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Multi-Criteria Decision Making for the Selection of E-Commerce Platforms using AHP-TOPSIS Model

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ABSTRACT

E-commerce links sellers and buyers in the virtual world and contributes to the economy of a country. However, there are many E-commerce platforms in the market which make it as multi-criteria decision-making problem for the buyers. This paper intends to propose an integrated AHP-TOPSIS model to study the selection of E-commerce platforms as consumers among undergraduate students. This study found that after sales service, with a weight of 0.3601, is the most crucial factor that drives consumers to engage in an E-commerce platform. Delivery speed, warranty services, and innovative products, with weights of 0.1268, 0.1256, and 0.1143 respectively, are the top three sub-criteria affecting consumers' intention to shop on the E-commerce platform. Shopee (0.6685), Taobao (0.3391), and Lazada (0.2177) are the three most preferred E-commerce platform while Zalora (0.1550) is the least visited E-commerce platform. In conclusion, the contribution of this paper is in proposing an integrated AHP-TOPSIS model for the selection of E-commerce platform in Malaysia. This integrated AHP-TOPSIS model helps decision makers to obtain optimality for complex problems. The significance of this paper is the adoption of a novel set of criteria in terms of innovative and contemporary, brand and quality, system content, price, and after sales service for the study of the selection of E-commerce platform in Malaysia. This study can also help consumers in selecting a suitable E-commerce platform in Malaysia.

Keywords:

Analytic hierarchy process; TOPSIS; E-commerce; Multi-criteria decision making; Weights

1. Introduction

Moving into the 21st century, the world has witnessed several global pandemics which shattered the economies of major, medium, and small players alike [1]. Traditional companies suffered from their conventional business strategies which were physical in nature. However, the pandemic has opened new opportunities in the virtual world where businesses and consumers in the upper and lower streams of the supply chain connect. The trend to participate in virtual transactions increase with potentially lower cost as manufacturers have the opportunities to

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engage with their customers directly without the need for middlemen even though delivery intermediaries are still required for logistical activities [2-4]. Around the world, famous E-Commerce players include eBay, Alibaba, and Amazon provide attractive economic advantages and comprehensive product information with smooth and quick interface which are appealing to customers [5]. Nowadays, E-commerce players do not only limit themselves in domestic trades, rather, they also engage in cross-border E-commerce to reach more markets [6-8]. Their critical success factor lies in their service innovation and efficiency to make them sustain in the E-commerce industry [9,10]. Besides some human factors such as education, computer, and internet skills, the attractiveness of the E-commerce platform also influences an individual's choice of engaging in E-commerce activities [11]. According to a study by Mou *et al.,* [12], in an E-commerce platform, the features capturing sellers and buyers were distinct. Sellers paid more attention to commissions, seller-buyer interactions, order management, and platform traffic while buyers were concerned about product information, lead time, seller ratings, tracking system, and the return and refund process. There are several factors that may influence a consumer's decision to purchase from an E-commerce platform, such as innovative and contemporary, brand and quality, system content, price, and after sales service [13-24].

As an E-commerce platform becomes more popular and the benefits of transacting on the E-commerce platform spread through word of mouth, more potential sellers and buyers will be attracted because of the trust beliefs and value perceptions [25,26]. Moreover, this also shows that there is a trend in which many consumers tend to follow. As macro and micro trends such as social, economy, technology, social, and government shift, there will be changes in consumers' lifestyles and demands [27-30]. If the economy is booming, consumers tend to purchase for personal satisfaction; if the economy is deteriorating, consumers will spend cautiously on necessities only [31]. In order to attract customers when the economy is good, E-commerce platform can launch more stylish and sophisticated products; when there is inflation, more essential items can be marketed [32]. As technological advancements happen continuously, there will be greater demands for new technologies in E-commerce platforms [33]. The government of Malaysia carried out the e-Belia program in 2021 which increased consumers' spendings on E-commerce platforms [34]. Spotting, understanding, and adapting to the consumer trends will increase the attractiveness of the E-commerce platform [35,36]. Product variety also affect a consumer's choice when selecting an E-commerce platform [37]. If an E-commerce platform houses large amounts of products which are useful, trendy, and innovative at attractive prices, consumers will be more likely to engage with the E-commerce platform [39]. Therefore, innovativeness and contemporary products, designs, and interface will attract more consumers to patronize an E-commerce platform.

Then, brand and quality of the products sold on the E-commerce platform will also increase consumer patronage [15,16]. Sorkun [38] found that product variety had a positive relationship with sales of e-retailers, thereby increasing the sales on the E-commerce platform. Quan and Williams [39] also noted that consumers will tend to shop in areas where the product variety is large for better brand and quality. When notable brands of high quality are sold on the E-commerce platform, these brands tend to attract more customers based on their market positioning strategies [16,40]. These brands will also perform various marketing efforts to promote their products on the E-commerce platform [41,42]. The E-commerce platforms can collaborate with these e-retailers to promote the E-commerce platform to more audiences and potential buyers [43]. Moreover, when these leading brands are sold by authorized distributors, customer trust and confidence to trade on the E-commerce platform will increase as they are driven by the concept that genuine products can be found in the E-commerce site [44,45]. For small and medium enterprises (SMEs) participating in online selling activities, the E-commerce platforms can also work with them to increase their brand

equity, thereby improving customer confidence level, attracting new customers, and retaining existing customers with high repurchase intention [46].

At the same time, system content is also an important element attracting consumers to purchase on the E-commerce site [17,18]. A consistently up-to-date E-commerce system offers consumers a smooth and better browsing and checkout experience which will make them stay for longer period of time and ignite their purchase and repurchase intention [47,58]. Meanwhile, using big data and artificial intelligence for data mining, E-commerce platforms can also understand their consumers well and tailor recommendations to each consumer, which is known as personalization [49,50]. While browsing through the E-commerce site, consumers will be more entertained when they find products which are more relevant to them [51]. By understanding consumer behaviour, E-commerce platforms can also do better sales forecasting to handle larger traffic on special occasions [52]. Predictive analytics using big data could analyse the visit time, cart size, popular searches, and other demographic information of consumers to allow the E-commerce platforms to establish strategies aimed at increasing purchasing behaviour [53,54]. Meanwhile, a good E-commerce system can also alert consumers on duplicate purchases or abnormal spending while checkout system can also be enhanced with more payment options such as pay later, instalments, or combined payments [55,56]. Formatting and picture quality in an E-commerce platform are also parts of system content which would affect consumers' confidence in using the E-commerce platform [17].

Price is also a crucial factor that determines a consumer's purchasing intention from the E-commerce platform [19-21]. Given that trading on E-commerce is non-monopolistic, sellers normally offer competitive pricing for undifferentiated products to gain market share [57]. Some E-commerce platforms allow sellers to perform bundle purchases in which two or more products usually purchased together can be bought at once at lower price [58,59]. There are also some E-commerce sites that have bulk purchase or wholesale features so that buyers can achieve economies of scale when purchasing above certain quantity [60,61]. Buyers are also inclined to purchase on E-commerce platforms if the platforms provide free shipping, discounts, or cashbacks [62]. Given the convenience of online shopping, buyers would also compare prices across several E-commerce platforms before deciding to place an order. After sales service and reverse logistics also affect a customer's intention to shop on an E-commerce platform [22-24]. Customers are sceptical to engage in E-commerce activities because of the lack of human contact. Post-purchase and after sales then play important roles to create a positive shopping experience [24,63]. Order tracking, delivery and cancellation processes are some of the post-purchase activities [63]. However, if there is late shipment and delivery, exchanges, and returns, the support that a customer receives determines the customer's repurchase decision. The resolution time for each after sale issue is crucial to reduce customer frustration. Having a team of professional and trained customer service representatives can reduce the resolution time, provide a win-win solution for both sellers and buyers, and develop good customer relationships [64].

The study of the selection of E-commerce platform among consumers is a multi-criteria decision making (MCDM) problem which considers various decision alternatives based on multiple decision criteria [65-68]. MCDM problem solving is a challenging task because of conflicting decision criteria in the decision-making process [69,70]. Analytic hierarchy process (AHP) was introduced by Thomas L. Saaty in the 1970s with high popularity [71-73]. AHP has been applied in various fields such as renewable energy resources [74], fuel cell power generation [75], supplier development evaluation [76], courier service providers [77] and language selection [78]. TOPSIS was proposed by Hwang and Yoon [79] in 1981 with much affirmation [80-82]. AHP identifies the weights of the decision criteria while TOPSIS ranks the decision alternatives. AHP works on pairwise comparison [83,84] while

TOPSIS ranks the decision alternatives according to the nearest with the positive ideal solution (PIS) and furthest from the negative ideal solution (NIS) [85,86]. The integrated AHP-TOPSIS model has been applied in medicine [87,88], water treatment [89-91], software development [92,93], material [94,95], mobile [96] and energy [97,98]. AHP-TOPSIS model can be used to study the selection of E-commerce platform among consumers. The application of digital tool in mobile commerce is important nowadays [99]. Therefore, this paper aims to study the selection of E-commerce platform among consumers using an integrated AHP-TOPSIS model. The contribution of this paper is to evaluate the E-commerce platforms based on innovativeness and contemporary, brand and quality, system content, price, and after sales service. This will help the E-commerce platforms to understand their strengths and weaknesses and improve accordingly. This will also help other potential consumers when they search for potential E-commerce platforms to shop on. This paper shall continue with methodology in Section 2, results and discussion in Section 3, and conclusion in Section 4.

2. Methodology

This paper proposes the AHP-TOPSIS method in studying the selection of E-commerce platforms among consumers. First, the issue of determining the selection of E-commerce platforms will be decomposed into a hierarchy structure as in the AHP model. Comparative judgments will be conducted among the decision criteria and sub-decision criteria. Then, the weights of the decision criteria will be used in TOPSIS to find out the optimal decision alternative. The proposed framework of this study is shown in Figure 1.

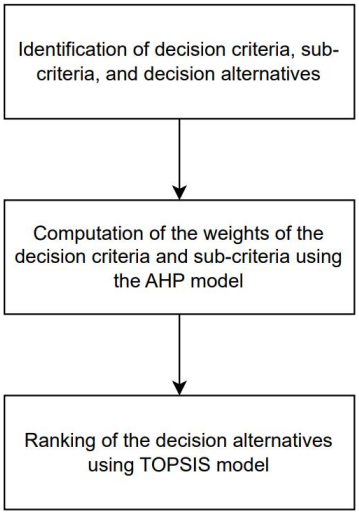

Fig. 1. Proposed framework

From Figure 1, this study consists of 3 steps. The first step starts with identifying the decision criteria, sub-criteria, and decision alternatives when selecting an E-commerce platform. Step 2 applies the AHP model to find out the weights of the decision criteria and sub-criteria. Then, the overall weights of the decision criteria will be used in the third step to rank the decision alternatives using TOPSIS model based on the shortest distance to the PIS and furthest distance to the NIS.

Table 1 presents the hierarchy structure to study the selection of E-commerce platform using the AHP-TOPSIS model. The top level shows the objective of this study which is to determine the selection of E-commerce platform among consumers. The middle level explains the decision criteria which include innovative and contemporary, brand and quality, system content, price, and after

sales service. The bottom level highlights the decision alternatives which consist of Taobao, Lazada, Zalora, Shopee, and social media.

Table 1
Hierarchy structure of study

Level	Explanation
Objective	Selection of E-commerce platform
Decision Criteria	Innovative and contemporary
	Brand and quality
	System content
	Price
	After sales service
Decision Alternatives	Taobao
	Lazada
	Zalora
	Shopee
	Social media

The decision criteria and sub-criteria to study the selection of E-commerce platforms are explained in Table 2.

Table 2
Decision criteria and sub-criteria

Main Criteria	Sub-Criteria
Innovative and contemporary	Innovative product
	Trendiest product
	Product variety
Brand and quality	Brand loyalty
	Product quality
	Authenticity
System content	User friendly
	Mobile friendly
	Product information
	Customer review
	Product price
	Promotion
	Shipping fee
After sales service	Speed of delivery
	Return and refund
	Warranty service

A survey is constructed and distributed to 100 undergraduate students to determine their selection of E-commerce platform. The involvement of undergraduate students is important in the association and survey [100]. Undergraduate students are chosen because they are computer and mobile literate. Undergraduate students are also likely to perform online shopping because of convenience, flexibility, and price [101,102]. The inputs from the respondents are important in the analysis of MCDM problems [103,104].

After collecting the completed surveys, AHP will be used to determine the weights of the decision criteria while TOPSIS model will rank the decision alternatives.

There are five steps in determining the weights of the decision criteria using AHP.

i. Step 1: Decomposing the issue into a hierarchy structure where the top level shows the objective of study, middle level explains the decision criteria, and bottom level highlights the decision alternatives [105]. The hierarchy structure has been reflected in Table 1.
ii. Step 2: Collecting data from the target respondents. The survey shall consist of two-way Likert scale pairwise comparison as shown in Table 3 [106].

Table 3
Pairwise comparison scale

Scale	Definitions
1	Equal importance
3	Moderate importance
5	Strong importance
7	Powerful importance
9	Extreme importance
2, 4, 6, 8	Intermediaries

iii. Step 3: Developing pairwise comparison matrix as shown in Eq. (1).

$$M = \begin{bmatrix} 1 & c_{12} & \cdots & \cdots & c_{1n} \\ 1/c_{12} & 1 & \cdots & \vdots & c_{2n} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \vdots & \vdots & \cdots & \ddots & \vdots \\ 1/c_{1n} & \cdots & \cdots & \cdots & 1 \end{bmatrix} \quad (1)$$

where c_{ij} shows the degree of preference of criterion i to criterion j.

iv. Step 4: Normalizing the matrix and calculating the weights of the decision criteria. Every element in the matrix shall be divided by the sum of the elements in the respective column to form a normalized matrix. Then, the mean of every row in the normalized matrix will show the weights of the decision criteria.
v. Step 5: Performing a consistency test with consistency ratio where the consistency ratio is the ratio of the consistency index to the random index as seen in Eq. (2). The result of the AHP model is accepted if the consistency ratio is below 0.10.

$$CR = \frac{CI}{RI} = \frac{\lambda_{max} - n}{(n-1)(RI)} \quad (2)$$

where CR is the consistency ratio, CI is the consistency index, RI is the random index, λ_{max} is the maximum eigenvalue of the matrix, and n is the number of criteria [107,108].

TOPSIS model involves six steps as discussed below [107,109-111].

i. Step 1: Constructing a matrix, p_{xy}, with size h x k where y is the criteria in a column ($y = 1,2,3, \ldots, k$) while x is the alternative in a row ($x = 1,2,3, \ldots, h$).
ii. Step 2: Evaluating the normalized matrix (r_{xy}) as shown in Eq. (3).

$$r_{xy} = \frac{p_{xy}}{\sqrt{\sum_{x=1}^{h} p_{xy}^2}}, \; x = 1,2, \ldots, h \text{ and } y = 1,2, \ldots, k \quad (3)$$

iii. Step 3: Computing the weighted normalized decision matrix (w_{xy}). The weights of the decision criteria which has been obtained from the AHP model reflects the importance of each criterion in selecting an E-commerce platform. w_{xy} is calculated by multiplying the weights of the decision criteria, w_y, with every element in the normalized decision matrix as shown in Eq. (4).

$$a_{xy} = w_y \cdot r_{xy} = w_y \cdot \frac{p_{xy}}{\sqrt{\sum_{x=1}^{h} p_{xy}^2}} \tag{4}$$

iv. Step 4: Calculating the PIS and NIS as listed in Eq. (5) and Eq. (6).

$$A_y^+ = \left\{\max\left(a_{xy}\right) if\ y \in Y; \min\left(a_{xy}\right) if\ y \in Y'\right\} \tag{5}$$

$$A_y^- = \left\{\min\left(a_{xy}\right) if\ y \in Y; \max\left(a_{xy}\right) if\ y \in Y'\right\} \tag{6}$$

where A_y^+ denotes the PIS while A_y^- denotes the NIS.

v. Step 5: Determining the geometric separation of PIS (S^+) and NIS (S^-) as in Eq. (7) and Eq. (8).

$$S^+ = \sqrt{\sum_{y=1}^{k} (a_{xy} - A_y^+)^2}, y = 1,2,3, \ldots, k \tag{7}$$

$$S^- = \sqrt{\sum_{y=1}^{k} (a_{xy} - A_y^-)^2}, y = 1,2,3, \ldots, k \tag{8}$$

vi. Step 6: Finding the relative closeness coefficient (C_x) as in Eq. (9) where C_x is between 0 and 1. The most optimum alternative shall have the greatest C_x value. The E-commerce platform can then be ranked from the greatest to the smallest C_x value.

$$C_x = \frac{S^-}{S^+ + S^-}, C_x \in [0,1], x = 1,2,3, \ldots, h \tag{9}$$

3. Result and Discussion

This section displays the results of the selection of E-commerce platforms among undergraduate students from the AHP-TOPSIS model. Figure 2 demonstrates the weights of the decision criteria computed using the AHP model.

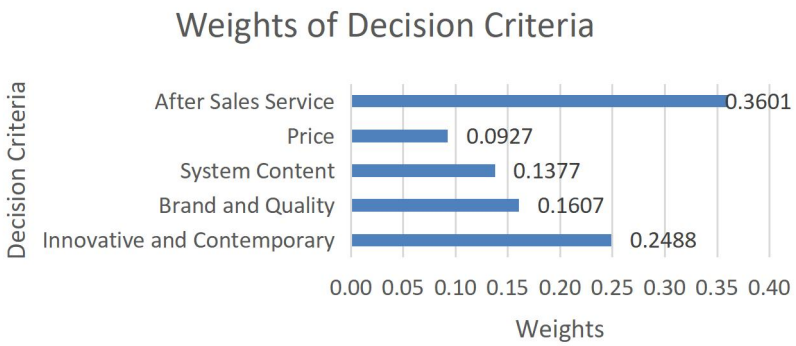

Fig. 2. Weights of decision criteria

As shown in Figure 2, after sales service has the highest weight of 0.3601, followed by innovative and contemporary, and brand and quality with weights of 0.2488 and 0.1607. This implies that after sales service is the most important criteria when selecting an E-commerce platform. System content (0.1377) and price (0.0927) are the less important criteria based on this study. This is in line with several studies which mentioned the importance of after sales service in driving customer satisfaction, profitability, and repurchase intention [112-115].

Table 4 displays the priority weights with the AHP decision tree.

Table 4
Priority weights with AHP decision tree

Criteria	Weight between criteria	Weight within criteria	Ranking within criteria	Weight among sub-criteria	Overall ranking
Innovative and Contemporary	0.2488				
Innovative product		0.4595	1	0.1143	3
Trendiest product		0.3164	2	0.0787	5
Product variety		0.2241	3	0.0557	7
Brand and Quality	0.1607				
Brand loyalty		0.4530	1	0.0728	6
Product quality		0.3325	2	0.0534	8
Product authenticity		0.2146	3	0.0345	13
System Content	0.1377				
User friendly		0.2891	2	0.0398	11
Mobile friendly		0.3244	1	0.0447	9
Product information		0.2801	3	0.0386	12
Customer review		0.1064	4	0.0146	16
Price	0.0927				
Product price		0.2931	2	0.0272	14
Shipping fee		0.4600	1	0.0426	10
Promotion		0.2469	3	0.0229	15
After Sales Service	0.3601				
Speed of delivery		0.3522	1	0.1268	1
Return and refund		0.2989	3	0.1076	4
Warranty service		0.3489	2	0.1256	2

The local weights and rankings, which are the weights and rankings of the sub-criteria within the main criteria are computed and shown in column 3 and 4 of Table 4. The top sub-criteria within the main criteria innovative and contemporary, brand and quality, system content, price, and after sales service are innovative product (0.4595), brand loyalty (0.4530), mobile friendly (0.3244),

shipping fee (0.4600), and speed of delivery (0.3522). The least preferred sub-criteria within the main criteria are product variety (0.2241), product authenticity (0.2146), customer review (0.1064), promotion (0.2469), and return and refund (0.2989).

The global weights and rankings of the sub-criteria are listed in column 5 and 6 in Table 4 and shown in Figure 3. Speed of delivery (0.1268) has the highest weight and is the most crucial sub-criteria in the selection of E-commerce platform among undergraduate students. Warranty service (0.1256), innovative product (0.1143), return and refund (0.1076), and trendiest product (0.0787) are among the top five attractive factors in selecting an E-commerce platform. This is followed by brand loyalty (0.0728), product variety (0.0557), product quality (0.0534), mobile friendly (0.0447), shipping fee (0.0426), user friendly (0.0398), product information (0.0386), and product authenticity (0.0345). The three least considered factors are product price, promotion, and customer review with weights of 0.0272, 0.0229, and 0.0146 respectively.

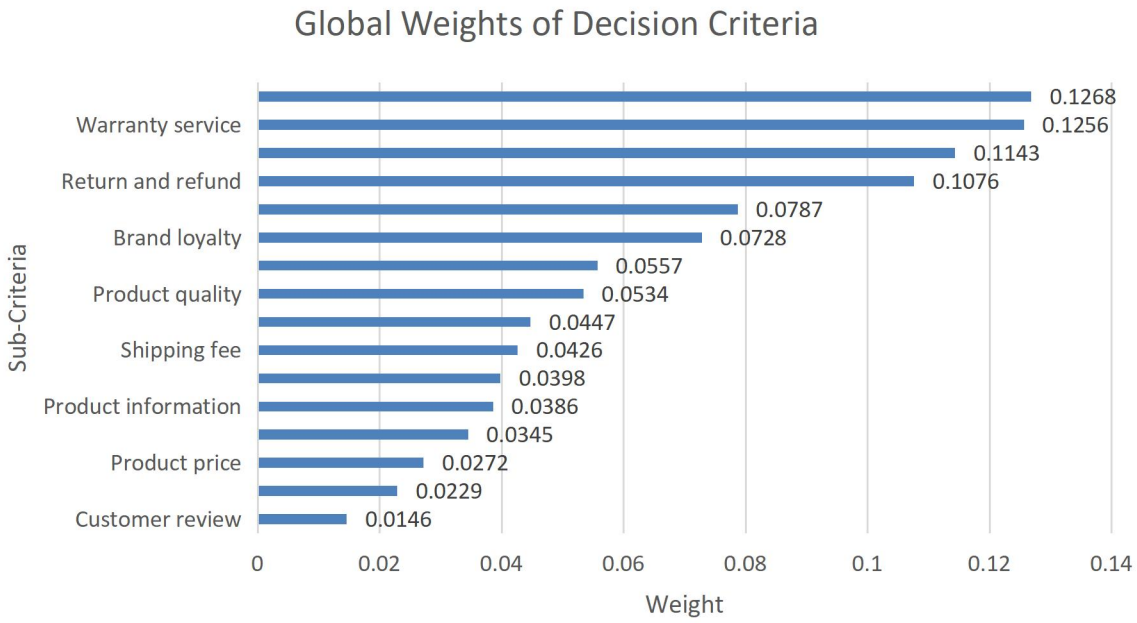

Fig. 3. Global weights of sub-criteria

Finally, using the weights of the decision criteria generated from the AHP model, the ranking of the E-commerce platforms can be performed. Table 5 tabulates the geometric separation of the E-commerce platform from the PIS (S^+) and NIS (S^-).

Table 5
Geometric separation from PIS and NIS

E-Commerce Platform	S^+	S^-
Taobao	0.0005	0.0003
Lazada	0.0004	0.0001
Zalora	0.0005	0.0001
Shopee	0.0002	0.0004
Social media	0.0004	0.0001

From Table 5, Shopee has the shortest geometric distance from S^+ (0.0002), followed by Lazada (0.0004), social media (0.0004), Taobao (0.0005), and Zalora (0.0005). This means that Shopee is the closest to the PIS. Meanwhile, Shopee also has the largest geometric distance from S^- (0.0004),

followed by Taobao (0.0003), Lazada (0.0001), Zalora (0.0001), and social media (0.0001). This implies that Shopee is the furthest from the NIS.

The relative closeness coefficients (C_x) and the rankings with regards to the PIS and NIS are shown in Table 6. Since Shopee has the shortest distance from PIS and furthest distance from NIS simultaneously, Shopee has the highest C_x of 0.6685 and is ranked number one. Taobao, Lazada, and social media have C_x of 0.3391, 0.2177, and 0.1587. These three E-commerce platforms are ranked second, third and fourth respectively. Zalora is the least selected E-commerce platform with a C_x of only 0.1550.

Table 6
Ranking of E-commerce platforms

E-Commerce Platform	C_x	Ranking
Taobao	0.3391	2
Lazada	0.2177	3
Zalora	0.1550	5
Shopee	0.6685	1
Social media	0.1587	4

Table 7 shows the consistency ratio table. Since the consistency ratio, CR, of all the main criteria and sub-criteria are below 0.10, the result of this study is acceptable.

Table 7
Consistency ratio table

	Number of Criteria / Sub-Criteria, n	λ_{max}	Consistency Index, CI	Random Index, RI	Consistency Ratio, CR
Main Criteria	5	5.1228178	0.0307	1.1200	0.0274
Sub-Criteria					
Innovative and contemporary	3	3.0010007	0.0005	0.5800	0.0009
Brand and quality	3	3.0618150	0.0309	0.5800	0.0533
System content	4	4.1984947	0.0662	0.9000	0.0735
Price	3	3.0007180	0.0004	0.5800	0.0006
After sales service	3	3.0037043	0.0019	0.5800	0.0032

4. Conclusions

The study of the selection of E-commerce platforms is a multi-criteria decision-making problem. An integrated AHP-TOPSIS model has been proposed to study the selection of E-commerce platforms. Based on the results of this integrated AHP-TOPSIS model, Shopee is the most popular E-commerce platform, followed by Taobao, Lazada, social media, and Zalora. The three most important decision criteria are after sales service, followed by innovative and contemporary, and brand and quality. Among the sub-criteria, the top five are delivery speed, warranty service, innovative product, return and refund, and trendiest product. Besides, among the five E-commerce platforms, Zalora has to improve to attract more consumers, such as by introducing more product varieties. In the academics, this study has contributed by proposing an integrated AHP-TOPSIS model to study the selection of E-commerce platforms. The proposed framework with this integrated AHP-TOPSIS model adopts decision criteria, sub-criteria, and decision alternatives which are novel. This integrated AHP-TOPSIS model helps decision makers identify the optimal solution for complex problems with high reliability and accuracy. In the industry, the results of this study portray the strengths and weaknesses of the E-commerce platforms to allow the management

teams to take improvement and reinforcement measures to reach greater heights. The outcomes of this study also highlight the important factors and sub-factors which lead to the success of an E-commerce platform. The management team will be able to draft enhancement plans with respect to each factor and sub-factor.

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