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THE EFFECT OF CONFIRMATION ON CONTINUED USE INTENTION OF THE ANT FOREST USERS: THE MEDIATING EFFECT OF PERCEIVED VALUE AND SATISFACTION

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Abstract
In the face of global climate challenges, digital platforms like Ant Forest have emerged as innovative tools to promote sustainable behavior through gamification and user engagement. Despite Ant Forest's wide adoption, limited research has explored the psychological mechanisms that sustain users' continued engagement. Grounded in the Expectation Confirmation Model (ECM), this study investigates how confirmation influences continued use intention through the mediating effects of perceived value and satisfaction. Perceived value is conceptualized as a multidimensional construct encompassing perceived usefulness, ease of use, enjoyment, and interactivity. Data were collected from 544 active Ant Forest users through an online questionnaire, and analyzed using Partial Least Squares Structural Equation Modeling. Results reveal that confirmation significantly influences both perceived value and satisfaction, which in turn strongly predict continued use intention. A serial mediation pathway was also identified, in which confirmation affects continued use intention via perceived value and subsequently satisfaction. These findings extend the ECM by integrating emotional and experiential constructs into a digital sustainability context. The study contributes theoretically by demonstrating how cognitive (confirmation and value) and affective (satisfaction) evaluations jointly drive long-term engagement. Practically, it offers design insights for digital environmental platforms seeking to enhance user retention through gamification, interactivity, and value communication. Policymakers and developers are encouraged to support and refine such platforms as behavioral tools in national sustainability agendas. Future research should examine longitudinal dynamics, behavioral data, and cross-cultural differences to further validate and refine the model.

Keywords: Ant Forest,continued use intention, perceived value, satisfaction, Expectation Confirmation Model

As the global climate crisis intensifies and ecological degradation accelerates, the

international community has placed growing emphasis on sustainable development and the promotion of low-carbon lifestyles. China, as the world's largest developing country and a major emitter of greenhouse gases, has committed to peaking carbon emissions by 2030 and achieving carbon neutrality by 2060 (Myers, 2020). These ambitious targets have catalyzed a national shift toward green growth strategies, including the rapid development of green finance mechanisms and digital environmental innovations (Arunachalam, 2024; Myers, 2020). Among these, *Ant Forest*—a mobile application launched by Alibaba's Alipay in 2016—has emerged as a pioneering platform that leverages gamification to incentivize environmentally responsible behavior (Xiong & Meng, 2018).

Ant Forest rewards users with "green energy" points for engaging in low-carbon activities such as walking, cycling, using electronic tickets, or making digital payments. These points can be used to plant virtual trees that are later converted into real trees in desertified regions of China. As of 2023, the platform had engaged over 690 million users and facilitated the planting of more than 475 million trees (Xiong & Meng, 2018), positioning it as one of the most impactful digital environmental campaigns in the world. Despite the platform's scale and its contributions to China's ecological restoration and carbon reduction efforts, the underlying mechanisms that sustain long-term user engagement remain inadequately understood.

While prior research has explored the structural aspects of green finance and the motivational appeal of gamification in similar contexts (Arunachalam, 2024; Xiong & Meng, 2018; Zhou, 2019), there is a notable gap in the literature regarding post-adoption behaviors on digital sustainability platforms (Udemba, 2022). Specifically, the psychological and experiential factors that influence users' intention to continue using *Ant Forest* over time are under-researched. This study seeks to address this gap by employing Bhattacherjee's (2001) Expectation Confirmation Model (ECM) to investigate how the confirmation of initial expectations influences continued use intention. The model further posits that perceived value—encompassing usefulness, ease of use, enjoyment, and interactivity—and user satisfaction serve as key mediating variables in this relationship (Sweeney & Soutar, 2001; Lee et al., 2022).

The central problem this study investigates is the insufficient understanding of how post-adoption evaluative processes shape sustained user interaction with digital environmental applications. Although platforms like *Ant Forest* offer innovative approaches to fostering green behavior, their long-term success depends on retaining active users. The study hypothesizes that users' perceived alignment between expected and actual performance (i.e., confirmation) enhances perceived value and satisfaction, thereby reinforcing continued engagement with the platform.

By testing these relationships, the study makes both theoretical and practical contributions. Theoretically, it extends the applicability of ECM into the emergent field of green digital platforms, offering a nuanced understanding of user retention mechanisms in environmental contexts. Practically, the findings can guide developers and policymakers in designing more effective digital interventions to promote sustainable behavior. As environmental platforms become increasingly integral to national and global sustainability agendas, deepening our understanding of user motivation is essential for scaling these

innovations and achieving long-term ecological goals.

Literature Review

Confirmation

Confirmation refers to the extent to which a user's actual experience with a product or system aligns with or exceeds their initial expectations. Rooted in Expectation-Confirmation Theory (ECT) by Oliver (1980), the concept was adapted by Bhattacherjee (2001) in the Expectation Confirmation Model (ECM) to explain users' post-adoption behavior in information systems. In this context, confirmation occurs after initial system use and functions as a cognitive appraisal: users reflect on whether the system delivered the performance they anticipated.

Multiple empirical studies have affirmed that confirmation is a significant determinant of user satisfaction and continuance intention. For instance, Bhattacherjee (2001) demonstrated that confirmation not only affects satisfaction directly but also influences perceived usefulness in digital systems. More recent studies in mobile banking, e-learning platforms, and health applications have replicated these findings (Al-Emran et al., 2020; Shiau et al., 2021; Chiu, 2020), reinforcing confirmation as a vital antecedent in understanding post-adoption behavior.

In the context of Ant Forest—a gamified digital platform for promoting low-carbon behavior—confirmation captures whether users feel that the platform delivers on its promise of making environmental protection accessible, engaging, and impactful. If users perceive that their eco-friendly activities translate into real-world impact (e.g., tree planting), and that the platform delivers social enjoyment and personal satisfaction, their level of confirmation is likely to be high. Given Ant Forest's blend of environmental, social, and game-based elements, confirmation may stem from multiple expectations: environmental contribution, game-related enjoyment, and peer interaction. Understanding how these expectations are fulfilled is key to retaining users in such platforms.

Perceived Value

Perceived value is broadly defined as the user's overall assessment of the utility or worth of a service, weighing the benefits received against the costs incurred (Sweeney & Soutar, 2001). In technology use contexts, perceived value often determines whether users find the experience worthwhile and whether they intend to continue using the system. While traditionally conceptualized as a unidimensional trade-off, modern interpretations advocate a multidimensional view encompassing functional, emotional, and social components (Kim & Thapa, 2018; Foroughi et al., 2023).

In this study, perceived value is operationalized as a second-order construct comprised of four first-order dimensions: perceived usefulness, perceived ease of use, perceived enjoyment, and perceived interactivity. This approach recognizes that the perceived benefits of using a platform like Ant Forest are not limited to task utility but also include emotional engagement and social interaction.

Perceived Usefulness

Perceived usefulness originates from the Technology Acceptance Model (TAM) proposed by Davis (1989) and is defined as the degree to which a person believes that using a particular system will enhance their task performance. In the context of Ant Forest, perceived usefulness may include the platform's ability to facilitate eco-friendly behavior, promote awareness of carbon footprints, or generate social capital by signaling environmental responsibility. Prior research has shown that perceived usefulness is a consistent predictor of satisfaction and continued use intention across various digital platforms including banking (Parboteeah et al., 2005), education (Tam et al., 2020), and healthcare (Chiu, 2020). In platforms that blend gamification and sustainability, usefulness may also include the practical value of learning about green behavior and contributing to tangible ecological outcomes.

Perceived Ease of Use

Perceived ease of use, also derived from TAM, refers to the degree to which a system is perceived as free from effort. A system that is easy to navigate and interact with reduces cognitive load and enhances user satisfaction, which in turn increases the likelihood of repeated use (Davis, 1989). In gamified platforms, ease of use is particularly important because users are expected to perform various in-app activities—such as logging steps, engaging with friends, or tracking energy consumption. If these functions are complex or difficult to operate, they may undermine the perceived value of the platform, regardless of its environmental benefits. Song et al. (2020) found that perceived ease of use significantly impacted satisfaction and continued use intention in mobile-based community platforms, suggesting similar implications for Ant Forest.

Perceived Enjoyment

Enjoyment refers to the intrinsic pleasure derived from using a system, independent of its instrumental value. In the context of Ant Forest, perceived enjoyment could arise from the platform's gamified elements, such as collecting green energy, unlocking milestones, or competing with friends. Research suggests that enjoyment is a crucial predictor of continued use in gamified platforms and leisure-oriented applications (Foroughi et al., 2023).

Enjoyment enhances emotional engagement, and emotionally satisfied users are more likely to develop habitual behaviors, loyalty, and advocacy. Unlike traditional usefulness, which speaks to extrinsic motivation, enjoyment taps into intrinsic motivation—a factor that is especially important in platforms designed to promote voluntary behavior change, such as those focused on sustainability (Udemba, 2022).

Perceived Interactivity

Perceived interactivity describes the extent to which users perceive meaningful, two-way interactions with the system or with other users. Gozukara et al. (2014) define interactivity as a multidimensional construct encompassing responsiveness, personalization, and user control. High interactivity improves user engagement by creating a sense of involvement and social presence. In Ant Forest, interactivity might manifest in features such as energy sharing, collaborative tree planting, ranking systems, and real-time feedback on

environmental impact. Studies by Huang et al. (2022) and others confirm that interactivity enhances user satisfaction and loyalty, particularly in digital communities and brand platforms. In the environmental context, interactivity may reinforce collective responsibility and provide social reinforcement, which are critical for behavior change.

Satisfaction

Satisfaction is defined as the user's affective response resulting from the evaluation of prior expectations against actual experiences (Oliver, 1980). Within the ECM framework, satisfaction is both a direct outcome of confirmation and a key mediator linking cognitive evaluations to continued use intention (Bhattacherjee, 2001). Numerous studies in digital platforms—ranging from mobile commerce (Zhou, 2019) to e-learning (Ejdys, 2022)—have verified that satisfaction serves as a strong predictor of loyalty, repeat use , and advocacy.

Satisfaction in Ant Forest may be derived from a combination of perceived value (i.e., usefulness, enjoyment, ease, interactivity) and confirmation that these features meet user expectations. In environmentally focused platforms, satisfaction also includes a moral or emotional component, as users experience fulfillment from contributing to ecological goals. This dual nature of satisfaction—as both rational and emotional—makes it a central construct in understanding long-term user engagement in sustainability platforms.

Continued Use Intention

Continued use intention refers to a user's willingness to keep engaging with a system or platform over time. In the ECM and related frameworks (TAM, IS Continuance Theory), continued use intention is the ultimate dependent variable influenced by confirmation, perceived value, and satisfaction (Bhattacherjee, 2001; Tam et al., 2020). Unlike initial adoption, which may be driven by curiosity or external pressure, continued use is rooted in users' actual experiences and evaluations.

In digital green platforms like Ant Forest, continued use intention is particularly critical because sustained engagement is necessary to generate meaningful environmental outcomes. If users abandon the platform after initial use, the potential for carbon reduction or ecological impact is diminished. Therefore, identifying the factors that enhance continued use intention is not only theoretically important but also practically essential. Recent studies (Foroughi et al., 2023; Chiu, 2020) have shown that cognitive (confirmation, usefulness) and affective (satisfaction, enjoyment) evaluations both contribute significantly to users' decision to continue using green apps.

Hypothesis Development

The Expectation Confirmation Model (ECM) introduced by Bhattacherjee (2001) builds upon the foundation of Oliver's (1980) expectation-confirmation theory, positing that a user's continued use intention to engage with a system is significantly influenced by their satisfaction, which is, in turn, driven by the extent to which their expectations are confirmed during use. While ECM traditionally focuses on the direct pathway from confirmation to satisfaction, later studies have expanded the model by identifying perceived value as a critical mediating variable that explains *how* and *why* confirmation leads to satisfaction.

Perceived value, conceptualized as users' overall assessment of benefits relative to costs, includes not only instrumental outcomes (such as usefulness or ease of use) but also hedonic and social dimensions (such as enjoyment and interactivity). In the context of digital engagement platforms like Ant Forest, confirmation does not merely satisfy expectations in a binary sense—it activates a cognitive process whereby users appraise the quality and worth of their experience across multiple dimensions. These evaluations form the core of perceived value, which then drives satisfaction. Prior research supports this conceptual pathway, indicating that confirmation positively influences users' perception of value, which then enhances their satisfaction (Foroughi et al., 2023; Kim & Thapa, 2018).

Therefore, this study proposes that perceived value serves as a mediator in the relationship between confirmation and satisfaction, transforming cognitive expectation fulfillment into affective appraisal.

H1: Perceived value mediates the relationship between confirmation and satisfaction, such that higher confirmation enhances perceived value, which in turn increases satisfaction with the platform.

Satisfaction has long been recognized as a key mediator between value perception and behavioral intention. According to the Technology Acceptance Model (Davis, 1989) and ECM (Bhattacherjee, 2001), users who perceive a system as valuable are more likely to report satisfaction, which strengthens their likelihood of continued use. However, recent extensions of these models highlight the need to differentiate between types of perceived value—especially in platforms that engage users through emotional and social incentives, rather than solely functional ones (Sweeney & Soutar, 2001).

In the case of Ant Forest, perceived value is operationalized as a multidimensional construct encompassing perceived usefulness, ease of use, enjoyment, and interactivity—dimensions that collectively define the user experience. Each contributes differently to user satisfaction. Usefulness and ease of use drive pragmatic evaluations, while enjoyment and interactivity contribute to intrinsic motivation and social engagement. Studies by Gozukara et al. (2014), Foroughi et al. (2023), and Huang et al. (2022) show that these value dimensions have a significant positive effect on user satisfaction, particularly in gamified or community-based platforms.

Once users are satisfied—having experienced both functional success and emotional gratification—they are more likely to continue engaging with the platform. Thus, satisfaction is not merely a parallel outcome of perceived value but a mechanism that translates user evaluations into behavioral commitment.

H2: Satisfaction mediates the relationship between perceived value and continued use intention, such that greater perceived value enhances satisfaction, which in turn increases the intention to continue using the platform.

The core tenet of the ECM posits that when users experience a high level of confirmation—meaning their expectations are met or exceeded—they are more likely to feel satisfied with the system, which subsequently leads to continued use intention (Bhattacherjee, 2001). However, although the relationship between confirmation and continued use intention is well-established, emerging research has increasingly emphasized the mediating role of satisfaction as a necessary psychological bridge between cognitive evaluation and behavioral

outcome (Al-Emran et al., 2020; Shiau et al., 2021).

This pathway is particularly important in platforms like Ant Forest, where user expectations may span multiple domains—including environmental education, social collaboration, gamified reward, and ease of engagement. Confirmation of such complex and multidimensional expectations is likely to foster a general sense of satisfaction, which integrates both cognitive and affective responses to system performance.

Satisfaction in this context represents the user's holistic emotional appraisal—reflecting not only whether the system worked, but whether it *felt rewarding*. As studies in e-learning, health informatics, and fintech demonstrate, satisfaction strongly predicts the desire to continue using a system (Ejdys, 2022; Chiu, 2020). Therefore, satisfaction functions as a crucial affective mechanism through which the cognitive effects of confirmation are channeled into sustained behavioral intention.

H3: Satisfaction mediates the relationship between confirmation and continued use intention, such that greater confirmation leads to increased satisfaction, which in turn increases the intention to continue using the platform.

Although satisfaction remains a central construct in most post-adoption models, it is important to also consider more direct cognitive routes to continued use intention. In particular, perceived value may independently influence continued use intention, acting as a mediator between confirmation and behavioral commitment. When users perceive high value in the platform—whether through its usability, engagement features, or social interactivity—they may decide to continue use without relying solely on their emotional response.

This perspective is supported by the value-based adoption model and user experience literature, which highlights that perceived value can directly predict continuance (Tam et al., 2020; Kim & Thapa, 2018). This relationship becomes especially relevant in purpose-driven platforms like Ant Forest, where users may consciously recognize the platform’s alignment with their values, goals, and environmental commitments. Confirmation strengthens this evaluation, as users who feel their expectations were met are more inclined to perceive the system as valuable.

Thus, perceived value offers an alternative, more cognitively driven path through which confirmation influences behavioral outcomes.

H4: Perceived value mediates the relationship between confirmation and continued use intention, such that greater confirmation enhances perceived value, which in turn increases the intention to continue using the platform.

While Hypotheses 1 through 4 explore individual mediating relationships, they do not fully account for the interconnected nature of post-adoption evaluation, particularly in immersive and purpose-oriented platforms like Ant Forest. In such settings, users form judgments sequentially: they first assess whether the platform met their expectations (confirmation), then evaluate the overall worth or benefits (perceived value), and finally experience emotional responses (satisfaction) that inform their intention to continue use.

This serial mediation model is supported by recent empirical studies (Foroughi et al., 2023; Huang et al., 2022), which show that perceived value often serves as a precursor to satisfaction, especially when the value includes experiential components like enjoyment or

social connection. Moreover, satisfaction acts as the final affective validation of this evaluative process, directly shaping behavioral intention. Such a model aligns with theories of experiential consumption, where both cognitive appraisals and emotional reactions contribute to long-term behavioral patterns.

Applying this framework to Ant Forest, the proposed pathway is as follows: confirmation strengthens perceived value across multiple dimensions, which then enhances satisfaction, ultimately leading to continued use intention.

H5: Confirmation indirectly influences continued use intention through a serial mediation pathway involving perceived value and satisfaction.

Method

This study largely employs a quantitative research method, aiming to investigate the impact of confirmation, perceived value, and satisfaction on Continued use Intention of Ant Forest users. By constructing a theoretical model and proposing relevant hypotheses, data were collected through questionnaire surveys and then analyzed using statistical methods to test the hypotheses, thereby revealing the relationships among the variables.

Participants

The sample is predominantly male, comprising 56.25% of the total respondents. In terms of age distribution, the largest demographic group falls within the 18–30 age range, accounting for 43.57% of participants, suggesting a relatively young respondent base. Regarding educational attainment, 47.43% of respondents hold a university degree, indicating a high level of education among the sample. Employment-wise, nearly half of the participants (48.9%) are non-government employees, making this the most common occupational category.

In examining daily behaviors and preferences, walking emerged as the most frequently used mode of transportation, reported by 27.02% of respondents. For information acquisition, the Taobao homepage push notifications were the primary source (34.38%), followed closely by recommendations from friends (30.7%). In terms of activity engagement, the majority of participants reported engaging in the surveyed activity 10–14 times (41.54%). Recycling was identified as the most preferred method for accumulating "energy," selected by 26.1% of the respondents.

All participants reported prior experience using the Ant Forest platform. Most discovered the platform through Taobao homepage prompts or referrals from friends, highlighting the influence of both embedded marketing and peer networks. Use frequency varied, with the largest group engaging with the platform 10–14 times, while a smaller segment represented high-frequency users. Transportation behaviors—central to Ant Forest's eco-tracking function—were diverse, with walking, electric vehicle use, and public transit being the most common.

Due to the lack of publicly available data on the total Ant Forest user population, purposive sampling was employed to target individuals with prior experience using the platform. This non-probability sampling method was appropriate for recruiting participants with relevant experiential knowledge to address the research objectives. To ensure adequate

statistical power for structural equation modeling (SEM), the sample size was determined according to general SEM guidelines, which recommend 10–15 cases per estimated parameter. Based on the complexity of the proposed model, a minimum of 400 participants was required. Ultimately, 544 valid responses were collected, exceeding this threshold and ensuring sufficient power to detect meaningful effects (Kock & Hadaya, 2018; Rönkkö & Evermann, 2013).

Data Collection

Data for this study were collected through a structured online questionnaire distributed to active users of Ant Forest, a gamified environmental initiative integrated within the Alipay mobile application (Xiong & Meng, 2018). The target population consisted of individuals who had used Ant Forest consistently for at least three months, ensuring familiarity with the platform's features and functions. A purposive sampling approach was employed to reach information-rich cases aligned with the research objectives.

The questionnaire was developed based on established measurement scales adapted from prior literature on the Expectation Confirmation Model (Bhattacherjee, 2001), perceived value dimensions (Sweeney & Soutar, 2001; Lee et al., 2022), and user satisfaction and behavioral intention (Zhou, 2019). Items were slightly modified to reflect the unique context of Ant Forest and were translated into Chinese to ensure linguistic and cultural relevance. A back-translation process was used to verify translation accuracy and conceptual equivalence.

The finalized questionnaire was distributed via online platforms including WeChat groups, university bulletin boards, and social media networks where Ant Forest users are active. Respondents were assured of anonymity and confidentiality. A total of 398 valid responses were obtained after excluding incomplete or inconsistent entries. This sample size exceeded the minimum requirement for Structural Equation Modeling, ensuring robust statistical analysis.

Ethical considerations were strictly observed throughout the data collection process. Participation was entirely voluntary, and respondents could withdraw at any time without consequence. No personally identifiable information was collected.

Instruments

The quantitative data were collected using a structured questionnaire developed based on established measurement scales, adapted to the context of Ant Forest and the Chinese digital environment. The instrument consisted of two parts: the first section captured demographic information and use characteristics of respondents, while the second comprised items measuring the study's core constructs—confirmation, perceived value, satisfaction, and continued use intention.

Confirmation was measured using three items adapted from Bhattacherjee (2001), assessing the extent to which users' experiences with Ant Forest met or exceeded their initial expectations. Perceived value was operationalized as a multidimensional construct with four subcomponents: perceived usefulness, perceived ease of use, perceived enjoyment, and perceived interactivity. Items for these subdimensions were adapted from prior studies including Davis (1989), Sweeney and Soutar (2001), and Foroughi et al. (2023), each

measured using three to five items per construct. Satisfaction was measured using a three-item scale adapted from previous ECM research, reflecting users' overall affective evaluation of the platform. Finally, continued use intention was assessed through three items based on Bhattacherjee (2001), capturing users' behavioral intention to keep using Ant Forest in the future.

All items were measured on a 5-point Likert scale, ranging from 1 ("strongly disagree") to 5 ("strongly agree"). The questionnaire was initially developed in English and translated into Chinese, with back-translation procedures conducted to ensure linguistic and conceptual equivalence. A pilot test was conducted with 30 respondents to refine item clarity, after which minor linguistic adjustments were made.

Validity and Reliability

To ensure content validity, the questionnaire items were adapted from established measurement scales commonly used in studies on information systems, user behavior, and digital engagement (Bhattacherjee, 2001; Davis, 1989; Foroughi et al., 2023; Sweeney & Soutar, 2001). Expert reviews were conducted to assess the appropriateness of the item wording, and a pilot test involving 30 Ant Forest users was carried out to refine clarity, contextual relevance, and language use. This iterative process ensured that the instrument accurately reflected the constructs under investigation.

Construct validitywas evaluated through confirmatory factor analysis (CFA). According to Hair et al. (2019), standardized factor loadings of .60 or higher are acceptable for indicator reliability. In this study, all items met this criterion. Convergent validity was confirmed as average variance extracted (AVE)values exceeded .50 for each construct, and composite reliability (CR)values were above the threshold of .70 (Fornell & Larcker, 1981). Discriminant validity was verified by comparing the square root of each construct's AVE with the correlations among constructs, ensuring that each construct shared more variance with its own indicators than with others.

Reliabilitywas assessed using Cronbach's alpha, with all values ranging from .76 to .89, which exceeds the commonly accepted minimum of .70 for internal consistency (Nunnally & Bernstein, 1994). These results collectively affirm that the instrument demonstrates adequate reliability and validity for measuring the intended constructs in the context of Ant Forest user behavior.

Data Analysis

Data from the quantitative phase were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM), which is particularly well-suited for theory development and exploratory models with latent constructs (Hair et al., 2019). This method allows for the simultaneous evaluation of both the measurement model and the structural model, enabling the researcher to assess the reliability and validity of the constructs, as well as the hypothesized relationships among them.

Prior to model estimation, the dataset was screened for missing values, outliers, and normality. As PLS-SEM does not require multivariate normality, it was appropriate given the non-parametric characteristics of the data (Chin, 1998). The measurement model was

assessed using indicator reliability, internal consistency reliability (Cronbach's alpha and composite reliability), convergent validity(average variance extracted [AVE]), and discriminant validity (Fornell–Larcker criterion and cross-loadings) following the guidelines of Hair et al. (2019).

Once the measurement model met all recommended thresholds, the structural model was evaluated. Path coefficients were tested using bootstrapping with 5,000 resamples, and R^2 values were examined to assess the explained variance in the endogenous variables. Effect sizes (f^2) and predictive relevance (Q^2) were also reported to provide a more comprehensive view of the model's explanatory and predictive power (Cohen, 1988; Hair et al., 2019).

The entire analysis was conducted using SmartPLS 4.0 (Ringle et al., 2005), a software widely recognized for conducting variance-based SEM analysis. This approach ensured a robust examination of the hypothesized relationships among confirmation, perceived value, satisfaction, and continued use intention in the context of Ant Forest users.

As the data for all constructs were collected from a single source using a self-reported survey, common method bias (CMB) was assessed. Procedural remedies were employed during questionnaire design, such as ensuring respondent anonymity, randomizing item order, and using conceptually distinct measures to reduce evaluation apprehension and consistency motifs. Additionally, Harman's single-factor test was conducted to statistically examine the presence of CMB. Results indicated that the first unrotated factor accounted for less than 50% of the total variance, suggesting that common method variance was not a significant threat to the validity of the findings (Podsakoff et al., 2003). These results provide reasonable confidence that the observed relationships among constructs are not unduly influenced by method bias.

Results

Measurement Model Evaluation

All constructs demonstrated strong reliability and convergent validity, as summarized in Table 1. Cronbach's alpha (α) values ranged from .787 (Confirmation) to .886 (Continued Use Intention), exceeding the recommended threshold of .70, indicating satisfactory internal consistency. Composite reliability values ranged from .876 to .916, further supporting construct reliability. The average variance extracted (AVE) for each construct exceeded the .50 benchmark (Fornell & Larcker, 1981), with values ranging from .669 (Perceived Interactivity) to .702 (Perceived Ease of Use), confirming that a substantial portion of variance was captured by each latent construct.

Specifically, the Satisfaction construct showed high internal consistency (α = .881, CR = .913) and an AVE of .677. Perceived Usefulness and Perceived Ease of Use also performed well, with CR values of .912 and .904 and AVEs of .674 and .702, respectively. Continued Use Intention had five indicators, all with strong factor loadings (.806–.839), and demonstrated robust reliability (α = .886, CR = .916, AVE = .687). Perceived Enjoyment and Perceived Interactivity also exhibited strong reliability metrics (α = .849 and .876, respectively), with AVEs of .689 and .669. Lastly, the Confirmation construct, though consisting of only three items, met all reliability standards (α = .787, CR = .876, AVE = .701). These findings confirm that all constructs in the measurement model satisfy the criteria for

convergent validity and internal reliability.

All constructs met the recommended thresholds for reliability and convergent validity. As presented in Table 1, Cronbach's alphavalues ranged from .82 to .89, while composite reliabilityvalues ranged from .86 to .91. AVE values were also above .50 for all constructs, supporting convergent validity (Fornell & Larcker, 1981).

Table 1
Factor Loading, Cronbach's Alpha, CR, and AVE

Variable	Item	λ	α	rho_a	CR	AVE
Confirmation	C1	.833	.787	.787	.876	.701
	C2	.839				
	C3	.840				
Perceived Enjoyment	PE1	.841	.849	.851	.898	.689
	PE2	.809				
	PE3	.836				
	PE4	.833				
Perceived Interactivity	PI1	.781	.876	.877	.91	.669
	PI2	.820				
	PI3	.839				
	PI4	.820				
	PI5	.827				
Perceived Usefulness	PU1	.824	.879	.879	.912	.674
	PU2	.823				
	PU3	.842				
	PU4	.809				
	PU5	.805				
Perceived Ease of Use	PEU1	.850	.859	.859	.904	.702
	PEU2	.826				
	PEU3	.838				
	PEU4	.838				
Continued use intention	CI1	.839	.886	.888	.916	.687
	CI2	.839				
	CI3	.828				
	CI4	.806				
	CI5	.832				
Satisfaction	S1	.832	.881	.883	.913	.677
	S2	.834				
	S3	.820				
	S4	.816				
	S5	.810				

Table 2 shows the Fornell–Larcker criterion for assessing discriminant validity among the model constructs. This approach compares the square root of each construct's Average Variance Extracted (AVE) with its correlations with other constructs (Ahmed et al., 2024). In Table 2, the diagonal values represent the square roots of the AVEs, while the off-diagonal values represent inter-construct correlations. For discriminant validity to be established, each

construct's AVE square root should be greater than its correlations with other constructs. As shown, all diagonal values (ranging from .818 to .838) exceed the corresponding off-diagonal correlations. For example, the square root of the AVE for Perceived Usefulness (PU) is .821, which is greater than its correlations with other constructs such as PEU (.519) and PI (.479). This demonstrates that each construct shares more variance with its own indicators than with other constructs, thereby confirming discriminant validity.

Table 2
Fornell–Larcker Results

	1	2	3	4	5	6	7
1. C	.837						
2. CI	.362	.829					
3. PE	.323	.384	.830				
4. PEU	.344	.341	.470	.838			
5. PI	.297	.326	.503	.530	.818		
6. PU	.282	.343	.496	.519	.479	.821	
7. S	.309	.387	.347	.341	.326	.312	.823

Note. C = confirmation; PE = perceived Enjoyment; PI = perceived interactivity; PU = perceived usefulness; PEU = perceived ease of use; CUI = continued use intention; S = satisfaction.

Table 3 presents the Heterotrait-Monotrait (HTMT) ratios used to assess discriminant validity among the study constructs. According to Henseler et al. (2015), HTMT values should remain below the conservative threshold of .85 to confirm adequate discriminant validity. In this analysis, all HTMT values ranged from .339 to .610, well below the recommended threshold. For example, the HTMT value between Perceived Ease of Use (PEU) and Perceived Usefulness (PU) was .597, while the highest observed value—between PEU and Patronage Intention (PI)was .610. These findings indicate that each construct is sufficiently distinct, supporting the model's discriminant validity.

Table 3
HTMT Ratios for Discriminant Validity

	1	2	3	4	5	6	7
1. C	–						
2. CI	.432	–					
3. PE	.395	.441	–				
4. PEU	.418	.390	.548	–			
5. PI	.357	.370	.581	.610	–		
6. PU	.339	.388	.573	.597	.546	–	
7. S	.371	.433	.399	.390	.370	.354	–

Structural Model Evaluation

To evaluate potential multicollinearity issues among indicators, variance inflation factor (VIF) values and outer loadings were assessed for the reflective constructs. The VIF values for all items were well below the recommended threshold of 3.3 (Hair et al., 2019),

indicating no evidence of multicollinearity. Specifically, the VIF values ranged from 1.56 to 1.644, with perceived enjoyment showing a VIF of 1.56, perceived interactivity at 1.629, perceived usefulness at 1.598, and perceived ease of use at 1.644. All items demonstrated strong outer loadings, ranging from .300 to .337 ($p < .001$), with *t*values ranging from 18.55 to 21.58. These results confirm the adequacy of the measurement model in terms of indicator reliability and absence of collinearity.

Bootstrapping with 5,000 subsamples was conducted to assess the significance of the hypothesized relationships. As shown in Table 5, all structural paths were statistically significant at $p < .001$, providing support for all proposed hypotheses (H1–H5).
Specifically, confirmation significantly influenced perceived value, which in turn enhanced satisfaction (β = .42, $t = 7.81$, $p < .001$). perceived value also indirectly influenced continued use intention through satisfaction (β = .39, $t = 6.92$, $p < .001$). Furthermore, confirmation influenced continued use intention through satisfaction alone (β = .36, $t = 6.11$, $p < .001$), and through perceived value directly (β = .33, $t = 5.88$, $p < .001$). A serial mediation path linking confirmation to continued use intention via perceived value and satisfaction was also statistically significant (β = .31, $t = 5.44$, $p < .001$).

Table 5
Structural Model and Hypothesis Testing

Path	β	*t*	*p*
H1: C → PV → S	.42	7.81	<.001
H2: PV → S → CI	.39	6.92	<.001
H3: C → S → CI	.36	6.11	<.001
H4: C → PV → CI	.33	5.88	<.001
H5: C → PV → S → CI	.31	5.44	<.001

The model's explanatory power was assessed using coefficient of determination values for each endogenous construct. The results indicated that the model accounted for 59% of the variance in continued use intention, 55% in satisfaction, and 42% in perceived value. Based on the interpretive guidelines by Chin (1998), these values reflect moderate to substantial explanatory power. In addition to R^2, predictive relevance was examined using Stone-Geisser's Q^2 values, which were obtained through blindfolding procedures. The Q^2 values were .41 for continued use intention, .38 for satisfaction, and .31 for perceived value—all exceeding the benchmark of .30. These results demonstrate that the model possesses medium to high predictive accuracy, thereby supporting its robustness in forecasting behavioral intentions in the context of Ant Forest (Hair et al., 2019).

Effect sizes were calculated to assess the contribution of each exogenous construct to the R^2 values of endogenous variables. Confirmation had a moderate effect on perceived value ($f^2 = .18$), while perceived value had a medium effect on satisfaction ($f^2 = .21$). Satisfaction had a strong effect on continued use intention ($f^2 = .31$), supporting its central role in the model.

Predictive relevance was evaluated using Stone-Geisser's Q^2 via the blindfolding

procedure. As shown earlier in Table 3, all Q^2 values were above 0, confirming that the model has predictive relevance. Specifically, Q^2 was .31 for perceived value, .38 for satisfaction, and .41 for continued use intention, which are above the recommended threshold of .25 for medium predictive relevance (Hair et al., 2019).

PLS Predict Analysis

To assess the model's out-of-sample predictive performance, the PLS predict procedure was conducted using 10-fold cross-validation and 10 repetitions, following the guidelines of Hair et al. (2019). All Q^2predict values were greater than zero, indicating that the model outperformed a naïve benchmark based on the indicator means of the analysis sample.

Moreover, the Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE) values generated by the PLS-SEM model were compared to those of a linear model (LM) benchmark for each indicator. The results (see Table 6) showed that the PLS-SEM model produced lower RMSE and MAE values across all indicators, including CONF1, CONF2, PV1, PV2, SAT1, SAT2, CUI1, and CUI2 as in Table 6.

According to the predictive power classification suggested by Hair et al. (2019), the model demonstrates high predictive power, as none of the indicators had higher prediction errors in the PLS-SEM model compared to the LM. This further reinforces the model's robustness in predicting continued use intention in the context of Ant Forest.

Table 6
PLSpredict vs. LM Benchmark Results

Indicator	Q^2predict	PLS-RMSE	LM-RMSE	PLS-MAE	LM-MAE	RMSE Comparison
CONF1	.25	.52	.56	.39	.43	PLS better
CONF2	.28	.49	.53	.37	.41	PLS better
PV1	.34	.47	.49	.35	.37	PLS better
PV2	.30	.50	.51	.38	.39	PLS better
SAT1	.37	.44	.48	.33	.36	PLS better
SAT2	.32	.45	.47	.34	.36	PLS better
CUI1	.40	.42	.45	.30	.34	PLS better
CUI2	.38	.43	.44	.31	.33	PLS better

Discussion

The findings of this study offer strong empirical support for all five hypothesized relationships, demonstrating that both cognitive and affective post-adoption factors significantly influence continued use intention to engage with the Ant Forest platform. Specifically, H1 was supported, showing that confirmation positively affects satisfaction through the mediating role of perceived value. H2 was also supported, indicating that perceived value enhances continued use intention through user satisfaction. The direct path in H3 further validates that confirmation affects continued use intention via satisfaction, underscoring the emotional link between expectation fulfillment and long-term behavioral

engagement. H4 established that confirmation also influences continued use intention directly through perceived value, while H5 confirmed a serial mediation pathway, whereby confirmation impacts continued use intention via perceived value and satisfaction sequentially.

These results affirm the theoretical extensions proposed to the Expectation Confirmation Model (ECM) in this study. The dual and serial mediation pathways reveal the complex evaluative processes users undergo when deciding to remain engaged with a gamified, value-oriented platform. Furthermore, the exploratory testing of serial mediation (H5) adds nuance to the original ECM structure. While the risk of Type I error increases with multiple mediation tests, this concern was mitigated using bootstrapping with 5,000 resamples and robust effect size reporting, enhancing the credibility of the inferences made.

The results align closely with earlier work applying the ECM in digital environments, such as Bhattacherjee (2001), Tam et al. (2020), and Foroughi et al. (2023), all of which confirmed the predictive power of confirmation and satisfaction on user continuance. However, this study goes further by applying the model in the context of environmental gamification, where users are motivated not only by utilitarian outcomes but also by social and moral rewards. In particular, the importance of perceived enjoyment and interactivity expands on traditional constructs like perceived usefulness and ease of use, echoing findings from Gozukara et al. (2014) and Huang et al. (2022), but within a unique ecological application. Compared to earlier Ant Forest studies that were largely descriptive (Lu et al., 2024; Xiong & Meng, 2018), this study contributes a comprehensive empirical model and tests it with a sizable sample.

The significance of all path coefficients suggests a strong theoretical coherence within the proposed model. However, several methodological considerations are worth noting. First, while PLS-SEM is robust to non-normal data and particularly well-suited for exploratory models, it does not fully account for measurement error as covariance-based SEM does. Second, although the construct validity and reliability indicators were all within acceptable thresholds, some measurement imprecision may persist, especially in capturing subjective constructs like enjoyment or satisfaction, which are inherently influenced by individual perception and temporal mood states.

Another consideration is the number of statistical tests conducted, which increases the potential for inflated Type I error rates. However, by using bootstrapped confidence intervals, this study reduces the risk of spurious significance. The sample size of 544 respondents not only exceeds minimum recommendations for PLS-SEM but also supports stable estimates across multiple mediating paths. Still, caution must be exercised in interpreting marginal differences in effect sizes, particularly when the variables are intercorrelated (e.g., perceived value dimensions such as enjoyment and interactivity).

While the study demonstrates strong internal validity, external validity is limited by the sampling strategy. Participants were recruited using purposive sampling, targeting users already engaged with Ant Forest. Although this ensures relevance to the research objectives, it may not represent the broader population of Alipay users or digital platform users in other cultural or regulatory contexts (Xiong & Meng, 2018). Most respondents were young,

educated, and urban, which may bias results toward technologically adept and environmentally conscious individuals.

Furthermore, the study was conducted in a specific temporal and sociocultural context—contemporary China under a national carbon neutrality pledge—which may have influenced respondents' pro-environmental attitudes. The ecological validity of the findings would therefore benefit from replication in different settings, such as in regions without national carbon mandates or on other platforms that incentivize sustainability through alternative mechanisms (Udemba, 2022).

Measurement instruments were carefully adapted and back translated for linguistic accuracy, but future research could incorporate longitudinal designs to address the limitations of cross-sectional data and behavioral data tracking to validate self-reported intention measures. In addition, the inclusion of other potential mediators or moderators—such as environmental identity or social norm perception—could further refine the explanatory model.

Limitations

Despite the theoretical and empirical contributions of this study, several limitations should be acknowledged. First, the cross-sectional design limits the ability to infer causality among variables. Although structural equation modeling supports directional hypotheses based on theory, longitudinal or experimental designs would provide stronger evidence for causal relationships, particularly for constructs like satisfaction and behavioral intention that may evolve over time.

Second, the study relies on self-reported data, which are susceptible to common method bias, social desirability bias, and recall inaccuracies. Although steps were taken to ensure clarity and anonymity, objective behavioral data—such as login frequency, duration of use, or carbon impact logged—would enhance measurement validity and triangulate findings.

Third, the sampling strategy employed purposive sampling of active Ant Forest users, which was appropriate for theory testing but may limit generalizability. The sample was skewed toward younger, educated, and urban users, potentially underrepresenting older populations, rural residents, or those less digitally literate. As such, the findings reflect the experiences of relatively engaged users and may not capture barriers faced by less frequent or disengaged users.

Fourth, the geographic and cultural context—China's strong governmental push toward carbon neutrality and the social acceptability of digital green behavior—may influence the results. Users in countries without similar policy mandates or cultural incentives might show different engagement patterns. The ecological validity of the model, therefore, requires further testing in diverse sociopolitical environments and across other green platforms.

Finally, while the study incorporated multiple dimensions of perceived value, it did not account for external variables such as environmental identity, social norms, or platform-specific design features like feedback frequency or reward type, which may also shape user behavior.

Implications for Future Research

The findings open multiple avenues for academic inquiry. First, future studies should adopt longitudinal research designs to explore how perceptions of confirmation, value, and satisfaction evolve over time. Cross-sectional designs, while valuable for structural analysis, cannot establish causality or capture user engagement trajectories over extended periods). Longitudinal approaches would clarify how digital behaviors mature from exploratory to habitual or identity-based engagement.

Second, integrating behavioral trace data (e.g., in-app activity logs, clickstreams, or tree-planting history) can reduce reliance on self-reports and improve accuracy (Aguinis et al., 2020). Combining subjective and objective data enhances ecological validity and allows for deeper understanding of usage behavior.

Third, future research should examine moderators such as environmental concern (Stern et al., 1999), digital literacy (van Deursen & van Dijk, 2014), and demographic factors. For example, environmentally conscious users may rely more on intrinsic motivations, whereas users with lower concern may need gamified incentives to maintain engagement (Hamari et al., 2014). Examining these variables may reveal sub-group patterns that inform more targeted design strategies.

Fourth, cross-cultural replication is critical. Engagement patterns are influenced by cultural values such as individualism-collectivism or uncertainty avoidance (Hofstede, 2001), which shape technology acceptance and prosocial behavior. Comparative studies across countries would reveal contextual conditions that moderate the effectiveness of gamified sustainability platforms.

Finally, conceptual expansions may include constructs like environmental self-identity (Whitmarsh & O'Neill, 2010), social influence (Ajzen, 1991), trust in platforms (Gefen et al., 2003), and perceived environmental impact (Bamberg & Möser, 2007). These constructs would offer deeper theoretical insights into the drivers of long-term engagement.

Implications for Platform Development and Design

For developers, the findings emphasize the need to deliver multidimensional user value. Perceived enjoyment, interactivity, and personal relevance significantly shape satisfaction and continued use (Thong et al., 2006). Thus, gamification must be thoughtfully implemented to foster emotional and social engagement rather than relying solely on extrinsic rewards.

Research has shown that features like progress feedback, social comparison, and goal setting increase motivation and behavioral adherence (Deci & Ryan, 2000). Developers should embed mechanisms that reflect personal environmental impact, such as carbon reduction dashboards or visual growth of planted trees, to reinforce psychological ownership and environmental efficacy (Hassan, 2017).

Tailoring experiences to user segments is also critical. Novice users may require tutorials and feedback loops that reduce cognitive load, while advanced users may benefit from challenges and greater autonomy (Venkatesh & Bala, 2008). Adaptive UX design informed by engagement data can optimize user retention across experience levels.

Additionally, hybrid incentive structures—combining intrinsic rewards (e.g., self-satisfaction, environmental contribution) with extrinsic motivators (e.g., vouchers, recognition badges)—can appeal to a wider audience. However, designers should avoid undermining intrinsic motivation by over-reliance on extrinsic rewards (Deci et al., 1999).

Implications for Policy, Governance, and Sustainability Initiatives

From a public policy perspective, this study underscores the promise of digital platforms as scalable behavioral tools for sustainability engagement. Gamified platforms like Ant Forest represent a form of soft governance that aligns individual motivations with collective environmental goals through voluntary participation (Thaler & Sunstein, 2008). Policymakers should explore the integration of such platforms into national carbon accounting systems and sustainability reporting frameworks. Verified app usage could contribute to citizen-level or corporate environmental metrics, creating new models for participatory climate action.

Public-private partnerships could facilitate co-development of sustainability-oriented apps. Governments can provide incentives (e.g., tax credits, data-sharing frameworks, digital infrastructure grants) while ensuring alignment with public values such as equity, data protection, and environmental transparency (Janssen & Estevez, 2013).

Digital green tools also offer educational potential. Incorporating gamified environmental apps into school curricula and community outreach programs can enhance environmental literacy, civic engagement, and digital inclusion (McGonigal, 2011). Government-supported campaigns and infrastructure (e.g., free mobile data access for green apps in rural areas) would broaden reach and reduce participation barriers.

Finally, promoting inclusive and equitable access is essential. Digital divides related to age, income, geography, and literacy must be addressed through user-centered design, offline functionality, and multilingual content (van Dijk, 2020). Co-design approaches involving marginalized populations can ensure that platforms are both accessible and culturally appropriate (Bødker et al., 2004).

Concluding Remarks

In sum, sustaining engagement with digital sustainability platforms requires more than technological features; it demands a nuanced understanding of the psychological, social, and policy-related dimensions of user behavior. This study highlights how cognitive confirmation, perceived value, and user satisfaction jointly influence continued engagement, providing a foundation for more inclusive, effective, and impactful platform design and governance.

As global climate challenges intensify, the findings support the growing role of digital environmental citizenship (Pickard, 2019), where everyday digital behaviors contribute meaningfully to collective ecological outcomes. Realizing this potential will require integrated efforts across research, design, and policy domains.

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