this method, the decision matrix must be created. The rows of the decision matrix contain the alternatives whose advantages are to be listed, and the columns contain the criteria to be used in decision making. Matrix A is the initial matrix created by the decision maker and is shown as follows:

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ . & . & \dots & . \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix}$$

m = number of alternatives, n = number of criteria, aij = n of alternatives. It symbolizes the evaluation score in terms of criteria.

Step 2: Creating the Normalized Decision Matrix:

After constructing the decision matrix A in the first phase, the following formula should be used to generate the normalized (standard) decision matrix Xij. For the cost and benefit criteria, the following normalization techniques are utilized. In terms of benefit criteria:

$$x_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}} \qquad i = 1,2,K,\ldots,m \quad , \quad j = 1,2,K,\ldots,n \qquad (3.1)$$

and for cost criteria:

$$x_{ij} = \frac{1/a_{ij}}{\sqrt{\sum_{k=1}^{m} \left(\frac{1}{a_{kj}}\right)^2}} \qquad i = 1,2,K,\ldots,m \quad , \quad j = 1,2,K,\ldots,n \qquad (3.2)$$

Calculations are made using equations. As a result of the calculations, the Xij matrix is obtained as follows:

$$X_{ij} = \begin{bmatrix} x_{11} & x_{12} & \ldots & x_{1n} \\ x_{21} & x_{22} & \ldots & x_{2n} \\ . & . & \ldots & . \\ x_{m1} & x_{m2} & \ldots & x_{mn} \end{bmatrix}$$

Step 3: Creating the Weighted Normalized Decision Matrix:

The significance of assessment elements for the decision maker may vary. The Y matrix is computed in order to capture the variations in relevance among the criteria inside the ELECTRE solution. The first step for the decision maker is the determination of the weights (Wi) assigned to the assessment criteria. The weighted normalized decision matrix Y is then constructed by multiplying the components in each column of the normalized matrix X by their corresponding Wi values. The Y matrix is expressed mathematically as:

$$V_{ij} = \begin{bmatrix} w_1 x_{11} & w_2 x_{12} & \ldots & w_n x_{1n} \\ w_1 x_{21} & w_2 x_{22} & \ldots & w_n x_{2n} \\ . & . & \ldots & . \\ w_1 x_{m1} & w_2 x_{m2} & \ldots & w_n x_{mn} \end{bmatrix} \quad , \quad V_{ij} = W_j X_{ij} \quad , \quad \sum_{i=1}^{n} W_j = 1 \qquad (3.3)$$

Step 4: Determining Compatibility and Dissonance Clusters:

The Y matrix is used to determine harmony and dissonance clusters. Decision points are compared with each other in terms of evaluation factors. For each pairwise alternative comparison, the criteria are divided into two separate sets. Ap and Aq (1,2, ….., m and p ≠ q) are preferred to Ap in the fitness set.

$$C(p,q) = \left\{ j \middle| V_{pj} \geq V_{qj} \right\} \qquad (3.4)$$

If the alternative Ap is worse than Ap, a "mismatch cluster" is created.

$$D(p,q) = \left\{ j \middle| V_{pj} \leq V_{qj} \right\} \qquad (3.5)$$

Each harmony set corresponds to a mismatch set in the ELECTRE approach. In other words, there are equal numbers of discordance and harmony clusters.

Step 5: Calculation of Compliance and Discord Indices:

The ELECTRE approach incorporates two indices, namely the harmony index and the discordance index, to quantitatively assess the interrelationships among items. The fit index, denoted as C(a,b), quantifies the extent to which an is equal to or superior to b in terms of goodness of fit. Conversely, the incompatibility index D(a,b) quantifies the extent to which b is unequivocally favored over a. Match sets are utilized in

order to create the fit matrix (C). The elements of matrix C are computed using the equation presented in the following formula:

$$C_{pq} = \sum_{j^*} W_{j^*} \qquad (3.6)$$

The concordance index (Cpq) provides a measure of certainty about the outcome of pairwise comparisons. The factors included inside the fit set C(p,q) are denoted as j*. As an example, The C12 element of the C12 = {1,4} matrix may be expressed as C12 = W1 + W4. The matrix C is represented by the following expression:

$$C = \begin{bmatrix} - & c_{12} & c_{13} & \dots & c_{1m} \\ c_{21} & - & c_{23} & \dots & c_{2m} \\ . & . & . & \dots & . \\ c_{m1} & c_{m2} & c_{m3} & \dots & - \end{bmatrix}$$

The mismatch matrix (D) is created by using the mismatch set. The elements of the incompatibility matrix are calculated using the following formula:

$$D_{pq} = \frac{\left(\sum_{j=0} \left| v_{pj^0} - v_{qj^0} \right| \right)}{\left(\sum_{j} \left| v_{pj} - v_{qj} \right| \right)} \qquad (3.7)$$

Here j^0 are the factors in the mismatch set D (p,q). The D matrix is shown below:

$$D = \begin{bmatrix} - & d_{12} & d_{13} & \dots & d_{1m} \\ d_{21} & - & d_{23} & \dots & d_{2m} \\ . & . & . & \dots & . \\ d_{m1} & d_{m2} & d_{m3} & . & - \end{bmatrix}$$

Step 6: Making Superiority Comparison:

Once the compatibility and incompatibility indices have been computed, their components are examined in a specific manner, resulting in the removal of inappropriate alternatives. The degree of dominance shown by the Ap option over Aq is contingent upon the magnitude of the compatibility index Cpq and the diminutiveness of the incompatibility index Dpq. To begin, it is necessary to compute the mean values of variables C and D, denoted as ¬ $\bar{C}$ and $\bar{D}$, respectively.

If the cost of option P, denoted as Cpq, is more than or equal to the threshold cost $\bar{C}$, and the benefit of option P, denoted as Dpq, is less than or equal to the maximum benefit $\bar{D}$, then option P is considered more favorable than the alternative. The core (K) is comprised of the alternatives that have been picked using the ELECTRE process. The formation of a kernel (K) occurs in accordance with the following two scenarios:

1. A decision point (alternative) within K is not more dominant than another decision point (alternative) within K.

2. A decision point (alternative) outside K is below at least one point inside K in the preference ranking.

Step 7: Calculation of Net Compliance and Non-Compliance Indices:

If there are several alternatives inside the core, the selection process is based on the calculation of net compatibility and incompatibility. These indices are used to assess the relative dominance of one option over the others.

$$C_p = \sum_{\substack{k=1 \\ k \neq p}}^{m} C_{pk} - \sum_{\substack{k=1 \\ k \neq p}}^{m} C_{kp} \qquad (3.8)$$

$$D_p = \sum_{\substack{k=1 \\ k \neq p}}^{m} D_{pk} - \sum_{\substack{k=1 \\ k \neq p}}^{m} D_{kp} \qquad (3.9)$$

It is the alternate solution set with the highest net fit index and the lowest net discord index. Cps are listed from biggest to smallest, Dps are listed from smallest to largest, and the net compatibility and discordance indices are presented from smallest to largest. Equations are used to compute it. The final ranking is determined by picking the highest "C" and lowest "D" number.

3. CONCLUSION and RECOMMENDATIONS

The supply chain method is a difficult field to apply because food and beverage businesses use approximately 3000 items of product and 30% of these products consist of perishable products. However, by applying an effective supply chain method; It will be possible to introduce high-value-added products to food and beverage businesses. Due to both the high number of items that need to be supplied and the fact that some of these product groups are perishable; It is possible for food and beverage businesses to reduce their costs by choosing the right supplier. The tourism sector is a sector with high demand fluctuations compared to other sectors. For this reason, every decision must be taken carefully. In order for the managers to make the right decision, the data they have must be reliable and comparable to each other. For this purpose, Electre, one of the multi-criteria decision-making methods, was examined and it was concluded that it can be used in choosing the right supplier for food and beverage businesses. It is possible to choose the right supplier by carefully examining Electre's superiority comparisons and the incompatibility indices it produces because of the comparisons. Long-term agreements can be made with suppliers thanks to the supplier network that will be created by choosing the right supplier.

This study aims to be a pioneering study for the use of multi-criteria decision-making methods in supplier selection in the food and beverage industry. It is hoped that the prepared study will form the basis for future studies.

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