SELECTING THE SUITABLE E-COMMERCE MARKETPLACE WITH NEUTROSOPHIC FUZZY AHP AND EDAS METHODS FROM THE SELLER'S PERSPECTIVE IN THE CONTEXT OF COVID-19

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ABSTRACT

E-commerce, which is defined as making commercial transactions in an electronic environment, is becoming widespread with the increase of the use of internet and mobile devices. COVID-19 has greatly changed the consumption habits of individuals, increasing interest in electronic sales channels. Regardless of their size, most companies and retailers are currently looking for ways to engage their customers through electronic channels due to the effect of COVID-19. In this process, the rapidly increasing trend of electronic commerce raises an important question for companies, "In which e-marketplace should we sell?" In this study, five criteria that are important in the choice of the right e-marketplace were determined and eight online alternative e-marketplaces were evaluated. The study was carried out using the neutrosophic fuzzy AHP and EDAS methods, which are multi-criteria decision making techniques, and a framework was established for choosing the right e-commerce marketplace for sellers.

Keywords: e-commerce; e-marketplace; pandemic; COVID-19; Multi-Criteria Decision Making; Neutrosophic Fuzzy AHP; EDAS

1. Introduction

Coronavirus disease (COVID-19) began in China and spread all over the world in a short time causing a global health crisis in 2020. During this crisis, countries have tried to reduce the number of cases and deaths and control the social impact of the pandemic with various national and international measures. The implementation of social distancing rules, personal isolation and quarantine practices have caused socio-

economic changes in societies around the world. One of these changes has been in the shopping habits of people from all walks of life. The COVID-19 pandemic has increased online spending, impacting investments in e-commerce and digital advertising. The pandemic almost forced individuals to meet their product and service needs on the internet (Erdoğan, 2020).

Developing technologies create innovations on a global scale. The internet, which becomes more and more a part of our lives every day, causes people's habits to change. The use of social media platforms has increased the most, followed by online video platforms and online sales channels (Taşdemir, 2018).

The intense use of the Internet has led to changes in the purchasing habits of consumers. Retailers, as well as consumers, have turned to online commerce because profit margins increase by selling at lower costs on internet platforms. These buying and selling transactions made through the internet are called e-commerce (Gürpınar, 2007). E-commerce is constantly growing worldwide, and the largest share of this growth belongs to huge online marketplaces. Many sellers today use existing online marketplaces because building and growing their own website is risky and time consuming. Online marketplaces such as Amazon and Alibaba, which are increasing in volume every day, are important platforms for sellers to grow their business in e-commerce. Online sellers have been known to increase their retail sales by 1250% when using these large e-marketplaces (Karlson, 2021).

An e-marketplace is defined as an inter-organizational information system that provides a 'virtual space' where multiple buyers and sellers can collaborate (e.g., exchange information on product/service offerings, either generic or industry-specific, and their prices) and transact (e.g., sell and buy products/services and pay for them), very often supported by a variety of services (e.g. financial, transport, logistic, etc.) (Loukis et al., 2011).

The COVID-19 pandemic has influenced traditional trade since the beginning of 2020. Traditional trade shares have become volatile and declined sharply. In 2020, the global gross domestic product (GDP) declined by 4.3%. Global commerce in products has decreased by 9%, while global trade in services has decreased by 15% (Sirimanne, 2021). The COVID-19 situation caused significant growth in e-commerce and a rise in the use of the internet to purchase services and products (Abraham, 2021). The World Trade Organization (WTO) stated that this is the time for e-commerce to save the global economy, and that it should intervene with vigor and vitality to demonstrate the importance and success of e-commerce in the field of e-trade and online purchasing (Abdelrhim and Elsayed, 2020). Thus, from 2019 to 2020, the shares of e-commerce of global retail climbed from 14% to 17%. In China, for example, between August 2019 and August 2020, the online retail share climbed from 19.4% to 24.6%. Over the same time period, Kazakhstan's internet retail share climbed from 5% to 9.4%. Between February and March 2020, the number of shopping applications downloaded in Thailand climbed by 60% (Sirimanne, 2021). Consistent with this situation, COVID-19 has been a strong motivator for each of the traditional market traders to move to Internet trade in order to preserve their

remaining shares and maintain their commercial field and market success (Abdelrhim and Elsayed, 2020). Therefore, the aim of this study is to show how sellers/retailers should select an e-marketplace to sell their products or services.

An e-marketplace selection literature investigation shows that most of the studies were performed from the buyer's viewpoint (Duan et al., 2010; Ozkok and Pappalardo, 2013; Kahraman et al., 2018; Wibowo and Yunianto, 2019; Lubis et al., 2022; Yunianto and Taryadi, 2022). They explain how buyers evaluate e-marketplaces and determine where to buy products. In the e-marketplace literature, there is very little research about evaluation of e-marketplaces from the seller's perspective (Schu and Morschett, 2017; Hidayat et al., 2021).. Therefore, another aim of this study is to fill this gap by evaluating e-marketplaces from the seller's perspective.

Multi-criteria decision making (MCDM) is the process of choosing the best option among alternatives by considering multiple criteria. MCDM is widely used in the literature in various fields to evaluate alternatives on the basis of criteria. The Analytic Hierarchy Process (AHP) is a widely used method in the literature to weight evaluation criteria. The Evaluation Based on Distance from Average Solution (EDAS) method is very useful in decision problems with conflicting criteria and is widely used in various problems in the literature such as evaluating steam boiler alternatives (Kundakcı, 2019), evaluating the barriers to renewable energy adoption (Asante et al., 2020), assessment of solid waste management performance (Behzad et al., 2020), supplier selection (Keshavarz-Ghorabaee et al., 2016; Karaşan and Kahraman, 2017), airline evaluation (Keshavarz-Ghorabaee et al., 2017e), hospital selection (Gündoğdu et al., 2018), inventory evaluation (Ilieva et al., 2018), evaluation of bank branches (Keshavarz-Ghorabaee et al., 2017c), ERP deployment strategy selection (Erkayman et al., 2018), solid waste disposal site selection (Kahraman et al., 2017), and financial performance evaluation of a food and drink index (Aldalou and Perçin, 2020). The EDAS method is used in various MCDM problems; however, we did not find any study evaluating e-marketplaces with the EDAS method. Thus, another aim of this study is to expand the use of this method.

In this study, a framework was created using neutrosophic fuzzy Analytical Hierarchy Process (AHP) and the Evaluation Based on Distance from Average Solution (EDAS), which are multi-criteria decision-making methods, so that retailers who want to sell via e-commerce marketplaces can choose the right e-marketplace from among the alternatives. Various e-commerce websites from all over the world were evaluated according to 5 criteria and a sample application study was presented.

This paper is constructed as follows; Section 2 includes background information and a literature review about e-marketplace selection. Section 3 contains a hybrid methodology consisting of the neutrosophic fuzzy AHP and EDAS methods and explains neutrosophic numbers, neutrosophic fuzzy ADP and EDAS. Section 4 includes the application steps for e-marketplace ranking and selection. Section 5 discusses the findings of the study. The last section includes the conclusions which

explain the contributions, managerial implications, limitations, and further research ideas.

2. Background and literature review

2.1. E-commerce and e-marketplaces

According to the definition of the World Trade Organization, e-commerce is the production, advertising and distribution of goods/services over telecommunication networks (Canbaz, 2007). According to IBM, e-commerce means making commercial transactions over the internet (Gürpınar, 2007). The Japan Electronic Commerce Center defines e-commerce as the fulfillment of all activities such as product design, production and promotion, commercial transactions and payment of accounts over all kinds of computer networks (Arslandere, 2010). While the Turkish Ministry of Commerce defines e-commerce as commercial transactions which are made online. It can also be defined as the purchase of products or services over the Internet. Selling or buying anything on the internet is within the scope of e-commerce activities (Ticaret, 2021).

The e-commerce model, which brings together individuals who want to sell or buy products/services from all over the world, differs from traditional trade methods by eliminating the concept of space and time. The scope of electronic commerce is purchasing and selling products and services, direct marketing of products and services to consumers, online tenders, design and production, shipment of goods, contracts with institutions and businesses, advertising, promotion and information, banking transactions carried out on the Internet, commercial keeping and tracking records, post-purchase support, using private and public services (İçigen and Kutlu, 2012).

E-commerce is gradually replacing classical commerce and its volume is increasing each year. Figure 1 shows the top 10 countries in order of retail e-commerce sales growth. Figure 2 illustrates the actual and estimated worldwide retail e-commerce sales, percent change, and percent of total retail sales from 2019 to 2025. According to this figure, it is predicted that retail e-commerce sales will reach 7385 trillion dollars in 2025.

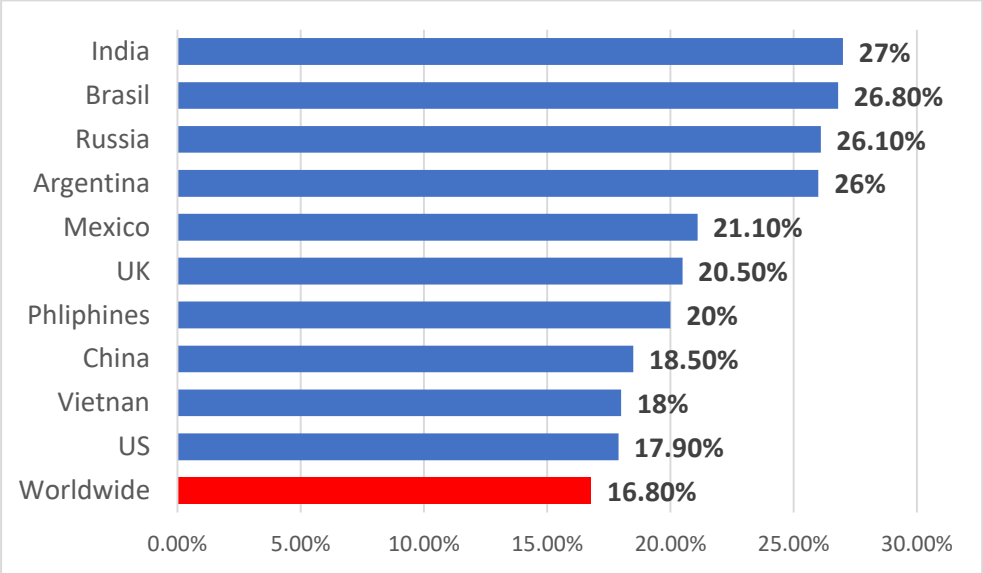

Figure 1 Top 10 countries, ranked by retail e-commerce sales growth, 2021 (% change) (Emarketer, 2021a)

Types of e-commerce in terms of the relationship between the parties are intercompany (B2B) e-commerce, business-to-consumer e-commerce (B2C), consumer-to-government e-commerce (B2G), business-to-government e-commerce (B2G), citizen-to-government e-commerce (C2G) and consumer-to-consumer e-commerce (C2C) (Bucaklı, 2007).

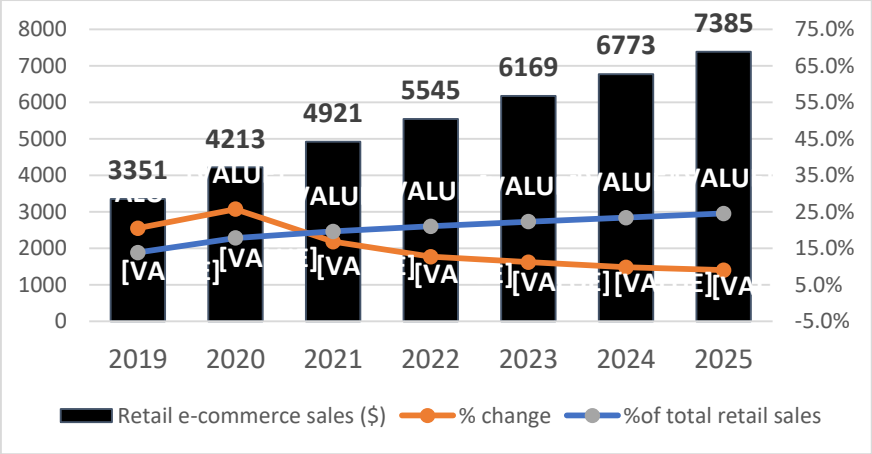

Figure 2 Retail e-commerce sales worldwide, 2019-2025 (trillions, % change, and % of total retail sales) (Emarketer, 2021b).

According to Kollmann and Lomberg (2010), an e-marketplace is a digital network that allows for electronic trade of products and/or services. This refers to the use of cutting-edge information and communication technology to support and conclude the

supply and demand matching process, respectively. Patel (2010) defined an e-marketplace as a virtual arena that allows buyers and sellers to meet and perform commercial transactions through mobile agent systems. According to Tan and Macaulay (2008), an e-marketplace is a web-based system that promotes and stimulates purchasing and selling in order to foster collaboration among trading partners from various industries. According to Kahraman et al. (2018), e-marketplaces, which are electronic spaces where vendors and buyers interact and perform various types of transactions such as buying, selling, and information exchange, are an alternative e-commerce route. E-marketplaces can be physical, virtual, or conceptual (Wang & Archer, 2007). While an e-marketplace performs the same functions as a physical one, digital systems are more efficient because they give more up-to-date information, a variety of support services, and simple transaction execution.

2.2. Literature review

In parallel with the general increasing interest, many research studies have been carried out on e-commerce. For e-market definitions and classifications, Wang and Archer (2007) conducted a review of the e-marketplace literature in order to clarify and explain facts concerning electronic markets that had previously been published. Boyacı and Baynal (2016) proposed a classification for e-commerce research and applications and conducted a literature review.

In the electronic business area, fuzzy multi-criteria decision-making approaches are widely used. These are mostly concerned with analyzing website quality, assessing website usability, and tracking consumer satisfaction. Because the focus of this study is on the evaluation and selection of e-marketplaces, the literature review was conducted in these areas.

Bhatti et al. (2020) examined the effects of the COVID-19 pandemic on e-commerce trends. Sharifi et al. (2006) proposed a categorization and selection methodology for e-marketplaces to improve supply chain alignment. Stockdale and Standing (2002) proposed a framework for the selection of electronic marketplaces via a content analysis approach. This framework supports electronic marketplace-related decision making which is based within the contexts of business drivers, internal company issues and e-marketplace facilitators. Büyüközkan (2004) proposed that fuzzy logic based on multi-criteria evaluation be used to improve the efficiency of decision making for e-marketplace selection in uncertain situations. This evaluation approach incorporates both fuzzy Analytic Hierarchy Process and fuzzy Delphi methodologies.

Guo (2007) claimed that as integration technologies advance, organizations will utilize more private, community, and public e-marketplaces and select their appropriate type of e-marketplace when evaluating the function-cost ratios of business interoperability on different types of B2B e-marketplace. Duan et al. (2010) presented a multi-criteria analysis approach for effectively evaluating and selecting the most appropriate electronic market (e-market) in electronic business by extending the TOPSIS method. Ozkok and Pappalardo (2013) provided an introduction of the most well-known fuzzy AHP techniques and their applications, as well as a case

study for selecting an e-marketplace for a company that manufactures and sells computer electronic parts in Türkiye. Kolomvatsos et al. (2014) discussed the fundamental elements of the negotiation and outlined a decision-support system for sellers in e-marketplaces. They proposed a decision-making mechanism based on Fuzzy Logic (FL) in order to handle uncertainty in the negotiation process.

Schu and Morschett (2017) identified, tested and explained factors influencing the foreign market selection behavior of European online retailers. They utilized a rank-ordered logistic regression model to see how different features affect overall judgments of market attractiveness, assuming that online retailers try to optimize the usefulness of markets for their unique interests based on the criteria they observed. Kahraman et al. (2018) used a modified version of Hesitant Fuzzy Analytic Hierarchy Process to model e-marketplace selection for buyers. Thitimajshima et al. (2019) performed exploratory research to identify the elements that influence the functionality of third-party B2B e-marketplaces from a seller's perspective. They presented ten criteria and mapped them into the domain-specific model for e-marketplaces. Wibowo and Yunianto (2019) conducted a study about the selection of e-marketplace with the fuzzy AHP and VIKOR methods. The alternative e-marketplaces selected were the top three that were frequently visited in Indonesia in 2019. Jaikumar (2019) argued that the selection of a seller from an e-marketplace is influenced by both assimilation-contrast-related evaluations of the display price of the goods and anchoring-related evaluations of the volume of seller reviews. He found that buyers prefer high-display-price vendors with many reviews over low-display-price sellers with few reviews.

Arif et al. (2020) prioritized the goods sellers alternatives in an e-marketplace by combining the VIKOR with the SMARTER methods using five selection criteria which are product price, number of products sold, seller score rating, number of reviews with five stars, and location distance. Yuianto and Wibowo (2020) described the e-marketplace selection approach using fuzzy AHP and the fuzzy MOORA approach in the alternative assessment and the fuzzy AHP method to weight the criteria

Kumar et al. (2021) aimed to determine registered vendors'/sellers' experiences with online marketplaces. They defined major dimensions of the seller experience using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). They found that the most important factors for sellers to evaluate e-marketplaces are "Registration,"; "Product Listing"; "Pricing Autonomy"; "Ease of Pick-up and Delivery"; "Credit of Receivables" and "Vendor Assistance."

Xu et al. (2021) investigated a collaborating mode selection problem for a manufacturer who distributes its products through an offline channel and an online platform under cap-and-trade regulations. The platform can be used as a marketplace or for reselling. They looked into the manufacturer's best operational decisions and mode selection for the platform in the face of demand disruptions. Hidayat et al. (2021) conducted their study to determine the e-marketplace that is suitable for use in terms of service quality, system quality, information quality, and vendor quality

owned by the e-marketplace. They conducted their study with ornamental plant traders and their choice of the right e-marketplace for their online business activities using the AHP method.

Lubis, Erdiansyah and Ramadhan (2022) investigated the use of decision support systems to choose an online marketplace. In this instance, they evaluated a number of websites or programs that are typically utilized by the public in online buying activities using the VIKOR and Rank Order Centroid methodologies. Yuianto and Taryadi (2022) developed a fuzzy decision making method for selecting the best e-marketplace using the integral total value method because choosing an e-marketplace has an effect on increasing income.

3. Methodology

Every day many decisions have to be made and the decision process includes various uncertainties and hesitations. This undeniable uncertainty is widely known and accepted in the decision-making process, especially in MCDM problems. A hybrid approach including the neutrosophic fuzzy AHP and EDAS methods was used in this study. The research methodology is shown in Figure 3. The motivation behind the use of these two methods together is that the AHP method is very useful in determining the criterion weights by compiling the opinions of various experts and the EDAS method is quite capable at evaluating alternatives.

After deciding on the evaluation criteria for e-marketplaces based on expert opinions and a literature review, these criteria were weighted using the neutrosophic fuzzy AHP method and the pairwise evaluation matrices of the experts. Next, an assessment was made for alternative e-marketplaces using the criteria's weights and the EDAS method.

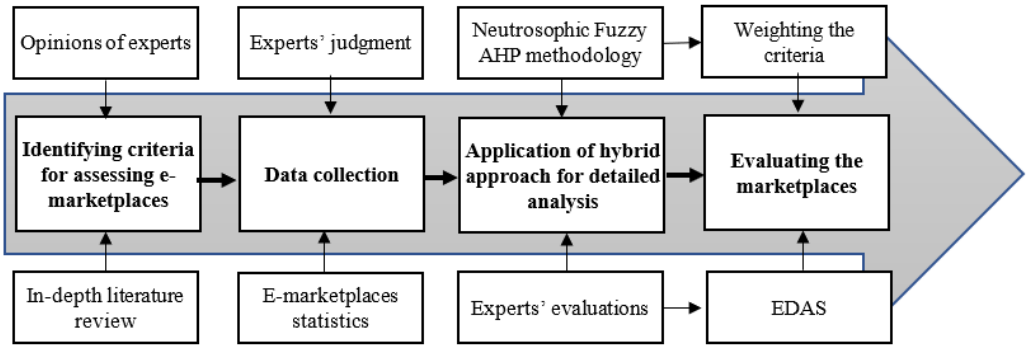

Figure 3 Methodology of research

3.1. Neutrosophic fuzzy AHP

The AHP was developed by Saaty (1980) and is a technique used by decision makers to evaluate the weight of their judgments and rank alternatives (Liu et al., 2020). This

method is based on multiple criteria and subjective marginal inputs. As each criterion is evaluated, these inputs are converted into scores (Pourghasemi et al., 2012). The AHP approach is a widely used decision-making tool that can assist decision makers in obtaining a solution based on a hierarchy of criteria and sub-criteria, with the top and bottom goals being examined as potential solutions (Stević et al., 2016). Despite its widespread use, the AHP technique has been criticized for its inability to deal with ambiguities and imprecision, making it difficult for decision makers to obtain a precise number. Fuzzy sets only consider the membership function (truth degree) and ignore non-membership (falsity degree) and indeterminacy degrees, resulting in a failure to reflect uncertainty and indeterminacy (Abdel-Basset et al., 2018b). The classical AHP does not include the concept of uncertainty and the fuzzy AHP does not fully and accurately reflect the thoughts of the decision makers (Abdel-basset et al., 2018a). Real-world situations, on the other hand, entail a great deal of ambiguity and uncertainty, necessitating the use of fuzzy numbers. As a result, the AHP and neutrosophic sets were integrated and transformed into the Neutrosophic Fuzzy AHP model (NF-AHP) (Aydın et al., 2019).

3.1.1. Definition of a neutrosophic set

Although fuzzy theory is a powerful tool, it has been found to be inadequate because it only characterizes linguistic terms by degree of membership (Kokoç and Ersöz, 2021). A neutrosophic set is a combination of a classical set, a fuzzy set, and an intuitionistic fuzzy set that effectively models real-world situations by taking into account all aspects of a choice scenario (i.e., truthiness, indeterminacy, and falsity) (Abdel-Basset et al., 2008a). Because membership was the symmetric equivalent of non-membership with respect to indeterminacy, the neutrosophic set served as a symmetric tool in the suggested method.

Some important definitions of neutrosophic sets are introduced as follows:

Definition 1 (Wang et al., 2010; Abdel-Basset et al., 2008a)**:** The neutrosophic set N is characterized by three membership functions of truth $T_{\tilde{a}}(x)$, indeterminacy $I_{\tilde{a}}(x)$ and falsity $F_{\tilde{a}}(x)$, where $x \in X$ and X are a space of points. Also, $T(x): X \to]0^-, 1^+[$, $(x): X \to I]0^-, 1^+[$ and $F(x): X \to]0^-, 1^+[$. There is no restriction on the sum of T (x), I (x), and $F(x)$, therefore

$$0^- \leq \sup T(x) + \sup I(x) + \sup F(x) \leq 3 \quad (1)$$

In order to apply the neutrosophic set theory to real-life problems, Wang et al. (2010) developed a single-valued neutrosophic set theory, a subclass of neutrosophic sets.

Definition 2 (Wang et al., 2010; Abdel-Basset et al., 2008a)**:** The following equation presents the form of a single-valued neutrosophic set N over X:

$$A = \{\langle x, T(x), I(x), F(x)\rangle : x \in X\} \quad (2)$$

where $T_{\tilde{a}}(x): X \rightarrow [0,1]$, $I_{\tilde{a}}(x): X \rightarrow [0,1]$ and $F_{\tilde{a}}(x): X \rightarrow [0,1]$, with $0 \leq T_{\tilde{a}}(x) + I_{\tilde{a}}(x) + F_{\tilde{a}}(x) \leq 3$ for all x ∈ X. The single valued neutrosophic (SVN) number is symbolized by N = ($t_{\tilde{a}}$, $i_{\tilde{a}}$, $f_{\tilde{a}}$), where $t_{\tilde{a}}$, $i_{\tilde{a}}$, $f_{\tilde{a}} \in [0,1]$ and $t_{\tilde{a}} + i_{\tilde{a}} + f_{\tilde{a}} \leq 3$.

Definition 3 (Yücesan, 2020; Abdel-Basset et al., 2008a)**:** The single valued triangular neutrosophic number, $\tilde{a} = \langle (a_1, a_2, a_3; t_{\breve{a}}, i_{\breve{a}}, f_{\breve{a}} \rangle$, is a neutrosophic set on the real line set *R*, where $T_{\tilde{a}}(x): X \rightarrow [0,1]$, $I_{\tilde{a}}(x): X \rightarrow [0,1]$ and $F_{\tilde{a}}(x): X \rightarrow [0,1]$ as sum of $T_{\tilde{a}}(x)$, $I_{\tilde{a}}(x)$ and $F_{\tilde{a}}(x)$ are between 0 and 3. Truth, indeterminacy and falsity membership functions are as follows:

$$T_{\tilde{a}}(x) = \begin{cases} t_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right) & (a_1 \leq x \leq a_2) \\ t_{\tilde{a}} & (x = a_2) \\ t_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right) & (a_2 < x \leq a_3 \\ 0 & otherwise \end{cases} \quad (3)$$

$$I_{\tilde{a}}(x) = \begin{cases} \left(\frac{a_2-x+i_a(x-a_1}{a_2-a_1}\right) & (a_1 \leq x \leq a_2) \\ i_{\tilde{a}} & (x = a_2) \\ \left(\frac{x-a_2+i_a(a_3-x)}{a_3-a_2}\right) & (a_2 < x \leq a_3 \\ 1 & otherwise \end{cases} \quad (4)$$

$$F_{\tilde{a}}(x) = \begin{cases} \left(\frac{a_2-x+f_a(x-a_1}{a_2-a_1}\right) & (a_1 \leq x \leq a_2) \\ f_{\tilde{a}} & (x = a_2) \\ \left(\frac{x-a_2+f_a(a_3-x)}{a_3-a_2}\right) & (a_2 < x \leq a_3 \\ 1 & otherwise \end{cases} \quad (5)$$

Definition 4 (Yücesan, 2020; Abdel-Basset et al., 2008a): Let $\tilde{a} = \langle (a_1, a_2, a_3; t_{\breve{a}}, i_{\breve{a}}, f_{\breve{a}} \rangle$ and $\tilde{b} = \langle (b_1, b_2, b_3; t_{\breve{b}}, i_{\breve{b}}, f_{\breve{b}} \rangle$ two single-valued triangular neutrosophic numbers and $\gamma \neq 0$ be any real number. Then, the addition of two triangular neutrosophic numbers is in Eq. (6), the subtraction of two triangular neutrosophic numbers is in Eq. (7), the inverse of a triangular neutrosophic number is in Eq. (8), the multiplication of two triangular neutrosophic numbers is in Eq. (9), and the division of two triangular neutrosophic numbers is in Eq. (10),

$$\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3); t_{\breve{a}} \wedge t_{\breve{b}}, i_{\breve{a}} \vee i_{\breve{b}}, f_{\breve{a}} \vee f_{\breve{b}} \rangle \quad (6)$$

$$\tilde{a} - \tilde{b} = \langle (a_1 - b_1, a_2 - b_2, a_3 - b_3); t_{\breve{a}} \wedge t_{\breve{b}}, i_{\breve{a}} \vee i_{\breve{b}}, f_{\breve{a}} \vee f_{\breve{b}} \rangle \quad (7)$$

$$\tilde{a}^{-1} = \langle (\frac{1}{a_3}, \frac{1}{a_2}, \frac{1}{a_1}); t_{\breve{a}}, i_{\breve{a}}, f_{\breve{a}} \rangle \quad where\ \tilde{a} \neq 0 \quad (8)$$

$$\tilde{a} * \tilde{b} = \begin{cases} \langle (a_1 b_1, a_2 b_2, a_3 b_3); t_{\breve{a}} \wedge t_{\breve{b}}, i_{\breve{a}} \vee i_{\breve{b}}, f_{\breve{a}} \vee f_{\breve{b}} \rangle \; if \; (a_3 > 0, b_3 > 0) \\ \langle (a_1 b_3, a_2 b_2, a_3 b_1); t_{\breve{a}} \wedge t_{\breve{b}}, i_{\breve{a}} \vee i_{\breve{b}}, f_{\breve{a}} \vee f_{\breve{b}} \rangle \; if \; (a_3 < 0, b_3 > 0) \\ \langle (a_3 b_3, a_2 b_2, a_3 b_3,); t_{\breve{a}} \wedge t_{\breve{b}}, i_{\breve{a}} \vee i_{\breve{b}}, f_{\breve{a}} \vee f_{\breve{b}} \rangle \; if \; (a_3 < 0, b_3 < 0) \end{cases} \quad (9)$$

$$\frac{\tilde{a}}{\tilde{b}} = \begin{cases} \langle \left(\frac{a_1}{b_1}, \frac{a_2}{b_2}, \frac{a_3}{b_3}\right); t_{\breve{a}} \wedge t_{\breve{b}}, i_{\breve{a}} \vee i_{\breve{b}}, f_{\breve{a}} \vee f_{\breve{b}} \rangle \; if \; (a_3 > 0, b_3 > 0) \\ \langle \left(\frac{a_1}{b_3}, \frac{a_2}{b_2}, \frac{a_3}{b_1}\right); t_{\breve{a}} \wedge t_{\breve{b}}, i_{\breve{a}} \vee i_{\breve{b}}, f_{\breve{a}} \vee f_{\breve{b}} \rangle \; if \; (a_3 < 0, b_3 > 0) \\ \langle \left(\frac{a_1}{b_1}, \frac{a_2}{b_2}, \frac{a_3}{b_3}\right); t_{\breve{a}} \wedge t_{\breve{b}}, i_{\breve{a}} \vee i_{\breve{b}}, f_{\breve{a}} \vee f_{\breve{b}} \rangle \; if \; (a_3 < 0, b_3 < 0) \end{cases} \quad (10)$$

3.1.2. Neutrosophic fuzzy AHP

The application steps of neutroscophic fuzzy AHP method are as follows: (Yücesan, 2020; Junaid et al., 2019)

Step 1: Select a group of experts.
Step 2: Structure the hierarchy of the problem.
Step 3: Structure the neutrosophic pair-wise comparison matrix of factors, sub-factors and alternatives, through the linguistic terms shown in Table 1.

Table 1
Linguistic terms and identical triangular neutrosophic numbers (Ahmad et al., 2019)

Saaty Scale	Explanation	Symbol	Neutrosophic Fuzzy Scale
1	Equally influential	EI	$\tilde{1} = \langle (1,1,1); 0.50, 0.50, 0.50 \rangle$
3	Moderately influential	MI	$\tilde{3} = \langle (2,3,4); 0.60, 0.35, 0.40 \rangle$
5	Strongly influential	SI	$\tilde{5} = \langle (4,5,6); 0.70, 0.30, 0.30 \rangle$
7	Very strongly influential	VSI	$\tilde{7} = \langle (6,7,8); 0.80, 0.25, 0.20 \rangle$
9	Absolutely influential	AI	$\tilde{9} = \langle (8,9,9); 0.90, 0.10, 0.10 \rangle$
2	Sporadic values between two close scales	EI-MI	$\tilde{2} = \langle (1,2,3); 0.55, 0.40, 0.45 \rangle$
4		MI-SI	$\tilde{4} = \langle (3,4,5); 0.65, 0.30, 0.35 \rangle$
6		SI-VSI	$\tilde{6} = \langle (5,6,7); 0.75, 0.25, 0.25 \rangle$
8		VSI-AI	$\tilde{8} = \langle (7,8,9); 0.80, 0.25, 0.20 \rangle$

According to expert judgment, the neutrosophic scale is accomplished. The neutrosophic pair-wise comparison matrices of factors will have the form shown in Eq. (11).

$$A^{\sim k} = \begin{bmatrix} \tilde{r}_{11}^k & \tilde{r}_{12}^k \dots & \tilde{r}_{1n}^k \\ \vdots & \ddots & \vdots \\ \tilde{r}_{n1}^k & \tilde{r}_{n2}^k & \tilde{r}_{nn}^k \end{bmatrix} \quad (11)$$

where $\tilde{r}_{ji} = \tilde{r}_{ij}^{-1}$ and is the a triangular neutrosophic number that measures the decision makers vagueness. The triangular neutrosophic fuzzy number is presented as where $\tilde{r}_{ij}^{k}$ is the preference relation of i^{th} criterion over j^{th} criterion according to k^{th} decision maker.

Step 4: Combine decision makers' evaluations with the geometric mean. By having more than one decision maker in the estimation process, the aggregated $\tilde{r}_{ji}$ of all the decision makers is calculated as in Eq. (12) for obtaining the final comprehensive preference values via taking average values of all decision makers preferences. Evaluations made by more than one expert are combined with the geometric mean. For the combined neutrosophic decision matrix, the calculation is made using Eq. (12) by means of Eq. (9).

$$\tilde{r}_{ij} = \sqrt[K]{\prod_{k=1}^{K} \langle (l_{ij}^{k}, m_{ij}^{k}, u_{ij}^{k}); T_{ik}^{k}, I_{ik}^{k}, F_{ik}^{k} \rangle} \tag{12}$$

Where $T_{ij} = min(T_{ik})^{1/k}$; $I_{ij} = (1 - (1 - \max(I_{ik}))^{1/k}$; $F_{ij} = (1 - (1 - \max(F_{ik}))^{1/k}$

The aggregated pair-wise comparison matrix according to the averaged preference values has the following form:

$$\tilde{A}^{k} = \begin{bmatrix} \tilde{r}_{11} & \tilde{r}_{12} \dots & \tilde{r}_{1n} \\ \vdots & \ddots & \vdots \\ r_{n1} & \tilde{r}_{n2} & \tilde{r}_{nn} \end{bmatrix} \tag{13}$$

Step 5: Calculate the weight of the criteria, sub-criteria and alternatives from the neutrosophic pair-wise comparison matrix, by transforming it to a deterministic matrix using the following equations, Eq. (15, 16). Thus, crispy values of neutrosophic pairwise comparison evaluation matrix are obtained.

Let $\tilde{a}_{ij} = \langle (a_1, a_2, a_3),\ t_a,\ i_a,\ f_a \rangle$ is a single valued triangular neutrosophic number and then score (S) of $\tilde{a}_{ij}$ is calculated as follows:

$$S(\tilde{a}_{ij}) = \frac{1}{8}[a_1 + a_2 + a_3]x(2 + T - I - F) \tag{14}$$

$$S(\tilde{a}_{ji}) = \frac{1}{S(\tilde{a}_{ij})} \tag{15}$$

The following deterministic matrix is obtained by compensating for the score value of each triangular neutrosophic number in the neutrosophic pair-wise comparison matrix.

$$A = \begin{bmatrix} 1 & a_{12} \dots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & 1 \end{bmatrix} \quad (16)$$

Step 6: Determine weights of criteria
After the crispy values are found, the total value of each column is calculated and divided by the sum of the columns in which each matrix element is located. This process is done until the last matrix element.

$$a'_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \quad , \quad i,j = 1,2,\dots,n \quad (17)$$

In the matrix obtained by dividing by the column total, the average of each row is taken and thus neutrosophic criterion weights are found by the following equation.

$$w_i = \frac{1}{n}\sum_{i=1}^{n} a'_{ij} \quad , \quad i,j = 1,2,\dots,n \quad (18)$$

Step 7: Verify the weighted matrix consistency
The consistency of the matrix should be evaluated based on the expert's judgment. By dividing the Consistency Index (CI) by the Random Index (RI), the consistency can be determined. The result should be less than 0.1. The consistency index is calculated using the following equations.

$$CI = \frac{\lambda_{max} - \mathrm{n}}{n-1} \quad (19)$$

$$\lambda_{max} = \left(\frac{1}{n}\right)\sum_{i=1}^{n} \frac{\sum_{j=1}^{n} a_{ij} w_j}{w_i} \quad (20)$$

As shown in the Eq. (21), the value of the Consistency Ratio (CR) is found by dividing CI by the value of RI. This is the consistency ratio of the comparison matrix.

$$CR = \frac{CI}{RI} \quad (21)$$

3.2. EDAS method

The EDAS method, developed by Ghorabaee et al. (2015), uses mean solutions to evaluate alternatives. In this method, two measures called positive distance from the average (PDA) and negative distance from the average (NDA) are considered to evaluate alternatives. An alternative with higher PDA values and lower NDA values is evaluated as better (Kahraman et al., 2017).

The algorithm of the EDAS method for a decision-making problem with m criteria and n alternatives is as follows (Stanujkic et al., 2017):

Step 1: Criteria and alternatives for decision-making problem are determined and decision matrix is constructed as follows:

$$X = [X_{ij}]_{nxm} = \begin{bmatrix} X_{11} & X_{21} \cdots & X_{1m} \\ \vdots & \vdots \quad \vdots & \vdots \\ X_{n1} & X_{n2} \cdots & X_{nm} \end{bmatrix} \tag{22}$$

Step 2: Average solutions (AV) for each criterion are calculated using the following equations.

$$AV = [AV_j]_{1xm}, \quad j = 1, \dots, m \tag{23}$$

$$AV_j = \frac{(\sum_{i=1}^{m} x_{ij})}{m}, \quad j = 1, \dots, m \tag{24}$$

where AV_j denotes the average solution of the j[th] criteria.

Step 3: PDA and NDA matrices are calculated according to the type of criteria (benefit and cost).

$$PDA = [PDA_{ij}]_{nxm} \tag{25}$$

$$NDA = [NDA_{ij}]_{nxm} \tag{26}$$

$$PDA_{ij} = \begin{cases} \frac{\max(0,(X_{ij} - AV_j)}{AV_j}, & j \in C_{max} \\ \frac{\max(0,(AV_j - X_{ij})}{AV_j}, & j \in C_{min} \end{cases} \tag{27}$$

$$NDA_{ij} = \begin{cases} \frac{\max(0,(AV_j - X_{ij})}{AV_j}, & j \in C_{max} \\ \frac{\max(0,(X_{ij} - AV_j)}{AV_j}, & j \in C_{min} \end{cases} \tag{28}$$

where C_{max} and C_{min} denote the benefit and cost criteria sets respectively

Step 4: Sum of weighted PDA and NDA for all alternatives are calculated using the following equations.

$$SP_i = \sum_{j=1}^{m} w_j PDA_{ij} \tag{29}$$

$$SN_i = \sum_{j=1}^{m} w_j NDA_{ij} \tag{30}$$

where $W = (w_1, w_2, \dots, w_j)$ denotes the vector of weights.

Step 5: The SP and SN values for all alternatives are normalized using Eq. (31) and Eq. (32), respectively.

$$NSP_i = \frac{SP_i}{\max(SP_i)} \tag{31}$$

$$NSN_i = 1 - \frac{SN_i}{\max(SN_i)} \tag{32}$$

Step 6: Assessment scores (AS) for all alternatives are calculated using Eq. (33). Here, AS values take values between 0 and 1 ($0 \leq ASi \leq 1$).

$$AS_i = \frac{1}{2}(NSP_i + NSN_i) \tag{33}$$

Step 7: The alternatives are sorted in ascending order according to the AS obtained. The alternative with the highest AS value is the best among the other alternatives.

4. Case study

This study is performed in a Turkish SME in a woman's apparel industry that desires to join an online marketplace abroad to strengthen its position in the market.

4.1. Determination of criteria

As in classical commerce, it is very important to determine the market potential, understand consumer trends and pricing, and determine the right e-marketplace in national or international marketing studies in e-commerce. Correctly identifying target customers and the e-marketplace are key to successful marketing. For this reason, it is very important to choose an e-marketplace using an analytical approach by evaluating the e-marketplaces in terms of various criteria.

Online marketplaces, which are increasing in size every day, are very useful platforms for sellers. Instead of dealing with building and growing their own websites, many retailers are making successful sales and increasing their business volume through these e-marketplaces. However, in order to achieve these successes, it is important to choose the right e-marketplace on the basis of various criteria. Each online marketplace has its own unique requirements, product categories, listing fees, and audiences. Different strategies should be researched and analyzed in order to sell in e-marketplaces, and it is necessary to determine in advance which strategies can provide the most profit for the products to be sold (Bigcommerce, 2021).

In order to determine the right e-marketplaces in e-commerce, sellers should seek answers to the following questions and make a comprehensive evaluation: (1) What is the popularity of the chosen online marketplace in the world? (2) What policies does the e-marketplace apply to sellers? (3) What is the average number of visits and traffic to the e-marketplace? (4) What are the commission rates that the e-marketplace charges sellers? (5) What is the total business volume of the e-marketplace? An effective and systematic evaluation of these issues in the selection of the e-marketplace will increase the market share of the company's products in the national and international market and contribute positively to profitability (Yıldız, 2019).

According to Kahraman et al. (2018), the most important factors affecting users selection of e-marketplaces are the number of buyers on the marketplace, shipping options, and fees.

In this context, an evaluation model consisting of 2 main criteria and 8 sub-criteria was created by experts to choose the right e-marketplace. Eight different e-marketplaces from Europe, Asia and North America were evaluated with this model. As a result of the literature review and brainstorming with the expert team, the two main criteria were determined to be (1) general features and (2) sellers' specific features. The first main criterion includes four sub-criteria which are the average number of visits, number of members, e-marketplace annual revenue and popularity. The second main criterion includes four sub-criteria which are commission rate, policies applied to sellers, supported channel features and monthly payment. General features are adapted from the literature as seen in Table 2. First, the two sub-criteria of the sellers' specific features are adapted from the literature and the last two sub-criteria were developed by the author after investigating the webpages of online markets such as Amazon and Trendyol to see what they provide to sellers and what they require from sellers. The evaluation criteria are presented in Table 2.

4.2. Determination of alternative e-marketplaces

Some important e-marketplaces around the world were selected as alternatives to be evaluated in the case study. These e-marketplaces are Bol, Allegro, and Trendyol from the European continent; Alibaba, Flipkart, Rakuten from the Asian continent; and Amazon and Etsy from the Americas.

Amazon: Amazon.com is an international e-commerce company that offers online retail, computing services, consumer electronics, digital content, as well as other local services such as daily deals and groceries. Amazon is the leading US e-retailer and e-marketplace with close to $386 billion in net sales in 2020 according to recent industry figures. Due to Amazon's global reach, it is also recognized as one of the most valuable brands worldwide (Statista, 2021; Amazon, 2021).

Etsy: Etsy is an online marketplace that acts as an intermediary between customers and artists, artisans of handmade goods, or collectors of vintage items. Items sold and purchased through Etsy range from clothing, jewelry and other decorative objects to arts and crafts supplies. After the launch of Etsy, the company had almost immediate success, reaching one million sales within a few years. The parent company of the platform generated revenue of approximately $1.72 billion in 2020. This corresponds to a growth of approximately 110% (Statista, 2021; Etsy, 2021).

Alibaba: Alibaba Group is China's leading online commerce platform, providing a wide range of B2B, B2C and C2C e-commerce services, mobile payments and logistics services. Alibaba.com was founded by Jack Ma and his team in April 1999 and is one of the ten most valuable companies worldwide. For the fiscal year ending in March 31, 2020, the Alibaba Group had an annual revenue of approximately US $72 billion and a net income of approximately US $19.6 billion (Statista, 2021; Alibaba, 2021).

Table 2
Evaluation criteria

Criteria	Explanation	Resources
General Factors		
Average number of visits	Average number of customers who visit each e-marketplace in a month	Kahraman et al. (2018), Yıldız (2019)
Number of members	Number of companies that sell their products in each e-marketplace	Kahraman et al. (2018), Yıldız (2019), Kolomvatsos (2014)
E-marketplace annual revenue	Total sales of each e-marketplace within a year	Yıldız (2019)
Popularity	Preferred by customers and offers a convenient way to compare prices and products from a single source.	Yıldız (2019), Büyüközkan (2004), Kahraman et al. (2018)
Factors for sellers		
Commission rate	User is charged a fee for each transaction. This by far the most popular online marketplace business model. When the customer pays the supplier, the marketplace charges a percentage or a fixed fee for its services.	Kolomvatsos et al. (2014), Kahraman et al. (2018)
Policies applied to sellers	Negotiation policies, customer's tactics and coalition tools as a value-added services in e-marketplaces.	Yıldız (2019)
Supported channel features	Services such as product offerings (EAN matching), automatic relationships, product content, pick-up point delivery, product status import, orders, cancellations, shipments (including carrier mapping), returns (channel and merchant), external fulfillment (LVB/FBB), repricing, fee reductions, product variations (sizes/colors) provided by e-marketplaces	Defined by authors
Monthly payment	Monthly fee which sellers have to pay to use e-marketplace	Defined by authors

Flipkart*:* Flipkart is an Indian e-commerce company headquartered in Bangalore, Karnataka, India and incorporated as a private limited company in Singapore. The company initially focused on online book sales before moving into other product categories such as consumer electronics, fashion, home supplies, groceries, and lifestyle products. Flipkart, along with Amazon India, is one of India's largest online retailers and marketplaces (Statista, 2021; Flipkart, 2021).

Bol: Bol.com is a web-shop based in the Netherlands and offers general merchandise in categories such as music, movies, electronics, toys, jewelry, watches, baby products, gardening and DIY. The store serves 11 million active customers in the Netherlands and Belgium as of 2020 and offers more than 23 million products. Since

2011, Bol.com has also opened its web-shop for retailers to sell, effectively becoming a platform. Since the launch of "sell through bol.com", more than 30,000 retailers have sold on the site (Emarketer, 2021; Bol, 2021).

Allegro: Allegro was founded in 1999 as an online auction website. It has been part of the renowned South African e-commerce group Naspers for years, but in October 2016 Naspers sold it to an investor funds alliance. More than 125,000 merchants and retailers from SMEs have registered on the site to sell a total of over 1 million products. They are required to pay a listing fee, sales commission, and a percentage of all commissions based on the number of successful sales. In 2020, the Polish e-marketplace Allegro generated a net revenue of approximately $1.07 million, up 54.2% compared to the same period the previous year (Statista, 2021; Allegro, 2021).

Rakuten: Rakuten is a multinational e-commerce company headquartered in Tokyo, Japan. It is a company founded in 1997 with the launch of the business-to-consumer (B2C) e-marketplace Rakuten Ichiba. Through its worldwide operating subsidiaries, Rakuten is involved in communications services, fintech and video distribution services, among others. The groups company's continued growth and successful efforts to expand its business portfolio are reflected in a decade-long upward trend in consolidated net income (Statista, 2021; Rakuten, 2021).

Trendyol: Trendyol, founded by Demet Mutlu in 2010, is Türkiye's largest e-commerce platform and is headquartered in Istanbul. As the company grew, it expanded its products and services and switched to the market model. It offers customers more than 300 million products each year covering many categories such as fashion, electronics, home and furniture, food, mother and baby, and cosmetics. The platform's mobile apps have more than 15 million customers every year, an average of 180 million mobile visits per month, and 45 million downloads so far. Trendyol, which defines itself as a technology company, uses the technology it has developed to digitize shopping (Bigcommerce, 2021; Trendyol, 2021).

4.3. Determination of criteria weights

Three experts working in e-marketplaces were identified to perform pairwise evaluations. The characteristics of experts are presented in Table 3.

Table 3
Characteristics of experts/decision makers

Expert	Sex	Education	Work experience in e-commerce	Sector	Position
Expert 1 (DM1)	Male	Bachelor;s Degree	5 years	E-commerce	Product manager of a company selling products on e-commerce web site
Expert 2 (DM2)	Male	Master's degree	8 years	E-commerce	Supplier manager
Expert 3 (DM3)	Female	Master's Degree	10 years	E-commerce	Owner of an e-commerce site

The AHP hierarchy structure was created for the appropriate e-commerce marketplace selection for suppliers. The hierarchy is shown in Figure 4. In the hierarchy structure, there are goals, criteria and alternatives, respectively, from top to bottom.

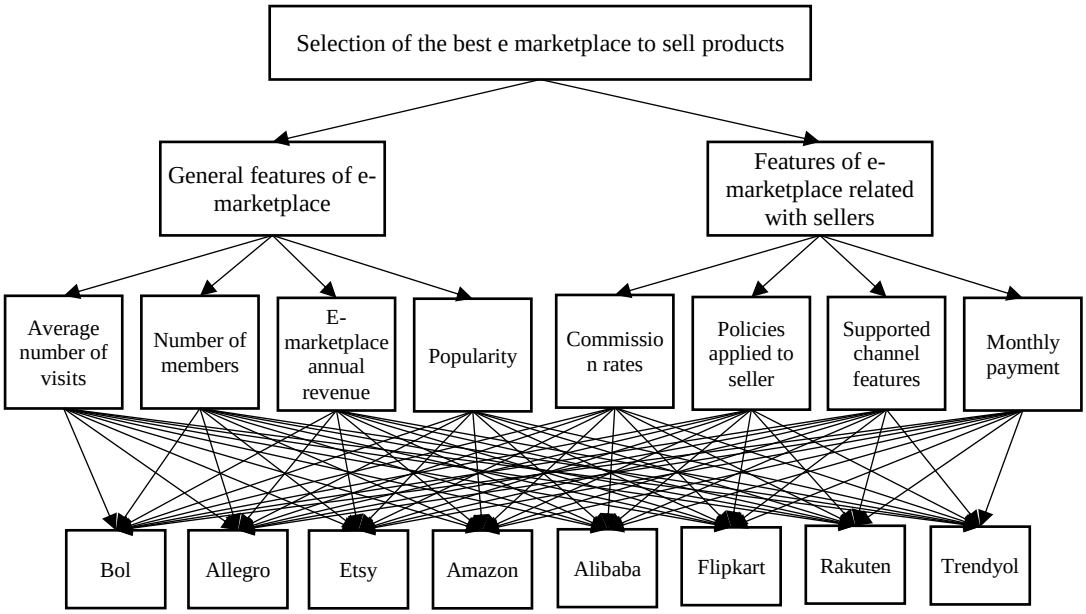

Figure 4 AHP hierarchy structure for e-commerce marketplace selection

In the AHP method, the criteria are evaluated by experts and their importance levels are scored relative to each other. The evaluation results performed by three different decision makers (DMs) are shown in Tables 4, 5 and 6 as pairwise comparison matrices of importance.

Table 4
Linguistic pairwise comparison matrix of main criteria

		Decision makers	Features of e-marketplace related with sellers	General features of e-marketplace
Features of e-marketplace related with sellers	A	DM1	EI	MI-SI
		DM2	EI	SI-VSI
		DM3	EI	MI
General features of a e-marketplace	B	DM1		EI
		DM2		EI
		DM3		EI

Table 5
Linguistic pairwise comparison matrix for features of e-marketplace related with sellers

			Commission rates	**Policies applied to seller**	**Supported channel features**	**Monthly payment**
			A1	**A2**	**A3**	**A4**
Commission rates	**A1**	DM1	EI	SI	MI-SI	EI
		DM2	EI	EI-MI	MI	MI
		DM3	EI	MI	1/MI	MI
Policies applied to seller	**A2**	DM1		EI	EI	1/MI
		DM2		EI	EI	1/MI-SI
		DM3		EI	1/MI	1/SI
Supported channel features	**A3**	DM1			EI	1/MI
		DM2			EI	1/SI
		DM3			EI	1/MI-SI
Monthly payment	**A4**	DM1				EI
		DM2				EI
		DM3				EI

Table 6
Linguistic pairwise comparison matrix for general features of a e-marketplace

			Average number of visits	**Number of members**	**E-marketplace annual revenue**	**Popularity**
			B1	**B2**	**B3**	**B4**
Average number of visits	B1	DM1	EI	SI	1/MI-SI	EI
		DM2	EI	MI-SI	1/MI-SI	1/MI
		DM3	EI	MI	1/MI	1/EI-MI
Number of members	B2	DM1		EI	1/SI	1/MI
		DM2		EI	1/SI-VSI	1/MI-SI
		DM3		EI	1/SI	1/SI
E-marketplace annual revenue	B3	DM1			EI	EI
		DM2			EI	MI
		DM3			EI	MI
Popularity	B4	DM1				EI
		DM2				EI
		DM3				EI

Linguistic pairwise matrices were transformed to a neutrosophic fuzzy pairwise evaluation matrix with the neutrosophic fuzzy numbers in Table 1. The geometric average of the expert evaluations was computed, and then aggregated evaluation matrices for the main criteria and sub-criteria are provided in Tables 7, 8 and 9.

Table 7
Aggregated neutrosophic pairwise evaluation matrix for main criteria

	A						**B**					
	a1	**a2**	**a3**	**ta**	**Ia**	**Fa**	**b1**	**b2**	**b3**	**tb**	**Ib**	**Fb**
A	1.00	1.00	1.00	0.50	0.50	0.50	5.65	6.65	7.65	0.78	0.25	0.22
B							1.00	1.00	1.00	0.50	0.50	0.50

The neutrosophic values in Tables 7, 8 and 9 were transformed to crisp values using Equation 13 as seen in Tables 10, 11 and 12. Similarly, the neutrosophic values in Table 7 were transformed to crisp values as seen in Tables 9, 10 and 11.

Table 8
Aggregated evaluation matrix for features of e-marketplace related with sellers

	Policies applied to seller						**Supported channel features**						**Monthly payment to e-marketplace**						**Average profitability rate of seller**					
	a1	a2	a3	**ta**	**Ia**	**Fa**	**b1**	**b2**	**b3**	**tb**	**Ib**	**Fb**	**c1**	**c2**	**c3**	**tc**	**Ic**	**Fc**	**d1**	**d2**	**d3**	**td**	**ld**	**Fd**
A1	1.00	1.00	1.00	0.50	0.50	0.50	2.52	3.56	4.58	0.63	0.33	0.36	0.53	0.69	0.94	0.49	0.35	0.49	1.59	2.62	3.63	0.53	0.38	0.46
A2							1.00	1.00	1.00	0.50	0.50	0.50	1.26	1.82	2.29	0.55	0.41	0.45	0.22	0.28	0.38	0.35	0.32	0.65
A3													1.00	1.00	1.00	0.50	0.50	0.50	0.44	0.53	0.69	0.42	0.33	0.57
A4																			1.00	1.00	1.00	0.50	0.50	0.50

Table 9
Aggregated neutrosophic pairwise evaluation matrix for general features of e-marketplace

	Average number of visits						**Number of members**						**E-marketplace annual revenue**						**Popularity**					
	a1	**a2**	**a3**	**ta**	**Ia**	**Fa**	**b1**	**b2**	**b3**	**tb**	**Ib**	**Fb**	**c1**	**c2**	**c3**	**tc**	**Ic**	**Fc**	**d1**	**d2**	**d3**	**td**	**ld**	**Fd**
B1	1.00	1.00	1.00	0.50	0.50	0.50	2.52	3.56	4.58	0.63	0.00	0.36	0.23	0.30	0.44	0.38	0.42	0.62	0.48	0.63	1.00	0.47	0.43	0.53
B2							1.00	1.00	1.00	0.50	0.50	0.50	0.17	0.20	0.25	0.30	0.30	0.70	0.19	0.24	0.31	0.33	0.32	0.66
B3													1.00	1.00	1.00	0.50	0.50	0.50	0.87	1.22	1.59	0.48	0.33	0.48
B4																			1.00	1.00	1.00	0.50	0.50	0.50

Table 9
Crisp values of neutrosophic numbers in Table 7

		A	B
Features of e-marketplace related with sellers	A	0.56	3.24
General features of a e-marketplace	B	0.31	0.67
Sub		0.87	3.90

Table 10
Crisp values of neutrosophic numbers in Table 8

		Commission rates	**Policies applied to seller**	**Supported channel features**	**Monthly payment**
Commission rates	A1	0.563	2.578	0.448	1.586
Policies applied to seller	A2	0.388	0.563	1.132	0.184
Supported channel features	A3	2.233	0.883	0.563	0.346
Monthly payment	A4	0.631	5.446	2.887	0.563
Sum		9.53	21.54	2.14	1.85

Table 11
Crisp values of neutrosophic numbers in Table 9

		Average number of visits	**Number of members**	**E-marketplace annual revenue**	**Popularity**
Average number of visits	**B1**	0.563	3.021	0.164	0.396
Number of members	**B2**	0.331	0.563	0.100	0.125
E-marketplace annual revenue	**B3**	6.110	9.979	0.563	0.764
Popularity	**B4**	2.523	7.980	1.309	0.563
Sum		3.81	9.47	5.03	2.68

The total value of each column is calculated and then each matrix element is divided by the sum of the columns as seen in Tables 9, 10 and 11. Average values of each line were calculated and criteria weights were obtained as shown in Tables 12, 13 and 14. As seen in Table 12, the most important criterion among the main criteria is features of e-marketplace related with sellers.

Table 12
Weights of main criteria

		A	B	Weights
Features of e-marketplace related with sellers	A	0.65	0.83	0.740
General features of a e-marketplace	B	0.35	0.17	0.260
				1.00

As seen in Table 13, the most important criterion among features of the e-marketplace related to sellers is monthly payment. This criterion is followed by commission rates, supported channel features and policies applied to sellers' criteria respectively.

Table 13
Weights of sub criteria for features of e-marketplace related with sellers

	Commission rates	**Policies applied to seller**	**Supported channel features**	**Monthly payment**	**Weights**
Commission rates	0.147	0.272	0.089	0.592	0.275
Policies applied to seller	0.102	0.059	0.225	0.069	0.114
Supported channel features	0.585	0.093	0.112	0.129	0.230
Monthly payment	0.165	0.575	0.574	0.210	0.381
					1.000

As seen in Table 14, the most important criterion among general features of the e-marketplace is e-market annual revenue. This criterion is followed by popularity, average number of visits and number of members, respectively.

Table 14
Weights of sub-criteria for general features of e-marketplace

	Average number of visits	**Number of members**	**E-marketplace annual revenue**	**Popularity**	**Weights**
Average number of visits	0.059	0.140	0.077	0.214	0.123
Number of members	0.035	0.026	0.047	0.068	0.044
E-marketplace annual revenue	0.641	0.463	0.263	0.413	0.445
Popularity	0.265	0.370	0.613	0.304	0.388
Sum					1.000

Lastly, the weights of the sub-criteria are multiplied by the weights of main criteria, and the global weights of all criteria are obtained as shown in Table 15.

Table 15
Weights of criteria

Main criteria	Weights	Sub-criteria		Weights	Global weights
Features of e-marketplace related with sellers	0.740	Commission rates	A1	0.275	0.204
		Policies applied to seller	A2	0.114	0.084
		Supported channel features	A3	0.230	0.170
		Monthly payment	A4	0.381	0.282
General features of e-marketplace	0.260	Average number of visits	B1	0.123	0.032
		Number of members	B2	0.044	0.011
		E-marketplace annual revenue	B3	0.445	0.116
		Popularity	B4	0.388	0.101

4.4 Evaluation of e-marketplace alternatives

After determining the weights of the criteria with the AHP method, the eight big e-commerce websites operating as retail e-marketplaces around the world were evaluated using the EDAS method on the basis of these weighted criteria. The decision matrix seen in Table 16 was created by data provided from the webpages of the e-marketplaces (Statista, 2021; Amazon, 2021; Etsy, 2021; Alibaba, 2021; Flipkart, 2021; Bol, 2021; Allegro, 2021; Rakuten, 2021; Trendyol, 2021). The average values (AV) of the criteria were calculated using Equation 9.

Table 16
Data of alternative e-marketplaces on the basis of each criterion

	CRITERIA							
	A1	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**
	min	**max**	**max**	**min**	**max**	**max**	**max**	**max**
Bol	15	6	11	0	80,630,000	13,000,000	5,179,780,000	366
Allegro	10	7	7	300	197,390,000	21,000,000	849,000,000	114
Etsy	25	7	15	6	405,640,000	90,600,000	1,724,000,000	61
Amazon	15	9	19	39.99	2,550,000,000	300,000,000	386,000,000,000	12
Alibaba	4	8	13	208.33	117,400,000	1,180,000,000	71,985,000,000	293
Flipkart	18	6	8	0	176,930,000	100,000,000	5,914,160,994	163
Rakuten	13	8	8	39	580,080,000	111,000,000	13,800,000,000	42
Trendyol	18	7	8	0	221,430,000	19,300,000	791,800,000	120
AV	15	7	11	74	541,187,500	229,362,500	60,780,467,624	146

Two matrices were calculated as positive distance to mean (PDA) matrix and negative distance to mean (NDA) matrix. The PDA and NDA matrices are presented in Table 17 and Table 18, respectively.

Table 17
PDA matrix

	A1	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**
Bol	0	0	0	1	0	0	0	1.5004
Allegro	0.3220	.	0	0	0	0	0	0
Etsy	0	0	0.3483	0.9191	0	0	0	0
Amazon	0	0.2115	0.7079	0.4608	3.7119	0.3079	5.3507	0
Alibaba	0.7288	0.0769	0.1685	0	0	4.1447	0.1843	1.0017
Flipkart	0	0	0	1	0	0	0	0.1136
Rakuten	0.1186	0.0769	0	0.474	0.072	0	0	0
Trendyol	0	0	0	1	0	0	0	0
Weights	0.2037	0.0841	0.1702	0.2820	0.0319	0.0114	0.1158	0.1009

Table 18
NDA matrix

	A1	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**
Bol	0.0169	0.0000	0.0112	0	0.8510	0.9433	0.9148	0
Allegro	0	0.3220	0.3708	3.0450	0.6353	0.9084	0.9860	0.2212
Etsy	0.6949	0	0	0	0.2505	0.6050	0.9716	0.5833
Amazon	0.0169	0	0	0	0	0	0	0.9180
Alibaba	0	0.7288	0	1.8090	0.7831	0	0	0
Flipkart	0.2203	0	0.2809	0	0.6731	0.5640	0.9027	0
Rakuten	0	0.1186	0.2809	0	0	0.5160	0.7730	0.7131
Trendyol	0.2203	0	0.2809	0	0.590844	0.9159	0.9870	0.1802
Weights	0.2037	0.0841	0.1702	0.2820	0.0319	0.0114	0.1158	0.1009

The PDA and NDA matrices were multiplied by the weights in Table 15 obtained by the neutrosophic fuzzy AHP method, and then the weighted NDA matrix and weighted PDA matrices were obtained as shown in Table 19 and Table 20, respectively. The weighted sum of the positive distances from the mean (SP) and the weighted sum of the negative distances from the mean (SN) values were obtained for each alternative by row sums from the weighted PDA and weighted NDA matrices given in Table 19 and Table 20, respectively.

Table 19
Weighted PDA matrix

	A1	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**	**Total**
Bol	0	0	0	0.2820	0	0	0	0.1514	0.4335
Allegro	0.0656	0	0	0	0	0	0	0	0.0656
Etsy	0	0	0.0593	0.2592	0	0	0	0	0.3185
Amazon	0	0.0178	0.1205	0.1300	0.1183	0.0035	0.6195	0	1.0096
Alibaba	0.1484	0.0065	0.0287	0	0	0.0473	0.0213	0.1011	0.3533
Flipkart	0	0	0	0.2820	0	0	0	0.0115	0.2935
Rakuten	0.0242	0.0065	0	0.1337	0.0023	0	0	0	0.1667
Trendyol	0	0	0	0.2820	0	0	0	0	0.2820

Table 20
Weighted NDA matrix

	A1	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**	**Total**
Bol	0.0035	0	0.0019	0	0.0271	0.0108	.1059	0	0.1492
Allegro	0	0.0271	0.0631	0.8588	0.0203	0.0104	0.1142	0.0223	1.1161
Etsy	0.1415	0	0	0	0.0080	0.0069	0.1125	0.0589	0.3278
Amazon	0.0035	0	0	0	0	0	0	0.0926	0.0961
Alibaba	0	0.0613	0	0.5102	0.0250	-	-	0	0.5965
Flipkart	0.0449	0	0.0478	0	0.0215	0.0064	0.1045	0	0.2251
Rakuten	0	0.0100	0.0478	0	0	0.0059	0.0895	0.0720	0,2251
Trendyol	0.0449	0	0.0478	0	0.0188	0.0105	0.1143	0.0182	0,2544

As seen in Table 21, normalized SP (NSP) and normalized NP (NSN) values were obtained by normalizing SP and SN values. Then, the averages of these values were taken and the evaluation scores (AS) were obtained for each alternative.

Table 21
EDAS results

Alternatives	**SP**	**SN**	**NSP**	**NSN**	**AS**	**Rank**
Bol	0.4335	0.1492	0.4293	0.8663	0.6478	2
Allegro	0.0656	1.1161	0.0650	0.0000	0.0325	8
Etsy	0.3185	0.3278	0.3155	0.7063	0.5109	5
Amazon	1.0096	0.0961	1.0000	0.9139	0.9569	1
Alibaba	0.3533	0.5965	0.3500	0.4656	0.4078	7
Flipkart	0.2935	0.2251	0.2907	0.7983	0.5445	3
Rakuten	0.1667	0.2251	0.1651	0.7983	0.4817	6
Trendyol	**0.2820**	0.2544	0.2794	0.7720	0.5257	4

The rank values formed by ordering the AS values from largest to smallest are also shown in Table 20. Accordingly, Amazon is the most preferred e-marketplace with

the current criteria and weights. It is followed by Bol, Flipkart, Trendyol, Etsy, Rakuten, Alibaba and Allegro, respectively.

5. Discussion

In this study, a framework was created for sellers to determine the right e-marketplace for selling their products. After a literature review and experts' assesments were conducted, two main-criteria and eight sub-criteria were determined to be the evaluation criteria, and these criteria were weighted using the neutrosophic fuzzy AHP method. Using these weighted criteria and the EDAS method, eight online marketplaces operating worldwide were determined as alternatives including Bol, Allegro, Trendyol, Alibaba, Flipkart, Rakuten, Amazon and Etsy. Then, using weighted criteria from the neutrosophic fuzzy AHP, these alternatives were evaluated using the EDAS method. As a result of the study, the most important three criteria for an e-marketplace selection problem are monthly payment demanded by the e-marketplace, commission rates and supported channel features, respectively. Another result of the study is that among the eight e-marketplaces, the most preferred e-marketplace is Amazon, followed by Bol, Flipkart, Trendyol, Etsy, Rakuten, Alibaba and Allegro, respectively.

When the literature was reviewed, most of the studies about e-marketplace evaluation and selection had been performed from the viewpoint of buyers. For the buyers, the most appropriate e-marketplace for purchasing a product via online shopping was determined (Wibowo and Yunianto, 2019; Lubis et al., 2022; Guo, 2007). There is very little research about the e-marketplace selection problem from the seller's perspective (Schu and Morschett, 2017; Hidayat et al., 2021). This study can fill that gap. When the EDAS literature was reviewed, no studies were found that used the EDAS method for the e-market selection problem. This study expands the usage of EDAS.

The e-marketplace selection problem is a MCDM problem. To solve this problem, some MCDM techniques are used; for example, AHP (Hidayat et al., 2021), fuzzy AHP (Büyüközkan, 2004; Ozkok and Pappalardo, 2013), modified Hesitant Fuzzy AHP (Kahraman et al., 2018), fuzzy AHP and VIKOR (Wibowo and Yunianto, 2019), fuzzy AHP and fuzzy MOORA (Yuianto and Wibowo, 2020), extended TOPSIS (Duan et al., 2010), VIKOR and SMARTER (Arif et al., 2020), VIKOR and Rank Order Centroid (Lubis et al., 2022). This study is one of the first studies to use the integrated neutrosophic AHP and EDAS methods to evaluate e-marketplaces.

6. Conclusion

The Internet has now become an indispensable part of our lives and its audience is growing every day. With the widespread use of the Internet, the consumption and purchasing habits of individuals have also changed. Individuals are increasingly turning to online commerce for almost all their needs. E-commerce, which has

accelerated its already increasing popularity with the effects of the COVID-19 epidemic, has become indispensable for many businesses and individuals.

E-commerce platforms, which destroy the concept of place and time, bring together sellers and customers, creating a wide e-marketplace, that is, a platform. E-commerce marketplaces, which allow sellers to grow their reach worldwide, also offer customers the opportunity to obtain their needs from all over the world. It is very important for sellers to determine the right e-marketplace from among many e-commerce marketplaces, to reach their target market and increase their profitability.

This study contributes to the literature by creating a practical model to explain the preference of e-marketplaces from the seller's perspective. It determines important factors in the e-marketplace literature that make them preferred. These factors will add to discussions on how and to what extent the features of e-marketplaces affect their preference by sellers.

These findings have implications for practitioners. This study can be a guide for sellers who decide to move their selling activities online by helping them evaluate alternatives of online marketplaces and choose the most appropriate from among them to sell their products. Sellers can increase their profitability by evaluating the criteria according to their own priorities and choosing the most suitable e-marketplace for them. This study can provide a scientific method for decision makers in companies who want to move their selling activities online. Another implication of the study is for e-marketplaces. From this study, e-marketplaces can understand which factors are important for sellers to perform in an online marketplace, and they can develop their channel features to be attractive for possible new sellers.

This study has several limitations. First, the respondents were limited to Turkish companies who want to sell their products in e-commerce marketplaces. The results cannot be generalized for other countries because they have different cultures or industry systems. For future studies, to generalize results, analyses can be performed in different countries.

Mostly, the AHP and its different configurations such as fuzzy AHP, Hesitant Fuzzy AHP are used to weight evaluation criteria for e-market selection problem. In future studies, different weighted methods such as SMART or CRITIC can be used. To evaluate alternatives, other MCDM techniques such as Additive Ratio Assessment (ARAS), Brown-Gibson Model (BGM), Best-Worse Method (BWM), or Deep Ranking Analysis by Power Eigenvectors (DRAPE) can be used to extend the use of these new techniques.

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