

Impact of the e-commerce supply chain on user stickiness in the context of live streaming services

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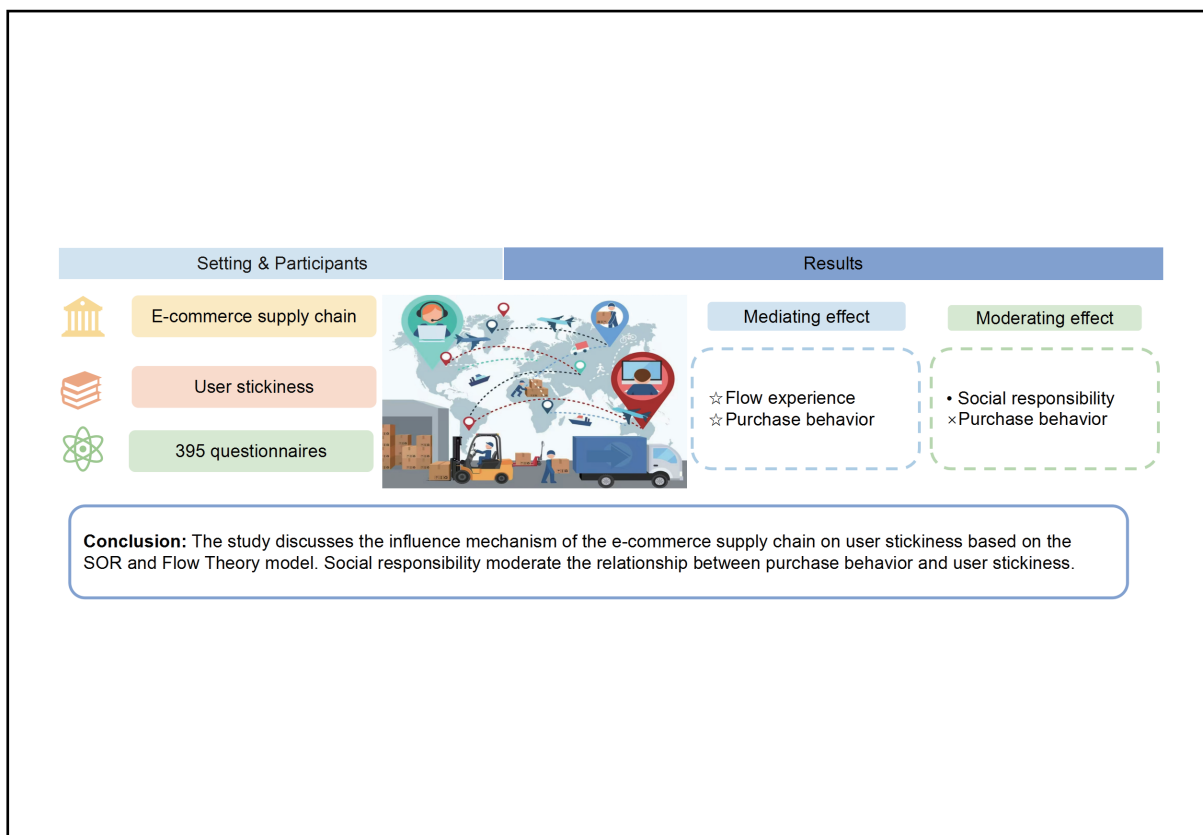
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Graphical abstract



With the exception that LQ has no significant effect on the FE, all the other hypotheses are verified.

Public summary

- Product quality, brand endorsement, order efficiency, platform services, promotional discounts, and opinion leaders are significant, but logistics quality is not related to the flow experience.
- Flow experience has a significant effect on purchase behavior, and purchase behavior has a positive effect on user stickiness.
- Social responsibility significantly positively moderates the relationship between purchase behavior and user stickiness.

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Abstract: As Internet media technologies continue to evolve, live streaming services have become increasingly influential in social life. The purpose of this paper is to develop a model between the e-commerce supply chain and user stickiness in the context of live streaming services on the basis of the SOR and flow theory models. Data were collected via a questionnaire and structural equation modeling via AMOS 26.0 software. The empirical results of 395 questionnaires indicate that product quality, brand endorsement, order efficiency, platform services, promotional discounts, and opinion leaders are significant, but that logistics quality is not related to the flow experience. Flow experience has a significant effect on purchase behavior, and purchase behavior has a positive effect on user stickiness. The results show that social responsibility significantly positively moderates the relationship between purchase behavior and user stickiness. The findings have important implications for the development of e-commerce and provide some additions to research in this area.

Keywords: SOR model; e-commerce supply chain; research mechanism; social responsibility; user stickiness

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1 Introduction

As internet media technologies continue to evolve, live streaming services have become increasingly influential in social life and continue to be used by users as an emerging service model that replaces traditional broadcast media services as a cheap and interesting alternative^[1]. During the epidemic, the nationwide stagnation of the real economy facilitated a continuous shift in consumer behavioral habits online^[2]. From live online classes to live bandwagons, live streaming services have not only reshaped the shape of various industries but also deepened consumers' dependence on them. Even today, the inertia of consumers' thinking about live streaming services has not abated. According to the China Internet Network Information Centre (CNNIC), which released the "50th China Internet Development Statistical Report" data, as of June 2022, the number of online shoppers in China had reached 841 million, accounting for 80.0% of all internet users. The explosive growth of the live e-commerce industry has successfully transformed the traditional consumer industry^[2], accelerating the pace of physical commerce to digital transformation.

As an increasing number of internet platforms become involved in e-commerce business, users' online consumption channels gradually diversify. As a result, the attention of users and the cost investment of live e-commerce enterprises make e-commerce enterprises pay increasing attention to the core competitiveness of the supply chain^[3]. Compared with the traditional supply chain, live e-commerce shortens the

links in the supply chain, in which the products in live e-commerce refer to the suppliers and producers, the anchor is a collection of distributors and retailers, supported by the live broadcasting platform^[4], and the whole process is linked by the logistic service, which finally reaches the consumers. Therefore, from the perspective of the supply chain, the basic business process of live e-commerce consists of five parts—the supply side, the platform side, the sales side, the transport side, and the consumer side—which correspond to the five links of the business value chain, such as suppliers, live e-commerce platforms, e-commerce anchors, logistics, and consumers, respectively. In this study, the anchor and the e-commerce live platform are considered as one link, considering that the anchor's behavior relies on the live platform. In the supply chain link, the consumer, as the most directly affected party, understanding the impact of each link of the e-commerce live supply chain on user perception helps enterprises gain a more detailed and intuitive understanding of user demand, optimizes the supply chain management strategy, enhances the supply chain management efficiency of e-commerce enterprises, and improves the quality of the live broadcasting service and the competitiveness of enterprises^[5]. Consequently, research on how the supply chain of live e-commerce affects user behavior in a live service context is highly important.

In the context of live-stream e-commerce, there are no absolute boundaries between the various segments of the supply chain, and each segment plays a key role in influencing consumer decisions^[6]. In the live-stream e-commerce model,

suppliers and manufacturers can bypass traditional distribution, agency and advertising channels and work directly with anchors to offer competitive prices to consumers^[7]. This approach not only shortens the distance between consumers and products but also accelerates product iterations and updates. Logistics plays a critical role as the link between suppliers, anchors and consumers, ensuring seamless delivery^[8]. The integration of these elements creates a unified consumer experience where product quality suppliers, logistics and engaging live streaming interactions work together to influence the consumer's decision-making process and ultimately their purchase behavior and stickiness. In this case, the roles of each segment are complementary, not hierarchical. Therefore, this study treats these three segments equally, which helps to gain a more comprehensive understanding of the impact of each segment in the e-commerce supply chain on consumer behavior.

However, the dramatic increase in the number of live e-commerce enterprises can lead to the emergence of problems such as user turnover and loyalty reduction while giving users more choices. In the existing stage, after live e-commerce has experienced an explosive period, many live e-commerce companies have taken building user stickiness as their goal^[9]. Although most of the discussions on the factors influencing user stickiness in the context of live streaming services have focused on the emotional level^[9], as competition in the e-commerce industry has become increasingly intense and the center of gravity of enterprises has shifted, such as supply chain management, the enhancement of customer loyalty has received increasing attention. In fact, every link in the e-commerce supply chain has an impact on the perception of user behavior, a good perceptual experience can induce an immersive experience, and users with a high immersive experience are highly engaged, which in turn generates positive emotions and ignores the passage of time. Previous studies have shown that immersive experience contributes to user purchase behavior, which in turn affects the generation of user stickiness^[10]. Therefore, it is essential to study how the supply chain of live e-commerce affects user stickiness to guide the development of the industry.

In this research, we constructed a mechanism model of how the live e-commerce supply chain affects user stickiness on the basis of the stimulus–organism–response (SOR) framework in the context of live streaming services, and the SOR theoretical model has been widely used in the study of user behavior in the context of online live streaming^[11]. There are three key elements in the S-O-R model, i.e., stimulus, organism and response. Among them, in the live streaming service context, three links in the supply chain of the live streaming e-commerce enterprise act as external stimuli (S), i.e., the supplier link, the logistics link, and the live streaming link, which have an impact on the user's cognitive–emotional impact (O) and produce an immersive experience. Then, the immersive experience state (O) triggered by the positive sense of experience causes the user to make a purchase, which in turn generates a repeated willingness to watch and purchase, i.e., sticky behavior (R).

In addition, this study highlights the gap between purchase behavior and user stickiness. Most of the current research on

live e-commerce supply chains focuses on single, random behaviors^[12], and there are fewer studies on further user stickiness. In fact, users may be influenced by intermediate factors, and purchase behavior does not necessarily lead to user stickiness. In particular, they live with goods in the “traffic code” at the same time but also face the dilemma of being difficult to regulate; the e-commerce industry service group is very large, and the responsibility of the enterprise has a more extensive impact. However, in recent years, anchor tax evasion, fake sales, the fabrication of data and other behaviors have endlessly affected both consumers and society; “Viya tax evasion case” and “Simba fake bird's nest event” have caused widespread social concern as well as the entire live broadcasting e-commerce industry. Ref. [13] reported that CSR has a positive effect on the generation of air travelers' loyalty. Ref. [14] demonstrated that corporate social responsibility awareness strengthens users' trust and promotes the generation of purchase intentions. Therefore, this study considers the inclusion of social responsibility in the model to narrow the gap between user purchase behavior and user stickiness.

The contributions of this study are threefold. First, the supply chain is very important to the competition between live e-commerce companies, but the current research has less macro research on the whole chain of the supply chain, and this study combines all the links of the supply chain to comprehensively consider the role relationships among the supplier link, the live streaming link, the logistics link, and the consumption link. Second, this study explores the influencing factors of user stickiness from the perspective of the service provider (i.e., the user's perspective). Most of the literature on live streaming services focuses on a single user's behavior, which includes participation in pop-up behaviors, persistent viewing behaviors, purchasing behaviors, impulsive consumption, etc.^[15,16]. There has been little research on the issue of users' recurring behavioral stickiness over a longer period of time. Third, this study attempted to explore the difference between purchase behavior and user stickiness. In most of the current studies, the analysis of user stickiness usually fails to go further and more often stops at the analysis of a single purchase behavior of live e-commerce consumers. This study investigated the reasons for the gap between purchase behavior and user stickiness through the influence of social responsibility.

2 Research hypotheses

2.1 SOR model

The stimulus–organism–response (SOR) framework was originally proposed by Mehrabian and Russell^[17]. There are three key elements in the SOR model, namely, the stimulus, the organism and the response. As external stimuli, environmental stimuli can be expressed in different forms, such as website features, marketing stimuli, environmental stimuli and contextual stimuli. Organism refers to individual states (e.g., affective state and arousal) and cognitive conditions (e.g., the cognitive state of the product)^[18]. The response generally refers to the behavioral reactions that occur as a result of changes in individual states after an individual passes through

an external stimulus, such as purchase behavior, impulsive behavior, and green behavior. In recent years, SOR theoretical models have been widely applied to the study of user behavior in the context of online live streaming. For example, based on SOR theory, a study constructed a model of the influence of online celebrities and reviews on consumers in the same context and verified how the consistency of the two affects users' purchase intentions^[18]. Another study used the SOR model to investigate the influencing mechanisms of atmospheric cues, such as background visual complexity and music tempo, in customers' live-stream shopping^[19]. One study explored the effects of the background fit of e-commerce live streaming on consumers' purchase intentions and the relevant internal psychological mechanism on the basis of the SOR model^[20]. The application of the SOR model in the context of online live streaming has been widely used by scholars and is very mature. Therefore, this study chooses the SOR model as the research basis to construct a model of the impact of the supply chain of live e-commerce enterprises on user stickiness in the context of live service.

First, in the live service context, the three links of the supply chain of live e-commerce enterprises act as external stimuli (S), i.e., the supplier link, the logistics link, and the live broadcasting link, which have an impact on users' cognitive-emotional impact (O) and produce an immersive experience. Then, the immersive experience state (O) triggered by the positive experience makes the user generate purchase behavior, which in turn generates repeated viewing and purchase willingness, i.e., user sticky behavior (R). The immersive rest experience plays a mediating role between the live e-commerce supply chain and purchase behavior, and purchase behavior plays a mediating role between the immersive experience and user stickiness. Finally, this study also examines the moderating role of social responsibility in the process from purchase behavior to user stickiness.

2.2 Flow theory

Flow theory was developed by Mihaly Csikszentmihalyi, who emphasized that when an individual reaches a state of high concentration while engaging in an activity, he or she experiences total immersion^[21]. In this state, the individual's attention is completely focused on the activity, forgetting self and time. In the context of live streaming e-commerce, flow theory can explain the impact of users' immersion experience on their purchase and stickiness behavior well. According to the theory, users who are able to enter a highly focused and immersed mental state while watching a live broadcast ignore the passage of time and pay strong attention to the live broadcast content and the goods displayed by the anchor^[22]. In the process, the anchor's interaction, product displays and promotions, and other external stimuli prompt the user to enter the flow experience and enhance his or her participation. The pleasure and immersion generated by users in the flow experience can significantly increase the likelihood of their purchase decision and lead them to exhibit repeat purchase behavior and greater stickiness. Thus, the theory serves as a psychological mechanism that explains how users become attracted to a live streaming platform through a highly immersive experience and remain loyal to the platform.

In addition, the role of platform services, promotions and opinion leaders has a key influence on the mobility experience. High-quality live platform services, such as the platform's ease of use, interactivity, and information richness, can help users enter the mobility experience quickly, increasing their desire to buy and stay longer^[23]. Time-limited promotions and interactions with opinion leaders can further increase users' focus, causing them to lose their sense of time during the shopping process and contributing to impulsive buying behavior. Through the mobile experience, users can obtain not only a good shopping experience but also long-term consumption habits and platform dependence, further improving the stickiness of the live e-commerce platform. Therefore, live e-commerce companies should focus on optimizing the user flow experience and enhancing the user's sense of immersion to promote purchase behavior and increase user stickiness.

2.3 Supplier segment

In reviewing the previous literature, we find that studies of the supply chain mainly start from the supplier's perspective, considering the supplier's technological innovation capability, the quality of the products offered, and so on^[24]. From the user perspective, the most intuitive thing for the user to feel is the information of the product itself, so we consider only product quality and brand advocacy to be included in the supplier link.

2.3.1 Product quality

Product quality is the consumer's subjective evaluation of the purchased good and intuitive perception of its quality. The more the consumer evaluates the quality of the commodity, the more likely they are to have a positive feeling. This is under the influence of the same factors, such as monetary payments and search costs. The above analysis concludes that product quality can positively affect the consumer flow experience.

In the context of a live service, consumers are more likely to obtain information about product quality. Anchors who display and try out the products in the live broadcast room share their experiences of using the products and word-of-mouth evaluations on the pop-up screen. This delivers information about the quality of the product content directly to consumers. Consumers quickly and intuitively assess product quality and perceive recommended products in live broadcasts as durable and reliable. Additionally, they consider whether products meet their unique needs, which leads to immersive thinking about the products and impacts their flow experience. Ref. [25] reported that product quality positively impacts customer satisfaction, which generates user concentration in the live room, promoting an immersive experience.

In live shopping, consumers gain detailed product information and a clear understanding of product quality through live video, which positively impacts their immersive experience. Building on this, the present paper proposes the following hypothesis:

H1: Within the context of live services, the product quality supplied by the provider has a positive effect on the flow experience.

2.3.2 Brand awareness

Brand awareness refers to consumers' ability to know or recall a brand. This includes the degree to which consumers are familiar with the brand, its commitment to quality, and the strength of the firm. It is also a crucial predictor of product performance^[26].

When choosing a product, consumers use brand awareness as a reference factor^[27]. They generally believe that a brand with high awareness will be more reliable than less known brands. Consumers tend to default to brands that offer better quality products, services, and performance, thus forming a positive sentiment toward the consumer in the live room. Moreover, Ref. [28] demonstrated that in live shopping, consumers lack systematic knowledge about the real situation of the product. They also reported that well-known brands are more likely to attract consumers and provide an immersive experience. Similarly, Ref. [29] reported that brand awareness serves as an external signal that influences consumer immersion.

In summary, brand awareness, as an external signal, affects consumer flow experience. On this basis, this paper proposes hypothesis H2.

H2: In the live service context, brand awareness provided by the provider has a positive effect on the flow experience.

2.4 Logistics link

According to previous studies in the context of online shopping, the logistics link is influenced primarily by factors such as order efficiency, delivery quality, delivery price, and customer service^[30]. As the majority of online purchases in the live e-commerce supply chain are packaged, the cost of logistics delivery is not taken into account in this study. Furthermore, delivery quality and customer service can be grouped together as the users' perceived logistics quality. Consequently, for this logistics chain, we choose to analyze order efficiency and logistics quality as the factors of interest.

2.4.1 Order efficiency

Order efficiency refers to whether an e-commerce company can deliver products to users in good condition within the promised time. Product delivery is a major challenge for online sellers, including live e-commerce companies, including orders even when they are processed, short product delivery cycles and products delivered in good condition.

A good product delivery time can ensure that the product arrives in good condition, reduce the possibility of product damage, and guarantee consistency between the physical product and the state of the product shipped by the live streaming merchant as much as possible, thereby improving user perception and creating a positive flow experience. Moreover, Ref. [31] reported that efficient order efficiency can improve the user's satisfaction with the merchant and enhance the user's emotional experience of live shopping, which contributes to the establishment of a good relationship between the two parties and improves the consumer's flow experience. Ref. [32] confirmed that the fulfillment of a product or service schedule negatively affects a user's perceived risk and improves the user's perception of positive emotions.

In summary, efficient order fulfillment reflects the professional competence and strength of live e-commerce. If consumers do not receive the products they purchased in the live broadcast on time, it will generate negative emotions toward the live merchant, which is considered not reliable enough, and thus reduce the degree of concentration on the live broadcast. On this basis, this paper proposes hypothesis H3.

H3: Order efficiency has a positive effect on flow experience in a live service context.

2.4.2 Logistics quality

Logistics quality refers to the level of an organization's ability to meet the logistics needs of its customers. In the context of live e-commerce platforms, logistics services are provided mainly in collaboration with third-party logistics companies. A previous study emphasized that logistics services should be customer-centric, making the definition and evaluation of logistics quality highly significant^[33].

In the context of e-commerce live broadcasting, logistics services have already been a crucial factor in enhancing the core competitiveness of enterprises. The consumer experience of shopping in a live streaming room is heavily influenced by logistics services^[34]. According to Ref. [35], the quality of logistics services has a positive effect on customer satisfaction.

A prompt, dependable, secure, and faultless logistics service system during live shopping contributes to producing a pleasant shopping experience and ultimately positively impacts the flow experience. On this basis, this paper proposes hypothesis H4.

H4: Logistics quality has a positive effect on the flow experience in a live service context.

2.5 Live streaming session

Previous studies have focused on the influence of live streaming sessions on user behavior through three factors: platforms, promotions, and anchor influencers^[36, 37]. This study considers the influence of live streaming sessions on user behavior through platform services, promotional discounts, and opinion leaders.

2.5.1 Platform services

The concept of e-service quality was first introduced by three scholars, Parasurman, Zeithaml, and Malhotra, who defined e-service quality (e-service quality or e-sQ) as a metric that expresses whether product screening, payment, and delivery of goods on a website are efficient^[38]. The definition of live e-commerce platform service in this study is from the consumer's perspective, which examines factors such as ease of use of the live platform, accuracy and richness of information, and caring customer service.

It has been proven that website quality design, which is a dimension of service quality, can significantly influence users' attitudes. Moreover, a study^[39] reported that e-service quality has an effect on consumer perceptions in the context of auctions. Ref. [40] also reported that if users are satisfied with a company's products and services, their attitudes toward the company are more positive. Thus, platform service reliability affects consumers' affective responses.

In the live service context, the more detailed and considerate the service provided by the platform to the consumer, the more likely the consumer is to have positive emotional factors toward the live room and the greater the willingness to stay in the live room, which can positively influence the flow experience. Therefore, hypothesis H5 is proposed.

H5: In the live service context, live e-commerce platform services positively affect users' perceptions of the flow experience.

2.5.2 Promotional discounts

When consumers shop online, price is the main factor, and they are more sensitive to price than traditional consumers are.

Promotional discounts are critical factors that encourage consumers to enter live rooms and prolong their stay while living. Merchants have launched various promotional discounts, including exclusive live prices, bonuses, limited-time activities, full reductions, etc. According to a previous study^[41], these various promotional discounts can give consumers the impression of a price reduction on the products, catch the majority of consumers' attention, and extend their viewing hours of the live broadcast. This, in turn, can increase the likelihood of consumers engaging in further purchasing behavior and improve their immersive experience.

Live streaming with goods offers promotional discounts in the form of time-limited seconds, coupons and gifts to win the customers' favor. This can create the perception of good value for money, generate a positive emotional response, and cause customers to ignore time. Therefore, this paper suggests Hypothesis H6:

H6: Promotional discounts in the live room positively affect users' perceptions of flow experience in the context of live service.

2.5.3 Opinion leaders

Opinion leaders are influential figures within a team who possess outstanding abilities in certain areas, a broad social range, and access to multiple sources of information. They have the ability to influence the attitudes of most people. In this paper, opinion leaders specifically refer to reddit anchors or subanchors in e-commerce live streaming platforms who tend to have high visibility in certain areas.

In the context of live streaming services, opinion leaders usually refer to celebrity anchors who have introduced and recommended specific products or brands in an engaging and innovative manner. Initially, consumers enter the live broadcasting room to watch first, but opinion leaders influence their interests, making them interested in certain products or anchors. In this state of mind, consumers become easily immersed in the live broadcasting room, disregarding their initial reasons for entry and time. Ref. [42] reported that opinion leaders positively affect consumers' intentions to purchase. Thus, we propose the following hypothesis H7.

H7: Opinion leaders in the live streaming room have a positive effect on users' perceptions of the flow experience in a live service context.

2.6 Flow experience

Flow experience is a psychological state in which people be-

come fully engaged in an activity, leading them to disregard their surroundings and lose track of time^[43]. It is characterized by a positive and optimal emotional state that triggers subsequent consumer behaviors.

Flow experience evokes positive emotions in consumers, which in turn affects their purchasing behavior. It is a key factor in predicting users' purchasing behavior, and studies have shown that the flow experience generated by online shopping has a positive effect on purchasing behavior^[44]. Consumers' purchase intentions may increase when the flow experience is strong. This, in turn, stimulates the purchasing behavior of consumers.

In a live streaming scenario, consumers are stimulated by various factors in the environment, such as people and things. This stimulation leads consumers to ignore the passage of time and focus on live streaming marketing activities, thereby triggering their intrinsic feelings of pleasure and enjoyment. As a result, consumers enter a state of concentration and immersion, which motivates them to make a purchase and stimulates their purchasing behavior^[45]. The above analysis leads to the proposal of hypothesis H8.

H8: In the live service context, the more positive the user's flow experience is, the easier it is to generate purchase behavior.

2.7 Differences between purchase behavior and stickiness and social responsibility

User stickiness refers to the behavioral manifestation of repeated viewing and purchasing and is also one of the manifestations of user loyalty. In the context of live streaming services, users promote only the subsequent generation of user stickiness on the basis of having one successful purchase behavior. Therefore, users' purchasing behavior in live e-commerce significantly and positively affects the generation of stickiness. However, the process of generating between behavior and stickiness is disrupted by external factors, and narrowing the gap between purchase behavior and user stickiness can provide powerful help to promote consumer loyalty and recognition of live e-commerce platforms and supply chain management of live e-commerce enterprises.

From the perspective of user perception, the information disseminated through social media, consumer comments and self-judgment are all capable of forming perceptual judgments of the anchor's social responsibility performance, i.e., social responsibility perceptions. In this study, from the perspective of user perception, social responsibility can be used to measure the social responsibility of anchors and live e-commerce platforms. Therefore, the concept of social responsibility actually describes the attitudes and behaviors of anchors and e-commerce companies toward social responsibility from a third-party perspective (i.e., users). A previous study^[13] showed that CSR has a positive effect on the creation of loyalty among air travelers. Ref. [14] demonstrated that corporate awareness of social responsibility strengthens users' trust and promotes the generation of purchase intentions. When users perceive that anchors have high moral literacy and social responsibility, user stickiness inspired by single, random purchases will be further strengthened, whereas when users believe that anchors and e-commerce enterprises do not

fulfill their social responsibility well and when negative events are exposed, the likelihood of generating repurchases and the role played by users will be significantly reduced. In the long run, the social responsibility performance of anchors and e-commerce enterprises has a significant moderating effect on users' willingness to use them again and repurchase and behavior.

In summary, this paper proposes hypotheses H9 and H10.

H9: In the live service context, the more positive the user's purchase behavior, the stronger the resulting user stickiness.

H10: In the live service context, the social responsibility of live e-commerce enterprises can promote users' repeated purchase behavior.

The preceding analysis leads to the research framework presented in Fig. 1.

3 Method

3.1 Sample and data collection

The starting date of the formal questionnaire was from 30th October 2022 to 10th January 2023, and the questionnaire was distributed online through Question Star, considering that the study group consists of users who have made live webcast purchases, and the online questionnaire limits this scope to a certain degree. The question star is powerful, user friendly, low cost and easy to operate. This helped us find age-appropriate participants who met our requirements. In addition, to control the quality and completeness of completion, the questionnaire was paid online to encourage the respondents to fill out the questionnaire carefully. The data collected were obtained with the approval of the ethics committee of Beijing Technology and Business University Scientific Research Ethics Committee, and informed consent was obtained from all individual participants during the data collection process. The data constitute a self-assessment questionnaire in which the participants voluntarily participated; the question-

naire was distributed through the Questionnaire Star form in China (<https://www.wjx.cn>).

Moreover, when the questionnaire was distributed, the restriction of "no IP address duplication" was set on the questionnaire to avoid duplication of the questionnaire by the same respondent to guarantee the quality of the questionnaire. To guarantee the accuracy of the survey scope, the questionnaire included the item "Have you ever watched live webcasts? (e.g., Taobao Live, Jittery Live, Xiaohongshu Live or Shutterbug Live)" and "Have you ever purchased a product from a live webcast?" Two skip logics were set: "Have you ever bought a product from a live webcast?" and "Have you ever bought a product from a live webcast?" If the respondent chose "haven't watch" or "haven't bought" in the screening questions, the question was closed directly. Users who choose "have seen" and "bought" could choose according to their real feelings about the live supply chain of e-commerce. To control the impact of common method bias, we took the following steps. First, we ask participants to read the informed consent form and tell them that there are no right or wrong answers in this study. This questionnaire will be kept strictly confidential, so they will all complete the questionnaire anonymously to protect their privacy. Second, we set up guiding and trapping questions. After the questionnaires were collected and sorted, a total of 460 questionnaires were recovered, and 395 valid questionnaires were obtained by eliminating the questionnaires that did not pass the screening questions and test questions, the questionnaires that were too short in time, and the questionnaires that had obviously unreasonable answers.

3.2 Measures

This paper forms the initial set of metrics by referencing established scales from domestic and foreign scholars, making necessary adjustments to each question item on the basis of the context of the live e-commerce supply chain. Following this, industry experts are invited to review and suggest modi-

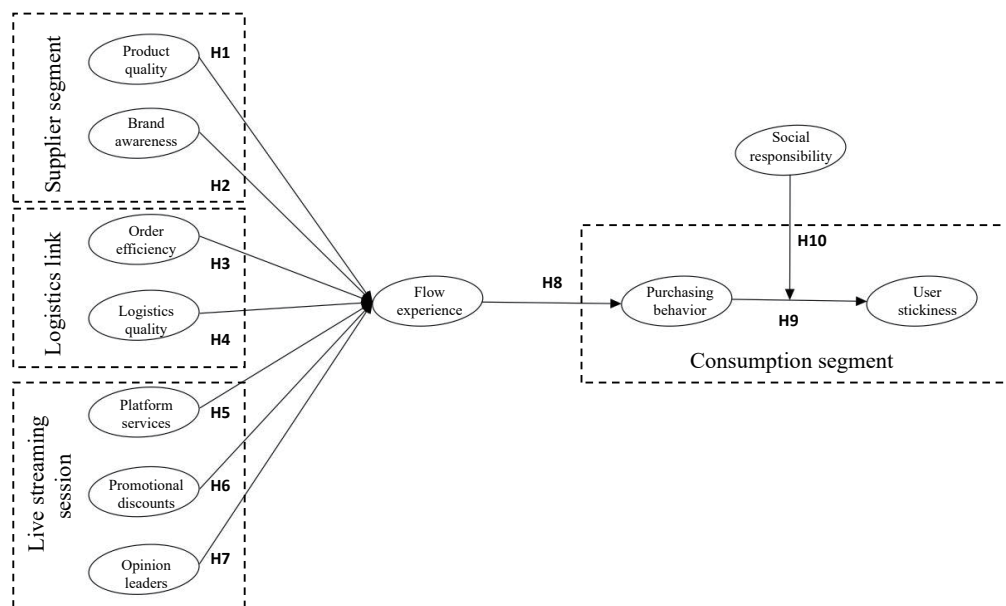


Fig. 1. Research framework.

fications to the questionnaire's questions, during which repeated modifications are carried out to produce the final version. Next, a preliminary survey is conducted to determine the official questionnaire. Following a reliability analysis of the gathered data, ineligible questions are removed or substituted, finally producing the official questionnaire.

In summary, the questionnaire is composed of three main aspects:

The first part consists of evaluative questions. This part helps determine the target group of the study by filtering out respondents who have not watched live webcasts or bought products from live broadcasting rooms, effectively narrowing the scope of survey respondents.

The second part comprises basic information about the survey respondents. This descriptive analysis employs variables such as gender, age, education, audience, and duration of watching live broadcasts.

The measurement variables scale is outlined in the third part. A total of 45 items were derived from previous studies and were slightly modified according to the research context of this study to meet the requirements of reliability and validity. Among them, the product quality measurement items came from Ref. [46]. The four brand awareness measurement items were from Ref. [47]. The measurement items of order efficiency, logistics quality, platform services, promotional discounts and opinion leaders were obtained from Refs. [38]. Ref. [10] provided four flow experience measurement items as a reference. The purchasing behavior measurement questions were from Ref. [48], whereas the user stickiness measurement questions were from Ref. [49]. In addition, we designed social responsibility measurement items with reference to Ref. [50].

The questionnaire included only judgmental and demographic items that had clear answers, chiefly in the form of multiple-choice questions. In contrast, the measurement scale section items were used to analyze the subjective attitudes of the respondents related to the measurement via a five-point Likert scale ranging from 1 (absolutely disagree) to 5 (absolutely agree).

3.3 Questionnaire presurvey

3.3.1 Presurvey data collection

To ensure the overall quality and validity of the questionnaire, a presurvey was conducted before the official questionnaire was distributed. First, brief communication will be conducted with the respondents, and questions that are likely to be misunderstood by the respondents will be modified so that the respondents can better understand the questionnaire. This presurvey uses Question Star for distribution and collection. A total of 120 presurvey questionnaires were distributed. After screening and deleting invalid questionnaires that did not meet the target range of the research objects, 103 valid questionnaires were ultimately collected.

3.3.2 Presurvey reliability analysis

Reliability represents whether the results measured by a questionnaire are stable and reliable. Generally, Cronbach's alpha is used as the criterion to test reliability. The Cronbach's

alphas of product quality, brand awareness, order efficiency, logistics quality, platform services, promotional discounts, opinion leaders, flow experience, purchasing behavior, user stickiness and social responsibility are 0.889, 0.710, 0.882, 0.776, 0.914, 0.848, 0.900, 0.907, 0.859, 0.907, and 0.909, respectively. In summary, the Cronbach's alpha values of the scales are all greater than 0.7, indicating that the questionnaire in this study has good reliability.

3.3.3 Presurvey validity analysis

Since the questionnaire items in this study are all derived from existing mature and representative scales, the content validity of this questionnaire is guaranteed. The structural validity of the questionnaire was examined through the KMO test and Bartlett's test of sphericity. The KMO value of the presurvey scale is 0.801, which is greater than 0.8; the significance P value of Bartlett's sphericity test is 0.000, which meets the significance level requirements in statistics, so the sample data of this scale are suitable for factor analysis.

Using the principal component analysis method and orthogonal rotation of the factors through the varimax method, a total of 11 factors were ultimately extracted. After excluding LQ2 and PS1 items with factor loadings less than 0.5, there are strong correlations between the remaining items and factors, which ensures that the scale has good structural validity.

4 Data analysis and results

Table 1 shows descriptive statistics of the sample. The participant sample comprised 147 males (37.22%) and 248 females (62.78%). The majority of the participants were aged between 18 and 40 years. A total of 67.34% of the respondents held a bachelor's degree. The results suggest that a large proportion of the sample has a high level of education. Regarding the duration of the respondents' live stream viewing, 34.15% of the respondents watched for less than half an hour, whereas 45.06% watched for 30–60 min, 18.23% watched for 1–3 h, and only 2.53% watched for more than 3 h. The data summary indicates that the majority of viewers spend less than 60 minutes watching live streams. This implies that there is still significant potential for e-commerce live broadcasts to enhance user engagement. Compared with the CNNIC data for all social media users, the t test results indicated that gender, age, family income, and education level did not significantly differ. The t test indicates that the distribution of our sample is similar to that of the CNNIC. Thus, our sample is generally representative of Chinese internet users.

4.1 Measurement model and analysis

To ensure the constructs' reliability and validity, CFA was performed via the AMOS 26.0 software package prior to testing the causal relationships between them. The following goodness-of-fit indices were obtained for the measurement model: the χ^2/df ratio was 1.042, less than 3; the CFI was 0.97, greater than 0.9; the IFI was 0.97, greater than 0.9; the NFI was 0.938, greater than 0.9; the TLI was 0.97, close to 0.9; the GFI was 0.946, greater than 0.9; and the RMSEA was 0.01, less than 0.5. The NFI was 0.938, greater than 0.9; the

Table 1. Demographic profile of the respondents.

Demographics	Classification	Frequency	Percentage
Gender	Male	147	37.22%
	Female	248	62.78%
Age	Below 18	1	0.25%
	18–25	112	28.35%
	26–30	90	22.78%
	31–40	118	29.87%
	41–50	32	8.10%
	51 and over	42	10.63%
Educational level	Junior high school and below	16	4.05%
	Junior college	35	8.86%
	Undergraduate college	266	67.34%
	Master degree or above	78	19.75%
Household monthly income	Less than ¥3000	21	5.32%
	¥3001–10000	200	50.63%
	¥10001–30000	144	36.46%
	More than ¥30001	30	7.59%
Viewing duration	Less than 30 min	135	34.15%
	30–60 min	178	45.06%
	1–3 h	72	18.23%
	More than 3 h	10	2.53%

TLI was 0.97, close to 0.9; the GFI was 0.946, greater than 0.9; and the RMSEA was 0.01, less than 0.5. On the basis of the goodness-of-fit indices, we can conclude that the measurement model's fit is acceptable. To measure the reliability of the structure, Cronbach's alpha and composite reliability values were selected. Table 2 displays Cronbach's alpha values ranging from 0.72 to 0.91, meeting the benchmark of exceeding 0.70. The composite reliability values for this study, which were in the range of 0.84–0.91, also met the threshold condition of being greater than 0.70. The extent to which the items actually reflect the structure of the survey is known as construct validity. This study assessed both convergent validity and discriminant validity. To test convergent validity, we used average variance extraction (AVE) and factor loading techniques. If the mean of the structure exceeds 0.50, it indicates good convergent validity. As illustrated in Table 2, all the constructs in this study had AVE values greater than 0.50, confirming convergent validity. Furthermore, the factor loadings for each measure exceeded 0.70, with values ranging from 0.73 to 0.85. On the basis of the aforementioned results, the structures clearly possess adequate reliability and convergent validity. Table 3 reveals that all the correlations between the constructs were below the square root of their corresponding AVE values, indicating satisfactory discriminant validity.

4.2 Structural model and results

The hypothesized relationships in the research model were tested via AMOS 26.0 software, usually in statistics, with the hypotheses that a CR value >1.96 and a *p* value less than 0.05

Table 2. Validity analysis.

Constructs	Items	Factor loading	Composite reliability (CR)	AVE
Product quality	PQ1	0.826	0.857	0.667
	PQ2	0.796		
	PQ3	0.827		
Brand awareness	BA1	0.816	0.872	0.631
	BA2	0.774		
	BA3	0.794		
	BA4	0.793		
Order efficiency	OE1	0.801	0.894	0.629
	OE2	0.785		
	OE3	0.816		
	OE4	0.754		
	OE5	0.807		
Logistics quality	LQ1	0.799	0.856	0.667
	LQ3	0.819		
	LQ4	0.832		
	LQ2	0.793		
Platform services	PS2	0.793	0.879	0.645
	PS3	0.791		
	PS4	0.794		
	PS5	0.834		
	PS1	0.780		
Promotional discounts	PD2	0.832	0.886	0.66
	PD3	0.840		
	PD4	0.797		
	PD1	0.780		
Opinion leaders	OL1	0.809	0.876	0.638
	OL2	0.809		
	OL3	0.790		
	OL4	0.787		
Flow experience	FE1	0.774	0.837	0.561
	FE2	0.713		
	FE3	0.766		
	FE4	0.744		
Purchasing behavior	BEH1	0.794	0.869	0.625
	BEH2	0.808		
	BEH3	0.751		
	BEH4	0.807		
User stickiness	US1	0.763	0.877	0.641
	US2	0.811		
	US3	0.843		
	US4	0.782		
Social responsibility	PSR1	0.808	0.885	0.657
	SR2	0.800		
	SR3	0.816		
	SR4	0.818		

are considered significant. The results of the model are shown in Table 4 below. The results show that in the supplier segment, product quality ($\beta = 0.17, p < 0.01$) and brand endorsement ($\beta = 0.18, p < 0.001$) are significantly related to flow experience, which supports hypotheses H1 and H2; in the logistics segment, order efficiency ($\beta = 0.15, p < 0.01$) positively affects flow experience, which supports hypothesis H3. However, the C.R. of logistics quality, value $< 1.96, \beta = 0.00$, surface logistics quality has no significant effect on flow experience, so it does not support hypothesis H4; in the live streaming session, platform services ($\beta = 0.16, p < 0.01$), promotional discounts ($\beta = 0.16, p < 0.01$), and opinion leaders ($\beta = 0.15, p < 0.01$) all have a significant and positive impact on the user's flow experience, which supports hypotheses H5, H6, and H7. Flow experience ($\beta = 0.45, p < 0.001$) has a significant effect on purchasing behavior, verifying that hypothesis H8 holds; finally, users' purchasing behavior in the live streaming room ($\beta = 0.44, p < 0.001$) has a positive effect on user stickiness, supporting hypothesis H9.

To verify social responsibility's moderating effect, following Aiken & West's suggestion, an interaction plot was drawn with reference to their graphical procedure, where values one standard deviation above and below the mean were assigned to social responsibility to plot its moderating effect, as shown in Fig. 2. The results of the analysis in Table 5 show that social responsibility significantly positively moderates the relationship between purchase behavior and user stickiness

($\beta = 0.205, p < 0.001$). To observe social responsibility's moderating effect more intuitively and to verify social responsibility's moderating effect, if the social responsibility of live streaming e-commerce increases, user stickiness in the context of live streaming services also increases, which supports H10.

5 Conclusions, implications, and limitations

5.1 Discussion of results

This study uses the SOR theoretical framework to develop a relationship model between the live e-commerce supply chain and user stickiness in the context of live streaming services. The study subsequently discusses the influence mechanism of the e-commerce supply chain on user stickiness. The empirical results indicate that product quality, brand endorsement, order efficiency, platform services, promotional discounts and opinion leaders are significant but that logistics quality is not related to the flow experience. Flow experience has a significant effect on purchasing behavior, and users' purchasing behavior has a positive effect on user stickiness. The results show that social responsibility significantly positively moderates the relationship between purchase behavior and user stickiness. The specific analysis is as follows.

The study revealed that suppliers' product quality and

Table 3. Means, standard deviations and correlations.

	OL	PD	OE	PS	BA	LQ	PQ	FE	BEH	US
OL	0.799									
PD	0.116***	0.812								
OE	0.107***	0.116***	0.793							
PS	0.128***	0.101***	0.117***	0.803						
BA	0.113***	0.104***	0.117***	0.117***	0.794					
LQ	0.141***	0.126***	0.138***	0.144***	0.144***	0.817				
PQ	0.113***	0.116***	0.120***	0.142***	0.102***	0.162***	0.817			
FE	0.143***	0.148***	0.164***	0.172***	0.153***	0.147***	0.152***	0.749		
BEH	0.069***	0.071***	0.079***	0.083***	0.074***	0.071***	0.073***	0.212***	0.791	
US	0.033***	0.034***	0.038***	0.039***	0.035***	0.034***	0.035***	0.101***	0.225***	0.801

Table 4. Results of hypothesis testing for structural equation modeling.

	ROUTE		B	S.E.	C.R.	p	β
PQ	→	FE	0.155	0.052	2.976	**	0.166
BA	→	FE	0.162	0.049	3.323	***	0.180
OE	→	FE	0.130	0.045	2.892	**	0.151
LQ	→	FE	0.000	0.054	0.007	0.994	0.000
PS	→	FE	0.145	0.049	2.971	**	0.160
PD	→	FE	0.147	0.050	2.923	**	0.155
OL	→	FE	0.141	0.052	2.723	**	0.147
FE	→	BEH	0.448	0.057	7.794	***	0.448
BEH	→	US	0.469	0.062	7.533	***	0.437

* represents $p < 0.05$, ** represents $p < 0.01$, and *** represents $p < 0.001$.

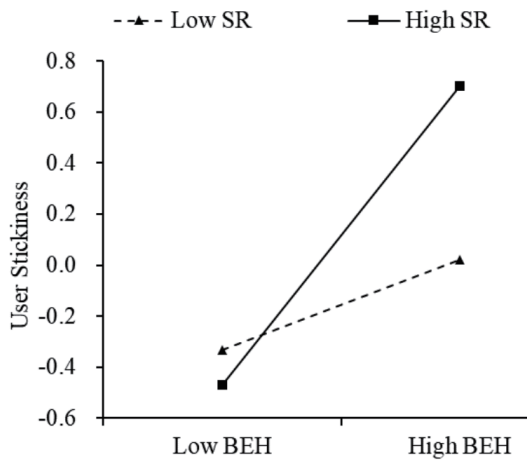


Fig. 2. Moderating effect of social responsibility.

Table 5. Analysis of moderating effects.

Items	β	SE	t	p
BEH	0.381	0.042	8.980	<0.001
SR	0.137	0.042	3.229	0.001
Regulating term	0.205	0.044	4.666	<0.001
R^2	0.195			
F	36.719 ($p < 0.001$)			

The dependent variable is user stickiness.

brand endorsement within the live streaming e-commerce supply chain have a significant positive effect on user stickiness. Moreover, both high-quality product quality and good brand endorsement promote the generation of user stickiness. The study concludes that the products supplied in the live service context are the fundamental reason for users to watch live broadcasts and should be one of the primary focuses of attention. Consequently, the study emphasizes that satisfying users' needs for product quality and branding represents a critical factor that enhances their likelihood of repeated visits and purchases. This finding corresponds with the results of prior research^[28, 29].

Second, in the logistics link of the live e-commerce supply chain, good order processing efficiency positively affects user stickiness, and this finding supports previous studies^[31]. However, logistics quality is unable to significantly affect the user flow experience, possibly because most of the logistics links of live streaming e-commerce companies are currently contracted with third-party logistics companies, and logistics quality does not have a strong direct relationship with live streaming e-commerce companies. When considering the logistics link, consumers do not have much right to decide on the choice of logistics companies, but consumers tend to focus their attention on issues such as whether live streaming e-commerce companies can process orders in a timely manner. As a result, consumers tend not to consider logistics quality when shopping in live ecommerce. Therefore, logistics quality has no significant effect on user stickiness.

Third, the platform services of the live streaming platform, promotional discounts offered to consumers and opinion lead-

ers in the live streaming e-commerce supply chain all have positive effects on user stickiness. This corresponds with the findings of previous studies^[42]. High-quality platform services can gain users' trust, which in turn facilitates the creation of user flow experiences; promotional discounts and opinion leaders are key competitive factors in live e-commerce, and opinion leaders are often similar to the so-called "Netflix", i.e., anchors with a certain degree of fan effect. If consumers perceive a certain degree of homogeneity between themselves and opinion leaders in terms of interests, tastes and values, they will emotionally trust the products recommended by opinion leaders, which in turn will positively influence the flow experience. Compared with traditional offline shopping methods, online consumers are more sensitive and transparent to price factors. When watching a live stream, consumers pay more attention to product offers. If the price offer of the same product within that live broadcast is lower than the consumer's psychological expectation of the price, then the consumer is prone to produce a more in depth, immersive experience of the content of the live broadcast, which further leads the consumer to take purchase action as a response.

Fourth, the user-perceived social responsibility of live e-commerce companies and anchors has a positive moderating effect on the generation of user stickiness, a finding that also supports the findings of previous studies^[13, 14]. In the context of e-commerce live streaming, users' evaluation and judgment of the anchor's social responsibility significantly contribute to the formation of user stickiness. If users perceive live streaming as possessing a high level of social responsibility, the formation of their behavioral stickiness is greatly increased, as evidenced by more live streaming visits, longer dwell times, and the recommendation and sharing of the live streaming room with friends and family.

Fifth, comprehensively observing the hypothesis test results of each influential factor in the three segments of the live e-commerce supply chain, it can be seen that, with the exception of the quality of logistics, the relative coefficient of brand endorsement is the highest in all the segments, but the test results of all the other factors are also more average, which indicates that each factor in the supply chain segment, i.e., product quality, brand endorsement, order efficiency, platform services, promotional discounts, and opinion leaders, is very important to consumers. These findings suggest that each link in the supply chain of live e-commerce is complementary to each other and works together to promote the generation of user stickiness.

5.2 Theoretical implications

The theoretical significance of this study mainly includes the following two aspects.

First, there are few studies on the impact of the entire live e-commerce supply chain on user stickiness, and this study helps to fill this theoretical gap from a new research perspective. In recent years, research on user behavior in the context of live streaming has been more common. However, most of the prior studies have concentrated only on short-term behaviors, such as impulse buying behavior and rewarding behavior, while neglecting the long-term and repeated behaviors of

users. This study focuses on user stickiness in the context of a live e-commerce supply chain, which enriches previous studies in the literature. Moreover, most prior studies focused on the influence of a certain link dimension on user stickiness while ignoring the focus on the e-commerce supply chain as a whole. This study emphasizes the important role played by the e-commerce supply chain in the process of generating user stickiness and verifies that product quality, brand endorsement, order efficiency, platform service, promotional discounts, opinion leaders, and flow experience positively affect user stickiness.

Second, this study focuses on exploring the issue of anchor and live e-commerce corporate social responsibility in the context of live e-commerce supply chains to complement the literature in the field of live e-commerce. With the end of the explosive period of the live streaming industry, social responsibility has become an important indicator for the assessment of anchors and e-commerce enterprises in the context of public regulation and state supervision. Starting from the perspective of user perception, the social responsibility in this study proposes that users' perception of anchors and e-commerce companies' implementation of social responsibility plays a crucial role in the formation of user stickiness, and empirical analyses prove that social responsibility positively contributes to the formation of user stickiness. Therefore, this study enriches the literature on social responsibility in the field of live e-commerce supply chains and develops new ideas for the research direction of social responsibility.

5.3 Practical implications

The above insights into the impact of a live e-commerce supply chain on user stickiness can provide some practical guidance for live e-commerce business enterprises to develop a supply chain management system and how enterprises can attract consumers to generate stickiness, including the following aspects.

First, in the supplier segment, good product quality and brand endorsement both have positive effects on the user's flow experience. To help consumers have a positive attitude toward product quality and brand endorsement, live e-commerce enterprises should have a rigorous screening system and process for the suppliers they cooperate with and should have a standardized system for examining product quality as well as brand endorsement. It is recommended that e-commerce enterprises establish a professional product team and have a rigorous understanding and testing of all categories of products before selling.

Second, in the logistics of the live e-commerce supply chain, the order processing efficiency of the e-commerce platform is a key factor for users to consider: whether the e-commerce enterprise can provide spot, whether the order can be processed in a timely manner, and the length of the delivery cycle and other issues affect the consumer's flow experience. Therefore, if live e-commerce enterprises can simplify the predelivery process, increase the number of staff to handle orders, prepare a sufficient amount of spot goods and agree with upstream suppliers on a shorter delivery cycle, they can improve the response speed of order processing, which will improve the quality of e-services to a certain degree and

strengthen the flow experience of consumers in the live broadcasting room.

In addition, platform services, promotional discounts and opinion leaders can all positively influence the user flow experience during a live streaming session. For live e-commerce enterprises, establishing a platform with smoother use and richer information will greatly improve the user's sense of experience. When the user sees more detailed information about the product introduction, more friendly customer service and a smoother sense of platform use, the sense of pleasure increases, and the flow experience increases. Moreover, live broadcast e-commerce enterprises should develop more consumer-friendly promotional strategies with upstream suppliers as much as possible to attract the generation of consumer flow experiences. On this basis, the anchor as an opinion leader is the core link in the entire live e-commerce supply chain, and live e-commerce enterprises can arrange professional courses for the anchor as a way to improve the anchor's professionalism. Anchors should also introduce and display products for consumers with a fuller attitude, enhancing the enjoyment and interactivity of live broadcasts and making it easier for consumers to stay within live broadcasts.

Finally, because social responsibility can promote the conversion of behavior to stickiness, consumers are becoming more aware of social and environmental issues, and corporate social responsibility (CSR) is becoming increasingly essential for live streaming e-commerce enterprises. At the policy level, the state can further strengthen the management of social responsibility in the live streaming e-commerce industry, introduce more detailed and strict supervision policies for the field, and reduce the emergence of vulgar, low-quality and negative live broadcasts. For live e-commerce enterprises, self-management should be strengthened, and an effective measure is that live e-commerce enterprises provide consumers with more transparent supply chain information, including information on suppliers, the content of corporate management of social responsibility, and other information involved in the chain, which will not only help live e-commerce enterprises fulfill their subjective initiative to fulfill their social responsibility but also enhance the outside world's confidence in the enterprise's social responsibility management confidence. At the individual level of the anchor, owing to the special nature of the anchor's identity, most of the anchors with a certain purchasing power of the live broadcasting room carry certain reddish qualities; that is, the anchor's words and actions largely represent live broadcasting e-commerce enterprises. Therefore, anchors should pay more attention to their words and actions and promote positive values and behaviors. Helping anchors build a more informed and responsible public image by promoting diversity, inclusion and positive values and contributing to a healthier and more just society.

5.4 Limitations and future research directions

The current study has several limitations that offer future research opportunities. First, this study focuses only on the influence of the supply chain on the stickiness of live e-commerce platforms in China's domestic environment. In the future, cross-border e-commerce platforms, such as TikTok,

Amazon Live, and Instagram, can be considered as a research context to consider the factors influencing the user behavior of cross-border e-commerce platforms and to enrich the research in this field. Moreover, this study considered the influence of each segment in the e-commerce supply chain on the user stickiness of e-commerce live streaming platforms, but it did not consider that there may also be an influential relationship between the segments. Subsequent studies can start from this perspective to explore the relationships among suppliers, logistics, and live streaming in depth. In addition, there may be other intermediate factors in the process of purchase behavior related to the formation of user stickiness, which can be studied in depth in the future.

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Conflict of interest

The authors declare that they have no conflict of interest.

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