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DETERMINATION OF CRITERIA FOR ELECTRICAL DISTRIBUTION: CASE OF ERZURUM PROVINCE

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ABSTRACT

In the globalized world, manufacturing businesses are trying to remain sustainable in the eye of intense competition, the fast-changing technology, and the continually selective and informed customers who are gradually becoming difficult to please. Businesses must make specific decisions in all their activities. Most of these decisions are strategic decisions and thus affect the competitive position of the business. One of the most important of these decisions is the ability to develop strategies that will ideally meet customer needs. In this research, we sought to determine the criteria used by electricity distribution companies to disseminate electricity in a way that meets the energy requirement of both consumer and industrial markets. In this context, 9 expert opinions were obtained.

The aim of the study is to determine the delivery criteria used in supplier selection, supplier's production adequacy and general status, quality and price main criteria and their sub-criteria and the Analytical Hierarchy Process (AHP) method were used for this purpose. The results revealed that the main criteria for the electrical distribution are "Delivery" and " Supplier's production adequacy and general status". "Quality" was determined to be the other main criterion affecting the distribution of electricity based on the AHP method. The main criterion that had the least effect on the distribution of electricity was "Price". In addition, the Weighted Aggregates Sum Product Assessment **(***WASPAS) method used in the selection of the ideal firm showed option A_2 to be the most ideal firm. The overall ranking is; $A_2 > A_1 > A_5 > A_4 > A_3$.*

Keywords: *AHP, WASPAS, Electricity Distribution Criteria*

INTRODUCTION

In the intensely competitive globalized environment, businesses must produce products and services that can adequately respond to customer demands by using their limited resources in the most efficient way to sustain their assets and gain superiority over their competitors. Undoubtedly, the most important factor affecting the growth, development and success of businesses today is the customers, who are the reasons for existence. The most important goal of any business is to maximize profits, and the achievement of this depends on the extent to which the customers accept the products and services they produce. In addition, in the global competitive environment, all conflicting elements such as quality, cost, speed and flexibility need to be met at the same time.

Businesses have to perform certain activities in order to achieve their basic goals. One of these activities, the purchasing stage, is a complex process because of the multitude of alternatives and diversity of decisions. Companies will make choices based on the costs when they receive the same or similar products and services, and based on delivery when they need to produce products urgently and will make choices based on product and service quality when quality is so important to them. The selection process is simple when it is affected by a single criterion. It becomes more complicated when there is more than one criterion. In these cases, the firms often seek to make more rational decisions by using Multi-Criteria Decision Making (MCDM) methods.

In this study, we tried to determine the criteria used in the distribution of electricity, which is an important cost in manufacturing enterprises, as well as choose the most ideal distributor company. Since no study has been done to reveal the importance of the criteria used in electricity distribution in the literature, the criteria used in the selection of suppliers and the information obtained from expert opinions were applied in Erzurum with the AHP approach. In this process, known as procurement, it is necessary to choose among various suppliers using nd many decision criteria such as firms, products, services and company criteria and distances. In addition, WASPAS method was used for the companies that employ 50 and more workers in the manufacturing sector in order to select the most ideal company in 5 companies providing electricity distribution in Erzurum province.

In the first part of the study, we reviewed studies in the literature on supplier selection. In the second part, we give information on the AHP and WASPAS methods and in the subsequent section, we implement the two methodologies, followed by the presentation of the results and the conclusion as well as suggestions for future studies.

LITERATURE REVIEW

The interest in supplier selection has become increasingly important. As such, we highlight some of the studies on supplier selection in this section. In a study to determine the supplier selection criteria, Dickson (1966) sent a questionnaire to the procurement companies and managers in Canada and the United States. From the 50 criteria used, the studies identified a total of 23 criteria commonly used in supplier selection, among which quality, delivery and performance history were the three most important criteria. Dickson grouped these 23 criteria into four different groups according to their importance.

Weber et al. (1991) reviewed 74 articles published since 1966 on the basis of the 23 relevant criteria. The study found price, delivery and quality criteria to be the three most commonly used criteria. The relevant criteria were considered in 80%, 58% and 53% of the articles, respectively. In addition, one of the other important results of the study was the use of multiple selection criteria in 47 of 74 articles, in other words, 64%. This reflects the MCDM feature of the supplier selection problem. Many methods have been used in the literature in the supplier selection problem. Analytical Hierarchy Process (AHP) is one of the most commonly used methods. Tam and Tummala (2001) applied a 6-stage AHP method for supplier selection of a telecommunications system. In another study, Bhutta and Huq (2002) separately applied the AHP and Total Cost of Ownership methods to the supplier selection problem and compared the two methods. The results led to the determination that AHP was superior is the most important factor in the ability to evaluate both quantitative and qualitative factors.

Levary (2008) used the AHP method to evaluate foreign suppliers in three different countries based on a total of four criteria, namely, country risk, risk of shipping companies delivering from the relevant countries, supplier reliability and reliability of the supplier's own suppliers. The AHP method was used by itself as well as in integration with other methods. Ghodsypour and O'Brien (1998) used a combination of AHP and linear programming (LP) methods for the first time in their work to establish a model that takes into account qualitative and quantitative factors in supplier selection. The developed model provides a structure that enables the distribution of orders to maximize the Total Purchase Value by selecting the best supplier.

In another article, Ha and Krishnan (2008) presented a model based on the calculation of the Combined Supplier Score. In the method developed, AHP was used in the evaluation of alternative suppliers' quantitative criteria, while Data Envelopment Analysis (DEA) and Neural Networks (NN) methods in evaluating the qualitative criteria. The model was applied to the problem of supplier selection in an automobile factory. Gencer and Gürpınar (2007), on the other hand, presented a model that uses Analytical Network Process (ANP) to evaluate the relationship between supplier selection criteria in feedback systematic. Demirtaş and Üstün (2008) used the multiple-objective mixed-integer linear programming Method together with ANP. Criteria are considered in 4 different clusters: benefit, opportunity, cost and risk (BOCR).

Çelebi and Bayraktar (2008) applied DEA and NN methods together in the supplier selection problem. Choy et al. (2002) presented an intelligent supplier management tool by bringing together Case-Based Reasoning (CBR) and NN methods to continuously monitor and compare supplier performance. Galankashi et al. (2015) aimed to prioritize green supplier selection criteria using the fuzzy AHP method. In addition, Rezaei et al. (2015) applied the best-worst case method (BWM) for cooking oils in the context of a food supply chain.

Song et al. (2017) used the DEMATEL method to rank sustainable supplier selection criteria for solar-powered air conditioner manufacturers. Ren and Lützen (2017) used fuzzy AHP method to select alternative energy sources in transportation. Wang and Tsai (2018) weighted the selection of solar panels by using fuzzy AHP and data enveloping method for use in a solar power-plant.

RESEARCH METHOD

This study used two-stage integrated MCDM methods to determine the importance of the criteria used in the distribution of electricity by manufacturing enterprises with 50 or more employees, as well as to determine the ideal electricity distribution company. The AHP was used to determine the criterion weights in the first step, and the WASPAS method used to determine the alternatives in the second step. In this section, the AHP and WASPAS methods, which are used to evaluate the importance of the criteria used in electricity distribution and ranking the most ideal electricity distribution companies, are explained.

PURPOSE AND SCOPE OF RESEARCH

The aim of this study was to determine the importance of the criteria used in the distribution of electricity. In this context, a face-to-face interview was conducted with 9 experts in Erzurum followed by a 9-scale questionnaire, containing bilateral comparison questions (Saaty, 2008, 122-196). The criteria for this study were determined based on expert opinions, literature review and Chamber of Industry, Commerce and enterprises as shown in the table below.

AHP METHOD

AHP, developed by Thomas L. Saaty in 1977, is one of the commonly used MCDM methods for solving complex problems. This method ranks decision alternatives in order of importance within the framework of the criteria determined by the decision-maker among many options (Clemen and Reilly, 2013; 118-121, Erdal and Akgün, 2014: 93, Korucuk and Erdal, 2018: 286-288).

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Step 1: Decision-making problem is defined.

At this stage, the problem is separated into sub-problems in a hierarchical order.

Step 2: An inter-criterion comparison matrix is created.

The inter-criterion comparison matrix is a square matrix of *nxn* dimensions. In the one-to-one comparison of criterions, Saaty's 1-9 significance scale is used (Saaty, 2008). Binary comparisons are the most important step of the AHP method. Relative measurement values are used to obtain binary comparisons.

Step 3: The percent significance distributions of the criteria are determined.

To determine the percent significance distributions of the criterion, the column vectors that make up the comparison matrix are used and *n* B column vectors are generated from *b* components. The formula (1) is used in the calculation of B column vectors.

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \qquad (1)$$

When *n* B column vectors are combined in a matrix format, the matrix C shown below is obtained.

$$C = \begin{bmatrix} c_{11} & c_{12} & \dots & c_{1n} \\ c_{21} & c_{22} & \dots & c_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ c_{n1} & c_{n2} & \dots & c_{nn} \end{bmatrix}$$

By using C matrix, percentage significance distributions showing the importance values of the criteria relative to each other can be obtained. For this purpose, the arithmetic mean of the row components forming the matrix C is taken and the column vector W, called the Priority Vector is obtained as shown in formula (2).

$$w_i = \frac{\sum_{j=1}^{n} c_{ij}}{n} \qquad (2)$$

Step 4: The consistency in criterion comparisons is measured.

Although the AHP has a consistent system in itself, the realism of the results will naturally depend on the consistency of the criterion comparisons made by the decision-maker between the criteria. AHP provides the possibility to test the consistency of the obtained Consistency Ratio (CR) with the priority vector found and hence one-to-one comparisons between the criteria. In a study where only AHP is used, both criteria and alternatives must comply with the 7 ± 2 rule (this rule is explained in detail by Saaty and Özdemir (2003)). Otherwise, it leads to inconsistency, which in turn leads to the final consistency rates of the established AHP model greater than 0.10. The essence of the CR calculation is a comparison of the number of criteria and a coefficient called the Basic Value (λ). For the calculation of λ, first, the column vector D is obtained from the product of the comparison matrix A and the priority vector W matrix.

$$D = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} x \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ w_n \end{bmatrix}$$

(3) as defined in the formula, the fundamental value (E) for each evaluation criterion is obtained from the section of the elements of the D column vector and the W column vector. The arithmetic mean of these values (formula (4)) gives the basic value for comparison (λ).

$$E_i = \frac{d_i}{w_i} \quad i = 1,2,\dots,n \qquad (3)$$

$$\lambda = \frac{\sum_{i=1}^{n} E_i}{n} \qquad (4)$$

After calculating λ, the Consistency Indicator (CI) is calculated using the formula (5).

$$CI = \frac{\lambda - n}{n-1} \qquad (5)$$

In the last stage, the CR value is obtained by dividing the CI by the standard correction value called Random Indicator (RI) (formula (6)).

$$CR = \frac{CI}{RI} \qquad (6)$$

The calculated CR value of less than 0.10 indicates that the comparisons made by the decision-maker are consistent. CR value greater than 0.10 indicates either a calculation error in the AHP or the inconsistency of the decision maker's comparisons.

WASPAS METHOD

This method, developed by Chakraborty and Zavadskas in 2012, is an MCDM approach that combines the results of WSM (Weighted Sum Model) and WPM (Weighted Product Model) and is also one of the methods that increase the accuracy of ranking (Zavadskas, et al., 2013: 3).

According to the study by Chakraborty et al., (2015), a decision matrix must be first created first in order to analyze this method. In order to normalize the decision matrix, the following equation (7) and equation (8) are used.

$$\bar{x}ij = \frac{\bar{x}ij}{maksi\ \bar{x}ij} \qquad (7)$$

$$\bar{x}ij = \frac{mini\ \bar{x}ij}{\bar{x}ij} \qquad (8)$$

According to Zavadskas et al., (2013), the total relative significance value for each alternative is first calculated according to the Weighted Total Model as in equation (9) and the total relative significance value for each alternative is calculated with the help of Equation (10).

$$Q_i^{(1)} = \sum_{j=1}^{n} w_j r_{ij} \qquad (9)$$

$$Q_i^{(2)} = \prod_{j=1}^{n} r_{ij}^{wj} \qquad (10)$$

Šaparauskas et al. (2011), in their study, calculated the combined optimality value for each alternative. This value obtained by using Equation (11) is calculated by taking into consideration the Weighted Sum Model and Weighted Product Model results.

$$Q_i = \lambda Q_i^{(1)} + (1-\lambda) Q_i^{(2)} = \lambda \sum_{j=1}^{n} \bar{x}ij\, w_j + (1-\lambda) \prod_{j=1}^{n} (\bar{x}ij)^{wj}, \lambda = 0,0,1,\ldots,1 \qquad (11)$$

IMPLEMENTATION

In this study, two-stage integrated MCDM methods were used to determine the importance of the criteria used in electricity distribution and to determine the most ideal electricity distribution company in manufacturing enterprises with 50 or more employees. The integrated AHP-WASPAS approach applied is shown schematically in Figure 1. According to the model; firstly, the criteria related to logistic risk factors were determined using expert opinions and literature review.

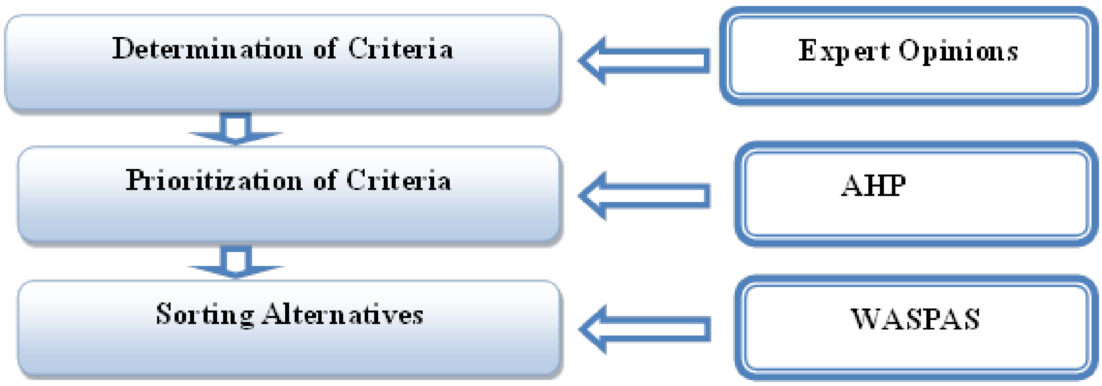

Figure.1 Integrated AHP-WASPAS implementation stages.

Since the criteria were not of equal importance, weighting was required. In this context, the AHP method was used to weight the electricity distribution criteria based on expert opinions. WASPAS method was then used to select the best electricity distribution company using weighted criteria. Table.1 below shows expert opinions and literature review used in determining the criteria.

Table.1 Decision Criteria

Main Criteria	Subcriteria	Reference
Delivery (C1)	Presence of Electricity Outage (C11)	Dickson (1966), Weber et al. (1991)
	Speed of Electricity (C12)	Dickson (1966), Weber et al. (1991), Tam and Tummala (2001)
Supplier's production adequacy and general status (C2)	Technological capacity and distance status (C_{21})	Chen et al. (2006)
	Technical/ machine proficiency and reputation (brand) and experience (C_{21})	Chen et al. (2006), Tam and Tummala (2001)
	Renewable Energy Production (C_{23})	Choy et al. (2002)
Quality (C_3)	Compliance with Product Specifications (C_{31})	Dickson (1966), Weber et al. (1991)
	Number of Quality / Product Certificate (C_{32})	Dickson (1966), Weber et al. (1991)
	Defective Product Return Ratio (C_{33})	Dickson (1966), Weber et al. (1991)
Price (C_4)	Service Rate (C_{41})	Dickson (1966), Weber et al. (1991)
	Discount Rate (C_{42})	Dickson (1966), Weber et al. (1991)
	Scoring (Tariff Diversity)(C_{43})	Dickson (1966), Weber et al. (1991)

WEIGHTING of CRITERIA

In this stage, the AHP method was used and a paired comparison questionnaire was developed to evaluate the criteria. A questionnaire was presented to 9 experts who are stakeholders in the participating enterprises. Accordingly, the consistency analysis of the paired comparison matrix was performed and the CR value was determined as 0.055. The fact that CR is less than 0.10 indicates that the results of matrix comparisons are consistent. In this context, Table 2 below presents the weight values of the main and sub-criteria.

Table.2 Weight Values for Main Criteria and Sub-Criteria

Main Criteria	Weights	Subcriteria	Local Weights	Global Weights
Delivery	0,457	Presence of Electricity Outage	0,533	0,243
		Speed of Electricity	0,467	0,214
Supplier's production adequacy and general status	0,367	Technological capacity and distance status	0,444	0,163
		Technical/ machine proficiency and reputation (brand) and experience	0,382	0,140
		Renewable Energy Production	0,173	0,064
Quality	0,145	Compliance with Product Specifications	0,512	0,074
		Number of Quality / Product Certificate	0,316	0,046

		Defective Product Return Ratio	0,172	0,025
Price	0,076	Service Price	0,439	0,033
		Discount Rate	0,226	0,017
		Scoring (Tariff Diversity)	0,335	0,026

According to Table 2, "*Delivery*" and " *Supplier's Production Adequacy and General Status*" were determined to be the most important main criteria for electricity distribution. "*Price*" was the main criterion that has the least impact on electricity distribution. Under the main criterion of "*Delivery*", " *Presence of Electricity Outage*" was found to be the most important subcriterion of the model. Under "*Supplier's Production Adequacy and General Situation*" *"Technological Capacity and Distance Situation*" is the sub-criterion with the most effect on the model, and under *"Quality*", the subcriterion that has the most effect on the model was "*Compliance with Product Specification* ". Under the last main criterion "*Price*","*Service Price*" was found to be the most impactful.

RANKING ALTERNATIVES

In this section, WASPAS method was used to rank the alternatives. Using the weights of the criteria obtained from AHP, the WASPAS method was used to perform the selection of the ideal company in the distribution of electricity. WASPAS questionnaire was used to evaluate each alternative within the framework of previously determined decision criteria. During the evaluation, participants were asked to give a score of 1-5 (1-worst, 5-best) to each alternative. The decision matrix of Table 3 is formed by taking the geometric mean of the points given by the decision-makers.

Table.3 Decision Matrix for WASPAS Method

Alternatives	C_1 Max.	C_2 Max.	C_3 Max.	C_4 Min.
A_1	3,79170	2,92249	4,27808	3,57754
A_2	4,64158	3,99804	2,02634	2,09216
A_3	2,96099	2,72315	2,28942	2,36379
A_4	2,02634	3,94304	3,81899	3,36494
A_5	3,93196	2,86388	4,04202	3,94304

Although the criteria are desired to be maximum and minimum, Table 4 was obtained using equation 4.

Table.4 WASPAS Method Normalized Decision Matrix

Criteria Weights	0,417	0,357	0,145	0,081
Alternatives	C_1	C_2	C_3	C_4
A_1	0,81689	0,73098	1	0,58480
A_2	1	1	0,47365	1
A_3	0,63792	0,68112	0,53515	0,88508
A_4	0,43656	0,98624	0,89268	0,62175
A_5	0,84711	0,71632	0,94528	0,53059

Q (1) values of the alternatives were calculated using the normalized decision matrix and equation 6 according to the Weighted Sum Model (WSM).

Table.5 Calculating the Total Relative Importance of Alternatives with WSM

Alternatives	C_1	C_2	C_3	C_4	$Q^{(1)}$
A_1	0,34064	0,26095	0,14500	0,04736	0,79395
A_2	0,41700	0,35700	0,06867	0,10810	0,92367
A_3	0,26601	0,24315	0,07759	0,07169	0,65844
A_4	0,18204	0,35208	0,12943	0,05036	0,71391
A_5	0,35324	0,25572	0,13706	0,04297	0,78899

Q (2) values of each alternative were calculated with the help of Equation 7 from the data in the normalized decision matrix in Table 3 and shown in Table 6.

Table.6 Calculating the Total Relative Importance of Alternatives with WPM (Weighted Product Model)

Alternatives	C_1	C_2	C_3	C_4	$Q^{(2)}$
A_1	0,91911	0,89415	1	0,95747	0,78687
A_2	1	1	0,89730	1	0,89730
A_3	0,82906	0,87188	0,91333	0,99016	0,65369
A_4	0,70778	0,99506	0,98367	0,96223	0,66661
A_5	0,93314	0,88771	0,99187	0,94996	0,78050

Using equation 8 (calculated as $\lambda = 0.5$), the relative and total significance levels of the alternatives were calculated in Qi and the obtained ranking is given in Table 7.

Table.7 Ranking Alternatives

Alternatives	$Q^{(1)}$	$Q^{(2)}$	$Q^{(i)}$	**Ranking**
A_1	0,79395	0,78687	0,79041	2
A_2	0,92367	0,89730	0,91048	1
A_3	0,65844	0,65369	0,65606	5
A_4	0,71391	0,66661	0,69026	4
A_5	0,78899	0,78050	0,78474	3

Table 7 shows that the most ideal firm in manufacturing enterprises is A2. The overall ranking is; A2> A1> A5> A4> A3.

CONCLUSION and DISCUSSION

Today, the success of enterprises does not only depend on the superiority of their activities or the positions of strength against their competitors but also on the accuracy and consistency of their long- and short-term decisions. Accurate and effective decisions take the business a step forward in the competitive environment while wrong decisions may cause businesses to lose their advantage or even disappear entirely. He most important task in the decision-making process undoubtedly falls on the business managers. In today's environment, full of uncertainty and continued difficulties in predicting the future, decision-making has become one of the most important tasks of management, to the extent of being considered as one of the business functions. Decision making also plays a vital role in the success of the managers. The results of this study, conducted to determine the importance of the criteria used in the distribution of electricity, reveal that the most important main criteria in the electricity distribution are "*Supplier Production Adequacy and General Status*" and "*Delivery*". On the other hand, "*Quality*" was found to be the other main criterion affecting electricity distribution. "*Price*" the main criterion that has the least impact on electricity distribution.

The results of the WASPAS method applied to the companies operating in the manufacturing sector and employing more than 50 workers, the most ideal company was the A2. The overall ranking is; A2> A1> A5> A4> A3.

The problem addressed in this study can be applied to different sectors. Similarly, the impact of different combinations of criteria affecting electricity distribution can be examined in future studies. In addition, different methods (e.g. DEMATEL, ELECTRE, TOPSIS, etc.) for prioritization of criteria affecting electrical distribution could be used and the results compared with those in this study.

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