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A Hybrid MCDM Model for Live-Streamer Selection via the Fuzzy Delphi Method, AHP, and TOPSIS

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Abstract: The development of the Internet is a key revolution of the 20th century. The Internet has led to a boom in e-commerce. Online shopping is generally the most popular shopping option for consumers. The coronavirus disease 2019 (COVID-19) pandemic has resulted in adopting various measures, such as lockdown and stay-at-home orders, in various countries. This has led to changes in people's consumption habits. In Taiwan, consumer behavior has also rapidly shifted to online shopping after the outbreak of the COVID-19. As livestreaming breaks time and space barriers, its real-time, interactive, and authentic features are unparalleled compared to other marketing methods, thereby creating a brand-new shopping experience for consumers. Accordingly, livestream shopping, a new consumption model, has developed and become an essential part of people's daily lives. Live-streamers, who are similar to salespersons in traditional markets, play a vital role in e-commerce livestreaming. The success of livestream shopping has highlighted the importance of live-streamers. The competition among live-streamers has become more intense because of the arrival of many newcomers. Thus, operators must make careful hiring decisions. However, no related literature in the past has investigated this important topic. Therefore, this study applied a hybrid multi-criteria decision-making (MCDM) model comprising the fuzzy Delphi method (screen the selection criteria), analytic hierarchy process (AHP) (obtain the weight of each dimension and criterion), and technique for order preference by similarity to ideal solution (TOPSIS) (rank the alternatives) to assist the managers of shopping websites in selecting live-streamers. We interviewed the managers of shopping websites and reviewed the related literature to compile the selection criteria. Following the fuzzy Delphi method, 15 important selection criteria were retained based on the 30 managers' opinions. Further, the criteria were classified into dimensions based on the previous literature and interviews conducted on managers to establish a hierarchical framework. On the basis of this hierarchical framework, AHP and TOPSIS were applied to help a case company select live-streamers. A comparative analysis between the outcomes from AHP and AHP/TOPSIS was also conducted in this study. This study is the first empirical study on live-streamers' selection and adds to the literature on livestreaming.

Keywords: live-streamer; fuzzy Delphi method; analytic hierarchy process (AHP); technique for order preference by similarity to ideal solution (TOPSIS); shopping website

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1. Introduction

The development of the Internet has been a significant revolution of the 20th century. Through the complex and rapid communication and the transfer of all kinds of data, the information content on the Internet has shown a high growth potential [1]. The Internet offers a channel for continuous and limitless information exchange. With the advancement of information technology and the gradual maturing of the e-commerce market, there has been a global annual increase in engagement in online shopping. Taiwan's online shopping market has also shown considerable growth [2]. Since its onset in the 20th century, the use of the Internet has increased globally, driving the rise of the e-commerce industry. The dot-com bubble crash in 2000 resulted in the Internet losing its popularity. However, the emergence of Web 2.0 in 2004 promoted the gradual rise of global e-commerce due to the gradual increase in the number of Internet users and the establishment of broadband networks [3].

The Internet is a competitive field for businesses, with e-commerce disrupting the traditional business models among firms and extensively impacting consumers' shopping patterns. Online shopping has no time and space restrictions; it allows consumers to make purchases without leaving their homes and offers personalized services. Therefore, it can inevitably become the consumers' preferred shopping channel [4]. Furthermore, the emergence of the Internet has expanded consumers' social connections and networks. The widespread adoption of the Internet among the e-generation has gradually changed the way in which consumers shop, leading to the rise of online shopping. With the development of the Internet and high population of Internet users, people's increasing reliance on the Internet has driven the advancement of the e-commerce industry, which has eventually led to a boom in the "stay-at-home economy." Thus, online shopping is generally the most popular shopping option among Internet users [5]. Recently, due to the COVID-19 pandemic, restrictions on outdoor shopping and self-management at home have changed people's consumption habits. With the ubiquitous adoption of mobile phones and the Internet, traditional retailers have switched to selling products online; therefore, online shopping is gradually becoming a new transaction channel [6].

Shopping websites are platforms set up by companies to provide services or products to consumers. Shopping websites have to engage in price wars and must employ their intangible competitive advantage against a host of competitors [7]. The evolution of the Internet has made people's lives more convenient while enabling the rapid rise of e-commerce. Consumers can complete most transactions on online platforms at the click of a button, completely disrupting the traditional shopping model in the process. This is of considerable convenience for busy consumers today, allowing them to purchase their preferred products in just a few minutes without having to go out. Generally, the original business model began to change with a rise in the emergence of shopping platforms; each platform emphasizes its competitive advantage in different ways, such as through the variety of products sold, speed of logistics, and price bidding. As business models are becoming similar to each other, these platforms are slowly losing their original brand features and advantages [8].

Due to the convenience generated by the Internet and a rapid expansion of the "livestreaming" feature in recent years, a new consumption model, namely "livestream shopping," has developed. Since it can reduce operating costs, it has become reasonable for traditional businesses to shift to a sales model that directly or concurrently runs livestream shopping. As a current trend in consumption, livestream shopping has become an indispensable aspect of people's daily lives in the modern era [9]. Livestream shopping is focused on the relationship between sellers and buyers. The widespread adoption of mobile devices has enabled users to watch a livestream any time and from any location. Therefore, livestream shopping has become a method of sale adopted by a host of sellers [10]. Users and live-streamers can realize equal and real-time communication via livestreaming platforms; similarly, it is possible for users to communicate with each other. Hence, livestreaming reduces the distance between companies and individuals [11].

When a live-streamer demonstrates a product to consumers and proactively helps them solve their problems, the consumers are more likely to purchase the product [12]. Moreover, the success of livestream shopping has highlighted the importance of live-streamers in e-commerce, who play an important role in livestream shopping, distinguishing it from traditional shopping [13]. In 2019, the e-commerce livestreaming industry witnessed a rapid growth, with increased competition among live-streamers due to the arrival of many newcomers [14]. Similar to salespersons in traditional markets, live-streamers play an essential role in e-commerce livestreaming. Hence, e-commerce operators must make careful hiring decisions [15]. Therefore, as live-streamers play an essential role, their selection is an MCMD problem, in which the most optimal solution can be determined based on the appropriate selection criteria and screening procedures.

Decision-making is a usual activity in daily life and plays a significant role. MCDM selects the optimal alternative under various criteria. To find the most preferred alternative, decision-makers provide alternative preferences [16]. However, each MCDM method has its pros and cons. There is no rule for identifying how to choose them [17]. Aktaş and Demirel [18] also indicated that it is very hard to determine the best MCDM method. To obtain robust results, applying more than one method is recommended. Data should be collected via group decision-making and expert discussion among the MCDM methods. The Delphi method is widely used for this purpose [19]. However, there are several shortcomings in its application, such as lack of direct feedback and obstruction in understanding certain concepts [20]. Additionally, it is time-consuming and produces incorrect results when there are semantically unclear items in the questionnaire. These shortcomings were subsequently overcome by scholars by incorporating fuzzy theory [21]. Decision-making scenarios (e.g., decision-making information, numeric values, and decision-maker cognition) faced by individuals are usually fuzzy. To make suitable and high-quality decisions in a scenario, the fuzzy set theory plays an important role. Zadeh [22] proposed the concept of "fuzzy sets," emphasizing that individuals' thinking, inference, and perception of surroundings are quite fuzzy in essence. Accordingly, the analysis method of fuzzy mathematics is more effective than the traditional quantitative method in making decisions in fuzzy scenarios [23]. In many decision-making problems, decision-makers obtain vague or imprecise information. To adequately settle such situations, the fuzzy set theory has become a powerful implement [16]. The fuzzy Delphi method primarily focuses on uncertainty and linguistic variables; the triangular fuzzy number in the fuzzy theory is used to improve the shortcomings of the traditional Delphi method. Additionally, the new method also reduces the time spent on data collection [24]. Previous studies have shown that the fuzzy Delphi method can obtain valid and reliable criteria [25,26]. Additionally, since the properties of the geometric mean can reduce the effects of extreme values and highlight the correlations of elements, it is used as a reference for the final selection of elements [21]. The fuzzy Delphi method has been successfully administered in many areas [27]. Furthermore, many studies [28–32] have applied the fuzzy Delphi method to screen the criteria for personnel selection. As a result, the geometric mean is adopted in the fuzzy Delphi method for representing the opinions of experts and screening the selection criteria for live-streamers.

Many studies have combined the fuzzy Delphi method with AHP to improve the research results. Most studies first identified important elements using the fuzzy Delphi method and then determined their importance using AHP [33]. TOPSIS serves as another appropriate option because it is suitable for multiple criteria, and it is simple and easy to understand [34]. Notably, TOPSIS is one of the most commonly applied methods to solve multi-attribute decision-making (MADM) problems. It is easy to understand and apply [35]. In the mathematical approach of MCDM, TOPSIS is most widely used [36]. AHP and TOPSIS are helpful and practical methods, respectively, for determining the relative importance of the elements and ranking the alternatives [37]. Additionally, the results obtained from AHP and TOPSIS are objective and accurate [38]. Thus, integrating them can produce more favorable results than using only TOPSIS [39]. It is worth noting that Tsai et al. [40] integrated them to select bloggers for hotels with no rank reversal occurrence in their study. Therefore, this study applied a hybrid MCDM model comprising the fuzzy Delphi method, AHP, and TOPSIS to assist the managers of shopping websites in selecting their live-streamers. Although livestream shopping is currently experiencing unprecedented growth, research on livestreaming businesses has only emerged recently [13]. For instance, Ma [13] developed an integrated model to explore the elements influencing livestream shopping intention. Chen [9] investigated the legal issues of Facebook live shopping. Chen et al. [14] investigated the influence of e-commerce livestreaming on customer repurchase intentions using empirical research approaches. Cheng et al. [10] investigated the influential elements of audiences' trust and loyalty intention toward online streaming broadcasters based on the elaboration likelihood model (ELM). Gong et al. [11] bettered the content quality and competitiveness of live platforms to improve the effect of livestream marketing. Hu and Chaudhry [15] used the stimulus-organism-response (SOR) model to explore how relational bonds improve customer engagement. Finally, Sun et al. [12] explored how livestream shopping affects consumer purchase intention. However, we found that no related literature in the past has investigated our specific topic.

To conduct this study, the managers of shopping websites were interviewed, and related studies were reviewed to compile a set of selection criteria. We used the fuzzy Delphi method to screen the selection criteria and then constructed a hierarchical framework. Next, the weights of each dimension and each selection criterion were determined and integrated using AHP. Lastly, to address the excessive pairwise comparison matrices and reduce difficulty filling out the questionnaire among the decision-makers, the integrated weights of the selection criteria compiled using AHP were incorporated into TOPSIS. This assists in selecting the best live-streamer, thereby increasing the efficiency of decision-making. The study's objectives are as follows:

1. Interview the managers of shopping websites and review related literature to compile the selection criteria. Then, screen the selection criteria for live-streamers based on the fuzzy Delphi method, classify them, and establish a hierarchical framework based on past literature and interviews with the managers. The hierarchical framework can be used to help the managers of shopping websites select live-streamers.
2. Assist the managers in a case shopping website to select the best live-streamer by incorporating the hierarchical framework in combination with AHP and TOPSIS.

The consecutive sections of this study are described as follows. The next section presents the conceptual framework, followed by the research methods. The fourth section features its application in an actual case study, where the managers of a shopping website are assisted in selecting the best live-streamer based on a hybrid MCDM model. Finally, the last section discusses the conclusions, research contributions, limitations, and suggestions for future research.

2. Conceptual Framework

This study assists the managers of shopping websites in selecting live-streamers by combining the fuzzy Delphi method, AHP, and TOPSIS. In this conceptual framework:

1. The first level is the objective.

   The objective is to select the best live-streamers.

2. The second level is the selection dimensions.

Important criteria are classified into dimensions based on past literature and interviews with the managers of shopping websites.

3. The third level is the selection criteria.

A set of selection criteria are compiled by interviewing the managers of shopping websites and reviewing related studies. Next, a questionnaire with a nine-point Likert scale is designed based on the fuzzy Delphi method and filled out by the managers of shopping websites. The higher the score of a criterion, the higher its level of importance. Important criteria are retained according to the geometric mean provided by the respondents.

According to the standard for screening criteria in the fuzzy Delphi method, a criterion with an over 80% importance level is generally regarded as important [41]. In other words, a criterion with a geometric mean of over 7.2 is regarded as a vital criterion based on conversion using the questionnaire on the nine-point Likert scale. This study establishes the selection criteria for live-streamers by referencing the discussed standard, where a criterion with a geometric mean of over 7.2 is regarded as an important criterion and should be retained. After confirming the selection criteria, they are classified into dimensions based on the literature review and interviews with the managers of shopping websites. Then, the second round of questionnaires is designed to assist a case study shopping website in selecting the most suitable live-streamer using AHP and TOPSIS.

4. The fourth level is the solution.

The managers of a shopping website in the case study are assisted in selecting the best live-streamer based on the hierarchical framework combined with AHP and TOPSIS.

3. Research Method

3.1. Fuzzy Delphi Method

The Delphi method, known as the expert survey method, primarily uses questionnaires to seek opinions from various experts on the problem, and then compiles and summarizes the comprehensive opinions. Next, the comprehensive opinions and questions are fed back to the experts before their opinions are sought once more. Thus, the expert consensus is gradually obtained after numerous iterations [42]. As the Delphi method is based on expert knowledge, complex issues are systematized after multiple iterations of questionnaire feedback to reach expert consensus. However, there are criticisms and limitations to its operation. For instance, this method involves many iterations of questionnaire feedback to achieve convergence, which is time-consuming, increases cost, and reduces response rate. Therefore, scholars continue to modify the operation of the Delphi method, ensuring its efficiency and reliability. After 1985, the fuzzy Delphi method was developed using the Delphi method mixed with the fuzzy theory to address the difficulties faced by the traditional Delphi method. Its advantages include the ability to deal with semantic ambiguity and retain more expert information [43].

The fuzzy Delphi method is an element selection method. Compared to the traditional Delphi method, it possesses the following advantages [44]:

1. It helps reduce the number of surveys.
2. It helps express expert opinions more completely.
3. It enables expert knowledge to be more rational and consistent with the need through the fuzzy theory.
4. It brings more economic benefits in terms of time and cost.

The fuzzy Delphi method enables elements to integrate opinions from experts in related fields and can truly reflect fuzziness and uncertainty in social sciences [45]. The traditional Delphi method is time-consuming, and it produces incorrect results when there are semantically unclear items in the questionnaire. However, these shortcomings in the Delphi method were subsequently overcome by scholars by incorporating the fuzzy theory. Furthermore, as the properties of the geometric mean can reduce the effects of extreme values and highlight the correlations of elements, it is used as a reference for the final selection of elements [21].

The fuzzy Delphi method has been successfully used in many areas [27]. As to the studies about personnel selection, it was utilized to screen the selection criteria for public relations personnel [28], tour guide [29], celebrity endorser [30], gamer for professional esports team [31], and variety show host [32]. As a result, opinions from the managers of shopping websites were extracted using the geometric mean in this study. Based on a previous study [41], a criterion with a geometric mean of over 7.2 is regarded as important and should be retained for selecting live-streamers.

3.2. AHP

AHP is a widely used MCDM approach that performs a pairwise comparison to establish the weights of the elements and the priority of the alternatives [46]. AHP is performed in seven steps, which are explained as follows [47]:

1. Confirm the problem

The scope of the research problems should be clearly defined and all the elements that may affect the problem should be considered.

2. List all elements related to the problem

All the elements related to the problem can be obtained through the Delphi method, brainstorming, and literature collection, without considering their order and relevance.

3. Construct a hierarchical framework

A hierarchical framework can be constructed to derive multiple levels according to the needs of the problem. There are no fixed methods for constructing a hierarchical framework. The uppermost layer of a hierarchical framework is the goal. Each of the bottom layers can include multiple elements, but it is recommended that they contain no more than seven elements because humans cannot compare more than seven elements simultaneously.

4. Questionnaire design and survey

AHP uses elements of the previous level of the hierarchical framework as the basis for evaluating elements of the current level. Based on the element at the upper level, any two elements at a certain level are compared to evaluate their relative contribution or importance. AHP involves the evaluation of the relative importance of elements of the same level through a pairwise comparison. The elements are rated using the following five scales on a scale of 1, 3, 5, 7, and 9, with 2, 4, 6, and 8 being the intermediate values. In other words, the participants use an element from the previous level as the evaluation benchmark to compare elements from each level through pairwise comparison on a scale of 1 to 9. The questionnaire must clearly state the questions for each pairwise comparison and include detailed instructions.

5. Establish a pairwise comparison matrix

The pairwise comparisons can represent the weights of elements.

6. Calculate the consistency ratio

To determine the appropriateness of the responses in the questionnaires, the consistency ratio of each pairwise comparison matrix is computed, and a ratio of less than 0.1 is considered acceptable.

7. Calculate the element weight in each level, perform integration between levels, and finally determine the priority of the alternatives.

There are several famous weighting means. Among them, AHP has been the most utilized, owing to its applicability and popularity [48]. As a result, we acquired the weight of each dimension and selection criterion based on AHP.

3.3. TOPSIS

Established by Hwang and Yoon in 1981, TOPSIS is an MCDM approach, based on the idea that a chosen alternative should be the closest to the positive ideal solution (PIS) and the farthest from the negative ideal solution (NIS). This method assumes that each element is either monotonically increasing or decreasing. If the element is a benefit, the greater the performance value, the greater the preference value. Conversely, if the element is a cost, the smaller the performance value, the greater the preference value. The PIS is composed of all the best values attainable by the elements, while the NIS consists of all the worst values attainable by the elements. Based on the Euclidean distance, alternatives are selected by calculating their closeness to the ideal solution. Its process is carried out based on the following steps [49]:

1. Create a normalized evaluation matrix.
2. Create a weighted evaluation matrix.
3. Determine the PIS and NIS.
4. Compute the separation.

The separation of each evaluation matrix in each alternative from the PIS and NIS is computed based on the Euclidean distance formula.

5. Compute the relative closeness to the ideal solution.

When the relative closeness approaches 1, an alternative is closer to the PIS and farther from the NIS. Therefore, the chosen alternative is the best.

6. Rank the alternatives.

We rank the alternatives based on their relative closeness.

TOPSIS has been successfully used for MCDM problems in many subjects. It involves a simple but effective mechanism to handle multiple criteria and is computationally efficient [50]. Additionally, TOPSIS is a useful approach for evaluating alternatives [51]. Hence, the alternatives were ranked in this study based on TOPSIS.

4. Application to Select the Optimal Live-Streamer

The criteria for selecting live-streamers were compiled based on interviews with the managers of shopping websites and a review of related prior literature [32,52,53] to design a fuzzy Delphi method-based questionnaire. The items in the questionnaire are valid as they were taken from existing literature. Additionally, after the first draft of the questionnaire was completed, the four managers of shopping websites were invited to modify its items and refine its wordings. This is done so that the questionnaire's content is closer to the practical scenario and more complete. Regarding response to the questionnaire, the managers of shopping websites scored the criteria on a nine-point Likert scale based on personal practical work experiences to reflect the importance of the criteria. The higher the score of a criterion, the higher its level of importance. The fuzzy Delphi method-based questionnaire was distributed via an online questionnaire system, with 40 questionnaires successfully collected. This study extracted the geometric mean of each criterion from 30 shopping website managers with over five years of business experience to improve the sample's representativeness and retained the criteria with a geometric mean of over 7.2 based on a previous study [41]. The results of the fuzzy Delphi method are shown in Table 1.

Table 1. Results of the fuzzy Delphi method.

Criteria	Geometric Means
Positive work attitude	8.4520
The ability to express clearly	8.4853
Emotional stability	8.6875
Respond to emergencies	8.2229
Past experience	5.9206
Live-streamer fee	8.1175
Degree of match between live-streamer and product	8.3859
Presentation of products in different ways	8.0000
Adaptation to company	6.0721
Interact well with the audience	8.1266
Complete work with others	8.0631
The ability to solve problems independently	8.2553
Professional knowledge	8.2877
Educational background	5.2367
Fulfill orders	8.6196
Handle work flexibly	8.3683
Extensive life experience	8.4013
Degree of self-confidence	8.5522
Strong desire to show oneself	6.0647
Adaptation to environment	6.0053

Lastly, the criteria were classified into dimensions based on past literature [32,52,53] and interviews with the managers of shopping websites to establish a hierarchical framework, described as follows:

1. The individual dimension includes five criteria: the ability to express clearly (introduce products clearly) [32,52,53], respond to emergencies (react appropriately to emergencies) [32,52,53], emotional stability (emotional steadiness) [32], positive work attitude (conscientious toward the work) [32,53], and extensive life experience (the rich of living experience) [52,53].
2. The work dimension includes five criteria: the ability to solve problems independently (the ability to resolve problems by oneself) [52,53], handle work flexibly (handle work in elastic way) [53], interact well with the audience [53], complete work with others (cooperate with others to finish work) [53], and fulfill orders (the ability to finish orders) [53].
3. The match dimension includes five criteria: presentation of products in different ways (present products in different ways) [53], professional knowledge (professional knowledge about products) [53], live-streamer fee (the cost of commissioning a live-streamer) (interviewee proposed), degree of match between live-streamer and product (match between live-streamer and product) (interviewee proposed), and degree of self-confidence [52,53].

The hierarchical framework, shown in Figure 1, was incorporated into a shopping website to assist its managers in selecting the best live-streamer. A questionnaire was designed based on the hierarchical framework in combination with AHP and TOPSIS. Four managers from the case study company were invited to respond to the questionnaire. The comprehensive score from group decision-making was determined by aggregating the geometric means obtained from the managers to analyze three live-streamers. In AHP, where the comprehensive score from group decision-making is obtained by aggregating geometric means, the consistency ratio of the questionnaire is less than 0.1. The pairwise comparison matrix and weight of the dimensions are shown in Table 2.

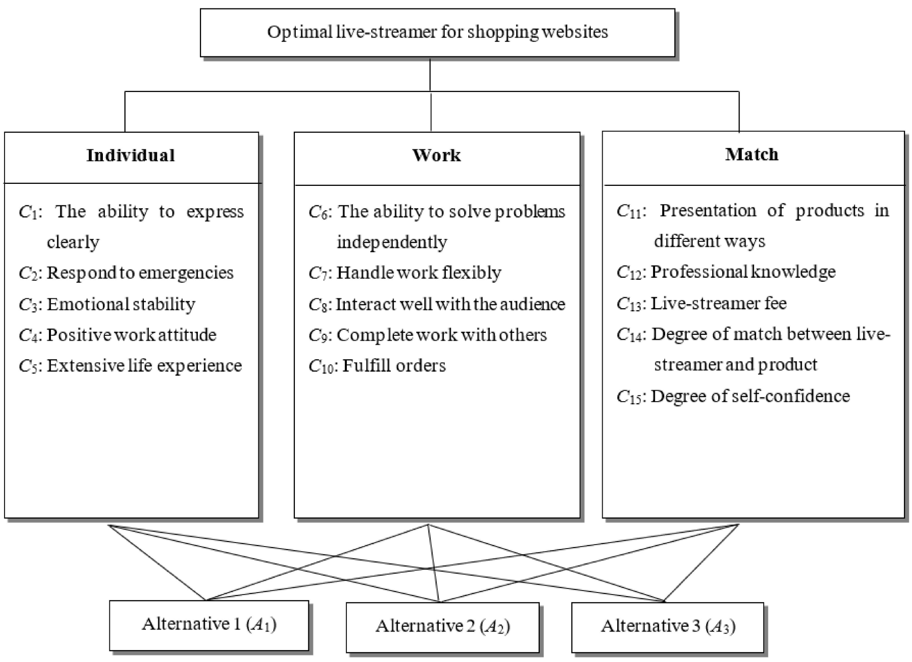

Figure 1. Hierarchical framework to select the optimal live-streamer for shopping websites.

Table 2. Pairwise comparison matrix between the dimensions.

	Individual	**Work**	**Match**	**Weights**
Individual	1.0000	1.6549	0.7598	0.3482
Work	0.6043	1.0000	0.5774	0.2271
Match	1.3161	1.7321	1.0000	0.4246

The consistency ratio is 0.0044.

Similarly, the weight of each criterion in a dimension was also obtained using a pairwise comparison matrix. For instance, the pairwise comparison matrix and weight of each criterion in the Individual dimension are shown in Table 3. The weight of each criterion after integration can be calculated by multiplying the weight of the criterion by the weight of the dimension to which it belongs, as shown in Table 4.

Table 3. Pairwise comparison matrix between the criteria within the Individual dimension.

	C_1	C_2	C_3	C_4	C_5	**Weights**
C_1	1.0000	1.3161	4.1618	2.4495	3.0801	0.3522
C_2	0.7598	1.0000	4.5590	2.0000	2.6321	0.2990
C_3	0.2403	0.2193	1.0000	0.4671	1.8612	0.0903
C_4	0.4082	0.5000	2.1407	1.0000	3.6002	0.1832
C_5	0.3247	0.3799	0.5373	0.2778	1.0000	0.0753

The consistency ratio is 0.0397.

Table 4. Weight of each criterion after integration.

	Dimension Weights	**Criteria Weights**	**Final Weights**
C_1	0.3482	0.3522	0.1227
C_2	0.3482	0.2990	0.1041
C_3	0.3482	0.0903	0.0315
C_4	0.3482	0.1832	0.0638
C_5	0.3482	0.0753	0.0262
C_6	0.2271	0.1723	0.0391
C_7	0.2271	0.1096	0.0249
C_8	0.2271	0.1975	0.0448
C_9	0.2271	0.1930	0.0438
C_{10}	0.2271	0.3276	0.0744
C_{11}	0.4246	0.1086	0.0461
C_{12}	0.4246	0.2168	0.0921
C_{13}	0.4246	0.2207	0.0937
C_{14}	0.4246	0.3420	0.1452
C_{15}	0.4246	0.1119	0.0475

In the TOPSIS section, the decision-makers scored the alternatives on a nine-point scale based on each criterion. A normalized evaluation matrix was created based on the evaluation matrix of opinions from the four managers obtained via the geometric mean as shown in Table 5. The normalized evaluation matrix was established based on following equation:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$$

Table 5. Normalized evaluation matrix table.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
A_1	0.5716	0.5700	0.5641	0.5580	0.5523	0.5550	0.6081	0.5708
A_2	0.5887	0.6275	0.6030	0.6327	0.6007	0.6409	0.6050	0.6078
A_3	0.5716	0.5304	0.5641	0.5369	0.5780	0.5303	0.5140	0.5521
	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	
A_1	0.5512	0.5708	0.5635	0.5776	0.5513	0.5849	0.5698	
A_2	0.6263	0.6284	0.5857	0.5799	0.6628	0.5588	0.5922	
A_3	0.5512	0.5285	0.5826	0.5746	0.5068	0.5879	0.5698	

i indicates alternatives, j indicates criteria, and x_{ij} indicates the i alternative under the j criterion to be evaluated.

In Tables 6 and 7, the weights of criteria determined using AHP were multiplied by the normalized evaluation matrix to obtain the weighted evaluation matrix of the alternatives and eventually determined the PIS and NIS. The PIS is composed of all the best values attainable by the criteria, while the NIS consists of all the worst values attainable by the criteria.

Table 6. Weighted evaluation matrix table.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
A_1	0.0701	0.0594	0.0177	0.0356	0.0145	0.0217	0.0151	0.0256
A_2	0.0722	0.0654	0.0190	0.0404	0.0157	0.0251	0.0151	0.0273
A_3	0.0701	0.0552	0.0177	0.0343	0.0151	0.0208	0.0128	0.0248
	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	
A_1	0.0242	0.0425	0.0260	0.0532	0.0517	0.0849	0.0271	
A_2	0.0275	0.0468	0.0270	0.0534	0.0621	0.0812	0.0281	
A_3	0.0242	0.0393	0.0269	0.0529	0.0475	0.0854	0.0271	

Table 7. PIS and NIS.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
PIS	0.0722	0.0654	0.0190	0.0404	0.0157	0.0251	0.0151	0.0273
NIS	0.0701	0.0552	0.0177	0.0343	0.0145	0.0208	0.0128	0.0248
	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	
PIS	0.0275	0.0468	0.0270	0.0534	0.0475	0.0854	0.0281	
NIS	0.0242	0.0393	0.0260	0.0529	0.0621	0.0812	0.0271	

The weights of criteria from AHP, $w = (w_1, w_2, \ldots, w_n)$, multiplied by the normalized evaluation matrix to obtain the weighted evaluation matrix can be shown as

$$v = \begin{bmatrix} v_{11} & v_{12} & \ldots & v_{1n} \\ v_{21} & v_{22} & \ldots & v_{2n} \\ \vdots & \vdots & \ldots & \vdots \\ v_{m1} & v_{m2} & \ldots & v_{mn} \end{bmatrix} = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \ldots & w_n r_{1n} \\ w_1 r_{21} & w_2 r_{22} & \ldots & w_n r_{2n} \\ \vdots & \vdots & \ldots & \vdots \\ w_1 r_{m1} & w_2 r_{m2} & \ldots & w_n r_{mn} \end{bmatrix}$$

The separation of each evaluation matrix in each alternative from the PIS and NIS was computed based on the Euclidean distance formula. Finally, we ranked the alternatives on the basis of their relative closeness to the ideal solution, showing in Table 8. In the case study, the first live-streamer is the best alternative, whereas the third live-streamer is the worst alternative. The company in the case study selected the first two live-streamers based on the conclusions of this study.

Table 8. Ranking of each alternative.

	Separation from the PIS	Separation from the NIS	Relative Closeness	Ranking
A_1	0.0114	0.0126	0.5263	1
A_2	0.0152	0.0157	0.5075	2
A_3	0.0156	0.0153	0.4942	3

The comparative analysis of the ranking results with AHP is demonstrated in Table 9. The results are the same. In other words, the effectiveness of this study is confirmed. However, combination with AHP and TOPSIS can avoid the excessive pairwise comparison matrices and reduce the difficulty of filling out the questionnaire among the decision makers.

Table 9. The ranking results of AHP.

	A_1	A_2	A_3
C_1	0.0564	0.0360	0.0303
C_2	0.0380	0.0416	0.0245
C_3	0.0119	0.0159	0.0036
C_4	0.0242	0.0285	0.0111
C_5	0.0091	0.0116	0.0054
C_6	0.0152	0.0169	0.0071
C_7	0.0091	0.0104	0.0054
C_8	0.0213	0.0180	0.0055
C_9	0.0204	0.0150	0.0084
C_{10}	0.0241	0.0156	0.0348
C_{11}	0.0220	0.0145	0.0096
C_{12}	0.0432	0.0248	0.0240
C_{13}	0.0308	0.0213	0.0416
C_{14}	0.0740	0.0390	0.0322
C_{15}	0.0204	0.0093	0.0178
Final weights	0.4201	0.3185	0.2613
Ranking	1	2	3

5. Conclusions

Livestreaming has quickly engaged a large number of netizens due to its real-time and interactive features, following its introduction by Facebook in 2016. E-commerce operators added the livestream marketing model to e-commerce after sensing a business opportunity, introducing a brand-new experience and feel to companies and consumers. However, with the rise in intense competition among live-streamers, who play an important role in e-commerce livestreaming, e-commerce operators must make careful hiring decisions. Unfortunately, no related literature in the past has investigated this important topic. Therefore, this study applied a hybrid MCDM model comprising the fuzzy Delphi method, AHP, and TOPSIS to assist the managers of shopping websites in selecting live-streamers.

The Delphi method is both a qualitative and quantitative research method based on expert knowledge. However, there are still many limitations to its application. Hence, based on the fuzzy Delphi method, this study invited experts to fill out a questionnaire and completed a survey, which addresses the semantic ambiguity among respondents, increases experts' intention to fill in the questionnaire, and reduces the loss of respondents resulting from numerous iterations, as in the traditional Delphi method. In contrast, it reduces the errors in experts' responses, improving the reliability of this study. The opinions from 30 managers of shopping websites were extracted using the geometric mean. The 15 important selection criteria were retained, including the ability to express clearly, respond to emergencies, emotional stability, positive work attitude, extensive life experience, the ability to solve problems independently, handle work flexibly, interact well with the audience, complete work with others, fulfill orders, presentation of products in different ways, professional knowledge, live-streamer fee, degree of match between live-streamer and product, and degree of self-confidence. Lastly, the criteria were classified into dimensions based on past literature and the interviews with the managers of shopping websites to establish a hierarchical framework. Past studies have shown that combining AHP with TOPSIS can produce objective and accurate results. Moreover, to avoid the many pairwise comparison matrices of AHP, which may cause difficulty for decision makers when filling out the questionnaire, the alternatives are ranked based on TOPSIS. A questionnaire was designed based on the hierarchical framework in combination with AHP and TOPSIS. Four managers from the case study company were invited to respond to the questionnaire to select the optimal live-streamer. The company selected the first two live-streamers based on the conclusions of this study. Additionally, the comparative analysis for the ranking results of AHP was also demonstrated in this study. The result showed that the effectiveness of this study is confirmed.

The research contributions are summarized as below:

1. Concerning the research topic, the selection of live-streamers is very important to shopping website operators. However, a review of previous studies has shown that this topic has not been explored in any literature. Furthermore, concerning methodology, this study proposes a hybrid MCDM model comprising the fuzzy Delphi method, AHP, and TOPSIS to enhance the decision-making quality and speed up the decision-making process. This model assists the managers of shopping websites to select the best live-streamer, thus making practical contributions and improvements on methodological deficiencies in previous studies.
2. The selection criteria for live-streamers are screened using the fuzzy Delphi method to establish a valid hierarchical framework.
3. To address the issue of excessive pairwise comparison matrices and thus reduce the difficulty in filling out the questionnaire among the decision-makers, the integrated weights of the selection criteria compiled using AHP are incorporated into TOPSIS. This assists in selecting the best live-streamer and increases the efficiency of decision-making.

Other languages were not included in this study as the questionnaire is mainly designed in traditional Chinese. Therefore, the results of this study do not involve cultures in other countries. This represents one of the limitations of this study. Additionally, due to time and cost constraints, this study adopted a cross-sectional approach that involved collecting data at only one point in time. The sensitivity analysis was also lacking in this paper. Finally, the suggestions for future research are:

1. In the fuzzy Delphi method section, opinions from more managers can be collected in the decision-making process to reduce errors.
2. When selecting live-streamers for the shopping websites, this study considers 15 important selection criteria. Future studies can take into account more related criteria to establish a complete selection model.
3. As some selection criteria are qualitative, it is not easy to express them with precise data. Additionally, scores are given to criteria or alternatives by managers based on subjective judgment. Therefore, this study recommends incorporating the concept of the fuzzy theory into AHP and TOPSIS in the future.

4. Future researchers can investigate this topic using other MCDM methods. For instance, AHP assumes that elements at each level in a hierarchical framework are independent of each other. This study recommends adopting analytic network process (ANP) that deals with influences among elements.

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