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E-Ticaretteki Pazaryeri Satıcı Seçimi Problemine Bulanık Hibrit Yaklaşım

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ÖZ

Günümüz şartları göz önüne alındığında ve COVID-19 küresel salgının ortaya çıkması durumu internet ticaretini zorunlu olarak arttırmıştır. Bu durum satıcıların çeşitlenmesi ve farklı sektörlerde sayılarının artmasına sebep olmuştur. İnternet satıcılarının artması müşteriler için hangi ürünü hangi satıcıdan nasıl alacağı konusunda karar vermesini zorlaştırmıştır. Bu sebeple pazaryeri siteleri incelenmiş ve müşterilerin tercihini etkileyen en önemli kriterler belirlenmiştir. Bu kriterlerin çoğu, karar vericilerin bulanık ifadeler kullanarak ifade edebilecekleri dilsel terimlere dayanmaktadır. Bu çalışmada, Bulanık Analitik Hiyerarşi Prosesi ve Bulanık Hiyerarşik TOPSIS yöntemlerinin birleştirilmesiyle bir hibrit model kullanılarak satıcı seçim problemi çözülmüştür. Çalışmada, satıcı puanları, müşteri yorumları ve alanında uzman kişilerden görüş alınmıştır. Üç ana kriter ve on yedi alt kriter belirlenmiş ve Bulanık Hibrit Yaklaşıma uygulanmıştır. Uygulanan hibrit yöntemin sonuçlarına göre en etkili ana kriter 0,68 ağırlıkla satıcının genel özellikleri olarak bulunmuştur. Satıcı ile iletişim kolaylığı ise 0,30 ağırlıkla bu ana kriterin bir alt kriterinden elde edilmiştir. Böylelikle yapılan analizler sonucunda müşterilerin satıcının genel özelliklerine ve satış sonrası iletişime diğer kriterlere göre çok daha önem verdiği görüşüne varılmıştır. Önerilen hibrit model Türkiye'deki pazaryeri satıcı seçimi problemine başarıyla uygulanmıştır.

A Fuzzy Hybrid Approach to the Marketplace Seller Selection Problem in E-Commerce

Research Article

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ABSTRACT

Considering today's conditions and the sudden emergence of the COVID-19 epidemic disease, internet commerce has necessarily increased. This situation has led to the diversification of vendors and an increase in their number in different sectors. The increase in internet sellers has made it difficult for customers to decide which product to buy from which seller and how. For this reason, the marketplace sites were examined and the most important criteria affecting the preferences of the customers were determined. Most of these criteria are based on linguistic terms that decision makers can express using fuzzy expressions. In this study, vendor selection problem is solved using a hybrid model by combining Fuzzy Analytical Hierarchy Process and Fuzzy Hierarchical TOPSIS methods. In the study, seller ratings, customer comments and opinions from experts in the field were taken. Three main criteria and seventeen sub-criteria were determined and applied to the Fuzzy Hybrid Approach. According to the results of the applied hybrid method, the most effective main criterion was found to be the general characteristics of the seller with a weight of 0.68. Ease of communication with the seller was obtained from a sub-criterion of this main criterion with a weight of 0.30. Thus, as a result of the analyzes made, it was concluded that the customers attach more importance to the general characteristics of the seller and to the after-sales communication than the other criteria. The proposed hybrid model has been successfully applied to the marketplace vendor selection problem in Turkey.

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1. Introduction

Nowadays, the rapidly growing consumption craze is often seen as e-shopping. It is also necessary not to ignore the negative situations encountered in the phases after the delivery of the purchased products. When it is desired to compare the characteristics of the desired products, and to take into account the qualities of the vendor, it can be questioned how and by what a decision should be made. Occasionally, this situation can become inextricable. In order to avoid this situation, it may be necessary to make the solution quantitative in order to be able to deal with a qualified vendor and to increase the satisfaction after sales. Deciding on how to buy, as well as features such as vendor and product selection, can be a time-consuming and misleading situation. The reason for this is the decrease in the level of reliability of the market together with the increase in websites and the increasing number of vendors. It is a controversial issue to discuss how effectively a product from any site and any vendor is handled, and the problems encountered after it is reached. The decision-making process starts from this stage. In order to conclude the decision-making correctly and effectively; in this study, the Fuzzy TOPSIS (Technique For Order Preference By Similarity To An Ideal Solution) method was used, which was formed by integrating fuzzy logic in Chang's extended analysis method and multi-criteria decision making methods. These methods are effective methods to solve the problem and make the results quantitative. When we look at the literature, we can see that decision-making problems are solved by integrating multi-criteria decision-making methods into fuzzy logic. Decision making can be done by a variety of methods, such as the Chang Method, fuzzy AHP (Analytic Hierarchy Process), fuzzy TOPSIS, fuzzy DEMATEL (Decision making trial and evaluation laboratory), and fuzzy MOORA (Multi-Objective Optimization Method by Ratio Analysis). Fuzzy AHP and TOPSIS, which are used for social areas including health and financial issues, are given in chronological order. Chan and Al-Hawamdeh (2002), Chan and Al-Hawamdeh studied government e-commerce training in Singapore. (Heo et al., 2010) aimed to determine the analysis of the evaluation factors for the evaluation of the renewable energy dissemination program using extended fuzzy AHP. Guler (2012), in the hospitality industry, aimed to expose the success factors of yield management practices with extended scope analysis.Taylan et al., (2014) aimed to use analytical tools to assess the overall risks of construction projects and their incomplete, uncertain situations. They put risk into an appropriate category and developed strategies and, at the same time, tried to eliminate the high risk factors. In this study, they benefited from the fuzzy AHP and fuzzy TOPSIS methods. Mandic et al., (2014) applied the fuzzy AHP and TOPSIS methods to analyze the financial parameters of Serbian banks. The aim of their work was to propose a fuzzy multi-criteria model that will facilitate the evaluation of financial performance. In her study, Zile (2015) developed a computer program based on A fuzzy logic by addressing a problem in occupational health and safety, and established a risk valuation analysis model. Besikci et al., (2016) tried to take measures that could be applied to operational energy efficiency by using the fuzzy AHP method in order to reduce ship fuel consumption in the maritime industry. Ly et al., (2016) developed a theory to evaluate the factors affecting the internet of thinks by using a blurred AHP analysis using a fuzzy set, and developing a rule-based decision support mechanism. Alizadeh et al., (2016) used the fuzzy AHP and TOPSIS methods together to select the most effective of various methods for processing alunite, a source of aluminum. Pandey et al., (2017) proposed an approach to assessing human resources and technology criteria based on the combined fuzzy AHP and fuzzy DEMATEL methods. Dožić et al., (2018) developed the approach to the choice of passenger aircraft type using the fuzzy AHP method and to select the types of aircraft that meet the requirements of the airline.Sirisawat and Kiatcharoenpol (2018) used the fuzzy AHP and fuzzy TOPSIS methods in their study for the electronics industry where; they compare the weight of each barrier by two-way, and proposed the methodology of sorting weights in the reverse logistics area. Ligus and Peternek (2018) tried to determine the most suitable low-emission energy technologies in Poland by using fuzzy AHP-TOPSIS methods in an integrated manner. Li et al., (2018) in their work determined the weights of the relationship between performance shaping factors and fuzzy logic to evaluate the reliability of the analytic hierarchy process more objectively, thus a fuzzy AHP based method was created. Aytore and Hasgul (2020) developed road selection for autonomous trucks in Turkey with fuzzy AHP. Ordu et al., (2021) aimed to better manage the process against the Covid19 epidemic by evaluating the productivity efficiency of the regions against the pandemic epidemic with the data envelopment technique.

Fuzzy AHP and TOPSIS used for security, risk and industry are given in chronological order. Junior et al., (2014) using the fuzzy AHP and fuzzy TOPSIS methods, making a comparison between the supplier, tried to create a model for selection. Akkaya et al., (2015) conducted a study by determining the criteria for evaluating the sectors that may be selected in the future, by applying an integrated fuzzy AHP and fuzzy MOORA approach to the problem of the industrial engineering sector. Sharma et al., (2018) tried to rank success factors using the fuzzy AHP method to improve safety and security in order to improve supply chain management in the sustainable food sector. Calabrese et al., (2018) aimed to develop a method for the selection of sustainability issues by integrating sustainability into the strategic decision-making process with the blurred AHP method. Li and Wei (2018) proposed a new mixed method based on the AHP method and THOWA method by determining criteria to solve the selection problem of the distribution systems. Abdel Basset et al., (2019) aimed at matching uncertain and incomplete information, which had a significant impact on risk management, using the neutrophilic analytic hierarchy process (N-AHP) and (N-TOPSIS) to integrate risks in the supply chain. Fuzzy AHP and TOPSIS methods used for environmental problems are given in chronological order. Amiri (2010) developed suggestions for project selection for the development of oil fields using the AHP and fuzzy TOPSIS methods of multi-criteria decision-making techniques and interpreted the results. Wichapa and Khokhajaikiat (2017) in their study, used a fuzzy AHP and target programming to make a case study on infectious waste centers and address the problem of multi-purpose facility layout. Gupta (2018) aimed to determine order preference by using a three-phase methodology in the last stage of the fuzzy TOPSIS method in order to evaluate the performance of the organizations on the basis of the role of green human resources management, their environmental management, and their applications in green management. Ordu and Fedai (2021) combined to optimize operations using three different methods. In the study, composable design and analysis, journey data envelopment analysis (DEA) and analysis process (AHP).

When all studies are considered, it is possible to see that the fuzzy AHP and fuzzy TOPSIS methods can be used as an effective solution method. When the literature is examined and the studies are analyzed, it has been chosen for the study with the result that fuzzy logic is effective and reliable, and AHP and TOPSIS methods are more accurate and precise results when combined with fuzzy logic.

2. Fuzzy Sets and Fuzzy Numbers

Zadeh (1965) was the first researcher to have the idea of fuzzy set theory: he proposed such a theory to handle vagueness in human thought and expression. Membership grades constitute the basis of objects found within a fuzzy set class definition. In this definition, each object is given a membership attribute and a membership function sets this attribute between 0 and 1.

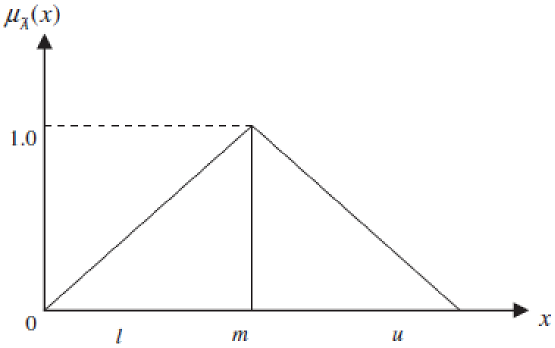

Figure 1. Triangle Membership Function

The tilde symbol, '~', is placed above to show that the number represents a fuzzy set. As seen in Figure.1, parameter l represents the smallest possible value, m is the most promising value and u is the largest possible value. A fuzzy event is defined by using these parameters (l,m,u) and known as a triangular fuzzy number (TFN), $\tilde{M}$.

The membership function of a TFN could be given as;

$$\mu(x|\widehat{M}) = \begin{cases} 0, & x < 1 \\ (x-l)/(m-l), & l \le x \le m, \\ (u-x)/(u-m), & m \le x \le u \\ 0, & x > u \end{cases} \tag{1}$$

A fuzzy number is always characterized using its corresponding left and right membership degrees, where the left side and right side representation of a fuzzy number are denoted by $l(y)$ and $r(y)$, respectively.

$$\widehat{M} = (M^{l(y)}, M^{r(y)}$$

$$= (l + (m - l)y , u + (m - u) y) \; y \in [0,1] \tag{2}$$

3. Proposed Model

The proposed model was designed to be used in single level, multi-attribute decision making (MADM) problems. Figure. 2 shows a general MADM hierarchy when a single decision objective, and criteria hierarchies are considered. The goal of the decision making process is situated on top of the decision hierarchy. In the first stage, criteria sets and alternatives are determined according to the context of the decision problem. A common approach is to list the alternatives and criteria set conducting a market analysis. The method assigns this step to the decision makers, and then the goal is solved through the evaluation of the alternatives according to the criteria provided by the decision makers.

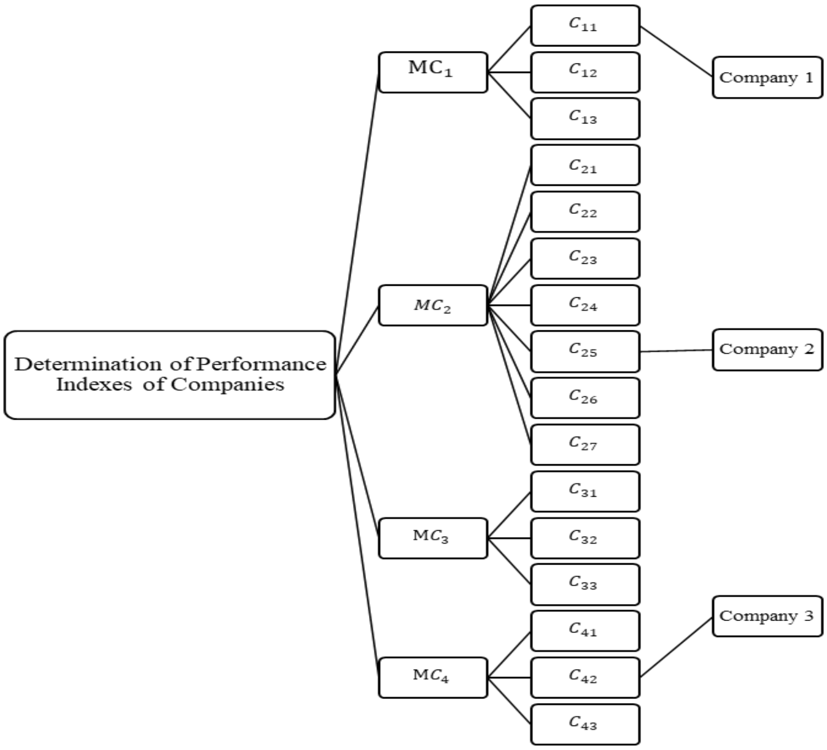

Figure 2. Hierarchical Structure

In the second stage, Chang's extent analysis model is used in order to calculate criteria weights (Ligus and Peternek, 2016). Ranking of the alternatives are obtained in the third stage of the model by using the fuzzy TOPSIS method. In order to solve MADM, our hybrid model combines the theoretical fundamentals from Chang’s extent analysis with the fuzzy TOPSIS method. Figure. 3 shows the activity diagram for the proposed hybrid model.

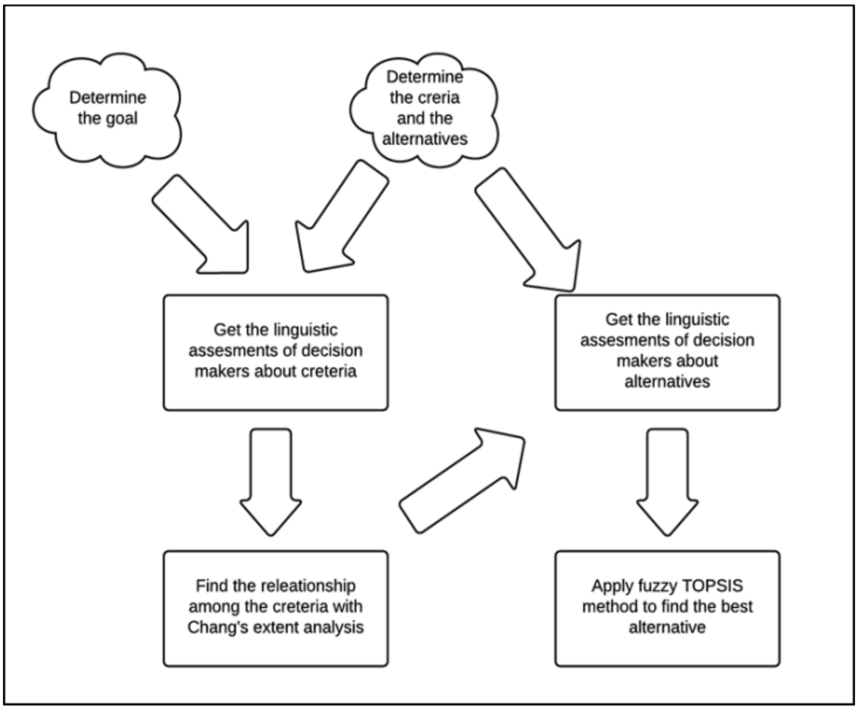

Figure 3. Hybrid model activity diagram

3.1. Fuzzy Analytic Hierarchy Process for Criteria Weights

The root of FAHP is extended to fuzzy set theory, which was proposed by Zadeh (1965). Instead of using crisp values, Buckley utilized fuzzy ratios. By doing so, Buckley introduced a hierarchical structures analysis environment. (Ali and Zadeh, 2016).

In the second stage of the proposed model, the weights of criteria are calculated by using Chang’s extent analysis. Initially, we define X= $\{x_1, x_2, x_3 \ldots.\}$ and G= $\{u_1, u_2, u_3 \ldots. u_m\}$ as an object set, and a goal set, respectively. According to the principles of Chang’s extent analysis, each object is taken correspondingly, and extent analysis for each of the goals, g_i, is implemented in order to obtain the values of *m* extent analyses with the following signs:

$$M_{g1}^{1}, M_{g2}^{2} \ldots., M_{gi}^{m}, \qquad i = 1,2,..n \qquad (3)$$

where Mg_{ij} (j= 1,2,….m) are triangular fuzzy numbers. After these assumptions are defined, Chang’s extent analysis includes four main steps:

Step 1: The value of the fuzzy synthetic extent with respect to the i^{th} object is defined as,

$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1'}^{m} M_{gi}^{j}\right]^{-1}$, and the fuzzy addition operation of m extent analysis value is performed for particular matrices such that:

$$\sum_{j=1}^{m} M_{gi}^{j} = \sum_{j=1}^{m} l_j \ , \ \sum_{j=1}^{m} m_j \ , \sum_{j=1}^{m} u_j$$

$$\sum_{i=1}^{n} \sum_{i=1}^{m} M_{gi}^{j} = \sum_{i=1}^{n} l_i \ , \ \sum_{i=1}^{n} m_i \ , \sum_{i=1}^{n} u_i$$

$$\left[\sum_{i=1}^{n} \sum_{j=1'}^{m} M_{gi}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i} \ ,\frac{1}{\sum_{i=1}^{n} m_i} \ , \ \frac{1}{\sum_{i=1}^{n} l_i}\right)$$

(4)

Step 2: The degree of possibility of M_2, such that $M_{2=} (l_2,m_2,u_2) \geq M_1$ is defined as $V(M_1 \geq M_1) = sup_{x \geq y} \lfloor \min (\mu_{M1}(x), \mu_{M2}(y)) \rfloor$

$V(M_1 \geq M_2) = \sup_{x \geq y} \lfloor \min(\mu_{M_1}(x), \mu_{M_2}(y)) \rfloor$ and can be denoted as:

$$V(M_2 \geq M_1) = \mu_{M1}(M_1 \cap M_2) = \mu_{M1}(d)$$
(5)

$$= \begin{cases} 1, & if \quad m_2 \geq m_{1,} \\ 0, & if \quad l_1 \geq u_{2,}, \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & , otherwise \end{cases}$$

Where d is the ordinate of the highest intersection point between μ_{M1} and μ_{M2}. The values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$ are needed in order to compare accordingly.

Step 3: The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers $M_i = (I = 1,2,....,k)$ can be defined by

$$V(M \geq M_1, M_2, ... M_k) = V[(M \geq M_1) \ and \ (M \geq M_2) \ .... \ and \ (M \geq M_k)]$$

$$= \min V(M \geq M_i), i = 1,2,3,...k$$

(6)

Assuming that, $d(A_i) = \min V(S_i \geq S_k), for = 1,2,3,..n; k \neq i$ Then, the weight vector is given by $W' = (d'(A_1), d'(A_2), ..., d'(A_n))^T$,where A_i= (1,2,3,…,n) are n elements.

Step 4: Normalized weight vectors $W = \left(d(A_1), d(A_2), \ldots., d(A_n)\right)^T$ are obtained after normalization. W is a nonfuzzy number that represents the priority weights of attributes (Ligus and Peternek, 2018).

3.2. Fuzzy TOPSIS for Alternative Ranking

In the third stage of the proposed model, the alternatives are ranked using the fuzzy TOPSIS method. There are numerous techniques in order to sort the alternatives based on a criteria set such as ELECTRE, TOPSIS, AHP, and PROMETHEE. The TOPSIS method was first proposed by Hwang and Yoon (Amiri, 2010), and is built on the shortest distance and longest distance mechanism. A preferable solution should have a short distance to the positive-ideal solution and a long distance to the negative ideal solution. Therefore, in order to be ranked first an alternative must have both shortest distance to positive ideal solution and farthest distance to negative ideal solution at the same time. The term Ideal solution is used to show the best criteria value, which is attainable from the alternatives under consideration. Negative ideal solution is used to indicate the opposite: worst criteria value which is attainable from the alternatives under consideration (Amiri, 2010). However, it is not generally feasible to get a direct value from a decision maker about any criteria in a typical decision problem.

When decision maker evaluations are vague, fuzzy logic substitutes as a good method to be used in solving MADM problems. When fuzzy theory is used along with the TOPSIS method it is called fuzzy TOPSIS. Fuzzy TOPSIS was developed as an extension of TOPSIS in order to encapsulate linguistic evaluations of alternatives and criteria (Wichapa and Khokhajaikiat, 2017). A great number of applications for fuzzy TOPSIS can be found in the literature (Zadeh, 1965; Chang, 1996; Mardani et al., 2015; Calabrese et al., 2018).

3.2.1. Alternative Set Definition and Obtaining Decision Maker Linguistic Assessment

At the beginning of the fuzzy TOPSIS method, the alternatives are assessed with respect to each criterion using the linguistic values given in Table 1, accordingly.

Table 1. Saaty's 1–9 linguistic scale (Buckley, 1985)

Linguistic terms	Triangular fuzzy numbers	Intensity of importance
Equal	$\tilde{1}$	(1,1,1)
Weak	$\tilde{3}$	(2/3,1,3/2)
Fairly strong	$\tilde{5}$	(3/2,2,5/2)
Very strong	$\tilde{7}$	(5/2,3,7/2)
Absolutely	$\tilde{9}$	(7/2,4,9/2)

The fuzzy assessment values are held in a $\widetilde{\mathrm{Y}}$ matrix. $\tilde{y}_{ij}$ holds the specific assessment of the decision maker for alternative *i* according to criteria *j* where (i=1,2,…,k),(j=1,2,…,l). k is the number of alternatives and l is the number of criteria at the lowest level of the decision hierarchy.

3.2.2. Normalizing the Fuzzy Assessment Matrix

The Normalized value $\tilde{n}_{ij} = (n_{ij,l},\ n_{ij,m},\ n_{ij,u})$ is calculated as;

$$\tilde{n}_{ij} = \frac{\tilde{x}_{ij}}{\sqrt{\sum_{i=1}^{m}(\mathrm{s}(\tilde{x}_{ij},0)^2)}} \quad , j = 1,\ n$$

where; $\mathrm{s}\left(\tilde{x}_{ij}, 0\right) = \frac{1}{4}(x_{ij,l} + 2x_{ij,m} +\ x_{ij,u})$

(7)

3.2.3. Calculating the Weighted Normalized Decision Matrix

The weights found in section 3.1 are used while calculating $\tilde{v}_{ij}$. The weighted matrix

$\tilde{v}_{ij} = (v_{ij,l},\ v_{ij,m},\ v_{ij,u})$ is calculated as;

$$\tilde{v}_{ij} = \mathrm{w_j} * \ \tilde{n}_{ij}$$

(8)

3.2.4. Determining the Positive Ideal Solutions and Negative Ideal Solutions

The set of positive ideal solutions and negative ideal solutions are given as follows;

$$\mathrm{A}^{+} = \{\tilde{v}_1^{+}, \tilde{v}_2^{+}, \dots, \tilde{v}_n^{+} = \left(\tilde{v}_{uj}\middle|\ j\ \in J\right), \left(\tilde{v}_{dj}\middle|\ j \in\ J'\right)\}$$

$$\mathrm{A}^{-} = \{\tilde{v}_1^{-}, \tilde{v}_2^{-}, \dots, \tilde{v}_n^{-}\} = \{\left(\tilde{v}_{dj}\middle|\ j\ \in J\right), \left(\tilde{v}_{uj}\middle|\ j \in J'\right)\} \quad (9)$$

Where *J* is associated with the positive criteria while J' is associated with the negative criteria.

3.2.5. Positive and Negative Distance Calculations of Alternatives

Each distance is calculated according to the following equations;

$$d_i^{+} = \sqrt{\sum_{j=1}^{\mathrm{n}}(\mathrm{s}(\tilde{v}_{\mathrm{j}}^{+}, \tilde{v}_{ij})^2)},\ i = 1,2, \dots, m\ ;$$

$$d_i^{-} = \sqrt{\sum_{j=1}^{\mathrm{n}}(\mathrm{s}(\tilde{v}_{\mathrm{j}}^{-}, \tilde{v}_{ij})^2)},\ i = 1,2, \dots, m)$$

(10)

3.2.6. Calculating the Relative Distances and Alternative Ranking

Relative distances are computed according to the following equations;

$$cl_i^{+} = \frac{d_i^{+}}{d_i^{+} + d_i^{-}}, i = 1, 2, \dots, k$$

$$cl_i^{-} = \frac{d_i^{-}}{d_i^{+} + d_i^{-}}, i = 1, 2, \dots, k$$

(11)

As mentioned before, in the classical TOPSIS method the most preferred alternative should simultaneously have the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution, which also certainly reflects the rational of human choice. Finally, the best alternative could be determined by using cl_i^{+} and cl_i^{-} parameters.

4. Application of the Proposed Hybrid Model to the Marketplace Vendor Selection Problem in E- Commerce

Surveys were created for this stage and the surveys were designed to reveal what customers pay attention to when choosing a vendor. The purpose of this application is to determine customer satisfaction levels.

4.1. Stage 1: The Goal of the Study is that Criteria and Hierarchy Determination

In this stage, the criteria and their hierarchy were determined. The goal definition for the proposed selection problem was given as; *"A Fuzzy Hybrid Approach to The Marketplace Vendor Selection Problem in E-Commerce"*. In order to gather the necessary information regarding the selection problem, customer reviews of Turkish E-Commerce Sites, and customer satisfaction surveys on websites and expert opinions were used. As a result of this researches, evaluation criteria were determined.

Based on the expert's experience, three main criteria (M) were determined forthe marketplace vendor selection problem in e- commerce (see Table 2),(General characteristics of the vendor (M1), properties of the product (M2), delivery and shipment (M3)).

Table 2. List of main criteria used in this problem

1. General Features of Seller
2. Product Features
3. Delivery and Shipment

4.2. Stage 2: Finding Main Criteria Weights

After determining main criteria, the evaluation table was created after a series of meetings with the experts, where they outlined their opinions about criteria based on the scale given in Table 3 (see Table 4).

Table 3. Pair wise comparison scale

Linguistic expression	**Triangular Fuzzy Numbers**	
	Number	**Equivalent of the number**
Equally important	(1,1,1)	(1,1,1)
Poorly more important	(2/3, 1, 3/2)	(2/3, 1, 3/2)
Fairly more important	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)
Highly more important	(5/2, 3, 7/2)	(2/7, 1/3, 2/5)
Extremely more important	(7/2, 4, 9/2)	(2/9, 1/4, 2/7)

Table 4. Evaluation of port selection main criteria

	M1	**M2**	**M3**
M1	(1, 1, 1)	(1, 1, 1)	(5/2, 3, 7/2)
M2	(2/3, 1, 3/2)	(1, 1, 1)	(2/3, 1, 3/2)
M3	(2/7,1/ 3, 2/5)	(2/3, 1, 3/2)	(1, 1, 1)

M*: Main criteria

After applying the Step-1 procedures of Chang's methodology to Table 4, the following fuzzy synthetic extent values (S) for each of main criteria were calculated accordingly.

S_{M1} (4.17, 5.00, 6.00) (1/12.9, 1/10.33, 1/8.45) = (0.32, 0.48, 0.71)
S_{M2} (2.33, 3.00, 4.00) (1/12.9, 1/10.33, 1/8.45) = (0.18, 0.29, 0.47)
S_{M3} (1.95, 2.33, 2.90) (1/12.9, 1/10.33, 1/8.45) = (0.15, 0.23, 0.34)

Based on the previously calculated fuzzy synthetic extent values and Step-3 procedures, the following $V(S_i>S_j)$ values were obtained. The values were found as explained in step two of Chang's methodology.

Table 5. Degree of possibility fuzzy number assessment

$V(S_i>S_j)$	**S_{M1}**	**S_{M1}**	**S_{M1}**
S_{M1}	-	0.40	0.07
S_{M2}	1.00	-	0.70
S_{M3}	1.00	1.00	-

Next, the weight for each criterion was calculated by applying the following equation to Table 5; $d(A_i) = \min V(S_i \geq S_k)$. Therefore, the minimum values of rows were used for calculating W_G. Then, W_G values were normalized to between 0 and 1.

W_G = (1.00, 0.40, 0.07)
Normalized W_G = (0.68 0.27 0.05)

4.3. Stage 2: Finding Sub-criteria Weights

After sub-criteria for the general characteristics of the vendor have been determined, (G), the evaluation table was created after a series of meetings with the experts where they outlined their opinions about the criteria based on the scale given in Table 6. (Ensuring communication with the vendor (G1), after-sales support service (G2), careful rigorous sales policy (G3), checking the products for damage (G4), vendor's product (G5), vendor's star rating (G6), vendor's positive comments (G7), vendor's negative comments (G8)).

Table 6. Sub criteria for the general characteristic of the seller

	G1	**G2**	**G3**	**G4**	**G5**	**G6**	**G7**	**G8**
G1	(1, 1, 1)	(5/2, 3, 7/2)	(5/2, 3, 7/2)	(7/2,4, 9/2)	(7/2, 4, 9/2)	(5/2, 3, 7/2)	(5/2, 3, 7/2)	(7/2,4, 9/2)
G2	(2/7,1/3,25)	(1, 1, 1)	(7/2, 4, 9/2)	(5/2,3, 7/2)	(5/2, 3, 7/2)	(3/2, 2, 5/2)	(5/2, 3, 7/2)	(5/2,3, 7/2)
G3	(2/7,1/3, 2/5)	(2/3, 1,3/2)	(1, 1, 1)	(5/2,3, 7/2)	(5/2, 3, 7/2)	(2/3, 1, 3/2)	(5/2, 3, 7/2)	(5/2,3, 7/2)
G4	(2/9,1/4, 2/7)	(2/9,1/4,2/7)	(2/9,1/4, 2/7)	(1, 1, 1)	(7/2, 4, 9/2)	(3/2, 2, 5/2)	(5/2, 3, 7/2)	(5/2,3, 7/2)
G5	(2/9,1/4,27)	(2/9,1/4,2/7)	(2/9,1/4, 2/7)	(5/2,3, 7/2)	(1, 1, 1)	(2/3, 1, 3/2)	(5/2, 3, 7/2)	(7/2,4, 9/2)
G6	(5/2,3,7/2)	(2/9,1/4,2/7)	(2/9,1/4, 2/7)	(3/2,2, 5/2)	(2/9, 1/4,2/7)	(1, 1, 1)	(3/2, 2, 5/2)	(1, 1, 1)
G7	(2/7,1/3, 2/5)	(2/9,1/4,2/7)	(2/9,1/4, 2/7)	(5/2,3, 7/2)	(2/7,1/3, 2/5)	(2/5,1/2, 2/3)	(1, 1, 1)	(3/2,2, 5/2)
G8	(2/7,1/3, 2/5)	(2/9,1/4,2/7)	(2/9,1/4, 2/7)	(2/3,1, 3/2)	(2/9, 1/4,2/7)	(1, 1, 1)	(2/5,1/2, 2/3)	(1, 1, 1)

After applying the Step-1 procedures of Chang's methodology to Table 6, the following fuzzy synthetic extent values (S) for each of the sub criteria were calculated accordingly.

S_{G1} (21.50 25.00 28.50) (1/28.5, 1/25, 1/21.5) = (0.18 0.23 0.31)
S_{G2} (18.28 21.33 24.40) (1/28.5, 1/25, 1/21.5) = (0.15 0.20 0.27)
S_{G3} (14.00 16.58 19.18) (1/28.5, 1/25, 1/21.5) = (0.11 0.16 0.21)
S_{G4} (13.78 15.91 18.08) (1/28.5, 1/25, 1/21.5) = (0.11 0.15 0.20)
S_{G5} (11.50 13.16 14.86) (1/28.5, 1/25, 1/21.5) = (0.09 0.12 0.16)
S_{G6} (4.84 5.57 6.38) (1/28.5, 1/25, 1/21.5) = (0.04 0.05 0.07)
S_{G7} (4.24 5.07 6.04) (1/28.5, 1/25, 1/21.5) = (0.03 0.05 0.07)
S_{G8} (3.68 3.99 4.42) (1/28.5, 1/25, 1/21.5) = (0.03 0.04 0.05)

Based on the previously calculated fuzzy synthetic extent values and Step-3 procedures, the following $V(S_i>S_j)$ values were obtained. Values were found as explained in step two of Chang's methodology.

Table 7. Degree of possibility fuzzy number assessment

$V(S_i>S_j)$	**S_{G1}**	**S_{G1}**	**S_{G1}**	**S_{G1}**	**S_{G1}**	**S_{G1}**	**S_{G1}**	**S_{G1}**
S_{G1}	-	0.75	0.30	0.20	0.00	0.00	0.00	0.00
S_{G2}	1.00	-	0.60	0.50	1.00	0.00	0.00	0.00
S_{G3}	1.00	1.00	-	0.64	0.55	0.00	0.00	0.00
S_{G4}	1.00	1.00	1.00	-	0.00	0.00	0.00	0.00
S_{G5}	1.00	1.00	1.00	1.00	-	0.00	0.00	0.00
S_{G6}	1.00	1.00	1.00	1.00	1.00	-	1.00	0.50
S_{G7}	1.00	1.00	1.00	1.00	1.00	1.00	-	0.66
S_{G8}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-

Next, the weight for each criterion was calculated by applying the following equation to Table 7; $d(A_i) = \min V(S_i \geq S_k)$. Therefore, the minimum values of rows were used for calculating W_G. Then, W_G values were normalized between 0 and 1.

W_G = (1.00 0.75 0.30 0.20 0.00 0.00 0.00 0.00)

Normalized W_G = (0.44 0.33 0.13 0.09 0.00 0.00 0.00 0.00)

After determining the sub-criteria of the properties of the product (U), the evaluation table was created after a series of meetings with the experts where they outlined their opinions about criteria based on the scale given in Table 8. (Warranty of the product (U1), return of the product (U2), free installation of the product (U3), compliance of the product with the description (U4), ease of payment of the product (U5)).

Table 8. Properties of the product sub criteria

	U1	**U2**	**U3**	**U4**	**U5**
U1	(1, 1, 1)	(7/2, 4, 9/2)	(7/2, 4, 9/2)	(7/2, 4, 9/2)	(7/2, 4, 9/2)
U2	(2/9, 1/4,2/7)	(1, 1, 1)	(7/2, 4, 9/2)	(5/2, 3, 7/2)	(7/2, 4, 9/2)
U3	(2/9, 1/4,2/7)	(2/9, 1/4,2/7)	(1, 1, 1)	(7/2, 4, 9/2)	(5/2, 3, 7/2)
U4	(2/9, 1/4,2/7)	(2/7, 1/3, 2/5)	(2/9, 1/4, 2/7)	(1, 1, 1)	(5/2, 3, 7/2)
U5	(2/9, 1/4,2/7)	(2/9, 1/4,2/7)	(2/7,1/ 3, 2/5)	(2/7,1/ 3, 2/5)	(1, 1, 1)

U*: Properties of the product sub criteria

After applying the Step-1 procedures of Chang's methodology to Table 8, the following fuzzy synthetic extent values (S) for each of sub criteria were calculated accordingly.

S_{U1} (15.00, 17.00, 19.00) (1/50.16, 1/44.74, 1/39.38) = (0.30, 0.38, 0.48)
S_{U2} (10.72, 12.25, 13.78) (1/50.16, 1/44.74, 1/39.38) = (0.21, 0.27, 0.35)
S_{U3} (7.44, 8.50, 9.56) (1/50.16, 1/44.74, 1/39.38) = (0.15, 0.19, 0.24)
S_{U4} (4.22, 4.83, 5.46) (1/50.16, 1/44.74, 1/39.38) = (0.08, 0.11, 0.14)
S_{U5} (2.00, 2.16, 2.36) (1/50.16, 1/44.74, 1/39.38) = (0.04, 0.05, 0.06)

Based on the previously calculated fuzzy synthetic extent values and Step-3 procedures, the following $V(S_i>S_j)$ values were obtained. The values were found as explained in step two of Chang's methodology.

Table 9. Degree of possibility fuzzy number assessment

$V(S_i>S_j)$	S_{U1}	S_{U2}	S_{U3}	S_{U4}	S_{U5}
S_{U1}	-	0.31	0.00	0.00	0.00
S_{U2}	1.00	-	0.27	0.00	1.00
S_{U3}	1.00	1.00	-	0.00	0.00
S_{U4}	1.00	1.00	1.00	-	0.00
S_{U5}	1.00	1.00	1.00	1.00	-

Next, the weight for each criterion was calculated by applying the following equation to Table 9; $d(A_i) = \min V(S_i \geq S_k)$. Therefore, the minimum values of rows were used for calculating W_G. Then, W_G values were normalized between 0 and 1.

$$W_G = (1.00 \quad 0.31 \quad 0.00 \; 0.00 \quad 0.00)$$

$$\text{Normalized } W_G = (0.76 \quad 0.24 \quad 0.00 \quad 0.00 \quad 0.00)$$

After sub-criteria of delivery and shipment (T) are determined, the evaluation table was created after a series of meetings with the experts where they outlined their opinions about criteria based on the scale given in Table 10. (Delivery fee (T1), product stock status (T2), product lead time (T3), good packaging during shipment (T4)).

Table 10. Delivery and shipment sub criteria

	T1	**T2**	**T3**	**T4**
T1	(1, 1, 1)	(7/2, 4, 9/2)	(5/2, 3, 7/2)	(5/2, 3, 7/2)
T2	(2/9, 1/4, 2/7)	(1, 1, 1)	(5/2, 3, 7/2)	(5/2, 3, 7/2)
T3	(2/7, 1/3, 2/5)	(2/7, 1/3, 2/5)	(1, 1, 1)	(5/2, 3, 7/2)
T4	(2/7, 1/3, 2/5)	(2/7, 1/3, 2/5)	(2/7, 1/3, 2/5)	(1, 1, 1)

T*: Delivery and shipment sub criteria

After applying Step-1 procedures of Chang's methodology to Table 10, the following fuzzy synthetic extent values (S) for each of sub criteria were calculated accordingly.

$$S_{T1} \quad (9.50 \quad 11.00 \quad 12.50) \quad (1/28.28,\ 1/24.90, 1/21.62) = \quad (0.34 \quad 0.44 \quad 0.58)$$

$$S_{T2} \quad (6.22 \quad 7.25 \quad 8.28) \quad (1/28.28,\ 1/24.90, 1/21.62) = \quad (0.22 \quad 0.29 \quad 0.38)$$

$$S_{T3} \quad (4.06 \quad 4.66 \quad 5.30) \quad (1/28.28,\ 1/24.90, 1/21.62) = \quad (0.14 \quad 0.19 \quad 0.25)$$

$$S_{T4} \quad (1.84 \quad 1.99 \quad 2.20) \quad (1/28.28,\ 1/24.90, 1/21.62) = \quad (0.07 \quad 0.08 \quad 0.10)$$

Based on the previously calculated fuzzy synthetic extent values and Step-3 procedures, the following $V(S_i>S_j)$ values were obtained. The values were found as explained in step two of Chang's methodology.

Table 11. Degree of possibility fuzzy number assessment

$V(S_i>S_j)$	S_{T1}	S_{T2}	S_{T3}	S_{T4}
S_{T1}	-	0.21	0.00	1.00
S_{T2}	1.00	-	0.23	1.00
S_{T3}	1.00	1.00	-	1.00
S_{T4}	1.00	1.00	1.00	-

Next, the weight for each criterion was calculated by applying the following equation to Table 11; $d(A_i) = \min V(S_i \geq S_k)$.Therefore, the minimum values of rows were used for calculating W_G. Then, W_G values were normalized between 0 and 1.

W_G = (1.00 0.21 0.00 1.00)

Normalized W_G = (0.452 0.095 0.00 0.452)

Table 12 summarizes the interactions between the weights of the main criteria and the sub-criteria.

Table 12. Integration of Weight of Main Criteria and Sub-Criteria

Main Criteria	Main Criteria's Weight	Sub-Criteria	Sub-Criteria's Weight	Integration of Weight of Main Criteria and Sub-Criteria
M1	0,68	G1	0.44	0.30
		G2	0.33	0.22
		G3	0.13	0.09
		G4	0.09	0.06
		G5	0.00	0.00
		G6	0.00	0.00
		G7	0.00	0.00
		G8	0.00	0.00
M2	0,27	U1	0.76	0.21
		U2	0.24	0.06
		U3	0.00	0.00
		U4	0.00	0.00
		U5	0.00	0.00
M3	0,05	T1	0.45	0.02
		T2	0.09	0.00
		T3	0.00	0.00
		T4	0.45	0.02

4.4. Stage 3: Applying Fuzzy TOPSIS

At this stage of the study, the fuzzy TOPSIS method was used to rank vendor alternatives. Alternative vendors are designated A1, A2 and A3 respectively. The experts evaluated three alternative vendor with regards to the evaluation criteria using linguistic terms (see Table 13). The linguistic terms were converted to fuzzy values using Table 1 as seen in Table 14. After getting fuzzy values for the market place vendor selection problem in the E-commerce problem, the normalized fuzzy assessment table was derived (see Table 15).

Table 13. Linguistic port site evaluation

Criterion	**Alternative1 (A1)**	**Alternative2 (A2)**	**Alternative3 (A3)**
G1. Contact the seller	Fairly	Weak	Very strong
G2. Support after sale	Fairly strong	Weak	Very strong
G3. Attentive and rigorous sales policy	Equal	Weak	Fairly strong
G4. Checks whether products are broken, broken or defective	Equal	Weak	Fairly strong
G5. Seller invoices the product and submits the original	Equal	Fairly strong	Fairly strong
G6. Seller's Star Rating	Equal	Weak	Fairly strong
G7. Seller's Positive Number of reviews	Weak	Weak	Weak
G8. Seller's Negative comments count	Weak	Weak	Weak
U1. Product warranty	Fairly strong	Fairly strong	Fairly strong
U2. Right of return and exchange of the product	Equal	Equal	Equal
U3. Free installation of the product	Weak	Weak	Equal
U4. The product complies with the specifications stated in the descriptions	Weak	Equal	Weak
U5. Ease of Payment for Products	Equal	Equal	Equal
T1. Delivery Fee	Equal	Equal	Equal
T2. Availability of Product	Fairly strong	Fairly strong	Abloute
T3. Product Supply Time	Weak	Weak	Weak
T4. Good packaging during shipment	Very strong	Fairly strong	Fairly strong

Table 14. Fuzzy values of port site evaluation

Criteria	**A1**	**A2**	**A3**
G1. Contact the seller	(3/2, 2, 5/2)	(2/3,1, 3/2)	(5/2,3,7/2)
G2. Support after sale	(3/2, 2, 5/2)	(2/3,1, 3/2)	(5/2,3,7/2)
G3. Attentive and rigorous sales policy	(1, 1, 1)	(2/3,1, 3/2)	(3/2,2,5/2)
G4. Checks whether products are broken, broken or defective	(1, 1, 1)	(2/3,1, 3/2)	(3/2,2,5/2)
G5. Seller invoices the product and submits the original	(1, 1, 1)	(2/3,1, 3/2)	(3/2,2,5/2)
G6. Seller's Star Rating	(1, 1, 1)	(2/3, 1,3/2)	(3/2,2,5/2)
G7. Seller's Positive Number of reviews	(2/3, 1, 3/2)	(2/3,1, 3/2)	(2/3,1,3/2)
G8. Seller's Negative comments count	(2/3, 1, 3/2)	(2/3 1, 3/2)	(2/3,1,3/2)

U1. Product warranty	(3/2, 2, 5/2)	(3/2 2, 5/2)	(3/2,2,5/2)
U2. Right of return and exchange of the product	(1,1,1)	(1,1,1)	(1,1,1)
U3. Free installation of the product	(2/3, 1, 3/2)	(2/3,1, 3/2)	(1,1,1)
U4. The product complies with the specifications stated in the descriptions	(2/3, 1, 3/2)	(1,1,1)	(2/3,1,3/2)
U5. Ease of Payment for Products	(1,1,1)	(1,1,1)	(1,1,1)
T1. Delivery Fee	(1,1,1)	(1,1,1)	(1,1,1)
T2. Availability of Product	(3/2, 2, 5/2)	(3/2,2,5/2)	(7/2,4,9/2)
T3. Product Supply Time	(2/3, 1, 3/2)	(2/3,1,3/2)	(2/3,1,3/2)
T4. Good packaging during shipment	(5/2,13,7/2)	(3/2,2,5/2)	(3/2,2,5/2)

Table 15. Normalized Fuzzy Assessment

Criterion	A1	A2	A3
G1	(0.4, 0.5, 0.7)	(0.2, 0.3, 0.4)	(0.7, 0.8, 0.9)
G2	(0.4, 0.5, 0.7)	(0.2, 0.3, 0.4)	(0.7, 0.8, 0.9)
G3	(0.4, 0.4, 0.4)	(0.3, 0.4, 0.6)	(0.6, 0.8, 1.0)
G4	(0.4, 0.4, 0.4)	(0.3, 0.4, 0.6)	(0.6, 0.8, 1.0)
G5	(0.3, 0.3, 0.3)	(0.5, 0.7, 0.8)	(0.5, 0.7, 0.8)
G6	(0.4, 0.4, 0.4)	(0.3, 0.4, 0.6)	(0.6, 0.8, 1.0)
G7	(0.4, 0.6, 0.8)	(0.4, 0.6, 0.8)	(0.4, 0.6, 0.8)
G8	(0.4, 0.6, 0.8)	(0.4, 0.6, 0.8)	(0.4, 0.6, 0.8)
U1	(0.4, 0.6, 0.7)	(0.4, 0.6, 0.7)	(0.4, 0.6, 0.7)
U2	(0.6, 0.6, 0.6)	(0.6, 0.6, 0.6)	(0.6, 0.6, 0.6)
U3	(0.4, 0.6, 0.8)	(0.4, 0.6, 0.8)	(0.6, 0.6, 0.6)
U4	(0.4, 0.6, 0.8)	(0.6, 0.6, 0.6)	(0.4, 0.6, 0.8)
U5	(0.6, 0.6, 0.6)	(0.6, 0.6, 0.6)	(0.6, 0.6, 0.6)
T1	(0.6, 0.6, 0.6)	(0.6, 0.6, 0.6)	(0.6, 0.6, 0.6)
T2	(0.3, 0.4, 0.5)	(0.3, 0.4, 0.5)	(0.7, 0.8, 0.9)
T3	(0.4, 0.6, 0.8)	(0.4, 0.6, 0.8)	(0.4, 0.6, 0.8)
T4	(0.6, 0.7, 0.8)	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)

Weights obtained at the end of section 4.2 were used in order to find the weighted normalized decision matrix, given in Table 16.

Table 16. Weighted normalized decision matrix

Criterion	A1	A2	A3
G1	(0.0, 0.1, 0.1)	(0.0, 0.0, 0.)	(0.1, 0.1, 0.1)
G2	(0.0, 0.0, 0.1)	(0.0, 0.0, 0.0)	(0.1, 0.1, 0.1)
G3	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)
G4	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)

G5	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)
G6	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)
G7	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)
U1	(0.3, 0.4, 0.6)	(0.3, 0.4, 0.6)	(0.3, 0.4, 0.6)
U2	(0.1, 0.1, 0.1)	(0.1, 0.1, 0.1)	(0.1, 0.1, 0.1)
U3	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)
U4	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)
U5	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)
T1	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)
T2	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)
T3	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)
T4	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)	(0.0, 0.0, 0.0)

Positive and negative ideal solutions were found after finding the weighted normalized matrix. A+ and A^- sets were found as follows;

A^+= {(0.01, 0.01, 0.01), (0.00, 0.00, 0.00), (0.00, 0.00, 0.00), (0.01, 0.01, 0.01), (0.05, 0.06, 0.08),…., (0.00, 0.00, 0.00)}

A^-={(0.01, 0.01, 0.01), (0.00, 0.00, 0.00), (0.00, 0.00, 0.00), (0.01, 0.01, 0.01), (0.01, 0.01, 0.01), ….,(0.00, 0.00, 0.00)}

Table 17 presents the positive and negative distances to the ideal solution based on the TOPSIS method.

Table 17. Distance values of each alternative from the positive and negative ideal solutions

Alternative	**d^+**	**d^-**
A1	0.02449	0.04293
A2	0.055952	0.008567
A3	0.036405	0.080376

Based on the positive and negative distances to the ideal solution, relative distances were calculated by using the equations given in section 3.2.6. Table 18 shows the relative distances to the ideal solution for the three given alternative vendors and show which vendor is the best choice. After we examined the results, we could conclude that A2 is the best vendor with a cl+ value of 0.867224 and a cl- value of 0.132776. A1 takes second place in the preferred order and A3 is the last choice.

Table 18. Relative distances

Alternative	**cl^+**	**cl^-**
A1	0.363252	0.636748
A2	0.867224	0.132776
A3	0.311738	0.688262

5. Conclusions

After the emergence of the Covid-19 epidemic, internet selling entered a period when it reached its peak, and in this period, everything from food to drink, from clothing to health began to be sold over the internet. Having to shop online has become an inevitable situation brought together by people's fear of pandemics and pandemic restrictions. This situation directly affected internet sellers as well, making it difficult for consumers to decide which shopping site to choose. At this point, the question of which seller in the selected site is more reliable arose. Thus, with the aim of increasing the efficiency of national shopping sites; preventing customers from turning to international shopping sites, and finding the shortcomings of national shopping sites will be financially valuable for our country. For this reason, in this study what customers pay attention to when choosing shopping sites, vendors and products was investigated. At the same time, customer satisfaction surveys and customer comments on shopping sites were examined in detail.

In this paper, we have seen a vendor may be selected using the alternative approach of a new hybrid model. After following the steps of the proposed model, the best vendor alternative can be selected. The main criterion (M) that the customers attach most importance to is the general characteristics of the vendor (M1) with 0.68, while the most important sub-criterion is the ability to communicate with the vendor (G1) with a value of 0.30. It is seen that they prefer A2 with 0.86 in vendor selection. Thus, it has been proved that the results of these research are in parallel with the results of the applied methods. Further research could benefit from the application of the other multi-attribute evaluation methods, such as fuzzy PROMETHEE and fuzzy DEMATEL, to the present selection problem and the comparison of the results.

Statement of Conflict of Interest

Author has declared no conflict of interest.

Author’s Contributions

The contribution of the author is 100%.

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