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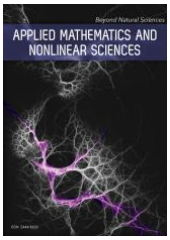

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Identification of Key Factors Influencing Consumer Purchase in Livestreaming Based on Principal Component Analysis and Combination Weighting

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Abstract

Based on the livestreaming of the e-commerce platform Taobao, this paper studied the consumers' online live streaming purchase decision behavior, taking causal snacks purchase as an example. In the paper, the principal component analysis (PCA) was applied to reduce dimension of the evaluation indicators of consumers purchase decision, and an evaluation index system for consumers' purchase of casual snacks under livestreaming was established, which consists of 5 first-level indicators and 20 sub-level indicators. In view of the uncertainty of expert evaluation, Using Fuzzy-DEMATEL analysis the evaluation index's logical relationships and influence relationships, and an Analytic Network Process (ANP) network based on the importance and relevance of consumer purchase influence was constructed. The weighted method of Fuzzy-DEMATEL and ANP combination is used to improve the objectivity of indexing importance. The experimental results showed that the amount of transaction guided by anchors, popularity of anchors, teamwork ability of livestreaming, brand awareness of snack and selection ability of livestreaming team were the key factors for consumers' purchasing decisions of snack under livestreaming. This research could help livestreaming e-commerce platforms, businesses and livestreaming marketing teams understand the consumers behavior better, thus improve the purchase intention of consumers from the key factors affecting their decision-making, increase the sales volume and the amount of attention of the products, and increase the volume of guided transactions and the number of fans for the livestreaming marketing teams.

Keywords: livestreaming marketing; PCA; Fuzzy-Dematel; ANP; key factors
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1 Introduction

Beginning in 2005, Online livestreaming developed rapidly and become popular as a new sales metho [1] in 2020 because of the outbreak of the novel coronavirus. Live marketing shows products, introduces products and answers customer inquiries and ultimately sells products through live broadcasting. With the participation of online celebrity hosts, livestreaming e-commerce stimulates the consumers' shopping desire with the high cost performance and the limit of quantity, showing the features of stronger scene aggregation effect and higher efficiency, and has become one of the important emerging forms of e-commerce [2] with the characteristics of national participation, trended development and industrialization. According to the data from iMedia Research, there are 587 million users of online livestreaming in China in 2020, accounting for 62% of the netizen, and it will continue to grow in the future [3].

In 2020, the Gross Merchandise Volume (GMV) of Taobao livestreaming exceeded 400 billion CNY, the GMV of Kuaishou livestreaming was 381.2 billion CNY, and the GMV of TikTok livestreaming was more than 100 billion CNY, accounting for 32.52%, 30.99% 8.13% of the total market share respectively [4]. The user scale of Taobao livestreaming has shown an explosive growth trend, and GMV has increased by more than 150% for three consecutive years since 2019， occupying an important position in many livestreaming platforms. Live marketing has become the fastest growing segment of e-commerce [5]. On the basis of the existing literature, Figure. 1 gives an example of the livestreaming e-commerce trading system.

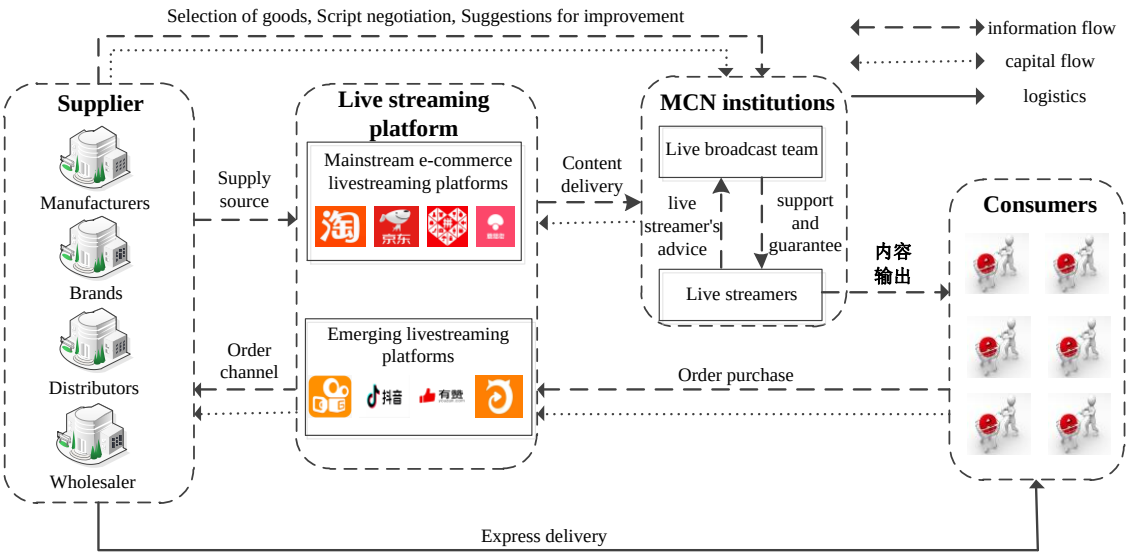

Figure 1. Livestreaming e-commerce trading system

The system consists of the supplier, the livestreaming platform, Multi-Channel Network(MCN) institutions and consumers. Suppliers mainly include commodity suppliers (i.e. manufacturers, brands, distributors); livestreaming platforms include mainstream platforms (e.g. Taobao, JD, Pinduoduo) and emerging platforms (e.g. Kuaishou, Tik Tok, Youzan, Xingxuan). MCN includes the livestreaming team and live streamers, who are mainly responsible for the creation of livestreaming contents. The supplier is composed of manufacturers, brand owners, distributors and wholesalers, who connect with the e-commerce platform to provide supplies and MCN institutions(or live streamers), determine the livestreaming content scheme, introduce the livestreaming platform for content output, and finally guide consumers to complete commodity transactions on the e-commerce platform.

With the improvement of national life quality and the diversification of consumer demand, leisure snacks have gradually become a common category in People's Daily consumption. The rapid development of Internet technology makes "food" no longer confined to geographical location and season, which further stimulates consumers' desire to buy leisure snacks. Based on taobao Live e-commerce platform, this paper takes leisure snacks as an example to study consumers' purchasing decisions.

2 Literature review

2.1 Influencing factors of consumers' purchasing behavior under livestreaming

The literature that using technology models to carry out researches on the influence of consumer purchase under Livestreaming Marketing mainly focused on the use of stimulus-organism-response model (SOR), structural equation model (SEM), regression analysis, technology acceptance model (TAM), etc. However, the studies that use the stimulus-organic-response model (SOR) has produced the most fruitful results. These studies used the SOR theory to study consumer behavior under livestreaming and believed that there was an important link between consumer perception and purchase intention. In addition, they mainly focus on the influence of livestreaming anchors, livestreaming interactivity and comprehensive perception during livestreaming on consumers' purchase intention. Focusing on the influence of livestreaming anchors on consumers' purchase intention, Zhao Baoguo et al. (2021) [6] verified that livestreaming anchors positively affect consumers' perception and thus consumers' purchase intention. Gao Yunhui [7] discussed the influence of anchor's specialization, interactivity and popularity on consumers' purchase intention. Zhou Yifei [8] analyzed the influence of livestreaming anchors on the purchase intention of college girls, and believed that the usefulness and interactivity of e-commerce influencers would have a significant impact, while the specialization and popularity of e-commerce influencers would not have a significant impact. Chen Mi [9] believed that the influence of anchors and two-way interaction positively affect consumers' purchase intention. Zhao Dawei et al. [10], Zhang Baosheng et al. [11], all believed that e-commerce anchors have an impact on consumers' purchase intention. In view of the impact of livestreaming interactivity on consumers' purchase intention, Zheng Qidi [12] analyzed the impact of livestreaming interaction on online consumers' cross-purchase intention, and Kang, K et al. [13] studied the dynamic impact of interactivity on customer engagement behavior, and Xue, J et al. [14] studied the effect of real-time interaction on livestreaming e-commerce participation and explored the impact of real-time interactions on social business engagement. In the research on the comprehensive perception of the livestreaming process, Chen Yongqi [15], Jiang Hang [16], Hu Chuan [17], and Ji Man [18] used SOR to establish the influence model of consumers' purchase intention under e-commerce livestreaming, and respectively found the factors that promote users' online purchase intention. Tian Xiaohan et al. [19] constructed the influence relationship model among live anchor factors, product factors, perceived functional risks and purchase intention, and Zhang Yuqi [20] constructed a theoretical model for the consumers' continuous purchase intention in e-commerce livestreaming. Xu, X et al. [21] studied the factors that affect consumers' purchase intention from situational and environmental stimuli, and Hu, M et al. [22] from emotional commitment and consumer engagement. Fengliang, X. I. E et al. [23], Tian Xiuying [24] studied the influencing factors of consumers' impulse purchase intention under livestreaming delivery, Dong Fang [25] studied the influencing factors under mobile e-commerce livestreaming which influence users' online purchase intention.

The researches using structural equation model mainly focus on consumer perception, and analyzes the factors that affect consumer purchases under livestreaming delivery by constructing a structural equation model. Ma, Y [26] confirmed the mediating role of livestreaming anchor's perception

between perceived network size and perceived utility, perceived engagement, social interaction, social presence, and self-expression. Liu Jia et al. [27] studied the influence of the service quality and value that the consumers' perceived on purchase intention in China's e-commerce livestreaming. Ye Jing et al. [28] used structural equation model to build a consumer purchase behavior model with livestreaming limited-time promotion and anchor trust as environment variables, and perceived value as intermediate variables. Meng Wenzhuo [29] constructed structural equation, using SEM to analyze the motivation of users to watch livestreaming of e-commerce sales. Wei Chao [30] takes the e-commerce users of Simba's livestreaming room as the research subject to analyze the relationship between users and anchors, conducting an empirical analysis on the influencing factors of users' actual purchase intention from the aspects of consumer perception, consumer trust, consumer loyalty, etc.

Researches that using regression analysis mainly focused on the research of consumer purchase intention. Sohn, J. W et al. [31] explored the attributes of social commerce to identify what drives purchase and demand. Wang Xueli [32] analyzed the influence of the characteristics of livestreaming influencers on consumers' trust and purchase intention. Zhang Qian et al. [33] investigated the cognition of online celebrity livestreaming with goods from the following two aspects: characteristics of online celebrity information sources and consumers' own perceptions, discussing its influence on purchase intention. Hou Fangwei [34] studied the correlation between the propagation behavior of Taobao anchors and consumers' expectations and requirements, and analyzed the impact of audience demand on usage behavior.

In the study of technology acceptance model (TAM),Wang Meiyue et al. [35] constructed a consumer willingness research model based on 11 variables from the three dimensions of the TAM model's perceived usefulness, perceived trust and perceived ease of use. Xiao Jing [36] based on the perspective of social existence, the six influencing factors of the characteristics of e-commerce livestreaming are deconstructed, and the consumer purchase intention model of e-commerce livestreaming platform is constructed. Li Zhenzhen et al. [37] established an analysis model of college students' willingness to use e-commerce livestreaming platforms.

2.2 MCDM

Consumer’s purchasing decision under livestreaming is a multi-criteria decision making behavior, and the methods commonly used in MCDM include AHP (Analytic Hierarchy Process), DEMATEL (Decision Experiment And Evaluation Laboratory), ANP, TOPSIS, etc. Emovon et al. [38] proposed the common practice in selection analysis is the combination of two or more MCDM methods, which can improve the accuracy of analysis results.On the application of the DEMATEL-ANP method, Liu, J. et al. [39] chose the sites that meet the conditions of landfill sites through this method, Huang, Y. et al. [40] DEMATEL -ANP method is used to identify the important factors affecting the development of smart cities, Bardhan, A. K. et al. [41] used it to study the factors that improve the overall performance of microfinance institutions, Arthur J. Lin et al. [42] analyzed the key factors that affect the operating performance of international shipping companies. Aiming at the defect of subjective error of expert scoring in traditional DEMATEL method, this paper introduces Fuzzy Set Theory and puts forward a method of influencing factors analysis based on Fuzzy- DEMATEL, which can reveal the strong and weak relationship between various factors and its influence mechanism. On the application of Fuzzy-DEMATEL-ANP method, Khalilzadeh, M. et al. [43] applied Fuzzy DEMATEL-ANP method to identify and evaluate the main risk factors of oil and gas projects. Yadav, A. K. et al. [44] used it to analyze the obstacles that hinder the implementation of flexible supply chain. Yadav, R. N. [45] used it to analyze factors affecting total quality management. These

empirical studies show that Fuzzy-DEMATEL-ANP can effectively identify the key factors affecting decision making in multi-criteria decision making problems.

2.3 Gap Areas and Highlights

Through the in-depth analysis of existing literature, the literature that researches on the influence of consumer purchase under Livestreaming Marketing mainly focused on the use of stimulus-organism-response model (SOR), structural equation model (SEM), regression analysis, technology acceptance model (TAM)etc., the existing evaluation of purchase decision has established an evaluation index system, but the main assumption is that each evaluation index is independent each other, and the mutual influence and relevance of each index is seldom considered. Consumer purchasing decision is MCDM behavior, and it is affected by many factors that have certain correlations.

Combined Weighting Method of Fuzzy-DEMATEL and ANP has been widely used in the field of scheme selection and key factor identification, whose stability and reliability have been proved. However, this method has not been applied to the analysis of influencing factors of consumers' purchasing decisions in livestreaming mode.

Research ideas and methods of this paper: On the basis of existing research, this paper proposes an evaluation model of consumer purchase decision which is suiTable for Livestreaming Marketing. Taking casual snacks as an example, the following four steps are used to identify the key factors influencing consumers' purchase (Figure 2).

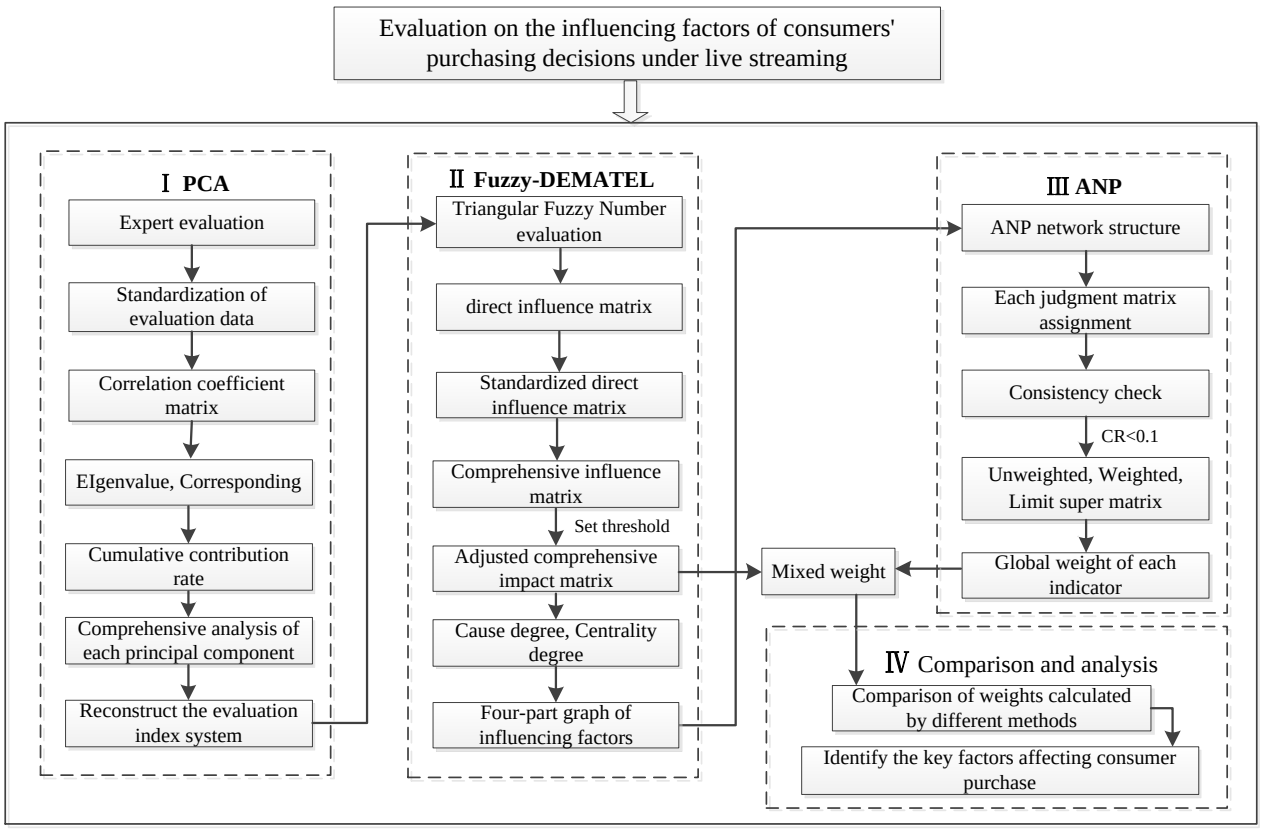

Figure 2. Technology roadmap

The first step is to use PCA method to effectively identify the evaluation indexes and optimize the index system of influencing factors for consumers' purchase of " Livestreaming Marketing ". In the

second step, Fuzzy-DEMATEL was used to further analyze the influence relationship of factors in the index system and draw the four-part graph of influencing factors. In the third step, the ANP method is introduced to calculate the global weight of each index, and the mixed weight is calculated with Fuzzy-DEMATEL synthesis matrix. In the final step, the weight values of influencing factors of consumer purchase are calculated by various methods, and verify the reliability of the evaluation method in this paper by comparing with Fuzzy-DEMATEL and ANP, thus identify the key factors that affect consumer purchases under Livestreaming Marketing.

3 Methodology

3.1 Construct the evaluation index system through literature search

Through literature reading and data retrieval, the evaluation index system of the influencing factors of consumers' purchase of leisure snacks from " Live-streaming Marketing" was preliminarily constructed(Table 1).

Table 1. Evaluation index system and source of influencing factors of consumers' purchase of leisure snacks "Livestreaming Marketing"

Level indicators	The secondary indicators	Index source
A1（Live platform）	A11（Platform visibility）	
	A12（platform standardization）	[46]
	A13（The number of third-party institutions for Influencer Marketing on the platform）	[47]
A2（Anchor）	A21（Anchor popularity）	[48]
	A22（Anchor's external image and temperament）	
	A23（Infectiousness of the anchor）	[49]
	A24（Anchor guide turnover）	[50]
	A25（Anchor word of mouth）	[51]
	A26（Launch activity）	
	A27（Shopping guide professional level and experience）	[52]
A3（Live interaction）	A31（Richness of interactive means）	[53]
	A32（Interactive channel patency）	[53][54]
	A33（Influencer star joins）	
	A34（Barrage interaction timeliness）	[55]
A4（Live Goods）	A41（Brand awareness of leisure snacks）	
	A42（Leisure snacks word of mouth）	
	A43（Leisure Snacks Visual Sensory）	[56][57]
	A44（Leisure snack prices）	[52]
	A45（Diversity of leisure snack promotion forms）	
A5（Livestreaming guarantee）	A51（Livestreaming team collaboration ability）	[58]
	A52（Bargaining power of the livestreaming team）	
	A53（Professionalism of the livestreaming team）	
	A54（Livestreaming team selection ability）	
	A55（Livestreaming team's ability to assist streaming）	
	A56（After-sales service guarantee）	

3.2 Principal component analysis

PCA [59] is a mathematical method in multivariate statistics to solve multi-variable high-dimensional complex system. The main principle of PCA is to minimize the loss of data information and reduce the high-dimensional variable space. The analysis steps are as follows:

Step 1: Standardize the expert evaluation of the original data.

$$Z_{ij} = \left(X_{xj} - \overline{X_j}\right)/S_j$$

Where $\overline{X_j} = \frac{1}{n}\sum_{i=1}^{n} X_{ij}; S_j^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(x_{ij} - \overline{x_j}\right)^2$

Step 2: Establish correlation coefficient matrix.

$$R = \left(r_{ij}\right)_{p\times p} = \left(S_{ij}/\sqrt{S_{ij}S_{ij}}\right)_{p\times p}$$

Where $i,\ j = 1,\ \ldots,\ p;\ S_{ij} = \frac{1}{n}\sum_{k=1}^{n}\left(X_{ik} - \overline{X_i}\right)\left(X_{jk} - \overline{X_j}\right)$

Step 3: Calculate the eigenvalue and corresponding eigenvector. Eigenvalues $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_P$ and eigenvector $\left(e_1 e_{2,}\ \ldots, e_p\right)$ are obtained from the correlation coefficient matrix R of X.

Step 4: Calculate the cumulative contribution rate. Select eigenvalue >1 to determine the principal component, and comprehensively analyze the practical significance of each principal component.

$$\alpha = \sum_{i=1}^{m} \lambda i \,/\, \sum_{j=1}^{p} \lambda j$$

3.3 Fuzzy-DEMATEL

DEMATEL is mainly used to analyze the mutual influence degree of each factor in complex system. Based on graph theory, visual causal diagram between system factors are constructed to obtain efficient solutions. Because of the uncertainty of the real world, the composers of this paper used fuzzy semantic expressions such as “important” and “relatively important” in scoring. The implementation steps of Fuzzy-DEMATEL are as follows:

Step 1: Establish an expert team composed of 15 experts ,enterprise executives, university scholars and senior consumers who are familiar with the e-commerce operation field of the snack industry. Experts Grading Method is used to evaluate the influencing factors of consumers' purchase of leisure snacks, which is based on quantitative and qualitative analysis to make quantitative evaluation by scoring, and its results have the characteristics of mathematical statistics. According to the effect degree of the influence relationship, the influencing factors are denoted as “NO influence”, “Very low influence (VL)”, “Low influence (L)”, “High influence(H)”, “Very high influence (VH)”, and then the expert evaluation terms are transformed into corresponding triangular fuzzy numbers [60], which are successively as follows: (0,0,0.25), (0,0.25,0.25), (0.25,0.5,0.75), (0.5,0.75,1), (0.75,1).

Step 2:Opricovic and Tzeng proposed the CFCS method. It is mainly used to defuzzy the initial value of expert scores [61]. The specific operation processes are as steps: (1) - (4), and the direct influence matrix A was finally obtained.

1) Standardization of triangular fuzzy numbers

$$xl_{ij}^{k} = \left(l_{ij}^{k} - minl_{ij}^{k}\right)/\triangle_{max}^{max}$$

$$xm_{ij}^{k} = \left(m_{ij}^{k} - minl_{ij}^{k}\right)/\triangle_{max}^{max}$$

$$xr_{ij}^{k} = \left(r_{ij}^{k} - minl_{ij}^{k}\right)/\triangle_{max}^{max}$$

Where $\triangle_{max}^{max} = \underset{1\le k\le K}{max}\, r_{ü}^{k} - minl_{ü}^{k}$

2) Left and right normalized number to calculate xls、xrs

$$xls_{ij}^{k} = xm_{ij}^{k}/(1 + xm_{xj}^{k} - xl_{ij}^{k})$$

$$xrs_{ij}^{k} = xr_{xj}^{k}/(1 + xr_{xj}^{k} - xm_{ij}^{k})$$

3) Calculate the clear value after deblurring

$$x_{ij}^{k} = \left[xls_{ij}^{k}(1 - xls_{ij}^{k}) + xrs_{ij}^{k}xrs_{ij}^{k}\right]/(1 - xls_{ij}^{k} + xls_{ij}^{k})$$

4) Calculate the average clarity value

$$Z_{ij} = \left(x_{xj}^{1} + z_{xj}^{2} + \cdots + z_{xj}^{k}\right)/K$$

Step 3: Standardize the established direct impact matrix A to obtain the standardized direct impact matrix B.

$$B = (b_{ü})_{n\times n} = (\underset{1\le i\le n}{max} \sum_{j-1}^{n} a_{ü}\,)^{-1}A$$

Step 4: Establish comprehensive impact matrix C, calculate the influence degree R, influenced degree D, cause degree (R - D) and centrality degree (R + D) of each impact factor.

$$C = (C_{ü})_{n\times n} = B(I - B)^{-1}$$

Step 5: Draw a four-part graph of influencing factors

Based on the operation results of Fuzzy-DEMATEL, draw the coordinate systems of four quadrants with centrality as horizontal axis and causality as vertical axis.

3.4 Weighting of ANP combination

ANP (Analytic Network Process) [62] is a decision -making method developed by Professor Saaty's based analysis method AHP, which is applicable to non-independent hierarchical structure that is more complex, which include two levels of factors: control layer and network layer. This method represents the relationship of each element in the system which is similar similar to network structure, and it is more suiTable for analyzing the real problems with complex relationship in the system. The steps to implement ANP combinatorial weighting are as follows:

Step 1: Establish ANP network structure diagram.On the basis of four-part graph, draw the ANP network structure diagram according to the relationship between various indicators.

Step 2: Set up the judgment matrix. The control layer element Ps that in ANP network structure diagram is the main criterion, and the network layer ejk is the secondary criterion. The indexes in the control factor layer and the network layer are pairwise compared by 1-9 scale method, and the judgment matrix of the first-level indexes and the corresponding judgment matrix of the sub-level indexes are established.

Step 3: Build the weighted supermatrix. All the judgment matrices are normalized to form the unweighted super matrix Ws. All normalized vectors are combined to form a weighting matrix Bs, Multiply the unweighted supermatrix Ws by the weighted matrix Bs to get the weighted supermatrix Wss whose columns are normalized.

$$W_{ss} = W_s B_s$$

Step 4:Determine the indicator weight. Calculate the weighted supermatrix Wss to the infinite power of the limit supermatrix W_{SS}^{∞}. Calculate the limit super matrix of each first-level index judgment matrix and sub-level index judgment matrix respectively, so as to determine the weight of the index.

$$W_{SS}^{\infty} = \lim_{t \to \infty} W_{ss}^{t}$$

Step 5:Mix weight. Select the global weight as column vector W_6. The comprehensive influence matrix T calculated by Fuzzy-DEMATEL and the global weight W_6 were mixed, and the mixed weight W_0 was obtained after the matrix column normalization.

$$W_0 = W_6 + T \times W_6 = W_6 \times (1 + T)$$

3.5 Comparison verification and identification of key factors

First, select a variety of evaluation methods to calculate the weight of each indicator. We choose several single comprehensive evaluation methods to calculate the weight of each indicator. For purpose of comparing with the Fuzzy-DEMATEL and ANP mixed weight proposed in this paper, we also choose the combination of two evaluation methods to calculate the weight of each indicator.

Second, reliability verification of evaluation method and identification of key factors affecting purchase. A two-dimensional line chart is drawn on the coordinate axis for each weight value to determine the important factors that influence consumers' purchasing decisions of leisure snacks under livestreaming. The key factors for consumers' purchasing decisions of snack products under Livestreaming Marketing are further determined by comprehensive consideration of the influencing factors in the four-part graph.

4 Application of the identification model of key factors affecting the purchase of " Live-streaming Marketing " for leisure snacks

4.1 Principal component analysis

Use PCA to reduce the dimension of the preliminary evaluation index system and reconstruct the evaluation indicator system of influencing factors of consumer purchase, specific steps are as follows:

1) Calculation of eigenvalue contribution rate and cumulative contribution rate

Use Matlab to standardize the original data matrix evaluated by 15 experts to obtain the coefficient matrix of the sample, and calculate its eigenvalue, principal component contribution rate and cumulative contribution rate. Through principal component load, 9 principal components are determined. Due to space limitation, only part of the calculation results of the principal components are listed (Table 2).

Table 2. Calculation results of principal components

The secondary indicators	The eigenvalue	Contribution / %	Cumulative contribution rate /%	Principal component 1	Principal component 2	…	Principal component 7	Principal component 8	Principal component 9
A11	5.5323	0.2213	0.2213	0.2939	-0.1057	…	-0.0948	-0.0182	-0.2224
A12	4.4911	0.1796	0.4009	0.2304	-0.1761	…	-0.1318	-0.0449	-0.3054
A13	2.9884	0.1195	0.5205	0.1913	-0.1429	…	0.1536	0.0610	0.3896
A21	2.8508	0.1140	0.6345	0.1122	0.2752	…	-0.0201	0.1497	-0.4323
A22	2.0208	0.0808	0.7153	0.2573	-0.2688	…	0.0940	0.1629	-0.2252
A23	1.8864	0.0755	0.7908	0.1839	0.1463	…	0.2739	0.1750	0.0196
A24	1.5488	0.0620	0.8527	0.1292	0.3916	…	-0.2155	0.1782	0.0802
A25	0.9683	0.0387	0.8915	0.2759	0.0710	…	0.3155	-0.3626	-0.4011
A26	0.8041	0.0322	0.9236	-0.0303	0.3118	…	0.1195	0.3720	0.0063
…	…	…	…	…	…	…	…	…	…
A41	0.0000	0.0000	1.0000	0.1292	0.3916	…	-0.2155	0.1782	0.0802
A42	0.0000	0.0000	1.0000	0.3777	-0.0165	…	-0.1409	0.0674	0.1063
A43	0.0000	0.0000	1.0000	0.3230	0.0846	…	-0.0274	-0.2253	0.0932
A44	0.0000	0.0000	1.0000	0.0499	-0.2209	…	0.1409	0.4464	-0.1090
A45	0.0000	0.0000	1.0000	0.2169	0.1581	…	0.0169	0.1565	0.0048
A51	0.0000	0.0000	1.0000	0.1007	0.0306	…	0.3355	-0.1257	0.2248
A52	0.0000	0.0000	1.0000	0.3777	-0.0165	…	-0.1409	0.0674	0.1063
A53	0.0000	0.0000	1.0000	0.1493	-0.0524	…	-0.0728	-0.1078	0.0069
A54	0.0000	0.0000	1.0000	-0.1280	0.0825	…	0.1391	0.1173	-0.3420
A55	0.0000	0.0000	1.0000	-0.0145	0.2184	…	0.2524	-0.2006	-0.0152
A56	0.0000	0.0000	1.0000	0.1690	0.2282	…	0.2912	-0.0194	0.1431

2) Comprehensively analyze of each principal component feature vector

The load value in Table 3 is the correlation coefficient between the common factors and the influencing variables of the purchase of Live-streaming Marketing snack consumers. The larger the absolute value is, the closer the relationship is. The principal component 1 is strongly positive related to A42, A52, A43. The principal component 2 is strongly positive related to A24, A41. Principal component 3 has a strong positive correlation with A53, A32, and a strong negative correlation with A34. Principal component 4 has a strong positive correlation with A54 and a strong negative correlation with A51. There was a strong negative related between principal component 5 and A27, A13, A12. Principal component 6 was positively related with A21, and negatively related with A11, A23, A56. Principal component 7 was positively and strongly related with A51, A25, and negatively correlated with A34. Principal component 8 has a strong positive correlation with A44, and a strong negative related with A31, A25. Principal component 9 has a strong positive related with A13, and a strong negative related with A21, A25, A54.

3) Reconstruct the evaluation index system of influencing factors of consumer purchase

Indexes A11、A12、...、A54、A56 with strong positive and negative correlations among principal components were retained, and indexes A22, A26, A33, A45 and A55 with weak correlations were deleted. The evaluation index system of influencing factors of consumers' purchase of snacks under Live-streaming Marketing was rebuilt, which consists of 5 first-level indicators and 20 sub-level indicators(as shown in Figure. 3).

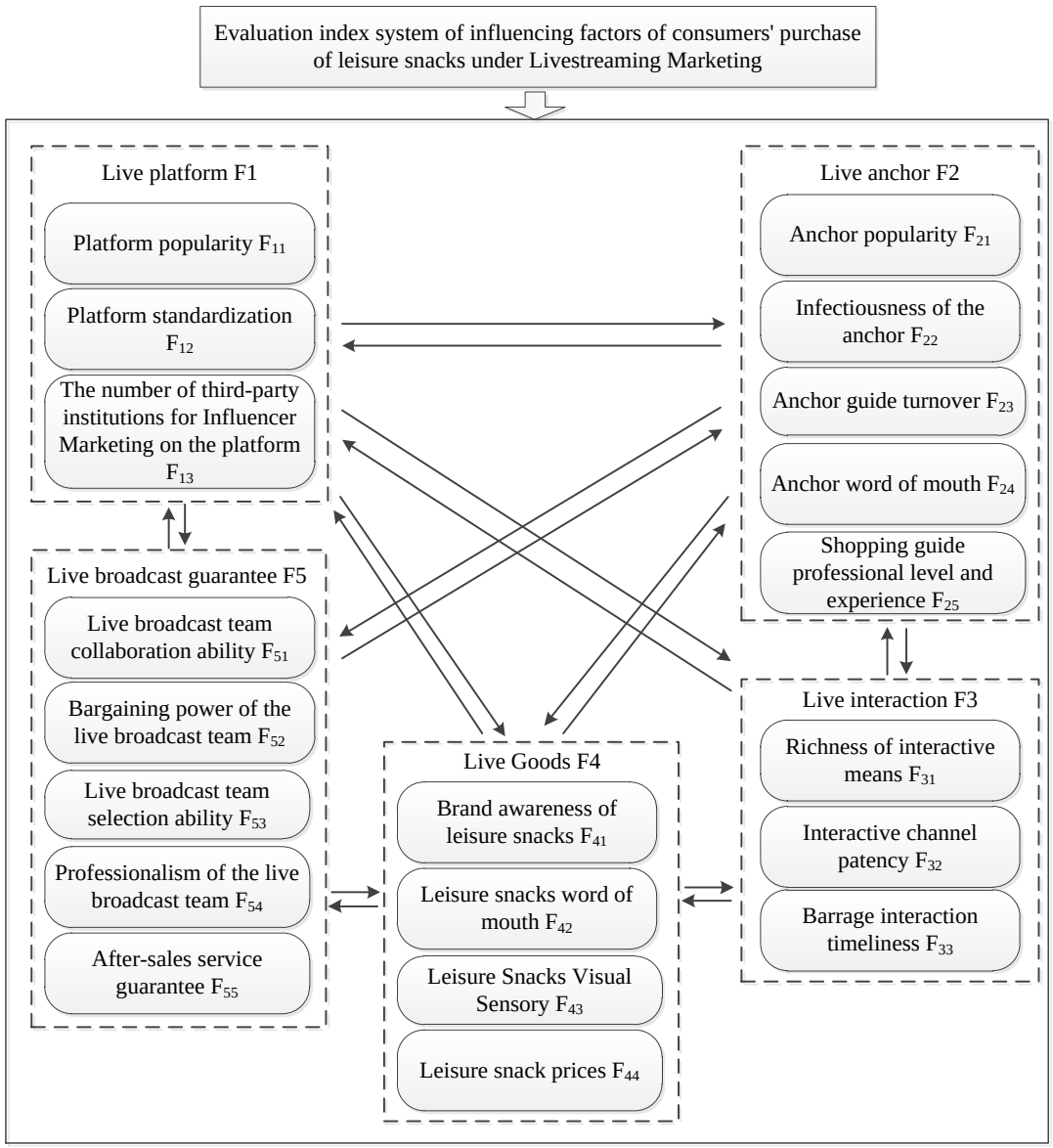

Figure 3. Evaluation index system of influencing factors of consumers' purchase of leisure snacks under Livestreaming Marketing

4.2 Fuzzy-DEMATEL analysis

Aiming at the defect of the subjective error of expert rating in the traditional DEMATEL method, Introduce the theory of fuzzy sets to analyze experts evaluation results by Fuzzy-DEMATEL, the specific steps are indicated as below (as follows):

1) Establish the fuzzy direct influence matrix

By summarizing the evaluation results of 15 experts (rounding decimals to integers), the fuzzy direct impact matrix between 5 first-level indicators and 20 sub-level indicators was established. Due to space limitations, only the fuzzy direct evaluation matrix of sub-level indicators were listed (Table 3).

Table 3. Fuzzy direct influence matrix of sub-level indicators

	F_{11}	F_{12}	F_{13}	F_{21}	F_{22}	F_{23}	F_{24}	F_{25}	F_{31}	F_{32}	F_{33}	F_{41}	F_{42}	F_{43}	F_{44}	F_{51}	F_{52}	F_{53}	F_{54}	F_{55}
F_{11}	NO	H	H	L	VL	L	VL	VL	L	L	VL	VL	VL	NO	VL	VL	NO	VL	NO	L
F_{12}	L	NO	H	L	VL	L	VL	NO	L	L	VL	VL	L	NO	VL	VL	NO	NO	NO	L
F_{13}	L	L	NO	L	VL	L	VL	VL	L	L	L	VL	NO	NO	VL	NO	NO	NO	NO	NO
F_{21}	L	VL	H	NO	VL	VH	H	L	L	L	L	H	L	NO	VL	H	H	L	L	L
F_{22}	VL	NO	VL	H	NO	VH	H	VL	L	VL	VL	L	VL	NO	NO	VL	VL	NO	NO	NO
F_{23}	L	VL	L	H	VL	NO	H	VL	VL	VL	VL	L	VL	NO	L	VL	L	VL	VL	VL
F_{24}	VL	VL	L	H	VL	H	NO	VL	VL	VL	VL	L	L	NO	VL	L	L	L	VL	L
F_{25}	VL	NO	VL	L	L	H	H	NO	H	L	L	L	VL	VL	VL	VL	L	L	VL	VL
F_{31}	VL	NO	L	VL	L	L	VL	VL	NO	VL	VL	VL	VL	VL	NO	NO	NO	NO	VL	NO
F_{32}	VL	VL	L	VL	L	L	VL	VL	L	NO	L	VL	VL	VL	NO	VL	NO	NO	VL	VL
F_{33}	NO	NO	NO	L	VL	VL	VL	VL	VL	VL	NO	NO	VL	NO	NO	VL	NO	NO	VL	NO
F_{41}	NO	NO	NO	VL	NO	L	VL	VL	VL	NO	NO	NO	H	VL	L	NO	VL	VL	NO	L
F_{42}	VL	NO	NO	L	VL	L	L	VL	VL	NO	NO	L	NO	VL	L	NO	L	VL	NO	L
F_{43}	NO	NO	NO	VL	L	L	NO	VL	VL	NO	NO	VL	L	NO	L	NO	VL	VL	NO	NO
F_{44}	VL	NO	NO	VL	NO	H	VL	NO	NO	NO	NO	L	L	VL	NO	NO	L	VL	NO	NO
F_{51}	NO	NO	NO	H	L	H	L	L	L	H	L	L	L	L	L	NO	H	L	L	L
F_{52}	NO	NO	NO	L	VL	H	L	L	NO	NO	NO	VL	L	VL	H	VL	NO	VL	VL	NO
F_{53}	NO	NO	NO	L	VL	L	L	VL	NO	NO	NO	L	L	L	L	VL	L	NO	L	VL
F_{54}	NO	NO	NO	L	VL	L	L	L	VL	VL	VL	L	L	VL	L	H	H	H	NO	L
F_{55}	VL	VL	NO	VL	NO	L	L	VL	NO	NO	NO	VL	L	NO	VL	VL	NO	NO	VL	NO

2) Adjust the synthesis matrix

The comprehensive impact matrix is determined on the basis of the normalized impact matrix, and the appropriate threshold value is 0.02 based on expert advice and repeated testing. In other words, the influence degree between indicators is negligible. Adjust the 6 values less than 0.02 in the comprehensive matrix to 0, and readjust the comprehensive matrix.Because of the space limitations, only list a part of adjusted comprehensive matrix (Table 4).

Table 4. Comprehensive matrix after adjustment

	F_{11}	F_{12}	F_{13}	…	F_{42}	F_{43}	F_{44}	F_{51}	F_{52}	F_{53}	F_{54}	F_{55}
F_{11}	0.0411	0.1019	0.1235	…	0.0582	0.0245	0.0487	0.0427	0.0459	0.0414	0.03	0.0844
F_{12}	0.0814	0.0316	0.1207	…	0.0899	0.024	0.0491	0.0419	0.0462	0.033	0.0292	0.0839
F_{13}	0.0773	0.0702	0.0478	…	0.0428	0.022	0.0435	0.0317	0.0409	0.0303	0.027	0.0373
F_{21}	0.097	0.0497	0.1415	…	0.1294	0.0405	0.0865	0.1266	0.1564	0.102	0.09	0.1109
F_{22}	0.046	0.0261	0.0587	…	0.0608	0.024	0.0449	0.0471	0.0621	0.0382	0.0313	0.0437
F_{23}	0.0818	0.0392	0.0941	…	0.0677	0.0265	0.0912	0.0497	0.099	0.049	0.0411	0.0558
F_{24}	0.0513	0.0386	0.0948	…	0.1077	0.0313	0.0663	0.0858	0.1073	0.0862	0.0464	0.0937
F_{25}	0.0498	0.0297	0.0644	…	0.0721	0.0388	0.0636	0.0519	0.1046	0.0866	0.0452	0.0571
F_{31}	0.0355	0.0217	0.0746	…	0.0417	0.0268	0.0308	0.025	0.0337	0.0254	0.0296	0.0282
F_{32}	0.0388	0.0318	0.0796	…	0.0467	0.0292	0.0346	0.0362	0.0376	0.0283	0.0327	0.0399
F_{33}	0.0229	0	0.0283	…	0.0391	0	0.0264	0.0328	0.032	0.0245	0.0295	0.0266
F_{41}	0.0265	0	0.03	…	0.1106	0.0285	0.0788	0.0247	0.0472	0.0345	0.0225	0.0744
F_{42}	0.0402	0.0237	0.0399	…	0.0514	0.0314	0.0862	0.0333	0.0904	0.0419	0.0279	0.0813
F_{43}	0.0256	0	0.0295	…	0.0784	0	0.076	0.0238	0.045	0.0333	0.0214	0.0286
F_{44}	0.0348	0.0202	0.0315	…	0.082	0.0281	0.039	0.0248	0.0809	0.0346	0.0221	0.0317

F_{51}	0.0502	0.0342	0.066	…	0.1257	0.0804	0.1157	0.0551	0.1534	0.0989	0.0883	0.104
F_{52}	0.0344	0.0236	0.042	…	0.0931	0.0328	0.1163	0.043	0.0553	0.0456	0.037	0.0402
F_{53}	0.0345	0.0247	0.0421	…	0.1014	0.0697	0.0953	0.0471	0.1005	0.0406	0.0738	0.0529
F_{54}	0.0414	0.0291	0.0513	…	0.1174	0.0447	0.1091	0.1171	0.146	0.1216	0.0423	0.0976
F_{55}	0.0339	0.028	0.0315	…	0.079	0	0.0412	0.0342	0.0374	0.0276	0.0299	0.0318

3) Calculate the influence degree, influenced degree, cause degree, and centrality degree ofeach level indicator factor(Table 5, Table 6)

Table 5. The first-level index factor Influence degree, Influenced degree, Cause degree, Centrality degree

Influencing factors	Influence degree	Rank	Influenced degree	Rank	Cause degree	Rank	Centrality degree	Rank
F1	3.2591	2	1.7389	5	1.5202	1	4.9980	4
F2	3.3051	1	2.5389	3	0.7662	2	5.8440	1
F3	1.3266	5	3.3966	1	-2.0700	5	4.7232	5
F4	2.5136	4	2.7714	2	-0.2578	4	5.2850	2
F5	2.5804	3	2.5389	4	0.0415	3	5.1193	3

Table 6. The sub-level index factor Influence degree, Influenced degree, Cause degree, Centrality degree

Influencing factors	Influence degree	Rank	Influenced degree	Rank	Cause degree	Rank	Centrality degree	Rank
F_{11}	1.2983	8	0.9445	17	0.3538	5	2.2428	13
F_{12}	1.2692	10	0.6241	19	0.6451	3	1.8933	18
F_{13}	1.105	13	1.2918	8	-0.1868	11	2.3968	10
F_{21}	2.2735	1	1.9809	2	0.2926	7	4.2543	1
F_{22}	1.2781	9	0.98	14	0.2981	6	2.2580	12
F_{23}	1.4031	6	2.604	1	-1.2009	20	4.0072	2
F_{24}	1.5717	5	1.7844	3	-0.2127	12	3.3560	3
F_{25}	1.6313	4	0.9871	13	0.6443	4	2.6184	7
F_{31}	0.8223	17	1.2568	9	-0.4344	16	2.0791	15
F_{32}	1.0001	14	1.0613	11	-0.0612	10	2.0613	16
F_{33}	0.6259	20	0.9547	16	-0.3288	14	1.5807	19
F_{41}	0.864	16	1.5893	5	-0.7254	19	2.4533	9
F_{42}	1.1339	12	1.595	4	-0.4611	17	2.7289	5
F_{43}	0.7865	19	0.6032	20	0.1833	9	1.3898	20
F_{44}	0.8717	15	1.343	7	-0.4714	18	2.2147	14
F_{51}	2.125	2	0.9747	15	1.1502	1	3.0997	4
F_{52}	1.2066	11	1.5216	6	-0.3150	13	2.7283	6
F_{53}	1.3148	7	1.0233	12	0.2914	8	2.3381	11
F_{54}	1.752	3	0.7974	18	0.9546	2	2.5493	8
F_{55}	0.7884	18	1.2042	10	-0.4158	15	1.9926	17

As can be seen from Table 5 that in terms of influence of the first-level, F2, F1, and F5 are the top three indicators, which indicates that they have the greatest influence on other first-level index factors. The top three centrality degree are F2, F4 and F5, which shows that the role of the above three factors in the influence of consumers' purchasing decisions under Livestreaming Marketing. Cause degree factors (positive value) F1, F2, and F5 have great significance in the influence of consumers purchasing leisure snacks under the livestreaming, and need to be considered. F3 and F4 (negative values) are easily affected by other first-level index factors and thus affecting consumers' purchase of leisure snacks under livestreaming.

It is shown in Table 6 that the top five secondary indicators are F_{21}, F_{51}, F_{54}, F_{25}, F_{24}. Results show that the five factors impact on the rest of the secondary index factors is the largest. Centrality degree ranks among the top five are F_{21}, F_{23}, F_{24}, F_{51}, F_{42}. It shows that five factors are the top five factors that play a role in consumers' decision to buy leisure snacks under the Livestreaming Marketing. When the cause degree value is more than zero, the element is the cause factor. The cause factors F_{51}, F_{54}, F_{12}, F_{25} and F_{11} have great significance in influencing consumers to buy leisure snacks and need to be considered. The element is the result factor when the cause degree value is less than zero, and the result factors F_{23}, F_{41}, F_{44}, F_{42}, F_{31}, F_{55} and other factors are more vulnerable to affected by other secondary index factors and thus have an impact on consumers' purchase of leisure snacks.

4) Draw the four-part graph of influencing factors

Taking the middle value of the centrality value (2.75) as the origin of the horizontal axis, a coordinate system of four quadrants is drawn, and the centrality and causality of each factor of the secondary index are displayed in the coordinate system (Figure. 4).

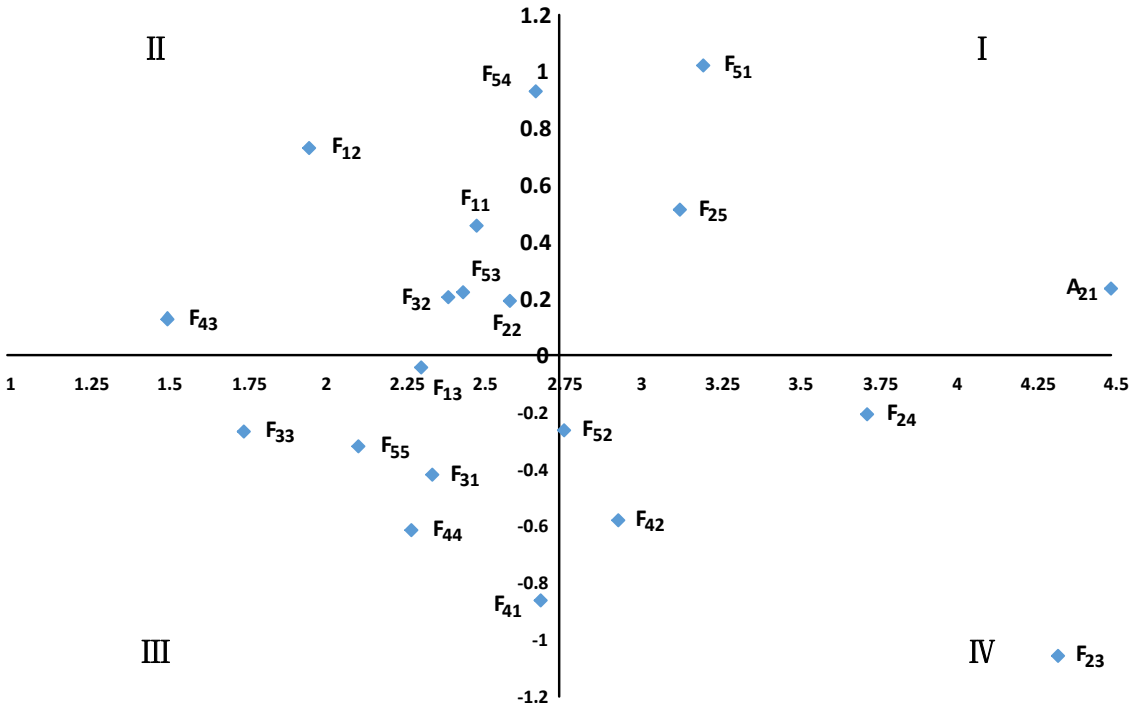

Figure 4. Four-part graph of influencing factors of consumers' purchase of leisure snacks under Livestreaming Marketing

Factors F_{51}, F_{25}, and F_{21} in the first quadrant have high centrality and causality, and have a greater impact on other factors. They are the key factors affecting consumer purchases under Livestreaming Marketing delivery, and are factors that enterprises should give priority to. In the second quadrant, F_{54} and F_{21} have higher causal degrees and slightly lower centrality, indicating that the above factors have a non-negligible impact on other factors. The reason and centrality of F_{43} are both low, indicating that companies should not only consider the visual impact of leisure snacks on consumers when choosing livestreaming, but should pay more attention to the quality and cost performance of the snack food itself. In the third quadrant, the degree of causation and centrality of F_{33} are both low, and the degree of cause is negative (result factor), which is less affected by other factors; The centrality of F_{23}, F_{24}, F_{42}, and F_{52} in the fourth quadrant is high, but the causal degree is low and negative

(consequential factor), which is more vulnerable to other factors greatly affected, indicating that the above factors are also the focus of consumers.

4.3 ANP Portfolio Empowerment

Through the combination weighting of ANP, the relationship between the factors is further determined, and finally the overall weight of the factors is calculated. The specific steps are indicated as below:

1) On the basis of the four-part graph of influencing factors of consumer purchase, the ANP network structure chart (Figure. 5) was drawn by conducting importance and correlation analysis on the influencing relationship of consumer purchase.

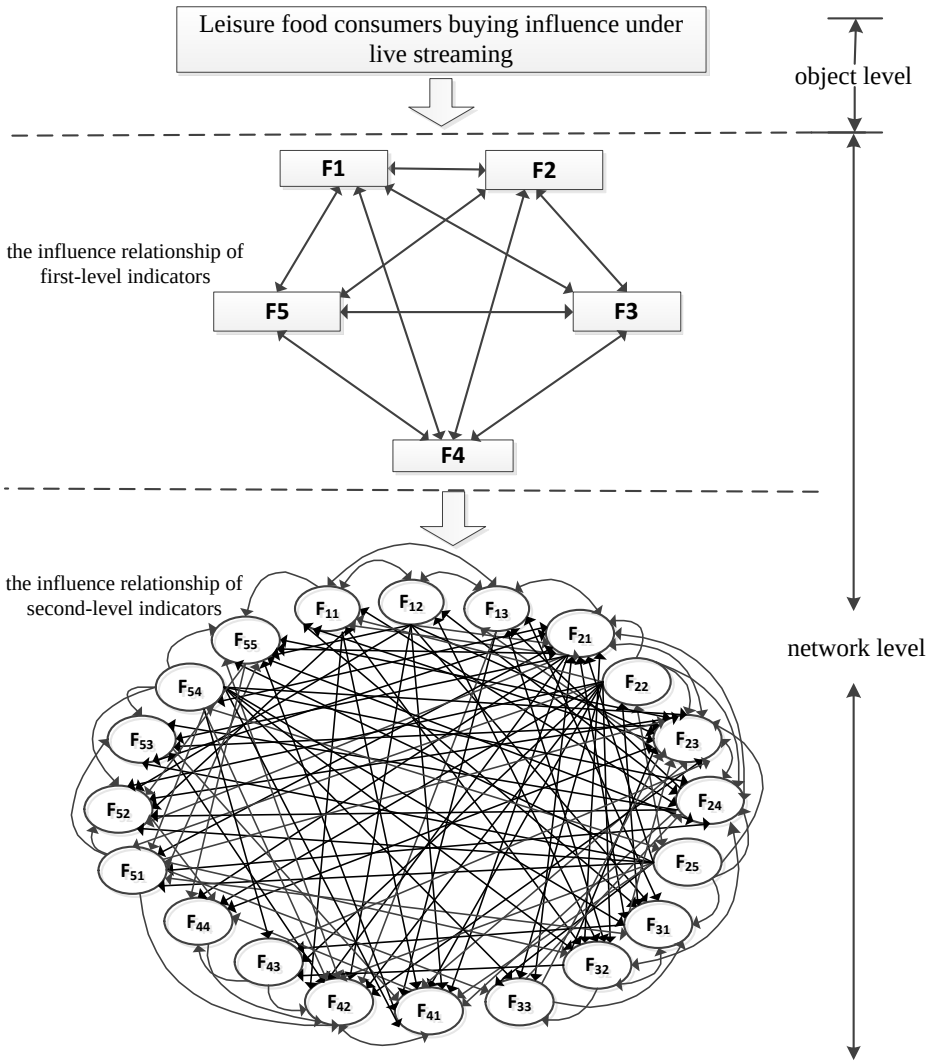

Figure 5. ANP Network Structure Diagram

2) Establish the judgment matrix. For the relationship between 5 first -level indicators and 20 sub -indicators, a total of 5 first -level indicators to judge matrix and 55 sub -indicators must be established and assigned a total of 5 first -level indicators.Because there are many judgment matrix to be established, this article uses SD Software (Super Decisions) to calculate 60 matrix.

3) Build the limit super-matrix. SD software is used to process the data of the above-mentioned first-level index judgment matrix and sub-level index judgment matrix to generate unweighted supermatrix, weighted super-matrix and limit super-matrix. Because of the space limitations, only some of the contents of the limit supermatrix are listed (Table 7).

Table 7. Limit supermatrix

	F_{11}	F_{12}	F_{13}	…	F_{42}	F_{43}	F_{44}	F_{51}	F_{52}	F_{53}	F_{54}	F_{55}
F_{11}	0.0710	0.0710	0.0710	…	0.0710	0.0710	0.0710	0.0710	0.0710	0.0710	0.0710	0.0710
F_{12}	0.0256	0.0256	0.0256	…	0.0256	0.0256	0.0256	0.0256	0.0256	0.0256	0.0256	0.0256
F_{13}	0.0478	0.0478	0.0478	…	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478
F_{21}	0.1040	0.1040	0.1040	…	0.1040	0.1040	0.1040	0.1040	0.1040	0.1040	0.1040	0.1040
F_{22}	0.0012	0.0012	0.0012	…	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
F_{23}	0.2056	0.2056	0.2056	…	0.2056	0.2056	0.2056	0.2056	0.2056	0.2056	0.2056	0.2056
F_{24}	0.0722	0.0722	0.0722	…	0.0722	0.0722	0.0722	0.0722	0.0722	0.0722	0.0722	0.0722
F_{25}	0.0004	0.0004	0.0004	…	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
F_{31}	0.0184	0.0184	0.0184	…	0.0184	0.0184	0.0184	0.0184	0.0184	0.0184	0.0184	0.0184
F_{32}	0.0169	0.0169	0.0169	…	0.0169	0.0169	0.0169	0.0169	0.0169	0.0169	0.0169	0.0169
F_{33}	0.0049	0.0049	0.0049	…	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049
F_{41}	0.1017	0.1017	0.1017	…	0.1017	0.1017	0.1017	0.1017	0.1017	0.1017	0.1017	0.1017
F_{42}	0.1009	0.1009	0.1009	…	0.1009	0.1009	0.1009	0.1009	0.1009	0.1009	0.1009	0.1009
F_{43}	0.0054	0.0054	0.0054	…	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054
F_{44}	0.0552	0.0552	0.0552	…	0.0552	0.0552	0.0552	0.0552	0.0552	0.0552	0.0552	0.0552
F_{51}	0.0174	0.0174	0.0174	…	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174
F_{52}	0.0553	0.0553	0.0553	…	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553	0.0553
F_{53}	0.0372	0.0372	0.0372	…	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372	0.0372
F_{54}	0.0043	0.0043	0.0043	…	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043
F_{55}	0.0547	0.0547	0.0547	…	0.0547	0.0547	0.0547	0.0547	0.0547	0.0547	0.0547	0.0547

4) Determine the indicator weight. SD software is used to calculate the partial weight and global weight of each indicator. (Table 8), and select the global weight as the column vector W_6.

5) Calculate the mixing weight. Formula (18) is used to mix the adjusted comprehensive influence matrix T and global weight W_6, normalize the column of the mixed weight matrix, and obtain the final mixed weight W_0 (Table 8).

Table 8. Each index weight

First-level indicator	Primary weight	Secondary indicators	Local weight	Global weight W_6	Mixed weight W_0
Live platform F1	0.14	Platform popularity F_{11}	0.4919	0.071	0.0563
		Platform standardizationF_{12}	0.1774	0.0256	0.0405
		The number of third-party institutions for Influencer Marketing on the platform F_{13}	0.3307	0.0477	0.0432
Live anchor F2	0.348	Anchor popularity F_{21}	0.2713	0.104	0.0933
		Infectiousness of the anchor F_{22}	0.0032	0.0012	0.0365
		Anchor guide turnover F_{23}	0.5363	0.2056	0.1107
		Anchor word of mouth F_{24}	0.1883	0.0722	0.0678
		Shopping guide professional level and experience F_{25}	0.0009	0.0004	0.0397
Live interaction F3	0.072	Richness of interactive means F_{31}	0.4567	0.0184	0.0265
		Interactive channel patency F_{32}	0.4207	0.0169	0.0286
		Barrage interaction timeliness F_{33}	0.1227	0.0049	0.0169
Live Goods F4	0.1978	Brand awareness of leisure snacks F_{41}	0.3864	0.1017	0.0614
		Leisure snacks word of mouth F_{42}	0.3835	0.1009	0.0674
		Leisure Snacks Visual Sensory F_{43}	0.0205	0.0054	0.0229
		Leisure snack prices F_{44}	0.2096	0.0552	0.0461
Livestreaming guarantee F5	0.242	Livestreaming team collaboration ability F_{51}	0.1032	0.0174	0.0564
		Bargaining power of the livestreaming team F_{52}	0.3274	0.0553	0.0529
		livestreaming team selection ability F_{53}	0.2201	0.0372	0.0470

		Professionalism of the livestreaming team F_{54}	0.0253	0.0043	0.0438
		After-sales service guarantee F_{55}	0.3240	0.0547	0.0419

4.4 Comparison verification and identification of key factors

Multiple evaluation methods are used to calculate index weights, and identify the key factors and validate the reliability of the method by the following steps:

1) Select a variety of evaluation methods to calculate the weight of each indicator

PCA, DEMATEL, Fuzzy-DEMATEL, entropy weight method and ANP evaluation method were used to calculate the weight of each indicator and the multiplication synthesis method was used to combine Fuzzy-DEMATEL and entropy weight method to assign weight, and the results were compared with the Fuzzy-DEMATEL and ANP mixed weight proposed in this paper. See Table 9 for the results.

Table 9. Different calculation methods to evaluate the weight of each indicator

Calculation method / **The evaluation indicator**	**PCA weight W_1**	**DEMATEL Weight W_2**	**Fuzzy-DEMATELweight W_3**	**Entropy weight method weight W_4**	**Fuzzy- DEMATEL and entropy weight multiplication synthesize the weight W_5**	**ANP global weight W_6**	**Fuzzy-DEMATEL and ANP mixed weight W_0**
F_{11}	0.0464	0.0458	0.0442	0.0444	0.0383	0.0710	0.1504
F_{12}	0.0559	0.0378	0.0389	0.0543	0.0413	0.0256	0.1082
F_{13}	0.054	0.0419	0.0468	0.0378	0.0346	0.0477	0.1155
F_{21}	0.0482	0.0816	0.0829	0.0584	0.0946	0.1040	0.2493
F_{22}	0.0501	0.0471	0.0443	0.0355	0.0307	0.0012	0.0974
F_{23}	0.0417	0.0807	0.0814	0.0624	0.0992	0.2056	0.2957
F_{24}	0.0512	0.0676	0.0654	0.0573	0.0732	0.0722	0.1810
F_{25}	0.0534	0.0575	0.0524	0.0518	0.0530	0.0004	0.1059
F_{31}	0.058	0.0432	0.0413	0.0328	0.0265	0.0184	0.0709
F_{32}	0.0493	0.0436	0.0401	0.0339	0.0266	0.0169	0.0764
F_{33}	0.0477	0.0321	0.0314	0.0440	0.0270	0.0049	0.0452
F_{41}	0.0417	0.0511	0.0498	0.0624	0.0607	0.1017	0.1640
F_{42}	0.0473	0.0542	0.0538	0.0368	0.0387	0.1009	0.1801
F_{43}	0.0522	0.0274	0.0273	0.0460	0.0245	0.0054	0.0612
F_{44}	0.0498	0.0428	0.0440	0.0560	0.0481	0.0552	0.1230
F_{51}	0.0544	0.061	0.0643	0.0618	0.0776	0.0174	0.1505
F_{52}	0.0473	0.0503	0.0534	0.0368	0.0384	0.0553	0.1413
F_{53}	0.0486	0.0445	0.0458	0.0632	0.0566	0.0372	0.1256
F_{54}	0.0507	0.0513	0.0529	0.0544	0.0562	0.0043	0.1171
F_{55}	0.0522	0.0387	0.0396	0.0699	0.0541	0.0547	0.1120

2) Verify the reliability of evaluation method and identify the key factors affecting purchase

All weight values calculated by the above method are plotted on the coordinate axis into the two-dimensional line chart as shown above (Figure. 6). By analyzing the situation of each weight value, we can see that F_{23} (anchor-guided turnover), F_{21} (anchor popularity), F_{24} (anchor word-of-mouth), F_{41} (leisure snack brand awareness), F_{42} (leisure snack word-of-mouth), F_{51} (livestreaming team collaboration ability), F_{52} (livestreaming team bargaining ability) , F_{53} (the ability of the livestreaming team to select products), and F_{55} (the after-sales service guarantee) are important factors that affect consumers' decision to buy leisure snacks under the Influencer Marketing. Combined with the

comprehensive analysis of the four-part graph of influencing factors (Figure. 4), it is concluded that F_{23} (anchor-guided turnover), F_{21} (anchor popularity), F_{51} (livestreaming team collaboration ability), F_{41} (leisure snack brand awareness), F_{53} (the ability of the livestreaming team to select products) are key factors that affect consumers' decision to buy leisure snacks under the livestreaming.

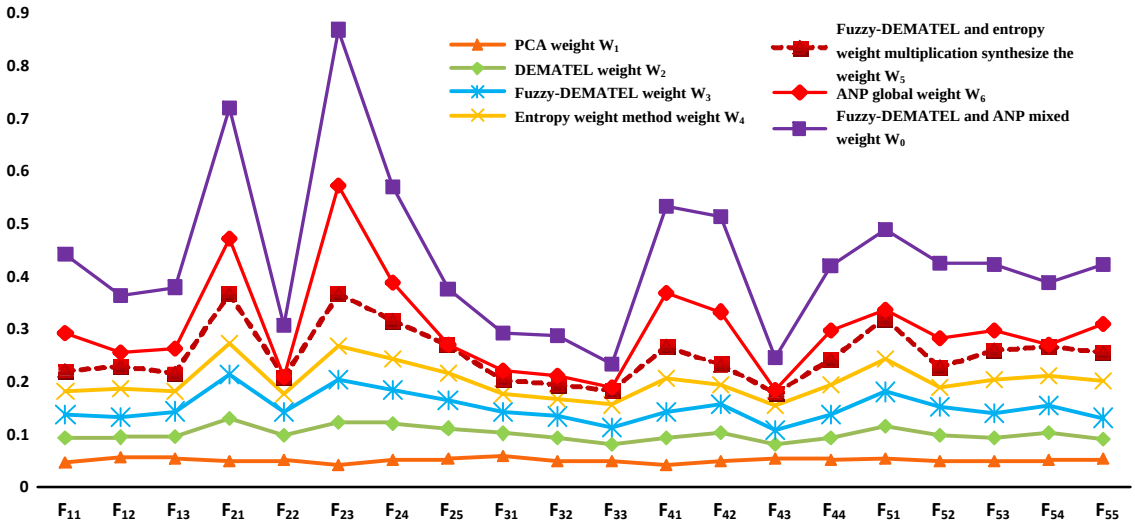

Figure 6. Comparison and analysis of weight values of each index

5 Research conclusions and discussion

5.1 Research conclusions

Based on the main level analysis and combination empowerment (Fuzzy-DEMATEL, ANP), a key factors identification model for consumer purchases of leisure snacks under Live-streaming Marketing is constructed. The research found that the anchor-guided turnover, the anchor's popularity, the collaboration ability of the livestreaming team , the popularity of the leisure snack brand, the ability of selecting products of the livestreaming team are the key factors that affect consumers to buy leisure snacks in webcasting.

5.2 Discussion

According to the result, "Anchor guide turnover " (F_{23}) is considered to be the most critical indicator affecting consumers' purchasing decisions in livestreaming marketing, which fully reflects the "herd effect" in consumer psychology. At present, China's livestreaming marketing is still in the stage of rapid development, with a large number of participants and uneven product quality. Consumers believe that making decisions by referring to the transaction amount of anchors can reduce transaction risks. "Anchor popularity " (F_{21}) and "Livestreaming team collaboration ability "(F_{51}) are the second and third most important factor affecting consumers' purchasing decisions in livestreaming marketing. The more popular anchors are, the more fans they have, and the more they can give full play to their position as opinion leaders. Moreover, good teamwork ability can provide clearer online shopping process, provide users with comforTable online consumption experience, enhance consumers' pleasure in watching livestreaming, and further promote them to make purchase decisions "Brand awareness of leisure snacks"(F_{41}) and "Livestreaming team selection ability "(F_{53}) are the fourth and fifth factors affecting consumers' purchasing decisions in livestreaming marketing, they are both closely related to product quality, fully reflecting the importance of product quality to consumers'

decisions. The research was conducive to the platform of live-stream e-commerce, the merchants and the live-stream delivery team to have a deeper understanding of consumer behavior. At the same time, we started with the key factors that affect consumers' decision-making, so as to better strengthen consumers' intention to purchase, increase the sales volume and commodity attention of merchants, and increase the transaction amount and the number of fans of the livestreaming team.

Combined with the research findings, can be improved in the following aspects: First, anchors should improve their own professional competence and enhancing consumers' perceived trust, so as to form a virtuous circle of "increase in turnover - increase in popularity of anchors - increase in turnover". Second, the e-commerce livestreaming has a significant Matthew effect. The anchor should be a "gatekeeper" and "opinion leader" in the persuasion and communication process, and use the anchor's own attraction to help fans or consumers to enhance their cognition and understanding of the products or services, actively expand the ways of interacting with fans, choose real-time barrage, online comments, online private messages and other methods to enhance the atmosphere of interaction with fans or consumers, stimulate fans or fans' interest in online livestreaming marketing, and increase the popularity of anchors. The third is that the livestreaming room is not as simple as it seems. Behind each livestreaming, there is a company team supporting the operation, cultivating excellent anchors suitable for the product, strengthening the cooperation of the team, and enhancing the team's ability to select products. An efficient e-commerce livestreaming team is the key to rapid growth. Fourth, to ensure product quality and product safety from the source through the application of new technologies, such as the implementation of product quality traceability technology, thus enhance the brand popularity of snack foods. Fifth, the livestreaming product selection team should improve their professional skills and comprehensive quality, such as, attach great importance to product quality, carefully select cooperative brands, personally try to recommend products, ensure product cost-effectiveness, improve the team's product selection ability, better meet the expectations of customers, and ensure the effective progress of livestreamings from the source.

6 Research significance and limitations

6.1 Research significance

There are new situations and new changes in the influencing factors of consumers' purchase intention under Live-streaming Marketing compared with the previous simple online shopping.The study has confirmed an important impact of “the anchor-guided turnover”, “the anchor’s popularity”, “the collaboration ability of livestreaming team”, “the popularity of the snack brand” and “the product selecting ability of livestreaming team” on consumers' purchasing decisions. This study broadened the thinking of consumers' purchasing behavior under livestreaming and is a useful supplement to the existing research on consumers' purchasing decision-making factors under livestreaming. In this study, dimension reduction processing of principal component analysis (PCA) was used to effectively identify the purchase evaluation indicators of consumers under Live-streaming Marketing, reserving most of the information of original variables. Impact factors indicator system for consumers' purchase of "livestreaming with goods" for leisure snacks, which are composed of livestreaming platform, livestreaming anchor, livestreaming interaction, livestreaming commodities and livestreaming guarantee, has been further optimized. In view of the uncertainty of expert evaluation, Fuzzy-DEMATEL analysis the evaluation index’s logical relationships and influence relationships, and the ANP network based on the importance and relevance of consumer purchase influence was constructed. DEMATEL-ANP combined weighting method is used to fully consider the interaction between complex indexes and improve the objectivity and scientificity of index importance calculation. The evaluation model not only expanded the research field of consumers' purchasing decision behavior, but also added the research perspective of the field of livestreaming shopping,

which laid a foundation for the in-depth research of “Live-streaming Marketing” consumers' purchasing behavior.

6.2 Limitations and prospects

In order to construct the key factors identification model, a lot of work was done in the process, but the study still has some limitations:

1) The evaluation of the influencing factors in this study was limited by the expertise of the evaluators. It was carried out by 15 enterprise executives, university scholars and senior consumers who are familiar with the e-commerce operation field of the snack industry. The number of evaluation samples was small, and the conclusions obtained from data analysis were convincing in a certain range. Follow-up studies should consider effectively expanding the number of evaluation objects or using big data, select data evaluators with different occupations, ages, and educational levels, expand the scope of sample selection, and further increase the objectivity of the research results.

2) The model proposed 5 first-level indicators and 20 sub-level indicators that are more representative and influential as influential factors of consumer purchasing decisions under marketing. However, the environmental changes of livestreaminging are diverse, consumers' purchase decision is complex and diverse, and the selected influencing factors are timely ones. Therefore, in the follow-up research, the influencing factors of purchase decision should be dynamically adjusted and improved in combination with the development of livestreaminging and products, so as to further improve the model and enrich the existing research results.

3) There are a large number of live-streaming and merchandising platforms in China, and the platform characteristics and audiences are different. Therefore, the factors influencing consumers' purchasing decisions under live-streaming and merchandising on Taobao live-streaming platform, which was selected in this paper, are unlikely to be applicable to all live-streaming and merchandising platforms. The follow-up research should refine the research content, and conduct comparative research on consumers' purchasing decision behaviors of different livestreaming platforms by category.

References

[1] T/ZEA 006—2020. (2020). Living streaming e-commerce talent training and evaluation specifications.

[2] Ying Zhang. (2020). Under the tuyere of live e-commerce, how do textile enterprises dance with the wind?. TEXTILE & APPAREL WEEKLY (32),18-19. https://doi.org/CNKI:SUN:FZZK.0.2020-32-009.

[3] IiMedia Research. (2021). Research Report on the Development of China's Online Live streaming Industry in the First Half of 2021.Guangzhou: Iimedia Consulting Group.

[4] Foresight Industry Research Institute. (2021). 2021-2026 Deep Research Report on Business Model Innovation and Investment Opportunities in China Webcasting Industry.Shenzhen: Shenzhen foresight Information Company Limited.

[5] MobTech(2021).2020 China Live Streaming Industry Development Insight.Beijing;Mob Research Institute.

[6] Baoguo Zhao & Yunfeng Wang.(2021). The influence of E-commerce Anchor Characteristics on Consumers’ Purchase Intention. Commercial Research (01),1-6. https://doi.org/10.13902/j.cnki.syyj.2021.01.001.

[7] Yunhui Gao.(2020). Research on the influence of network anchor Characteristics in E-commerce livestreaming on Consumers' Purchase Intention [Harbin (Hei Longjiang)] : Harbin Institute of Technology

[8] Yifei Zhou. (2020). Research on the e-commerce social media influencer on college girl's purchase intention based on SOR theory [Inner Mongolia] : Inner Mongolia University

[9] Mi Chen. (2020). Study on Consumers' purchase intention can be influenced by Web celebrity sales Promotion in Live streaming [Guang Zhou(Guang Dong)] : South China University of Technology

[10] Dawei Zhao & Jiaxin Feng.(2021). The Impact of Characteristics of E-commerce Anchor as a Key Opinion Leader on Comsumers' Purchase Intention. Commercial Research(04),1-9. https://doi.org/10.13902/j.cnki.syyj.2021.04.001.

[11] Baosheng Zhang, Qingpu Zhang & Chenguang Zhao. (2021). The Influence of Webcast Charateristics on Consumers' Purchase Intention under E-commerce Live streaminging Mode—the Mediating Role of Consumer Perception. China Business and Market(06),52-61. https://doi.org/10.14089/j.cnki.cn11-3664/f.2021.06.005.

[12] Qidi Zheng. (2021).A study on the impact of live-streaming with interactivity on consumers' willingness to cross-purchase. Popular Standardization (11),140-142. https://doi.org/CNKI:SUN:DZBH.0.2021-11-050.

[13] Kang, K., Lu, J., Guo, L., & Li, W. (2021). The dynamic effect of interactivity on customer engagement behavior through tie strength: Evidence from live streaming commerce platforms. International Journal of Information Management, 56, 102251.

[14] Xue, J., Liang, X., Xie, T., & Wang, H. (2020). See now, act now: How to interact with customers to enhance social commerce engagement?. Information & Management, 57(6), 103324.

[15] YongQi Chen. (2020). Research on the Influence Factors of E-commerce Live streaming on Consumers' Purchase Intention [Jinan(Shan Dong)] : Jinan University

[16] Hang Jiang.(2020). A study of the influence factors of the Consumer purchase intention of E-commerce Live streaming and platform operation strategy [Beijing] : Beijing University of Posts and Telecommunications

[17] Chuan Hu. (2020). Research on the Influencing Factors and Relationships of Users' Online Purchase Intention in Live Streaming E-commerce [Jinan(Shan Dong)] : Jinan University

[18] Man Ji & Xiangzhi Zhuo.(2020). Factors influencing consumers' purchase intention in e-commerce webcast environment based on SOR model. Journal of Huaibei Normal University(Philosophy and Social Sciences)(04),49-57. https://doi.org/CNKI:SUN:HBMS.0.2020-04-008.

[19] Xiaohan Tian, Liangrui Guo & Baolu Wang. (2021). Research on the Purchase Intention of Apparel Consumers in Taobao Live Based on the Theory of Perceived Risk. Journal of Beijing Institute of Fashion Technology(Natural Science Edition) (01),61-66. https://doi.org/10.16454/j.cnki.issn.1001-0564.2021.01.010.

[20] Yuqi Zhang. (2020). Study on the Continuance Intention of E-commerce Livestreaming based on SOR Approach [Bei Jing] : Beijing Foreign Studies University

[21] Xu, X., Wu, J. H., & Li, Q. (2020). What drives consumer shopping behavior in live streaming commerce?. Journal of Electronic Commerce Research, 21(3), 144-167.

[22] Hu, M., & Chaudhry, S. S. (2020). Enhancing consumer engagement in e-commerce live streaming via relational bonds. Internet Research.

[23] Fengliang, X. I. E., & Jianhong, L. U. O. (2021, March). Research on the influence of live streaming commerce affordances on consumers' impulse purchase intention based on SPSS25. 0 and Amos23. 0. In 2021 2nd International Conference on E-Commerce and Internet Technology (ECIT) (pp. 95-99). IEEE.

[24] Xiuying Tian. (2020). A Study on Impulse Buying Desire of Live E-commerce Consumers Based on S-O-R Model [Liaoning(Da Lian)] : Dalian Maritime University

[25] Fang Dong. (2019). Research in consumer purchase intention based on live mobile e-commerce contexts. Marketing Industry (25),137+162. https://doi.org/CNKI:SUN:YXJI.0.2019-25-104.

[26] Ma, Y. (2021). To shop or not: Understanding Chinese consumers' live-stream shopping intentions from the perspectives of uses and gratifications, perceived network size, perceptions of digital celebrities, and shopping orientations. Telematics and Informatics, 59, 101562.

[27] Jia Liu,Yunjie Zou & Zexi Liu. (2021). Analysis of factors influencing consumer's purchase intention in live e-commerce based on SEM model. Statistics & Decision (07),94-97. https://doi.org/10.13546/j.cnki.tjyjc.2021.07.019.

[28] YE Jing & HU Cuilan. (2021).The impact of live streaming time-limited promotion and anchor trust on consumers' clothing purchasing behavior. Journal of Silk (04),57-67. https://doi.org/.

[29] Wenzhuo Meng. (2020). An empirical analysis of user' motivation to watch live streaming with goods from the perspective of use and gratifications theory: the case study of Taobao live streaming platform. Science & Technology for China's Mass Media(04),113-115. https://doi.org/10.19483/j.cnki.11-4653/n.2020.04.032.

[30] Chao Wei. (2020). From Trust to Conversion: An Empirical Study on the Impact of Kwai Live streaming on Users' Purchase Intention. [Bei Jing] : Minzu University of China

[31] Sohn, J. W., & Kim, J. K. (2020). Factors that influence purchase intentions in social commerce. Technology in Society, 63, 101365.

[32] Xueli Wang. (2020). Research on Impact of Internet Celebrity Live streaminging on Consumers' Purchase Intention Based on Hierarchical Regression Analysis. Scientific & Technical Information of Gansu(11),76-80. https://doi.org/CNKI:SUN:LZKQ.0.2020-11-024.

[33] Qian Zhang, Ning Pei, Huihui Cao, Longyan Wang & Honglin Yin. (2021). Investigation on the Perception of celebrities Live streamer with Goods and Promotion Countermeasures. Market Modernization (09),21-23. https://doi.org/10.14013/j.cnki.scxdh.2021.09.008.

[34] Fangwei Hou. (2020). Research on the audience effect of Taobao live streaming hosted by internet celebrity from the perspective of the theory Use and Cratification [Nanchang (Jiang Xi)] : Nanchang University

[35] Meiyue Wang, Yumeng Dong & Kai Zhang. (2021). Research on the Impact of E-commerce Livestreaming on Consumers' Consumption Intention. Trade Fair Economy (05),25-28. https://doi.org/CNKI:SUN:SZJJ.0.2021-05-010.

[36] Jing Xiao. (2020). Research on Consumers' Purchase Intention of E-commerce Live Streaming Platform Based on Social Presence Perspective [Guilin (Guang Xi)] : Guilin university of technology

[37] Zhenzhen Li, Wanru Xiao & Xueqin Zhao. (2021). Influencing Factors of College Students' Use of E-commerce Live Streaming Platform: Case Study of Taobao Live. Information Research (01),72-78. https://doi.org/CNKI:SUN:QBTS.0.2021-01-010.

[38] Emovon, I. , & Oghenenyerovwho, O. S. . (2020). Application of mcdm method in material selection for optimal design: a review. Results in Materials, 7, 100115.

[39] Liu, J. , Li, Y. , Xiao, B. , & Jiao, J. . (2021). Siting MSW landfills via the integration of DEMATEL-ANP and clustering algorithm in a fuzzy logic environment (Case Study: Lanzhou, China).

[40] Huang, Y. , & Hu, Y. . (2021). Research on key influence factors of sustainable development capability of smart city based on hybrid decision model. Journal of Physics: Conference Series, 1972(1), 012046 (8pp).

[41] Bardhan, A. K. , Nag, B. , Mishra, C. S. , & Tarei, P. K. . (2021). An integrated framework for analysing performance indicators of indian microfinance institutions: a multi-stakeholder perspective. Benchmarking An International Journal, ahead-of-print(ahead-of-print).

[42] Arthur J. Lin, Hai-Yen Chang, & Brian Hung. (2022). Identifying key financial, environmental, social, governance (esg), bond, and covid-19 factors affecting global shipping companies—a hybrid multiple-criteria decision-making method. Sustainability, 14.

[43] Khalilzadeh, M. , Shakeri, H. , & Zohrehvandi, S. . (2021). Risk identification and assessment with the fuzzy dematel-anp method in oil and gas projects under uncertainty. Procedia Computer Science, 181(3), 277-284.

[44] Yadav, A. K. , & Samuel, C. . (2022). Modeling the barriers of the resilient supply chain: a fuzzy-dematel approach. Journal of Advanced Manufacturing Systems.

[45] Yadav, R. N. , Kumar, D. , Sharma, A. K. , & Virmani, N. . (2022). Analysing human and system related barriers of tqm in automobile industries using fuzzy dematel approach. International Journal of Productivity and Quality Management, 35.

[46] Menru Rao, Zhongqian Wu, Rui Tang, Junai Chen & Shaoya Zhou. (2021). Analysis of factors influencing the purchase decision of consumers in the new media era by live streaming. Modern Business Trade Industry (01),56-58. https://doi.org/10.19311/j.cnki.1672-3198.2021.01.024.

[47] Tanghui Liang. (2020). Study on the value realization path of TV media live streaming with goods under MCN model. Radio & TV Journal (09),5-6. https://doi.org/10.19395/j.cnki.1674-246x.2020.09.001.

[48] Haihua Wang, Yu Li, Lijun Xiong & Mei Du. (2019). Influence of Live Web Celebrity Attributes on Users Value Co-creation. Shanghai Management Science(04),19-26. https://doi.org/CNKI:SUN:SGLK.0.2019-04-005.

[49] He Xu, Hongjian Qu & Jianzhong Cai. (2020). The Influence of Webcast on Consumer's Purchase Intention. Journal of Beijing Institute of Fashion Technology(Natural Science Edition)(02),88-94. https://doi.org/10.16454/j.cnki.issn.1001-0564.2020.02.013.

[50] IReaearch. China Live Streaming E-Commerce Industry Monthly Operation and Year-End Stocktaking Data Monitoring Report from November to December 2020[R]. Beijing: IResearch Institute, 2021.

[51] Qianni Huang. (2021). Analysis on the influencing factors of purchase intention of agriculture products live streaming.Market Modernization(01),69-71. https://doi.org/10.14013/j.cnki.scxdh.2021.01.024.

[52] Xinchuan Think Tank. (2020). Insight Report on Live Streaming goods Industry in 2020.Beijing:Beijing Xinchuan Think Tank Technology Co.,LTD.

[53] Mingxiao Dan.(2019). Analysis on the influencing factors of live streaming purchase intention. Modern Economic Information (01),357-358. https://doi.org/CNKI:SUN:XDJZ.0.2019-01-309.

[54] Jie Li. (2021). Research on the impact of rural e-commerce live streaming on consumers' purchase intention. Business China (Z1),122-123. https://doi.org/CNKI:SUN:JSGZ.0.2021-Z1-043.

[55] He Xu, Hongjian Qu & Jianzhong Cai. (2021). Influencing factors of apparel consumer's implusive purchase willingness in the context of webcasting. Journal of Donghua University(Natural Science)(05),111-120. https://doi.org/10.19886/j.cnki.dhdz.2020.0189.

[56] Xinxin Tian & JingJing Tian. (2020). A study of factors influencing consumers' purchase intention in e-commerce live streaming - Taobao live streaming as an example. Science and Technology & Innovation (20),4-8. https://doi.org/10.15913/j.cnki.kjycx.2020.20.002.

[57] Haiquan Chen,Yi Zhang & Wenqian Guo. (2020). A Study on the Impact of Influencers on Fan's Purchase Intention in Live streaminging Platform. China Business and Market (10),28-37. https://doi.org/10.14089/j.cnki.cn11-3664/f.2020.10.003.

[58] T/CCPITCSC060—2020. (2021). Professional Competence Requirements for Live streamer.

[59] Xiaorui Shi, Yuankun Wang, Jinyu Bian, Dong Wang & Jichun Wu. (2018). Identification of key driving factors of water resources carrying capacity. Journal of Nanjing University(Natural Science)(03),628-636. https://doi.org/10.13232/j.cnki.jnju.2018.03.019.

[60] Huiping Cheng & Qi Peng. (2019). Identification and Analysis of the Key Influencing Factors on Technical Security Rist of Personal Cloud Storage Service. Library and Information Service (16),43-53. https://doi.org/10.13266/j.issn.0252-3116.2019.16.005.

[61] Opricovic, S., & Tzeng, G. H. (2003). Defuzzification within a multicriteria decision model. International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, 11(05), 635-652.

[62] Saaty, T. L. (2005). Theory and applications of the analytic network process: decision making with benefits, opportunities, costs, and risks. RWS publications.

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