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The Impact of Green Innovation in Social Media Live on Customer Loyalty Based on Tiktok Platform in Sichuan of China

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Abstract. Green innovation has become a key path for live-streaming platforms to achieve sustainable development. This study takes TikTok users in Sichuan Province as the research object, collects 400 valid data samples through a questionnaire survey, and conducts quantitative analysis using SPSS, AMOS, and PROCESS tools to explore the influence mechanism of green innovation in social media live-streaming on customer loyalty. The results show that: Green innovation has a direct positive impact on customer loyalty ($\beta=0.63$, $p<0.001$); perceived value and social identity respectively play a partial mediating role in the relationship between the two, with the proportions of indirect effect to total effect being 23.4% and 28.4% in turn; green atmosphere significantly strengthens the positive effects of green innovation on perceived value ($\beta=0.173$, $p<0.001$) and social identity ($\beta=0.172$, $p<0.001$); the incentive mechanism effectively enhances the impacts of perceived value ($\beta=0.196$, $p<0.001$) and social identity ($\beta=0.213$, $p<0.001$) on customer loyalty. The structural equation model shows a good fit (CMIN/DF=1.070, RMSEA=0.038, CFI=0.943). This study enriches the existing theoretical system of research and practical guidance, and facilitates the green and high-quality development of the live-streaming industry.

Keywords: Green Innovation, Customer loyalty, Perceived Value, Social Identity, Green Atmosphere, Incentive Mechanism.

1. Introduction

As an important form of the digital economy, social media live-streaming e-commerce is profoundly reshaping consumption patterns. Through real-time interaction, scenario-based presentation, and traffic aggregation, it drives the development of the global market. The scale of China's e-commerce live-streaming users has exceeded 597 million, among which the annual transaction volume of the TikTok platform reaches 1.41 trillion yuan. In Sichuan Province, the development index of live-streaming e-commerce ranks first in the central and western regions; in 2024, the number of store-based live-streaming merchants increased by 113% year-on-year, demonstrating its core role in regional economic development and consumption upgrading (Sichuan Online, 2024).

However, with the expansion of the industry, ethical and environmental issues have become increasingly prominent: phenomena such as vulgar content, inferior products, and sales of non-environmentally friendly products in some live-streaming rooms, as well as the lack of social responsibility among streamers, have undermined consumers' trust (Wang, R. Q., 2019). Against this backdrop, the "dual-carbon" goals have deepened the concept of green consumption: 98% of consumers recognize the value of environmental protection, and 43% are willing to pay a premium for sustainable products (Accenture, 2022). Live-streaming platforms urgently need to respond to such demands through green innovation (e.g., standardizing streamers' behaviors, promoting environmentally friendly products, and optimizing green logistics), but relevant practices are still in the exploratory stage (Liu,Y. , 2023).

Although existing studies have touched upon the connection between live-streaming e-commerce and green development from different dimensions, they have failed to form a systematic closed loop. Based on the social presence theory, Jiang, L.Q., &Wang,Y. (2022) confirmed that social presence affects purchasing behavior through loyalty, but did not involve the green dimension; from the perspective of the interaction ritual chain, Gao, S., Jiang, F. T., & Chang, Y. M.. (2023) analyzed the driving factors of user loyalty, yet ignored the role of environmental protection practices. Li Lei and Liu Changyou (2022) explored the impact of live-streaming on green consumption preferences and found that the psychological contract substitution effect would change consumption choices, but did not address how innovation converts preferences into loyalty.Zhang, B., & Zhu, J. C (2024) mentioned the role of green attributes in consumption intention, but failed to construct a transmission framework from innovation to loyalty.

More notably, industry practices have highlighted an urgent need for theoretical support: Li, C.T., Zhou,R., & Zhang, H. X. (2024) pointed out that green sustainability will become the core orientation of live-streaming e-commerce, but lacked empirical evidence to reveal the connection between green innovation and loyalty; Zheng,T.F. (2025) proposed practical paths for cultivating green live-streaming rooms, but did not clarify how to design innovation dimensions; Xie, S., & Zhang, Y. L.(2025) emphasized the importance of platform supervision for the sound development of the industry, but did not discuss how supervision acts on user loyalty through green innovation; Liu, H. N., & Song, Q. R.(2025) called on streamers to promote green transformation and advocated driving the greening of live-streaming e-commerce with new-quality productive forces, yet neither answered the core question of "how green innovation specifically affects customer loyalty".

In summary, existing studies either focus on user behavior mechanisms but ignore green variables, focus on green consumption but fail to connect innovation with loyalty, or propose practical directions but lack theoretical modeling, leaving significant gaps. Therefore, this study takes TikTok live-streaming in Sichuan as the research object, aiming to: (1) define the core dimensions of green innovation in social media live-streaming (e.g., content standardization, product environmental friendliness, and supply chain sustainability); (2) construct a theoretical model of "Green Innovation - Perceived Value - Social Identity - Customer Loyalty" and reveal its influence mechanism. This study not only fills the theoretical gap in the relationship between green innovation and loyalty, but also provides empirical basis for enterprises and policymakers, facilitating the green transformation of

live-streaming e-commerce.

2. Literature Review and Hypotheses Development

2.1 Social media live Green innovation impact on customer loyalty

Against the backdrop of the deep integration of the digital economy and the concept of green development, green innovation in social media live-streaming has become a key path for platforms to enhance user stickiness. Green innovation in social media live-streaming refers to live-streaming platforms integrating the concept of green into links such as content production, technology application, streamer development, supply chain management, logistics and distribution, and marketing promotion. It achieves the sustainable development of the live-streaming ecosystem through dimensions including green live-streaming content, low-carbon technology tools, responsible streamers, environmentally friendly supply chains, green logistics, and sustainable marketing (synthesized from Gao X., 2019; Wang, J. Y. , 2020; Shao, P., & Yi, W. , 2024, etc.). This innovative model not only responds to social demands for environmental protection but also strengthens emotional connections by meeting users' diverse needs, thereby influencing customer loyalty.

A cross-cultural study by Garcia, M., & Rodriguez, C. (2023) shows that users have a significant preference for the green functions of live-streaming platforms (such as virtual fitting to reduce waste and carbon footprint tracking). Users in Europe and America focus on practicality, while Asian users value emotional resonance. Both reflect that green innovation can enhance recognition by matching user needs, laying the foundation for loyalty. Gao X.(2019) points out that live-streaming platforms achieve sustainable growth through the "live-streaming + green" strategy; integrating the concept of green into users' life scenarios can strengthen users' sense of dependence on the platforms. Wang, R. Q. (2019) emphasizes that the concept of "green live-streaming" and high-quality streamer images can shape positive social values, reduce the impact of negative information, and enhance user trust—and trust is the core driving factor of customer loyalty.

From the perspective of green communication, Ji, A.Y., & Li, H. C. (2019) proposes that the green content and educational framework of live-streaming platforms can strengthen users' awareness of the platforms' social responsibility and promote the transformation of value recognition into continuous usage behavior. Studies by Ai, X.Y. (2020) and Liu, Y. (2021) both confirm that green live-streaming platforms with high-quality content can stand out in competition; their standardized and healthy ecological environment can improve user satisfaction, and satisfaction is a direct antecedent of loyalty. Li,L., & Liu,C.Y.(2022) finds that green innovation in live-streaming e-commerce can influence consumption decisions through the psychological contract mechanism: when users perceive that the platform's green initiatives meet their environmental expectations, their willingness for continuous interaction will be strengthened. A case study by Shao, P., & Yi, W. (2024) further shows that the green value propositions of clothing live-streaming (such as environmentally friendly products and extended responsibility systems) can significantly increase user repurchase rates, confirming the promoting effect of green innovation on loyal behaviors.

In summary, green innovation in social media live-streaming strengthens the emotional connection and behavioral stickiness between users and platforms through the path of "demand satisfaction - trust building - value recognition - continuous behavior". Therefore, this study puts forward the following hypothesis:

H1: Social media live Green innovation has a positive impact on customer loyalty .

2.2 The Role of Perceived Value and Its Mediating Mechanism

In the social media live-streaming ecosystem, perceived value serves as a key link connecting green innovation and customer loyalty. Perceived value refers to the comprehensive evaluation of functional value (e.g., product practicality, cost-effectiveness), emotional value (e.g., pleasurable experience, emotional resonance), and social value (e.g., social identity, environmental contribution) that

consumers perceive during live-streaming interactions (synthesized from Lian,Y.,& Fu,T. J., 2022; Guo, D. M., & Cheng, J. F. , 2024, etc.).

The logic that perceived value directly drives customer loyalty has been verified by multiple studies. Jiao et al. (2023) clearly pointed out that the higher the functional, hedonic, and symbolic values consumers perceive in live-streaming, the stronger their loyalty to the platform or streamer, and the more likely they are to engage in repeat purchase behavior. Wu, Y., & Huang, H. (2023) found that perceived value significantly enhances continuous purchase intention by strengthening consumer trust, and continuous purchase is a core manifestation of loyalty. Lu, C. X. (2022)'s study also shows that perceived value plays a mediating role between streamers' social capital and consumers' continuous purchase intention, indirectly confirming the positive impact of perceived value on loyal behaviors. Collectively, these studies indicate that perceived value strengthens consumers' stable relationship with the platform by meeting their practical needs, emotional demands, and social identity.

Green innovation in social media live-streaming needs to be converted into customer loyalty through perceived value. Zhang, H.(2023) found that live-streaming green innovation (e.g., green product information dissemination) affects purchase intention by improving consumers' perceived utility. Lee, S., & Kim, Y. (2023) pointed out that green functions in live-streaming (e.g., environmental interaction design) can enhance utilitarian value and emotional value, thereby strengthening consumers' behavioral tendencies—indicating that green innovation needs to exert its role through value perception. Yan, X. X., et al. (2021), Lian, Y., & Fu, T. J. (2022), and others confirmed that perceived value plays an important role between live-streaming characteristics and purchase behavior. By analogy to the context of green innovation: green innovation in live-streaming (e.g., green content, low-carbon technology) acts as an external stimulus, first improving consumers' perception of functional, emotional, or social value, and then further strengthening their loyalty.

In summary, based on the logic of direct influence between variables and the mediating mechanism, it can be concluded that perceived value has a positive impact on customer loyalty and plays a mediating role between green innovation in social media live-streaming and customer loyalty. Therefore, this study puts forward the following hypotheses:

H2: Perceived value positively influences customer loyalty .

H4: Perceived value plays a mediating role in the impact of social media live Green innovation on customer loyalty .

2.3 The Role of Social Identity and Its Mediating Mechanism

Social identity refers to the sense of belonging and value consensus formed by consumers in group interactions, manifested as self-identity, group identity, and consumption identity. It exerts a significant impact on customer loyalty in the social media live-streaming scenario. Social identity directly promotes customer loyalty by strengthening emotional connections and a sense of group belonging. A study by Smith, J., & Johnson, K. (2024) found that after consumers form social identity through interactions with streamers and audiences in live streams, their loyalty to the brand is significantly enhanced—especially when they perceive shared interests and a sense of belonging, they are more likely to engage in continuous purchase behavior. Brown, R., & Taylor, S. (2023) also confirmed that consumers establish emotional connections with brands and streamers through social identity, and these connections enhance their willingness to repurchase and engage in referral behaviors, consolidating loyalty. Taking the Xiaomi community as an example, Zhou, X. Y. (2022) pointed out that after social identity enhances group identification, it can effectively expand the fan economy, indirectly confirming its positive effect on loyalty.

Green innovation in social media live-streaming can indirectly influence customer loyalty through social identity. Green innovation (e.g., environmental protection-themed live streams, dissemination of green values) can trigger consumers' identification with environmental protection groups. Zhang, J. M., & Qin,W.J.(2024) mentioned that green consumption behavior affects actions through moral

self-identity; by analogy, green innovation in live streams may enable consumers to enhance their social identity by identifying with the values of the "environmental protection group".. Lee, S., & Kim, Y.(2023) found that social identity improves live-streaming participation and loyalty by strengthening the sense of group belonging, and green innovation can precisely serve as the trigger for such identity. When consumers perceive shared environmental protection concepts with streamers and audiences in green live streams, they form social identity, which then translates into loyalty to the platform.

In summary, by strengthening consumers' sense of group belonging, emotional connections, and value consensus, social identity has a significant positive impact on customer loyalty; at the same time, green innovation in social media live-streaming can exert an indirect influence on customer loyalty by triggering consumers' self-identity, group identity, and consumption identity. Therefore, this study puts forward the following hypotheses:

H3: Social identity positively influences customer loyalty .

H5: Social identity plays a mediating role in the process of social media live Green innovation affecting customer loyalty .

2.4 The Moderating Role of Green Atmosphere

Green atmosphere, as a comprehensive representation of environmental protection elements and social norms in the environment, exerts a moderating effect on the influence process of green innovation in social media live-streaming (Zhang, Y., & Du, J. G. 2024). It amplifies the effect of green innovation in live-streaming by strengthening consumers' perception of green value and group identification.

Green atmosphere can enhance consumers' perception of the value implied in green innovation in live-streaming. Meng, Y. H. et al. (2020) found that when enterprises emphasize the attributes of green products through live-streaming, consumers' perceived value is significantly improved, and green psychological benefits play a moderating role. Green atmosphere can be analogous to this moderating force: when green innovation in live-streaming (e.g., display of environmental protection attributes) is consistent with the surrounding green atmosphere (e.g., social advocacy for environmental protection), consumers are more likely to recognize its functional and emotional values. Chen, W. D. et al. (2024) confirmed that highlighting green attributes in live-streaming can enhance purchase intention, while Lu,H.L., &Meng,D.Y.(2024) pointed out that green atmosphere strengthens consumers' recognition of green value.

Green atmosphere can strengthen the social identity triggered by green innovation in live-streaming. Lu, H. L., & Meng, D. Y.(2024) mentioned that under a green atmosphere, consumers are more susceptible to conformity influence and enhance their group identification with green behaviors. When green innovation in live-streaming (e.g., environmental protection-themed interaction) is embedded in a strong green atmosphere, consumers will more strongly perceive consistency with environmental protection groups, thereby enhancing social identity.and found that emphasizing green values can promote consumers' green behaviors, and green atmosphere can amplify this effect—making it easier for green innovation in live-streaming to trigger the cognition of "I belong to the environmental protection group" and strengthen social identity.

In summary, green atmosphere strengthens the perception of value and sense of group belonging through green innovation in social media live-streaming. Therefore, this study puts forward the following hypotheses:

H6: The green atmosphere positively moderates the process of social media live Green innovation affecting perceived value.

H7: The green atmosphere positively moderates the process of social media live Green innovation affecting social identity.

2.5 The Moderating Role of Incentive Mechanism

Incentive mechanisms guide consumer behavior through economic rewards (such as discounts and

subsidies) or social recognition (such as points and honors). They play a strengthening role in the relationships between perceived value, social identity, and customer loyalty, effectively enhancing the positive impact on loyalty.

Perceived value influences loyalty by meeting consumers' functional and emotional needs, and incentive mechanisms can amplify this effect. Jiang,Y. et al. (2021) found that reputational incentive mechanisms can increase consumers' willingness to pay a premium for green agricultural products, indicating that incentives can strengthen the conversion of perceived value (e.g., trust value) into purchase behavior—and the continuity of purchase behavior is precisely loyalty. A study on dynamic discount strategies by Garcia, M., & Rodriguez, L. (2024) showed that moderate discounts (10%-30%) can boost sales; essentially, this is achieved by incentives enhancing the impact of perceived economic value on repeat purchases (loyalty). Xie, G. F., Lin, L. M., & He, X. L.(2024) also confirmed that green consumption incentive policies moderate the conversion from consumption intention to behavior, and since perceived value is the core source of intention, incentive mechanisms will strengthen the positive effect of perceived value on customer loyalty.

Social identity influences loyalty through a sense of group belonging, and incentive mechanisms can strengthen the connection between this sense of belonging and loyalty. Smith, A., & Johnson, L. (2023) pointed out that government incentives prompt enterprises to place greater emphasis on the dissemination of environmental protection values, which enhances consumers' identification with environmental protection groups; incentives (such as subsidies) further reinforce the perception that "group members should provide continuous support," thereby improving loyalty. The green consumption point system studied by Zeng, H.Y., & Kang,Y.F. (2022) stimulates consumption behavior through reward mechanisms. For consumers with strong social identity, points serve not only as evidence of group belonging but also as motivation for sustained loyalty. Li, H.L. (2023) mentioned that incentive measures guide low-carbon consumption, and consumers with strong social identity are more likely to maintain loyalty under incentives—because incentives strengthen the positive feedback of "conforming to group norms."

In summary, through economic or social rewards, incentive mechanisms respectively amplify the positive impacts of perceived value and social identity on customer loyalty. Therefore, this study puts forward the following hypotheses:

H8: The incentive mechanism plays a positive moderating role in the process by which perceived value affects customer loyalty.

H9: The incentive mechanism plays a positive moderating role in the process by which social identity affects customer loyalty.

2.6 Theoretical Foundations: TAM Theory and SOR Theory

The Technology Acceptance Model (TAM) was proposed by Davis, F. D. (1989). Its core proposition is that users' acceptance of information technology is determined by perceived usefulness and perceived ease of use. Perceived usefulness refers to the degree to which users believe a technology can improve their behavioral effectiveness, while perceived ease of use refers to users' subjective judgment on the ease of operating the technology. In the context of social media live-streaming, TAM can explain the mechanism of users' acceptance of green innovation content: when green innovation in live-streaming is perceived by users as "useful" and "easy to use", users are more likely to develop a positive attitude, which in turn influences their consumption behavior.

This study integrates TAM with green innovation, arguing that green innovation in social media live-streaming needs to enhance customer loyalty by improving users' perceived value. For example, Meng, Y. H. et al. (2020) found that emphasizing the attributes of green products in live-streaming can significantly improve consumers' perceived value, which is consistent with the impact of perceived usefulness on behavioral intention in TAM. In addition, a study by Smith, A., & Johnson, L. (2023) showed that the dissemination of environmental protection values in live-streaming can strengthen the

emotional connection between users and brands—this can be regarded as an extension of perceived usefulness, as green innovation not only meets functional needs but also satisfies users' needs for social responsibility.

The Stimulus-Organism-Response (SOR) model was proposed by Mehrabian, A., & Russell, J. A. (1974). It holds that external environmental stimuli ultimately trigger behavioral responses by influencing individuals' internal states. In this study, green innovation in social media live-streaming (e.g., environmental protection-themed interactions, green product displays) constitutes the external stimulus (S); users' psychological states such as perceived value and social identity form the organism (O); and customer loyalty is the behavioral response (R).

Specifically, as part of environmental stimuli, green atmosphere can moderate the impact of green innovation in live-streaming on perceived value and social identity. Lu, H. L., & Meng, D.Y.(2024) pointed out that green atmosphere, by strengthening consumers' sense of belonging to environmental protection groups, makes it easier for green innovation in live-streaming to trigger the cognition of "I belong to the environmental protection group"—this is consistent with the logic of the SOR model, where stimuli influence responses (loyalty) by affecting the organism's state (social identity). Furthermore, as a supplement to external stimuli, incentive mechanisms can strengthen the positive effects of perceived value and social identity on loyalty through economic rewards (e.g., discounts) or social recognition (e.g., points), forming a path of "stimulus - strengthening the organism - enhancing the response".

In summary, the integration of TAM and the SOR model provides a systematic framework for explaining the impact of green innovation in social media live-streaming on customer loyalty. Meanwhile, green atmosphere and incentive mechanisms, as key moderating variables, further refine the dynamic relationship between external stimuli and internal psychological states.

3. Research Design and Methodology

3.1. Research Model and Hypotheses

Based on the theoretical framework constructed in the previous chapter, this study proposes a structural model to empirically test the relationships between green innovation in social media live-streaming, perceived value, social identity, and customer loyalty. This conceptual model assumes that: green innovation in social media live-streaming exerts direct and indirect impacts on customer loyalty through the two mediating variables of perceived value and social identity, while green atmosphere and incentive mechanisms play moderating roles.

Green innovation in social media live-streaming is believed to be able to enhance customers' perceived value and social identity by disseminating environmental protection information, fostering interactive trust, and shaping green consumption scenarios. Conversely, the improvement of perceived value and social identity is expected to strengthen customer loyalty. Meanwhile, green atmosphere and incentive mechanisms are hypothesized to moderate the strength of these relationships, amplifying the positive impacts of green innovation on perceived value and social identity, as well as the impacts of perceived value and social identity on loyalty.

The structural model proposed in this study includes the following 9 research hypotheses:

H1: Social media live Green innovation has a positive impact on customer loyalty .

H2: Perceived value positively influences customer loyalty .

H3: Social identity positively influences customer loyalty .

H4: Perceived value plays a mediating role in the impact of social media live Green innovation on customer loyalty .

H5: Social identity plays a mediating role in the process of social media live Green innovation affecting customer loyalty .

H6: The green atmosphere positively moderates the process of social media live Green innovation affecting perceived value.

H7: The green atmosphere positively moderates the process of social media live Green innovation affecting social identity.

H8: The incentive mechanism plays a positive moderating role in the process by which perceived value affects customer loyalty .

H9: The incentive mechanism plays a positive moderating role in the process by which social identity affects customer loyalty .

This study will adopt Structural Equation Modeling (SEM) to test the above hypothetical paths. This method is suitable for analyzing complex causal relationships among multiple latent variables and can simultaneously evaluate the fit of both the measurement model and the structural model.

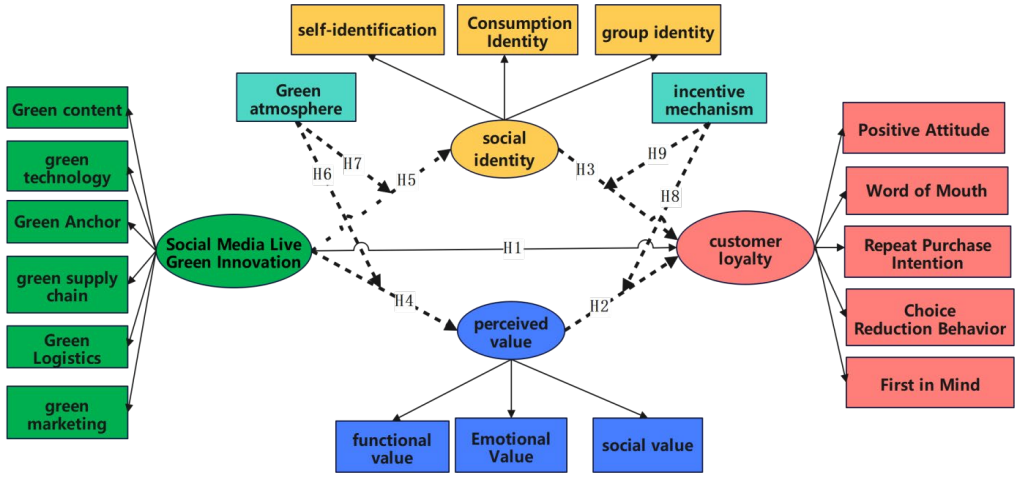

Fig. 1: Conceptual Framework of the Study

3.2. Study Design and Ethical Statement

This study adopts a quantitative research method, aiming to explore the structural relationships between green innovation in social media live-streaming, perceived value, social identity, and customer loyalty. Taking TikTok users in Sichuan Province, China as the research subjects, it selects customers with live-streaming shopping experience as the data source to construct an empirical model applicable to live-streaming platforms. The research design employs Structural Equation Modeling (SEM) for path analysis, focusing on testing the causal logic between variables. The measurement tools are developed based on mature scales from existing literature (covering dimensions such as green content, perceived value, and social identity).

Data are collected through Questionnaire Star, an online survey platform, using structured questionnaires for distribution. All questions adopt a 5-point Likert scale (1 = "Strongly Disagree", 5 = "Strongly Agree") to measure users' subjective perceptions of green innovation behaviors in live-streaming, perceived value, social identity, and customer loyalty. The questionnaire collection process strictly adheres to the principle of anonymity and does not include any personal privacy information such as names, phone numbers, or IP addresses, so as to fully respect the privacy of respondents.

In terms of ethics, this study has passed the expert ethical review and obtained a review certificate. Although it does not involve biomedical or high-risk research, it still strictly follows the basic ethical norms of social science research. An informed consent statement is included at the beginning of the questionnaire, clearly informing respondents that participation is voluntary, the information is only

used for academic research purposes, the data analysis does not involve individual identification, and no adverse effects will be caused to them. Based on the non-private and non-sensitive nature of the data, the anonymization process, and the results of the expert ethical review, this study strictly abides by the principles of "informed consent, data anonymity, and exclusive use", ensuring the ethical rationality of the research design and the legality of the data.

3.3 Determination of Sample Size

When analyzing the study's sample size, the researchers used Structural Equation Modeling (SEM) and estimated the sample size based on observable variables. They followed a commonly used rule of thumb, which recommends 10-20 samples per observable variable (refer to Schumacker, R. E., & Lomax, R. G. 2016; Hair, Risher, Sarstedt & Ringle, 2020). This study includes 19 observable variables; therefore, the appropriate sample size is 20*19=380. Considering the need to exclude invalid questionnaires, the final sample size of the study is expected to be 400 respondents.

3.4 Pilot Test of the Sample

To ensure the scientificity and rationality of the formal questionnaire, this study conducted a pilot test before the formal survey. A sample of 120 respondents who met the research subject criteria (users in Sichuan Province who have used TikTok live-streaming for shopping continuously for 3 years and make no less than 10 purchases annually) was selected. Pre-survey questionnaires were distributed via Questionnaire Star (an online survey platform), and 112 valid questionnaires were retrieved, resulting in an effective recovery rate of 93%.

The pilot test results show that all indicators meet the research requirements:In terms of content validity, the Item-Objective Congruence (IOC) values evaluated by 5 experts are all 1.00, indicating that the questionnaire items are highly consistent with the research objectives.In terms of reliability, the Cronbach's Alpha coefficients of the overall scale and each dimension range from 0.852 to 0.925, all higher than 0.7, demonstrating excellent internal consistency.In terms of construct validity, the fit indicators of the Confirmatory Factor Analysis (CFA) model are good: CMIN/DF ranges from 1.030 to 1.306 (less than 3), RMSEA is less than 0.05, and RFI, IFI, TLI, CFI, and AGFI are all greater than 0.9.In terms of convergent validity, the Average Variance Extracted (AVE) values of each dimension are all greater than 0.5, and the Composite Reliability (CR) values are all greater than 0.7.In terms of discriminant validity, the correlation coefficient of each dimension is less than the square root of the corresponding AVE.

In summary, the pilot test results indicate that the reliability and validity of the questionnaire scale meet the research requirements. No items need to be deleted, and the scale can be directly used in the subsequent formal study.4. Data Analysis and Results

4. Data Analysis and Results

4.1 Descriptive statistical analysis

This study distributed and collected questionnaires through the Questionnaire Star platform. The questionnaires were mainly targeted at consumers in Sichuan who have been shopping on the TikTok live-streaming platform for more than three consecutive years with no less than 10 shopping times per year, so as to ensure the stability of the sample and the traceability of the data. The entire process lasted three months. To ensure the comprehensiveness and accuracy of the data, the distribution and collection of questionnaires were divided into three stages. In the first stage, 150 questionnaires were distributed and 135 were collected; in the second stage, 150 questionnaires were distributed and 142 were collected; in the third stage, 200 questionnaires were distributed and 179 were collected. After the efforts of the three stages, a total of 500 questionnaires were distributed and 456 were collected. Subsequently, the research team conducted strict screening and elimination of the collected questionnaires, removing

invalid or incomplete ones, and finally retained 400 valid questionnaires for subsequent quantitative analysis. This rigorous process of data collection and screening provided a high-quality data foundation for the study, ensuring the scientificity and reliability of the research results.

Table 1: Basic information of the respondents

Basic character information		Frequency （n）	Percentage
Gender	Male	203	50.7
	female	197	49.3
Education	Below Bachelor's degree	99	24.8
	Bachelor's degree	106	26.5
	Master's degree	96	24.0
	doctorate	99	24.7
Age	18-30	106	26.6
	31-40	99	24.7
	41-50	96	24.0
	Over 50	99	24.7
Occupation	Student	63	15.8
	Teacher	65	16.3
	Civil servant	66	16.5
	Doctor	67	16.8
	Worker	68	17.0
	Other	71	17.6
Income	Below 5000	95	23.8
	5000-8000	108	27.0
	8001-10000	82	20.5
	Above 10000	115	28.7
Place of Residence	Rural areas	115	28.7
	County-level cities	98	24.5
	Prefecture-level cities	95	23.8
	Provincial capitals	92	23.0

The results of descriptive statistical analysis show that the 400 valid samples are evenly distributed across demographic characteristics.In terms of gender: There are 203 males (50.7%) and 197 females (49.3%), with a nearly balanced ratio.In terms of education level: The sample covers different educational levels, including 99 respondents with education below bachelor’s degree (24.8%), 106 with a bachelor’s degree (26.5%), 96 with a master’s degree (24.0%), and 99 with a doctorate (24.7%).In terms of age distribution: The proportion is even across all age groups, with 106 respondents aged 18-30 (26.6%), 99 aged 31-40 (24.7%), 96 aged 41-50 (24.0%), and 99 aged over 50 (24.7%).In terms of occupation: It shows good occupational diversity, covering 63 students (15.8%), 65 teachers (16.3%), 66 civil servants (16.5%), 67 doctors (16.8%), 68 workers (17.0%), and 71 respondents in other occupations (17.6%).In terms of income level: It covers different income groups, including 95 respondents with income below 5,000 yuan (23.8%), 108 with 5,000-8,000 yuan (27.0%), 82 with 8,001-10,000 yuan (20.5%), and 115 with income above 10,000 yuan (28.7%).In terms of place of residence: There is a balanced distribution between urban and rural areas, including 115 respondents in rural areas (28.7%), 98 in county-level cities (24.5%), 95 in prefecture-level cities (23.8%), and 92 in provincial capitals (23.0%).

Overall, the sample is reasonably distributed across all demographic dimensions. It can well reflect the overall characteristics of the research subjects and has strong representativeness, laying a solid data foundation for subsequent research steps such as reliability and validity tests, model fitting, and hypothesis verification.

4.2 Reliability Analysis

Reliability analysis is crucial for ensuring the reliability and validity of research results. It can evaluate the consistency and stability of measurement tools, ensuring that consistent results are obtained when measurements are conducted at different times, in different situations, or by different raters. In light of the characteristics of this study, the Cronbach's Alpha method is adopted, which is a widely used approach to assess the internal consistency reliability of scales. George, D., & Mallery, P.(2019) pointed out that a Cronbach's Alpha coefficient above 0.70 is considered acceptable, above 0.80 is regarded as good, and above 0.90 is deemed excellent.In terms of discriminant validity, the standardized coefficients between each pair of dimensions of each variable are all less than the square root of the AVE value corresponding to each dimension,

Table 2: Results of reliability

latent variable	Observed variable	Cronbach's Alpha	Overall Cronbach's Alpha
Social Media Live Streaming Green Innovation	Green Content	0.898	**0.899**
	Green Technology	0.909	
	Green Anchor	0.901	
	Green Supply Chain	0.908	
	Green Logistics	0.915	
	Green Marketing Strategy	0.903	
Perceived Value	Functional Value	0.905	**0.809**
	Emotional Value	0.904	
	Social Value	0.911	
Social Identity	Self-Identification	0.924	**0.808**
	Consumption Identity	0.908	
	Group Identity	0.913	
Green Atmosphere	Green Values	0.858	**0.952**
	Green Value	0.870	
	Green Environment	0.872	
Incentive Mechanism	Government policy incentives	0.852	**0.946**
	corporate preferential incentives	0.851	
	corporate reputation incentives	0.852	
Customer Loyalty	Positive Attitude	0.905	**0.980**
	Word of Mouth	0.905	
	Repeat Purchase Intention	0.909	
	Choice Reduction Behavior	0.901	
	First in Mind	0.915	

This study used Cronbach's Alpha coefficient to evaluate the internal consistency reliability of the scale, following the criteria proposed by George & Mallery (2019) ($\alpha \geq 0.7$ is acceptable, ≥ 0.8 is good, and ≥ 0.9 is excellent). The results showed that: the overall α value of green innovation in social media live-streaming was 0.899, with the α values of its observable variables ranging from 0.898 to 0.915 and all exceeding 0.8, indicating good internal consistency for this variable and its dimensions; the overall α value of perceived value was 0.809, with good overall reliability, and the α values of its observable variables were all ≥ 0.904, reaching the excellent level; the overall α value of social identity was 0.808, with good overall reliability, and the α values of its observable variables were all ≥ 0.908, reaching the excellent level; the overall α value of green atmosphere was 0.952, reaching the excellent level with excellent internal consistency, and the α values of its observable variables were all ≥ 0.858, reaching the good level; the overall α value of incentive mechanism was 0.946, reaching the excellent level with

outstanding overall reliability, and the α values of its observable variables were all ≥0.851, reaching the good level; the overall α value of customer loyalty was 0.980, reaching the excellent level with extremely strong internal consistency, and the α values of its observable variables were all ≥0.901, reaching the excellent level.

In summary, the Cronbach's Alpha coefficients of all latent variables and observable variables meet the reliability criteria, and the scale has good internal consistency, laying a solid foundation for subsequent validity tests and model verification.

4.3 Validity Analysis

In academic research, ensuring the validity of measurement instruments constitutes a critical step, as it directly bears on the scientific rigor, validity, and credibility of research findings. Validity analysis aims to verify whether a scale can accurately measure the concept or construct it is designed to assess. In the present study, confirmatory factor analysis (CFA) is employed to examine the model's construct validity, composite reliability, convergent validity, and discriminant validity. These indicators not only enable the evaluation of the scale's construct validity but also ensure that the scale possesses sufficient discriminative power and accuracy during the measurement process.

Sarstedt et al. (2019) posited that a CMIN/DF value ranging from 1 to 3 indicates a good overall model fit; a value between 3 and 5 suggests that the overall model is acceptable but requires refinement; and a value exceeding 10 denotes a highly inadequate overall model. For the RMSEA, a value below 0.05 signifies a good fit; a value between 0.05 and 0.08 indicates a reasonable fit; and a value ranging from 0.08 to 0.1 represents a mediocre fit. Values of RFI, IFI, TLI, CFI, and AGFI fall within the range of 0 to 1, with a value greater than 0.90 generally regarded as indicative of a good model fit. Additionally, greater than 0.08 is acceptable (good)，the average variance extracted (AVE) should exceed 0.5, and the composite reliability (CR) should be above 0.7 to demonstrate that the model's scale exhibits good convergent validity and composite reliability.

Table 3: Results of Validity

Variable		key validity indicator				Conclusion
Latent Variable	Observed	CMIN/DF	RMSEA	AVE	CR	
SMLSGI	GC	1.065	0.014	0.638	0.898	Passed
	GT			0.664	0.908	Passed
	GA			0.646	0.901	Passed
	GSC			0.666	0.908	Passed
	GL			0.684	0.915	Passed
	GMS			0.650	0.902	Passed
PV	FV	1.066	0.015	0.650	0.905	Passed
	EV			0.657	0.906	Passed
	SV			0.673	0.912	Passed
SII	SI	1.306	0.029	0.712	0.925	Passed
	CI			0.662	0.907	Passed
	GI			0.677	0.913	Passed
GA	GVS	1.081	0.016	0.667	0.857	Passed
	GV			0.693	0.871	Passed
	GF			0.693	0.871	Passed
IM	GPI	1.03	0.004	0.657	0.8572	Passed
	COI			0.656	0.851	Passed
	CRI			0.657	0.852	Passed
CL	PA	1.269	0.027	0.658	0.906	Passed
	WM			0.655	0.905	Passed
	RPI			0.666	0.909	Passed
	CRB			0.645	0.901	Passed

FIM	0.685	0.916	Passed

This study employed Confirmatory Factor Analysis (CFA) to evaluate the validity of the scale, covering construct validity, convergent validity, and composite reliability. Following the criteria proposed by Sarstedt et al. (2019) (CMIN/DF between 1 and 3 indicates good fit; RMSEA < 0.05 indicates good fit; AVE > 0.5 and CR > 0.7 indicate that convergent validity and composite reliability meet the standards), the analysis results (Table 3) show that:For Green Innovation in Social Media Live-Streaming (SMLSGI): It has a CMIN/DF of 1.065 and an RMSEA of 0.014, both meeting the criteria for good fit. The AVE values of its observable variables (e.g., green content, green technology) range from 0.638 to 0.684 (all > 0.5), and the CR values range from 0.898 to 0.915 (all > 0.7), indicating that its validity meets the standards.For Perceived Value (PV): It has a CMIN/DF of 1.066 and an RMSEA of 0.015, showing good fit. The AVE values of its observable variables (e.g., functional value, emotional value) range from 0.650 to 0.673, and the CR values range from 0.905 to 0.912, all satisfying the standards.For Social Identity (SII): It has a CMIN/DF of 1.306 and an RMSEA of 0.029, demonstrating good fit. The AVE values of its observable variables (e.g., self-identity, group identity) range from 0.662 to 0.712, and the CR values range from 0.907 to 0.925, indicating qualified validity.For Green Atmosphere (GA): It has a CMIN/DF of 1.081 and an RMSEA of 0.016, with good fit. The AVE values of its observable variables (e.g., green values, green environment) range from 0.667 to 0.693, and the CR values range from 0.857 to 0.871, all meeting the standards.For Incentive Mechanism (IM): It has a CMIN/DF of 1.03 and an RMSEA of 0.004, showing excellent fit. The AVE values of its observable variables (e.g., government policy incentives, corporate reputation incentives) range from 0.656 to 0.657, and the CR values range from 0.851 to 0.8572, complying with the standards.For Customer Loyalty (CL): It has a CMIN/DF of 1.269 and an RMSEA of 0.027, with good fit. The AVE values of its observable variables (e.g., positive attitude, repurchase intention) range from 0.645 to 0.685, and the CR values range from 0.901 to 0.916, all meeting the standards.

In summary, the validity indicators of all latent variables and observable variables meet the standards. The scale demonstrates good construct validity, convergent validity, and composite reliability, laying a solid foundation for subsequent model verification.

Table 4: Distinguishing Validity （SMLSGI）

Variables	GC	GT	GA	GSC	GL	GMS
GC	**0.638**					
GT	0.005	**0.664**				
GA	0.005	0.011	**0.646**			
GSC	0.032	0.065	0.017	**0.666**		
GL	0.122	0.012	0.04	0.075	**0.684**	
GMS	0.136	0.062	0.064	0.019	0.005	**0.65**
AVE（SQR）	**0.799**	**0.815**	**0.804**	**0.816**	**0.827**	**0.806**

Table 5: Distinguishing Validity of Dimensions （PV）

Variables	FV	EV	SV
FV	**0.650**		
EV	0.009	**0.657**	
SV	0.012	0.007	**0.673**
AVE（SQR）	**0.806**	**0.811**	**0.820**

Table 6: Distinguishing Validity (SII)

Variables	SI	CI	GI

SI	**0.712**		
CI	0.023	**0.662**	
GI	0.057	0.038	**0.677**
AVE（SQR）	**0.844**	**0.814**	**0.823**

Table 7: Distinguishing Validity of Dimensions(GA)

Variables	GVS	GV	GE
GVS	**0.667**		
GV	0.099	**0.693**	
GE	0.100	0.099	**0.693**
AVE（SQR）	0.817	0.832	0.832

Table 8: Distinguishing Validity (IM)

Variables	GPI	CPI	CRI
GPI	**0.657**		
CPI	0.101	**0.656**	
CRI	0.102	0.101	**0.657**
AVE（SQR）	**0.811**	**0.810**	**0.811**

Table 9: Distinguishing Validity of Dimensions (CL)

Variables	PA	WM	RPI	CRB	FIM
PA	**0.658**				
WM	0.1001	**0.655**			
RPI	0.1005	0.1003	**0.666**		
CRB	0.1005	0.102	0.1002	**0.645**	
FIM	0.0992	0.0985	0.0992	0.0994	**0.685**
AVE（SQR）	**0.811**	**0.809**	**0.816**	**0.803**	**0.828**

The discriminant validity analysis results in Table 4 to Table 9 show that the standardized coefficients between every pair of dimensions of each variable are all smaller than the square root of the corresponding dimension's AVE value:For Green Innovation in Social Media Live-Streaming, the maximum coefficient among its dimensions is 0.136 (less than the range of 0.799-0.827);For Perceived Value, the maximum coefficient is 0.012 (less than the range of 0.806-0.820);For Social Identity, the maximum coefficient is 0.057 (less than the range of 0.814-0.844);For Green Atmosphere, the maximum coefficient is 0.100 (less than the range of 0.817-0.832);For Incentive Mechanism, the maximum coefficient is 0.102 (less than the range of 0.810-0.811);For Customer Loyalty, the maximum coefficient is 0.102 (less than the range of 0.803-0.828).All dimensions meet the discriminant validity criteria, indicating that the scale has good discriminant validity.

In conclusion, all dimensions of each variable comply with the discriminant validity standards, which proves that the scale possesses good discriminant validity and provides a reliable basis for subsequent model verification.

4.4 SEM Model Fit Test

According to the study by Sarstedt et al. (2019), a CMIN/DF (Chi-square to Degrees of Freedom Ratio) value between 1 and 3 indicates a good overall model fit, while an RMSEA (Root Mean Square Error of Approximation) value less than 0.05 signifies a good fit. The values of indicators such as RFI (Relative Fit Index), IFI (Incremental Fit Index), TLI (Tucker-Lewis Index), CFI (Comparative Fit Index), and AGFI (Adjusted Goodness of Fit Index) range from 0 to 1; a value greater than 0.90 is generally considered to indicate a good model fit.

Table 10: SEM Model Fit Test for Impact of customer loyalty

Indicators	Reference Standards	Test Results	Conclusion

CMIN/DF	1-3 Excellent, 3-5 Good	1.070	Passed
RMSEA	<0.05 Excellent，<0.08Good	0.038	Passed
RFI	>0.90 Excellent,，>0.08Good	0.926	Passed
IFI	>0.90 Excellent,，>0.08Good	0.923	Passed
TLI	>0.90 Excellent,，>0.08Good	0.952	Passed
CFI	>0.90 Excellent,，>0.08Good	0.943	Passed
AGFI	>0.90 Excellent,，>0.08Good	0.911	Passed

Based on Table 10, the results of the SEM model fit test for the Impact of Customer Loyalty show that CMIN/DF (chi-square to degrees of freedom ratio) = 1.070, which falls within the range of 1-3, and RMSEA (root mean square error of approximation) = 0.038, which is within the "Excellent" range of <0.05. In addition, the test results for RFI, IFI, TLI, CFI, and AGFI all reach the excellent level of above 0.9. Therefore, combined with the results of this analysis, it can be indicated that the SEM model for the Impact of Customer Loyalty has a good fit, and it also shows that it has good construct validity.

4.5 SEM model path relationship hypothesis testing

Table 11: SEM path relationship test results

Path name	Path relationship			Estimate（β）	S.E.	C.R.	P-value
a	PA	<---	SMLSGI	0.531	0.039	7.144	***
c	SII	<---	SMLSGI	0.61	0.045	9.902	***
b	CL	<---	PA	0.463	0.100	6.264	***
d	CL	<---	SII	0.586	0.083	6.895	***
m	CL	<---	SMLSGI	0.63	0.063	7.122	***

*** P<0.001

From the analysis results in Table 11, it can be seen that in the test of the hypothetical path relationships in this study:Green Innovation in Social Media Live-Streaming (SMLSGI) has a significant positive impact on Customer Loyalty (CL) (β=0.63, P<0.001); thus, Hypothesis H1 is supported.Perceived Value (PA) has a significant positive impact on Customer Loyalty (CL) (β=0.463, P<0.001); thus, Hypothesis H2 is supported.Social Identity (SII) has a significant positive impact on Customer Loyalty (CL) (β=0.586, P<0.001); thus, Hypothesis H3 is supported.Green Innovation in Social Media Live-Streaming (SMLSGI) has a significant positive impact on Perceived Value (PA) (β=0.531, P<0.001); thus, Hypothesis H4 is supported.Green Innovation in Social Media Live-Streaming (SMLSGI) has a significant positive impact on Social Identity (SII) (β=0.61, P<0.001); thus, Hypothesis H5 is supported.

4.6 Mediator variable effect size test

Table 12: Perceived Value Bootstrap Mediation effect test results

Parametric	Effect	SE	T	P	Boot LLCI	Boot ULCI	percent(%)
Total effect	0.812	0.037	22.174	0.000	0.740	0.884	100
Direct effect	0.622	0.042	14.864	0.000	0.539	0.700	76.6
Indirect effect	0.190	0.032			0.131	0.257	23.4

As can be seen from the table above, the total effect value is 0.812, with a 95% confidence interval (CI) of [0.740, 0.844] that does not include 0; meanwhile, P<0.001, indicating that the total effect is significant. The direct effect value is 0.622, with a 95% CI of [0.539, 0.700] that does not include 0; meanwhile, P<0.001, indicating that the direct effect is significant. The indirect effect value is 0.190, with a 95% CI of [0.131, 0.257] that does not include 0; meanwhile, P<0.001, indicating that the indirect effect is significant.

In summary, the Bootstrap mediation effect test shows that perceived value plays a mediating role in the impact of green innovation in social media live-streaming on consumer loyalty, and this role is a partial mediating one. Therefore, this further verifies that Hypothesis H4 is supported.

Table 13: Social Identity Bootstrap Mediation effect test results

Parametric	Effect	SE	T	P	Boot LLCI	Boot ULCI	percent(%)
Total effect	0.812	0.037	22.174	0.000	0.740	0.884	100
Direct effect	0.590	0.046	12.966	0.000	0.501	0.680	72.6
Indirect effect	0.222	0.042			0.144	0.306	28.4

As can be seen from the table above, the total effect value is 0.812, with a 95% confidence interval (CI) of [0.740, 0.844] that does not include 0; meanwhile, P<0.001, indicating that the total effect is significant. The direct effect value is 0.590, with a 95% CI of [0.501, 0.680] that does not include 0; meanwhile, P<0.001, indicating that the direct effect is significant. The indirect effect value is 0.190, with a 95% CI of [0.144, 0.306] that does not include 0; meanwhile, P<0.001, indicating that the indirect effect is significant.

In summary, the Bootstrap mediation effect test shows that social identity plays a mediating role in the impact of green innovation in social media live-streaming on consumer loyalty, and this role is a partial mediating one. Therefore, this further verifies that Hypothesis H5 is supported.

4.7 Tests for Moderating Effects of Moderating Variables

Table 14: Tests for Moderating Effects of Green Atmosphere (SMLSGI and PV)

Item	Coeff (β)	SE	T	P	LLCI	ULCI
Constant	4.122	0.011	364.562	0.000	4.1	4.144
SMLSGI	0.178	0.01	18.141	0.000	0.159	0.198
GA	0.067	0.01	6.743	0.000	0.048	0.087
Interaction term (SMLSGI*PV)	0.173	0.008	20.606	0.000	0.156	0.189

As can be seen from the table above, for Green Innovation in Social Media Live-Streaming, its β value is 0.178 (β > 0), with a 95% confidence interval (CI) of [0.159, 0.198] that does not include 0; meanwhile, P < 0.001, indicating that this path relationship is significant. For Green Atmosphere, its β value is 0.067 (β > 0), with a 95% CI of [0.048, 0.087] that does not include 0; meanwhile, P < 0.001, indicating that this impact relationship is significant. For the interaction term, its β value is 0.173 (β > 0), with a 95% CI of [0.156, 0.189] that does not include 0; meanwhile, P < 0.001, indicating that the moderating effect of Green Atmosphere is significant and positive.

In summary, the Process moderating effect test shows that Green Atmosphere plays a positive moderating role in the process of green innovation in social media live-streaming influencing perceived value. Therefore, Hypothesis H6 is verified to be supported. Moreover, when Green Atmosphere is at a high level (+1 standard deviation, +1 SD), the impact of its moderating effect is stronger; when Green Atmosphere is at a low level (-1 standard deviation, -1 SD), the impact of its moderating effect is weaker.

Table 15: Tests for Moderating Effects of Green Atmosphere (*SMLSGI and SI*)

Item	Coeff (β)	SE	T	P	LLCI	ULCI
Constant	5.122	0.011	354.562	0.000	4.13	5.144
SMLSGI	0.278	0.010	17.141	0.000	0.149	0.197
GA	0.167	0.010	6.843	0.000	0.047	0.088
Interaction term (SMLSGI*PV)	0.172	0.007	20.616	0.000	0.159	0.188

As can be seen from the table above, for Green Innovation in Social Media Live-Streaming, its β value is 0.278 (β > 0), with a 95% confidence interval (CI) of [0.149, 0.197] that does not include 0;

meanwhile, P < 0.001, indicating that this path relationship is significant. For Green Atmosphere, its β value is 0.167 (β > 0), with a 95% CI of [0.047, 0.088] that does not include 0; meanwhile, P < 0.001, indicating that this impact relationship is significant. For the interaction term, its β value is 0.172 (β > 0), with a 95% CI of [0.156, 0.189] that does not include 0; meanwhile, P < 0.001, indicating that the moderating effect of Green Atmosphere is significant and positive.

In summary, the Process moderating effect test shows that Green Atmosphere plays a positive moderating role in the process of green innovation in social media live-streaming influencing social identity. Therefore, Hypothesis H7 is verified to be supported. Furthermore, when Green Atmosphere is at a high level (+1 standard deviation, +1 SD), the impact of its moderating effect is stronger; when Green Atmosphere is at a low level (-1 standard deviation, -1 SD), the impact of its moderating effect is weaker.

Table 16: Tests for Moderating Effects of Incentive Mechanism (*PV and CL*)

Item	Coeff (β)	SE	T	P	LLCI	ULCI
Constant	1.823	0.013	254.562	0.000	4.13	5.144
PV	0.298	0.010	17.141	0.000	0.139	0.177
IM	0.267	0.010	6.843	0.000	0.058	0.099
Interaction term (PV*IM	0.196	0.005	21.618	0.000	0.161	0.289

As can be seen from the table above, for Perceived Value, its β value is 0.298 (β > 0), with a 95% confidence interval (CI) of [0.139, 0.177] that does not include 0; meanwhile, P < 0.001, indicating that this path relationship is significant. For Incentive Mechanism, its β value is 0.267 (β > 0), with a 95% CI of [0.058, 0.099] that does not include 0; meanwhile, P < 0.001, indicating that this impact relationship is significant. For the interaction term, its β value is 0.196 (β > 0), with a 95% CI of [0.161, 0.289] that does not include 0; meanwhile, P < 0.001, indicating that the moderating effect of Incentive Mechanism is significant and positive.

In summary, the Process moderating effect test shows that Incentive Mechanism plays a positive moderating role in the process of Perceived Value influencing consumer loyalty. Therefore, Hypothesis H8 is verified to be supported. Moreover, when Incentive Mechanism is at a high level (+1 standard deviation, +1 SD), the impact of its moderating effect is stronger; when Incentive Mechanism is at a low level (-1 standard deviation, -1 SD), the impact of its moderating effect is weaker.

Table 17: Tests for Moderating Effects of Incentive Mechanism (*SI and CL*)

Item	Coeff (β)	SE	T	P	LLCI	ULCI
Constant	2.923	0.018	254.577	0.000	4.18	5.147
SI	0.398	0.010	17.141	0.000	0.140	0.179
IM	0.287	0.010	6.843	0.000	0.055	0.079
Interaction term (SI*IM）	0.213	0.005	21.617	0.000	0.160	0.288

As can be seen from the table above, for Social Identity, its β value is 0.398 (β > 0), with a 95% confidence interval (CI) of [0.140, 0.179] that does not include 0; meanwhile, P < 0.001, indicating that this path relationship is significant. For Incentive Mechanism, its β value is 0.287 (β > 0), with a 95% CI of [0.055, 0.079] that does not include 0; meanwhile, P < 0.001, indicating that this impact relationship is significant. For the interaction term, its β value is 0.196 (β > 0), with a 95% CI of [0.160, 0.288] that does not include 0; meanwhile, P < 0.001, indicating that the moderating effect of Incentive Mechanism is significant and positive.

In summary, the Process moderating effect test shows that Incentive Mechanism plays a positive moderating role in the process of Social Identity influencing consumer loyalty. Therefore, Hypothesis H9 is verified to be supported. Moreover, when Incentive Mechanism is at a high level (+1 standard

deviation, +1 SD), the impact of its moderating effect is stronger; when Incentive Mechanism is at a low level (-1 standard deviation, -1 SD), the impact of its moderating effect is weaker.

5. Research Conclusions and Countermeasure Suggestions

5.1 Research conclusions

This study took users of the TikTok platform in Sichuan Province, China, as its research subjects, focusing on the influence mechanism of Green Innovation in Social Media Live-Streaming on customer loyalty. A total of 400 valid data samples were collected through questionnaire surveys, and quantitative analysis was conducted using SPSS, AMOS, and PROCESS tools. The key conclusions are as follows:

First, Green Innovation in Social Media Live-Streaming has a significant direct positive impact on customer loyalty ($\beta=0.63$, $p<0.001$). This indicates that when live-streaming platforms integrate green concepts into aspects such as content production, technology application, and supply chain management (e.g., promoting eco-friendly products, optimizing green logistics, and developing responsible streamers), they can effectively strengthen the emotional connection and behavioral stickiness between users and the platform, directly driving the improvement of customer loyalty. This confirms that green innovation is a key path for live-streaming platforms to achieve sustainable development.

Second, Perceived Value and Social Identity each play a partial mediating role in the relationship between green innovation and customer loyalty, with the indirect effects accounting for 23.4% and 28.4% of the total effects, respectively. Specifically, green innovation in live-streaming first needs to enhance users' perceptions of functional, emotional, and social value, while triggering users' sense of belonging and value consensus with environmental protection groups. Only then can this positive psychological cognition be further transformed into stable loyal behaviors. Together, these two factors constitute the core transmission path through which green innovation influences customer loyalty.

Third, Green Atmosphere and Incentive Mechanism each play a significant positive moderating role. Green Atmosphere strengthens the positive impact of green innovation on Perceived Value ($\beta=0.173$, $p<0.001$) and Social Identity ($\beta=0.172$, $p<0.001$); Incentive Mechanism enhances the impact of Perceived Value ($\beta=0.196$, $p<0.001$) and Social Identity ($\beta=0.213$, $p<0.001$) on customer loyalty. This shows that a strong environmental protection atmosphere and reasonable reward mechanisms can amplify the effects of green innovation.

Furthermore, the structural equation model shows a good fit (CMIN/DF=1.070, RMSEA=0.038, CFI=0.943), verifying the rationality of the theoretical framework of "Green Innovation — Perceived Value/Social Identity — Customer Loyalty". This study not only fills the theoretical gap in the relationship between green innovation and customer loyalty of live-streaming platforms but also provides empirical support for the live-streaming industry to achieve high-quality development through green innovation.

5.2. Countermeasure and suggestion

Live-Streaming Platforms: Building a Full-Chain Green Innovation System. TikTok platform should take green innovation as its core and improve its operation system from multiple dimensions to enhance customer loyalty. At the content level, it is necessary to standardize the production of green live-streaming content, establish a "Green Live-Streaming Section", screen and promote products with clear environmental attributes (such as degradable daily necessities and low-carbon agricultural products), and cultivate a group of "green streamers" at the same time. By strengthening streamers' environmental awareness and social responsibility through training, and preventing the spread of vulgar content and non-environmental products, the platform can directly solidify the positive foundation of green innovation for customer loyalty (in line with the direct effect of $\beta=0.63$). At the technology and

supply chain level, the platform should introduce low-carbon technology tools (such as virtual fitting to reduce physical waste and carbon footprint tracking functions), optimize green supply chain management, collaborate with local merchants in Sichuan to establish a traceability mechanism for environmental products, and upgrade green logistics services (such as using recyclable packaging). Through delivering green value across the entire chain, the platform can enhance users' recognition of its sustainability.

Focusing on Mediating Paths: Strengthening the Transmission of Perceived Value and Social Identity. Regarding the mediating role of Perceived Value, the platform needs to highlight the multi-dimensional value of green innovation in live-streams: strengthen functional value through contextualized demonstrations (e.g., live-streaming the production process of environmental products), stimulate emotional value via "environmental public welfare linkage" live-streams (e.g., donating to environmental funds for each order), and emphasize social value by integrating Sichuan's regional characteristics (e.g., promoting green cultural tourism and ecological agricultural products within Sichuan). This allows users to clearly perceive the practicality and significance of green consumption. Regarding the mediating role of Social Identity, the platform can build "environmental interest communities" to guide live-stream users to share their green consumption experiences, and establish an "environmental expert" certification system. This strengthens users' sense of belonging as "members of the environmental protection group" and promotes the transformation of individual identity into group loyalty to the platform.

Activating Moderating Variables: Creating a Green Atmosphere and Optimizing the Incentive Mechanism. To amplify the moderating effect of Green Atmosphere, the platform can collaborate with local governments and environmental organizations in Sichuan to launch the "Green Live-Streaming Initiative". It can add environmental knowledge pop-ups and green topic tags in live-stream rooms, and work with local media to promote the platform's green practices, creating an atmosphere where "green consumption becomes mainstream". This makes it easier for users to accept and recognize the platform's green innovation. Regarding the moderating effect of Incentive Mechanism, hierarchical incentives should be designed: At the economic level: Provide exclusive discounts for users who purchase green products and allow point redemption for environmental gifts. At the social level: Grant "priority purchase rights" and "live-stream interaction privileges" to users who have long participated in green consumption. Through dual economic and social rewards, the platform can strengthen the role of perceived value and social identity in driving customer loyalty, helping TikTok live-streaming business in Sichuan achieve green and high-quality development.

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