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Gamification in C2C Secondary Marketplace Apps: From Motivating Sustainable Behavior to Unintended Overconsumption

Abstract

Purpose This study integrates affordance theory and self-determination theory to examine how gamification affordances on consumer-to-consumer (C2C) secondary marketplace apps influence users' pro-environmental behaviors. Drawing on the concepts of warm glow and moral licensing, it investigates how pro-environmental actions via apps may unintentionally lead to overconsumption.

Design/methodology/approach We recruited 613 respondents who had recently used Xianyu, a leading C2C secondary marketplace app in China, to sell their unwanted possessions. Data were analyzed using SmartPLS 4.0 to test the proposed path relationships.

Findings The findings showed that instrumental and hedonic affordances, but not social affordances, are crucial for enhancing pro-environmental motivations. Users' engagement in pro-environmental actions is driven by autonomous (intrinsic) and controlled (extrinsic) motives. Engaging in pro-environmental actions via apps can increase the warm glow effect, which, in turn, may unintentionally contribute to overconsumption behaviors, including over-purchase, hedonic consumption, and impulse purchase. Moral licensing strengthened the impact of warm glow on hedonic consumption and impulse purchase.

Originality This research offers a novel perspective by demonstrating how gamification affordances promote pro-environmental behaviors yet may indirectly drive overconsumption through the emotional benefits of these actions. By highlighting both positive motivations and potential unintended consequences, this study provides a comprehensive understanding of gamification's impact in C2C secondary marketplaces.

Practical implications This study suggests C2C secondary marketplace apps can design gamified elements to sustain pro-environmental motivations while reducing overconsumption by leveraging instrumental and hedonic affordances, emphasizing long-term environmental impact, and mitigating moral licensing through ongoing commitment.

Keywords affordance theory; self-determination theory; warm glow; moral licensing; pro-environmental behaviors; overconsumption

1. Introduction

1.1 C2C Secondary Marketplace

Consumer-to-consumer (C2C) secondary marketplaces refer to platforms that enable direct transactions between consumers outside primary business-to-consumer channels (Zhang *et al.*, 2023b). The rise of these apps provides a convenient and efficient way for customers to sell possessions they no longer need (Moriuchi and Takahashi, 2022). These apps not only facilitate the exchange of used items among customers but also offer a practical solution for extending the life cycle of possessions and promoting sustainable behaviors (Cano *et al.*, 2023). In addition to well-known platforms like eBay and Vinted, some brands (e.g., H&M, New Balance) have launched their own marketplaces to allow customers to trade directly (Hultberg

and Pal, 2023; Ludmir, 2024). This trend demonstrates businesses' ongoing commitment addressing customers' pro-environmental needs (Arman and Mark-Herbert, 2022).

1.2 Gamification in C2C Secondary Marketplaces and Pro-Environmental Behaviors

Gamification, which is the use of game elements in non-game contexts, can effectively enhance user engagement and shape behaviors in various digital contexts (Huang *et al.*, 2019). It has been increasingly used to encourage pro-environmental behaviors (Zhou *et al.*, 2023). Prior research has demonstrated that gamified elements, such as rewards, leaderboards, and social influence, can encourage sustainable actions, including energy conservation, recycling, and eco-friendly transportation choices (Chen *et al.*, 2024; Hsu, 2022; Kazhamiakin *et al.*, 2021). In C2C secondary marketplace apps, gamified elements like point systems, badges, and challenges help maintain user engagement and promote environmentally conscious practices, thereby supporting circular economy principles (Godinho Filho *et al.*, 2024).

1.3 Research Gap and Study Contribution

C2C secondary marketplaces are commonly seen as promoting sustainable consumption by enabling the resale and reuse of goods, but they may also unintentionally drive excessive consumption (Ma *et al.*, 2019). This unintended outcome may stem from the warm glow effect, where users feel emotional gratification (Hartmann *et al.*, 2017), and moral licensing, where prior good actions justify environmentally harmful behaviors (Merritt *et al.*, 2010; Lasarov and Hoffmann, 2020). The availability of recycling options can reframe disposal as moral and make consumers feel more justified in purchasing items that they may not need (van Doorn and Kurz, 2021; Jeong, 2025).

Although gamification has been widely recognized for enhancing motivation and engagement in sustainable behavior, its potential to trigger unintended psychological processes remains underexplored. This study addresses that gap by integrating affordance theory (Gibson, 1977) and self-determination theory (SDT) (Deci and Ryan, 2000) to explore how gamified elements influence motivations and behaviors. Affordance theory highlights action possibilities offered by platform design, whereas SDT explains whether motivations are driven intrinsically or extrinsically. Building on this integrated framework, we further examine how gamification affordances facilitate pro-environmental actions, which can generate a warm glow response and may unintentionally promote various forms of overconsumption. We also examine the role of moral licensing as a moderating mechanism that can intensify the relationship between warm glow and indulgent consumption behaviors.

1.4 Aim and Objectives

This research investigates how gamification affordances in C2C secondary marketplace apps influence user motivation toward pro-environmental behaviors and whether these behaviors can unintentionally lead to overconsumption. Using Xianyu, the largest C2C secondary marketplace app in China (Fan, 2023), as the empirical context, this study aims to examine how gamification affordances in C2C secondary marketplace apps influence users' intrinsic and extrinsic motivations toward pro-environmental behaviors, investigate how warm glow and moral licensing shape the relationship between pro-environmental behaviors and overconsumption in C2C secondary marketplace apps, and discuss the business implications of leveraging gamification to promote sustainable behaviors while addressing the potential risks associated with overconsumption.

This study contributes theoretically by integrating affordance theory with SDT to offer a nuanced view of how digital platforms influence both positive and unintended consumer behaviors. Practically, the findings provide guidance for platform designers and marketers to maximize the benefits of gamification without exacerbating overconsumption.

2. Theoretical Background

2.1 Affordance Theory and Gamification Affordances

Affordance refers to how individuals perceive the potential actions that an object can afford or accommodate (Gibson, 1977). For example, a C2C secondary marketplace offers users opportunities to earn financial returns by selling unwanted items. Affordance theory has been widely applied in gamification studies to discover the extent to which users in a gamified system perceive the possible actions they can perform (Oppong-Tawiah *et al.*, 2020). Gamification affordances refer to the degree to which gamified elements support user actions and goals (Zhang *et al.*, 2023a; Hamari, 2017). Previous studies have conceptualized different types of gamification affordances, ranging from goals supported by fundamental functions, such as earning points and rewards, to more sophisticated motivational mechanisms, such as fostering interactions and obtaining feedback (Hassan *et al.*, 2019; Shen *et al.*, 2020). For clarity and parsimony, these affordances are grouped in this study into three broad categories based on the classification of Huang and Zhou (2021) and Wang *et al.* (2022): instrumental affordances (e.g., earning rewards), social affordances (e.g., facilitating social interaction), and hedonic affordances (e.g., supporting self-expression). Each of these affordance categories, along with their distinct characteristics and influences on user motivation in C2C secondary markets, is further explained in Appendix A.

2.2 Self-Determination Theory

SDT explains people's intrinsic and extrinsic motives driving individual behaviors (Deci and Ryan, 1985). It describes how individuals act in a self-determined manner to the degree to which they align their actions with these motivations. The applications of the theory have been wide-ranging, including students' learning outcomes and engagement (Chiu, 2021), healthy lifestyles (Gillison *et al.*, 2019), and business leadership (Kanat-Maymon *et al.*, 2020). These studies described how people were influenced by different types of motivation and how these motivations shaped their behaviors (Deci and Ryan, 2000). Additionally, prior literature has demonstrated the effectiveness of SDT in explaining users' engagement in information systems and pro-environmental behaviors (Koo and Chung, 2014; Ng *et al.*, 2024).

Deci and Ryan (2000) distinguished different types of motivations, from the most self-determined (intrinsic motives) to the least self-determined (extrinsic motives). An individual may engage in pro-environmental behaviors driven by intrinsic motivation, such as a personal commitment to environmental protection, or extrinsic motivation, such as fulfilling social expectations. These intrinsic and extrinsic motivations could also be conceptualized as a continuum that moves from autonomous to controlled levels, where autonomous motivation reflects personal interests and beliefs, whereas controlled motivation shows action influenced by pressures/obligations from forces extrinsic to the self (Deci and Ryan, 2000; Koo and Chung, 2014). SDT provides insights into various motivations and offers an in-depth understanding of individual behaviors (Kelley and Alden, 2016). Based on the taxonomy of human motivation developed by Ryan and Deci (2000), which distinguishes between intrinsic and extrinsic

motivations through the perceived locus of causality, we conceptualize the five types of motivations into two broad categories: autonomous (intrinsic) and controlled (extrinsic). Further details on the two broad categories of motivation and their associated types of motivations are provided in Appendix B.

2.3 Warm Glow

The warm glow theory was originally developed in economics and focuses on the psychological benefits derived from the act of giving to charity (Andreoni, 1990). It describes the emotional gratification that individuals experience when contributing to the public or social good (Nunes and Schokkaert, 2003). This concept aligns with negative-state relief theory, which suggests that individuals engage in pro-social behaviors to alleviate negative emotions and experience positive feelings (Bae, 2023; Catlin and Wang, 2013). Prior studies have explored the impact of warm glow across various pro-social contexts such as charitable donation (Lilley and Slonim, 2014) and purchasing fair-trade products (Iweala *et al.*, 2019). In an environmental context, warm glow fosters a sense of personal fulfillment when individuals perceive their actions as environmentally responsible (Hartmann *et al.*, 2017). Unlike traditional cost-benefit evaluations, warm glow emphasizes psychological benefits that extend beyond financial or time-related costs (Lv *et al.*, 2024).

Warm glow can be viewed from two perspectives: anticipated, the expected psychological rewards from pro-social behavior, and experienced, the actual emotional gratification from such actions (Hartmann *et al.*, 2017; van Doorn and Kurz, 2021). This study focuses on experienced warm glow in C2C secondary marketplaces and examines how resale and recycling contributes to users' emotional gratification. While this experienced warm glow can reinforce sustainable actions (e.g., Bazaraa *et al.*, 2022), it may also create a sense of reduced personal responsibility toward consumption, whereby users perceive their purchases as less environmentally harmful because of their engagement in resale and recycling activities (Catlin and Wang, 2013). This mechanism may unintentionally contribute to overconsumption. Prior literature has shown that interventions aimed at reducing environmental impacts can sometimes backfire; this phenomenon is known as the rebound effect (Andrew and Pigosso, 2024). For example, improvements in energy efficiency, such as LED lighting and energy-efficient appliances, can lead to a relaxation of energy-saving behaviors and offset potential energy-savings (Andrew and Pigosso, 2024). van Doorn and Kurz (2021) offered a novel perspective on the psychological mechanism of warm glow as a driver of unintended consequences. Their research demonstrated that when presented with recycling options, people may psychologically frame their waste creation as a contribution to the collective good that elicits a warm-glow effect that reinforces consumption.

2.4 Moral Licensing

Pro-environmental behaviors often involve individuals' moral concerns and are thus considered moral behaviors (Steg and Vlek, 2009). People perceive themselves as moral beings and take steps to uphold their moral image in response to their moral or immoral actions and surrounding conditions. Moral behaviors involve a compensatory mechanism in which people who have engaged in past moral behaviors believe that they are entitled or licensed to engage in other problematic behaviors (Merritt *et al.*, 2010). In contrast, people who have engaged in negative behaviors are more likely to subsequently perform positive behaviors; this is known as moral cleansing (Jordan *et al.*, 2011). Similar to the neutralization theory of Matza and Sykes (1957), individuals justify their immoral behaviors by rationalization, such as

claiming that the behavior is beyond their control or that it causes minimal harm. One of rationalization techniques, the 'metaphor of the ledger', is comparable to moral licensing, where individuals feel entitled to engage in negative actions by compensating with prior positive behavior (Klockars, 1974; Siponen and Vance, 2010). Lasarov and Hoffmann (2020) explained that moral licensing operates like 'an internal bank account' from which individuals acquire moral credits by acting good but withdraw credits to pay for bad actions. Prior studies have shown that individuals who recall their past behaviors are more likely to engage in subsequent problematic behaviors, such as climate-related behavior, including meat consumption and air travel (Burger *et al.*, 2022), and energy consumption (Tiefenbeck *et al.*, 2013).

3. Research Model and Hypotheses

Building on the models proposed by Huang and Zhou (2021) and Xu *et al.* (2022), we adopted the paradigm that conceptualizes 'gamification affordances–psychological outcomes–behavioral outcomes' as the foundation for this study. Our research model investigates how different gamification affordances influence various user motivations. Additionally, we examine the mechanisms linking pro-environmental behaviors to overconsumption by incorporating the potential roles of warm glow and moral licensing. Recognizing that demographic factors may also affect pro-environmental and consumption behaviors (Patel *et al.*, 2017), four demographic variables (gender, age, education level, and income) were included in the model as control variables. Furthermore, to account for potential response biases, social desirability was included as an additional control variable. Figure 1 illustrates the research model.

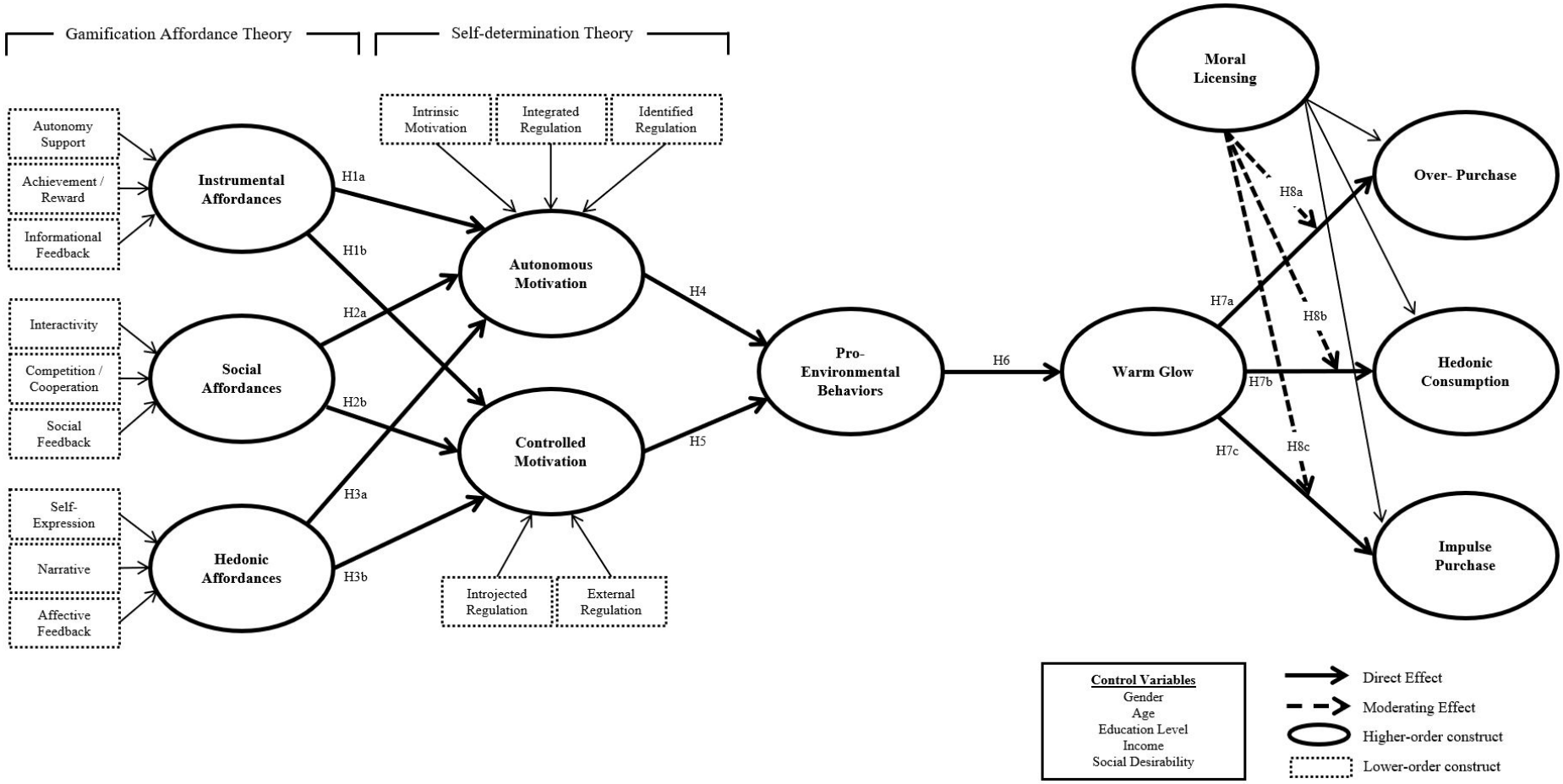

Figure 1 The Research Model
Source: Authors' own work

3.1 Gamification Affordances and Motivation

Prior studies have indicated that instrumental affordances not only increase user engagement and perceived consumption value (Cha *et al.*, 2024) but also motivate users to perform pertinent behaviors (Shin, 2022). Instrumental affordances, such as the possibility of earning points and receiving relevant feedback, play a crucial role in sustaining user engagement. For example, Mills and Allen (2020) found that instrumental affordances can be internalized into intrinsic motivation by enhancing personal satisfaction and reinforcing a sense of achievement, thereby encouraging sustainable behaviors. Sailer *et al.* (2017) demonstrated that instrumental affordances significantly boost users' perceived competence and task meaningfulness, thereby reinforcing intrinsic motivation through behavior-guiding rewards and performance tracking. Hamari (2017) showed that instrumental affordances, such as badges as rewards, function as social markers that influence social validation. Overall, instrumental affordances provide users with opportunities for personal choice, reward attainment, and access to useful information, which can positively influence both intrinsic and extrinsic motivations for engaging in pro-environmental behaviors. Thus, the following hypotheses are proposed:

H1a: Instrumental affordances positively influence autonomous motivation.
H1b: Instrumental affordances positively influence controlled motivation.

Social affordances can enhance users' perceived value of the system and strengthen their psychological ownership of behavioral contexts, thereby increasing user involvement in targeted behaviors (Shi *et al.*, 2022; Xu *et al.*, 2022). For example, Wang and Wang (2025) found that social affordances act as an extrinsic motivational force by fostering social connections and community engagement, which, in turn, enhances users' commitment to the platform. Li *et al.* (2024) demonstrated that social interactions and collaboration toward shared community goals provide users with personal enjoyment, further reinforcing their engagement. This sense of belonging and connection can shape users' self-concept by internalizing the values of the marketplace, integrating them into their identities (Steg *et al.*, 2016). Therefore, social affordances influence both intrinsic and extrinsic motivations for pro-environmental behaviors in C2C secondary marketplaces. The following hypotheses are proposed:

H2a: Social affordances positively influence autonomous motivation.
H2b: Social affordances positively influence controlled motivation.

The pursuit of hedonic goals is recognized as a key component in encouraging pro-environmental actions (Steg *et al.*, 2014). For example, Palos-Sanchez *et al.* (2024) found that users are more likely to engage with platforms when they perceive their usage experience as enjoyable and entertaining. Moreover, hedonic affordances offer users opportunities for self-expression and emotional connections to the platform's values, which foster a deeper sense of personal involvement (Jia and Yu, 2025). These experiences enhance individual satisfaction and reinforce personal values, which further motivates engagement in sustainable practices (Du *et al.*, 2025). By making pro-environmental actions both enjoyable and emotionally rewarding, hedonic affordances strengthen users' motivations to engage and promote their continued participation in pro-environmental behaviors. Therefore, the following hypotheses are proposed:

H3a: Hedonic affordances positively influence autonomous motivation.
H3b: Hedonic affordances positively influence controlled motivation.

3.2 Motivation and Pro-Environmental Behaviors

Numerous behavioral theories inherently incorporate both autonomous and controlled motivations. For example, in the theory of planned behavior (Ajzen, 1991), attitudes reflecting autonomous motivation and subjective norms denote controlled motivation. Value-belief-norm theory (Stern *et al.*, 1999) and goal framing theory (Lindenberg and Steg, 2007) also consider personal and social influences on individual behaviors. These frameworks have been widely applied to understanding pro-environmental behaviors by acknowledging the influence of intrinsic (autonomous) and extrinsic (controlled) motivators (e.g., Lee *et al.*, 2023). More specifically, prior research has demonstrated that SDT provides an effective framework for predicting pro-environmental actions and has highlighted the importance of considering both types of motivation (e.g., Ng *et al.*, 2024). In C2C secondary marketplace apps, users' engagement in pro-environmental behaviors is influenced by both intrinsic (e.g., personal values and attitudes) and extrinsic motivations (e.g., social considerations). Therefore, the following hypotheses are proposed:

H4: Autonomous motivation positively influences pro-environmental behaviors.
H5: Controlled motivation positively influences pro-environmental behaviors.

3.3 Pro-Environmental Behaviors, Warm Glow, and Overconsumption

Prior studies have shown that individuals experience positive emotional gratification (i.e., warm glow) when engaging in pro-social or pro-environmental behaviors (Hartmann *et al.*, 2017; Taufik *et al.*, 2015). Emotional experience makes people feel positive and reinforces their sense of correctness for continued engagement in such behaviors (Lv *et al.*, 2024). C2C secondary marketplace apps, which emphasize their role in supporting environmental sustainability and promoting a circular economy, can trigger the psychological satisfaction of warm glow by highlighting the positive impact of users' actions (Jeong, 2025). When individuals sell unwanted products via these platforms, they may feel a sense of pride and accomplishment, believing that their actions contribute meaningfully to environmental sustainability. Therefore, we propose the following hypothesis:

H6: Pro-environmental behaviors positively influence warm glow.

Despite their environmental benefits, recycling options can inadvertently increase resource use. Catlin and Wang (2013) found that individuals use more resources (e.g., paper) when recycling is available, and Qi and Roe (2017) showed that informing consumers about composting can lead to more food waste than simply highlighting landfill effects, indicating a potential rebound effect. Warm glow, the positive emotional gratification from pro-environmental behaviors, can further encourage additional consumption. van Doorn and Kurz (2021) showed that warm glow leads individuals to perceive their actions as environmentally responsible, promoting continued purchasing. Similarly, Sun and Trudel (2017) found that anticipation of recycling increased consumption beyond functional needs. Karmarkar and Bollinger (2015) also found that shoppers using reusable bags were more likely to buy indulgent products. Collectively, these studies suggested that emotional gratification from pro-environmental behaviors can unintentionally encourage overuse or indulgent consumption.

We extend this argument by emphasizing that warm glow plays a crucial role in C2C secondary marketplaces. Consumers may believe that additional purchases do not exacerbate environmental issues because resale and recycling reduce waste while simultaneously

contributing to waste reduction (Arman and Mark-Herbert, 2022). Therefore, we hypothesize that pro-environmental behaviors in these marketplaces increase warm glow, which, in turn, raises the likelihood of overconsumption.

We conceptualize overconsumption as over-purchase, hedonic consumption, and impulsive buying (Håkansson, 2014; Ananda *et al.*, 2023). Over-purchase refers to buying more than needed (Talwar *et al.*, 2022). Hedonic consumption refers to buying for pleasure rather than necessity (Liu *et al.*, 2020). Impulse purchase involves unplanned buying driven by immediate urges (Trivedi *et al.*, 2022). Francke and Carrete (2023) conceptualized overconsumption as a self-regulation failure. According to Baumeister (2002), such failures include deficits in goal monitoring, emotion regulation, and impulse control: over-purchase reflects goal-monitoring failures, hedonic consumption arises from emotion-regulation deficits, and impulse purchase results from poor inhibitory control (Becker *et al.*, 2024; Sun *et al.*, 2024).

Therefore, we propose the following hypotheses:

H7a: Warm glow positively influences over-purchase.
H7b: Warm glow positively influences hedonic consumption.
H7c: Warm glow positively influences impulse purchase.

3.4 The Moderating Effect of Moral Licensing

Prior studies have proven the impact of moral licensing on individuals engaging in immoral or unethical behaviors (Blanken *et al.*, 2015). For example, Xu *et al.* (2020) found that individuals who engaged in environmentally friendly behaviors in one setting (e.g., daily habits) were less likely to sustain these behaviors while traveling. Similarly, Burger *et al.* (2022) found that pro-environmental actions could be followed by actions that offset their benefits. Moral licensing can be triggered by contextual cues, such as feedback or framing. For instance, Tiefenbeck *et al.* (2013) found that participants who received positive feedback for reducing their water consumption subsequently increased their electricity use. Similarly, Clot *et al.* (2022) showed that individuals who were nudged to take environmentally friendly actions initially responded positively, but when the action was framed as a moral act (e.g., signing a petition), they later exhibited more indulgent behaviors. These findings highlight that moral licensing is not an automatic outcome of pro-environmental behaviors but rather a contextually induced and subjective psychological state.

In this study, we conceptualize moral licensing not as a consequence of pro-environmental behaviors but as a belief system that interacts with individuals' emotional responses. Users who experience warm glow from sustainable actions on C2C secondary marketplaces (e.g., reselling unused items) may develop a sense of moral entitlement. The effect of warm glow on overconsumption is amplified when users endorse moral licensing—the idea that prior good deeds justify later indulgent or less environmentally responsible actions (McCarthy, 2024). Therefore, we propose the following hypotheses:

H8a: Moral licensing positively moderates the relationship between warm glow and over-purchase.
H8b: Moral licensing positively moderates the relationship between warm glow and hedonic consumption.
H8c: Moral licensing positively moderates the relationship between warm glow and impulse purchase.

In addition to the proposed moderation hypotheses, the research model (Figure 1) also incorporated the direct effects of moral licensing on overconsumption. Including these direct effects enables a proper interpretation of the moderation effects (Hair *et al.*, 2022).

4. Methodology

4.1 The Study Context

This research specifically focuses on Xianyu (literally 'Idle Fish'), a subsidiary of Alibaba and the largest C2C secondary marketplace apps in China, with a daily transaction volume exceeding 1 billion yuan (approximately USD 140 million) (Fan, 2023). As of December 2024, more than 600 million registered users are actively engaged with this platform, with an annual growth rate of 30% (Fan, 2024). Xianyu has been actively promoting the environmental benefits of waste reduction and carbon emissions reduction through product trading among users (Sayers, 2022). It incorporates gamified elements such as points, user performance tracking, comparisons among users, and forums for social interactions to encourage recycling, reuse, and sustainable consumption. It thus provides an ideal context for studying the impact of gamification on pro-environmental behaviors and its potential unintended effects on overconsumption.

4.2 Data Collection

We commissioned a professional online survey company, SoJump (https://www.wjx.cn/), which has access to a user base of 300 million people in China. The demographic profile of respondents is presented in Table 1. Details regarding sampling procedures, inclusion and exclusion criteria, survey administration, and data cleaning are provided in Appendix C.

Table 1 Demographic characteristics

Variable	Characteristics	N = 613	%
Gender	Male	297	48.45%
	Female	316	51.55%
Age (years old)	18 - 20	7	1.14%
	21 - 25	92	15.01%
	26 - 30	133	21.70%
	31 - 35	222	36.22%
	36 - 40	98	15.99%
	41 - 45	22	3.59%
	46 - 50	26	4.24%
	More than 50	13	2.12%
Monthly Family Income (in RMB)	Less than 10,000	48	7.83%
	10,001 - 30,000	204	33.28%
	30,001 - 60,000	172	28.06%
	60,001 - 100,000	79	12.89%
	100001 - 150,000	58	9.46%
	More than 150,001	52	8.48%
Highest Level of Education	Secondary or below	24	3.92%
	Associate degree or higher diploma	81	13.21%
	Bachelor's degree	423	69.00%
	Master's degree	78	12.72%
	PhD or doctoral degree	7	1.14%
Selling Frequency in the Past 3 months	Once	68	11.09%
	Twice	223	36.38%
	Three times	255	41.60%
	Four times or more	67	10.93%

Source: Authors' own work

4.3 Measures

All measurement items were adapted from prior literature, and their reliability and validity were confirmed through pre-testing. Details of the pre-test procedures, translation, item modifications, and social desirability control are provided in Appendix D, while the full list of measurement items is presented in Appendix E.

4.4 Data Analysis

Partial least squares structural equation modelling (PLS-SEM) was employed for data analysis using SmartPLS 4.0. Detailed justifications for using PLS-SEM, along with the reflective-formative modeling approach, higher-order construct estimation, and model settings, are provided in Appendix F.

5. Results

5.1 Common Method Bias

To assess common method bias (CMB), we applied Harman's single-factor test using SPSS. The results indicated that the variance explained by the first factor was 32.84% (less than 50%), suggesting that CMB was not a significant concern in this study (Podsakoff *et al.*, 2003).

5.2 Measurement Model

A reflective-formative model was adopted to assess the relationships between the lower- and higher-order constructs (Becker *et al.*, 2012). According to Hair *et al.* (2022), the measurement model is evaluated to examine the reliability and validity of the proposed model by assessing

indicator reliability, internal consistency, convergent validity, and discriminant validity for reflective constructs, and convergent validity, multicollinearity, and the relevance and significance of indicators for the formative constructs.

The assessment of reliability and validity of the reflective measurement model is presented in Appendix G. Discriminant validity was assessed using Heterotrait-monotrait (HTMT) ratio (Appendix H). The formative measurement model was assessed for multicollinearity, significance of outer weights, and convergent validity. Detailed results are provided in Appendix I. The combined assessments of the reflective and formative measurement models indicate that all evaluation criteria recommended by Hair *et al.* (2022) were satisfactorily met, providing strong evidence of the reliability and validity of the proposed model.

5.3 Structural Model

Before assessing structural relationships, multicollinearity was examined using VIF values, which ranged from 1.132 to 2.674, below the recommended threshold of 3.33 (Hair *et al.*, 2019), indicating that multicollinearity was not an issue.

Following Hair *et al.* (2022), the structural model was assessed by calculating path coefficients and t-values to examine the relationships between constructs, using the PLS bootstrap method with 10,000 subsamples. As shown in Table 2, instrumental affordances positively influenced autonomous motivation ($\beta = 0.335$, $p < 0.001$) and controlled motivation ($\beta = 0.243$, $p < 0.001$), supporting H1a and H1b. Social affordances had non-significant effects on autonomous motivation ($\beta = 0.158$, $p > 0.05$) and controlled motivation ($\beta = 0.173$, $p > 0.05$), rejecting H2a and H2b, while hedonic affordances positively influenced autonomous motivation ($\beta = 0.555$, $p < 0.001$) and controlled motivation ($\beta = 0.252$, $p < 0.001$), supporting H3a and H3b. Autonomous motivation ($\beta = 0.627$, $p < 0.001$) and controlled motivation ($\beta = 0.348$, $p < 0.001$) positively influenced pro-environmental behaviors, supporting H4 and H5. Pro-environmental behaviors positively influenced warm glow ($\beta = 0.648$, $p < 0.001$), supporting H6. Warm glow positively affected over-purchase ($\beta = 0.293$, $p < 0.001$), hedonic consumption ($\beta = 0.514$, $p < 0.001$), and impulse purchase ($\beta = 0.334$, $p < 0.001$), supporting H7a, H7b, and H7c. All significant relationships were supported by 95% confidence intervals that did not include zero, indicating the robustness and stability of the estimated coefficients. Effect sizes (f^2) were interpreted following Cohen (1988) (i.e., $f^2 \geq 0.35$ indicates a large effect, $0.15 \leq f^2 < 0.35$ a medium effect, and $0.02 \leq f^2 < 0.15$ a small effect). Most paths showed at least a small effect, with notable medium-to-large effects for the effect of instrumental affordances on autonomous motivation ($f^2 = 0.176$), hedonic affordances on autonomous motivation ($f^2 = 0.333$), autonomous motivation on pro-environmental behaviors ($f^2 = 0.502$), pro-environmental behaviors on warm glow ($f^2 = 0.269$), warm glow on hedonic consumption ($f^2 = 0.287$), and warm glow on impulse purchase ($f^2 = 0.266$) (Table 2).

The explanatory power of the model was evaluated using R^2 values following Hair *et al.* (2022): R^2 values of 0.75, 0.50, or 0.25 can be described as substantial, moderate, and weak, respectively. The R^2 values for autonomous motivation ($R^2 = 0.583$), controlled motivation ($R^2 = 0.429$), pro-environmental behaviors ($R^2 = 0.426$), warm glow ($R^2 = 0.420$), over-purchase ($R^2 = 0.484$), hedonic consumption ($R^2 = 0.696$), and impulse purchase ($R^2 = 0.528$) were greater than the recommended criterion benchmark of 0.10 (Chin, 1998), indicating that that the endogenous constructs were accurately explained by the exogenous constructs in the research model (Table 2). Overall, the model demonstrates moderate to substantial explanatory power across key endogenous variables.

Table 2 Assessment of structural model

Hypothesis	Std beta	p-value	CI	f^2	R^2
Autonomous motivation					0.583
H1a: INA → AMO	0.335	< 0.001	[0.242; 0.423]	0.176	
H2a: SOC → AMO	0.158	n.s.	[-0.132; 0.277]	0.007	
H3a: HEA → AMO	0.555	< 0.001	[0.470; 0.643]	0.333	
Controlled motivation					0.429
H1b: INA → CMO	0.243	< 0.001	[0.131; 0.346]	0.024	
H2b: SOC → CMO	0.173	n.s.	[-0.008; 0.288]	0.010	
H3b: HEA → CMO	0.252	< 0.001	[0.140; 0.362]	0.032	
Pro-environmental behaviors					0.426
H4: AMO → PEB	0.627	< 0.001	[0.541; 0.708]	0.502	
H5: CMO → PEB	0.348	< 0.001	[0.248; 0.433]	0.006	
Warm glow					0.420
H6: PEB → WAG	0.648	< 0.001	[0.592; 0.706]	0.269	
Over-purchase					0.484
H7a: WAG → OVP	0.293	< 0.001	[0.172; 0.386]	0.139	
Hedonic consumption					0.696
H7b: WAG → HEC	0.514	< 0.001	[0.488; 0.627]	0.287	
Impulse purchase					0.528
H7c: WAG → IMP	0.334	< 0.001	[0.241; 0.421]	0.266	
Moderating effect					
H8a: MOR × WAG → OVP	0.044	n.s.	[-0.008; 0.117]	0.009	
MOR → OVP	0.238	< 0.001	[0.136; 0.341]	0.054	
H8b: MOR × WAG → HEC	0.108	< 0.05	[0.028; 0.184]	0.020	
MOR → HEC	0.304	< 0.001	[0.178; 0.392]	0.022	
H8c: MOR × WAG → IMP	0.092	< 0.05	[0.015; 0.126]	0.018	
MOR → IMP	0.257	< 0.001	[0.141; 0.364]	0.045	
Control variable					
Gender → WAG	-0.054	n.s.	[-0.245; 0.115]		
Gender → PEB	-0.028	n.s.	[-0.082; 0.133]		
Gender → OVP	0.033	n.s.	[-0.093; 0.167]		
Gender → HEC	0.095	n.s.	[-0.046; 0.211]		
Gender → IMP	-0.023	n.s.	[-0.461; 0.098]		
Age → WAG	-0.060	n.s.	[-0.180; 0.006]		
Age → PEB	-0.008	n.s.	[-0.072; 0.135]		
Age → OVP	-0.068	n.s.	[-0.168; 0.077]		
Age → HEC	0.024	n.s.	[-0.120; 0.028]		
Age → IMP	0.096	n.s.	[-0.004; 0.287]		
Education → WAG	0.052	n.s.	[-0.026; 0.142]		
Education → PEB	-0.008	n.s.	[-0.074; 0.060]		
Education → OVP	0.018	n.s.	[-0.034; 0.070]		
Education → HEC	0.041	n.s.	[-0.021; 0.098]		
Education → IMP	0.016	n.s.	[-0.035; 0.067]		
Monthly income → WAG	0.026	n.s.	[-0.053; 0.107]		
Monthly income → PEB	-0.060	n.s.	[-0.153; 0.033]		
Monthly income → OVP	0.035	n.s.	[-0.052; 0.152]		
Monthly income → HEC	0.029	n.s.	[-0.060; 0.119]		
Monthly income → IMP	-0.117	n.s.	[-0.309; 0.051]		
Social desirability bias → WAG	0.036	n.s.	[-0.044; 0.144]		
Social desirability bias → PEB	0.016	n.s.	[-0.076; 0.100]		
Social desirability bias → OVP	-0.075	n.s.	[-0.261; 0.090]		
Social desirability bias → HEC	-0.037	n.s.	[-0.151; 0.052]		
Social desirability bias → IMP	-0.117	n.s.	[-0.309; 0.051]		

Note: AMO = Autonomous motivation, CMO = Controlled motivation, HEA = Hedonic affordances, HEC = Hedonic consumption, IMP = Impulse purchase, INA = Instrumental affordances, MOR = Moral licensing, OVP = Over-purchase, PEB = Pro-environmental behaviors, SOC = Social affordances, WAG = Warm glow; n.s. = non-significant (p > 0.05).
Source: Author's own work

5.4 Moderating Result

The moderation effect of moral licensing was examined using the two-stage approach because of its robustness and higher statistical power in detecting interaction effects. The two-stage approach is widely regarded as the standard for moderation analysis in PLS-SEM due to its

universal applicability to both formative and reflective constructs (Hair *et al.*, 2022; Sarstedt *et al.*, 2019). Constructs (warm glow and moral licensing) were split into high and low groups based on their mean scores (Moon *et al.*, 2023). The results in Table 2 showed that moral licensing significantly moderated the relationships between warm glow and hedonic consumption ($\beta = 0.108$, $p < 0.05$), and between warm glow and impulse purchase ($\beta = 0.092$, $p < 0.05$), with 95% confidence intervals excluding zero, confirming stability and significance. Effect sizes were small for hedonic consumption ($f^2 = 0.020$) and impulse purchase ($f^2 = 0.018$). Direct effects also indicated that moral licensing significantly influenced over-purchase ($\beta = 0.238$, $p < 0.001$), hedonic consumption ($\beta = 0.304$, $p < 0.001$), and impulse purchase ($\beta = 0.257$, $p < 0.001$) respectively. The moderation effect was plotted (see Figures 2 and 3), indicating that the higher the level of moral licensing, the stronger the positive relationship between warm glow and hedonic consumption, as well as between warm glow and impulse purchase.

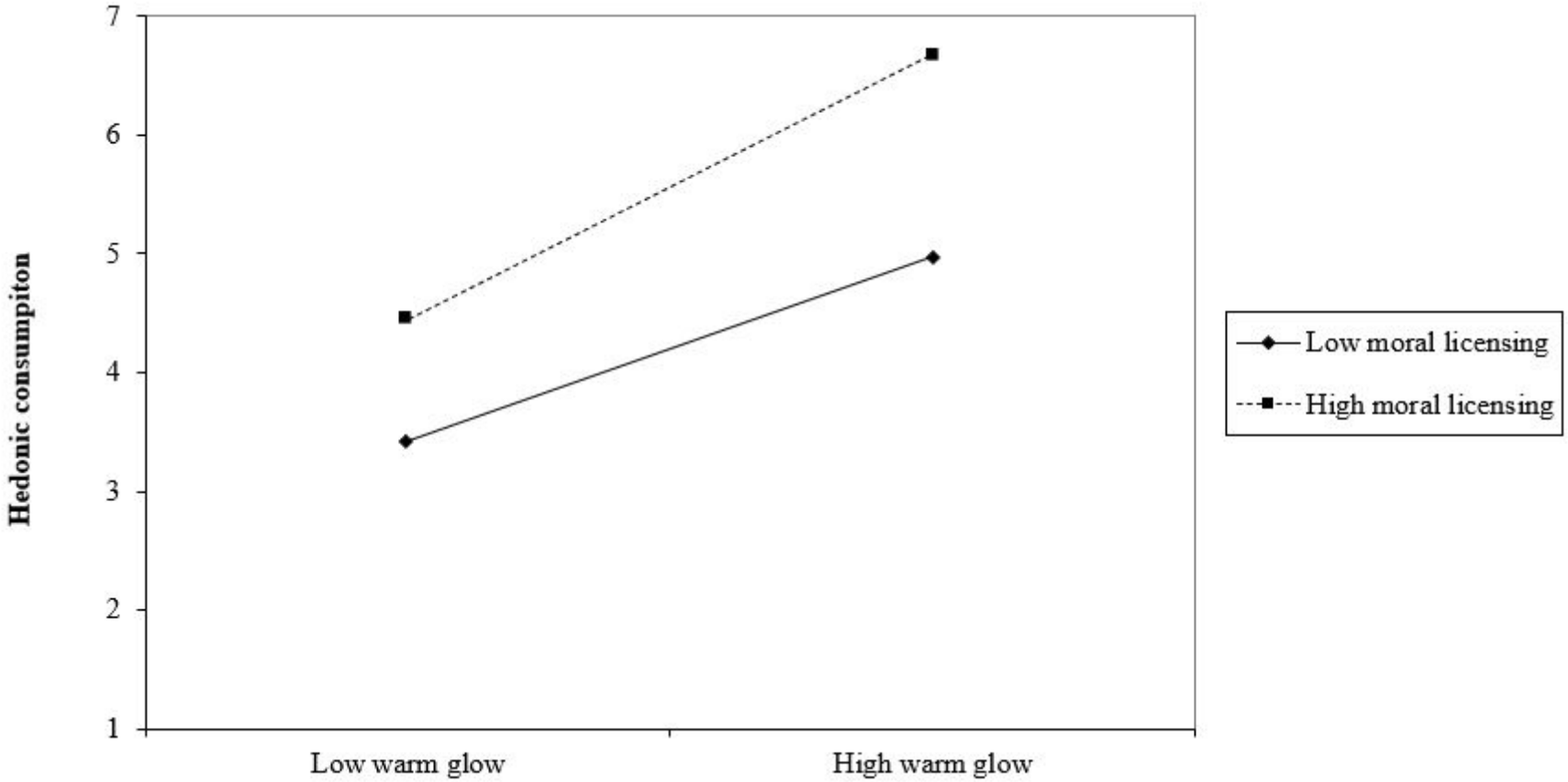

Figure 2 Interaction plot of warm glow and moral licensing on hedonic consumption
Source: Author's own work

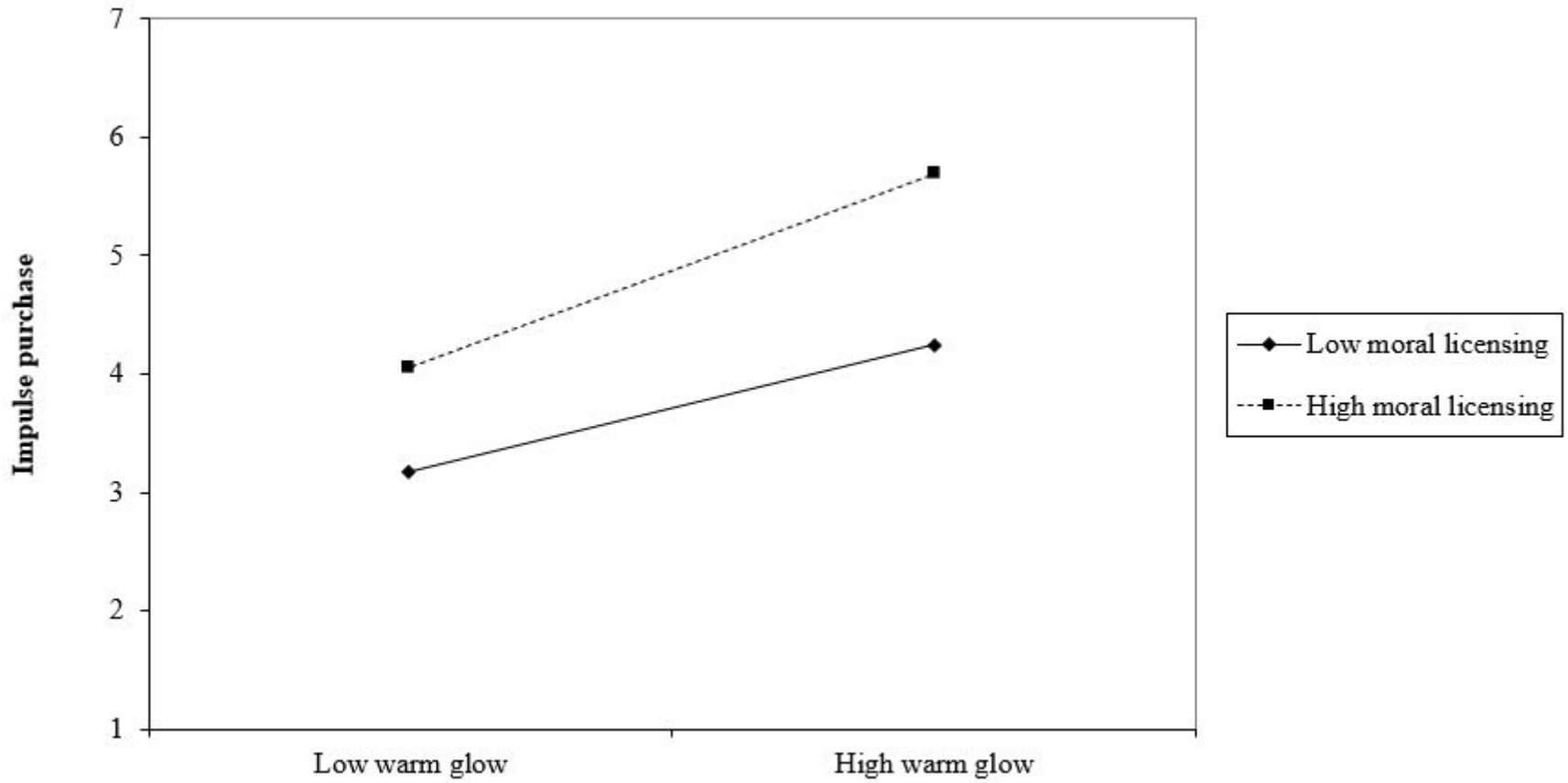

Figure 3 Interaction plot of warm glow and moral licensing on impulse purchase
Source: Author's own work

6. Discussion and Implications

6.1 Theoretical Implications

This study makes two significant contributions to literature. First, we examine the impact of gamification affordances in C2C secondary marketplace apps on users' pro-environmental motivations. The findings show that instrumental and hedonic affordances, but not social affordances, influence intrinsic and extrinsic motivations. This suggests that gamified elements that support user goals and enrich experiences are central to shaping pro-environmental motivations (Cha *et al.*, 2024). Contrary to previous research (e.g., Huang and Zhou, 2021), social affordances appear less important in C2C marketplaces. While these gamified elements facilitate interaction, they appear less effective in strengthening pro-environmental motivations. Unlike household recycling or organic purchasing, which are tied to social norms (Canova *et al.*, 2023), selling items via C2C apps is more individualistic and task-oriented, driven mainly by personal benefits (Jang and Kim, 2023). As these actions are less visible than other pro-environmental behaviors, social affordances become less influential (Uren *et al.*, 2021). This pattern is especially evident among younger to middle-aged users, who prioritize convenience and already satisfy social needs through other platforms such as social media or messaging apps (Atay and Ashlock, 2022). Furthermore, our findings reveal that both autonomous and controlled motivations influence pro-environmental behaviors, suggesting they are driven by both intrinsic and extrinsic motives (Aviste and Niemiec, 2023). Integrating gamification affordances with SDT thus offers a comprehensive understanding of the key gamification affordances and motivational forces that contribute to users' pro-environmental actions.

Second, this study extends gamification research that primarily focused on positive outcomes, such as citizenship behaviors (Xu *et al.*, 2022) and user engagement (Zhang *et al.*, 2023a), by investigating how C2C secondary marketplace apps may also unintentionally promote overconsumption. Users who recycle items experience psychological rewards, specifically a warm glow effect, which drives over-purchase, hedonic consumption, and impulsive buying. van Doorn and Kurz (2021) explained that recycling second-hand items can be perceived as morally correct behavior, encouraging continued purchasing under the assumption that items can later be resold. In line with moral licensing theory (Merritt *et al.*, 2010), our findings demonstrate that when individuals perceive that they have engaged in moral behaviors in the past, the impact of warm glow on hedonic consumption and impulse purchase is strengthened. However, this moderating effect does not extend to over-purchase behavior, suggesting that individuals feel entitled to indulge in pleasurable or spontaneous purchases, but not in excessive volume-based consumption, which is more typically driven by situational and contextual factors (Jhawar *et al.*, 2024). Overall, this study offers deeper insights into the psychological mechanisms underlying gamified sustainability interventions and help explain the potential pitfalls in their design.

6.2 Practical Implications

This study offers valuable insights for platform developers on designing gamification affordances that enhance pro-environmental motivation while mitigating the unintended consequences of warm glow and moral licensing. A key challenge lies in balancing the encouragement of sustainable behaviors with the risk of overconsumption, that is, the moral dilemma faced by C2C secondary marketplace platforms. We propose the following strategies to reinforce sustained pro-environmental motivations through instrumental and hedonic

affordances, reduce overconsumption by emphasizing long-term environmental impact over short-term gratification (warm glow), and mitigate moral licensing by fostering a long-term commitment to sustainable behavior.

Our findings show that instrumental and hedonic affordances are central to motivating pro-environmental behaviors. Developers should prioritize instrumental affordances such as feedback, rewards, and analytics to track environmental contributions (Grgecic *et al.*, 2015), alongside hedonic affordances like storytelling and community-driven sustainability activities that make sustainable consumption engaging (Cha *et al.*, 2024).

Since warm glow may encourage overconsumption, platforms could integrate tools that track long-term consumption and resale (Lim *et al.*, 2025). Highlighting cumulative impacts of buying and selling, rather than short-term gratification, can help users see sustainability as an ongoing contribution, strengthening both environmental outcomes and platform engagement. Educational content embedded in apps can further raise awareness of overconsumption's environmental costs (Lučić and Uzelac, 2024).

To reduce moral licensing, platforms should promote features that emphasize long-term progress, such as achievements, challenges, and leaderboards (Cao and Solangi, 2023). Community-driven gamified elements, like sustainability pledges and community accountability, can reinforce ongoing pro-environmental engagement and discourage justification of future indulgence.

These strategies also carry broader societal implications. As C2C secondary marketplaces shape consumption habits, they can shift users from linear (buy-use-dispose) to circular (reuse-resell-repurpose) models (Konietzko *et al.*, 2019; Schwanholz and Leipold, 2020). Mitigating warm glow and moral licensing helps prevent a false sense of sustainability and ensures that pro-environmental actions lead to real benefits. Ultimately, reinforcing continuous engagement through digital platforms can raise awareness of collective impacts and influence social norms toward responsible consumption.

7. Conclusion and Further Research

This study integrated affordance theory and SDT to explain how gamification affordances in C2C secondary marketplace apps shape user motivations, pro-environmental behaviors, and unintended overconsumption. Results show that instrumental and hedonic affordances enhance pro-environmental motivations, driven by both autonomous and controlled motives. Importantly, engaging in sustainable actions through apps fosters warm glow, which can unintentionally trigger over-purchase, hedonic, and impulse consumption. Moral licensing strengthens the relationship between warm glow and both hedonic and impulsive consumption. These findings clarify the psychological mechanisms underlying gamified sustainability interventions and highlight the impact of such platforms, in both promoting and potentially undermining sustainability.

Several limitations suggest directions for future research. First, this study focused on sellers using Xianyu in China; extending analyses to other platforms and cultures could reveal how motivations differ across collectivist and individualist contexts (Yang *et al.*, 2024; Tam and Chan, 2017). Second, the cross-sectional design limits its ability to establish causal inference; longitudinal studies could better capture how sustained engagement with gamified elements shapes long-term behaviors and consumption patterns. Third, reliance on self-reported survey

data risks recall bias; future work should use objective behavioral data (e.g., app usage records) to validate findings. Fourth, our categorization of gamification affordances as instrumental, social, and hedonic may simplify their dynamic interplay. Future research could develop more dynamic frameworks to capture the fluid and multifaceted roles of gamified elements.

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Appendix A – Extended Discussion of Gamification Affordances

This categorization aligns with goal framing theory (Lindenberg and Steg, 2007) that distinguishes three overarching goals influencing individuals' decision-making and behaviors: a *gain goal* refers to the instrumental benefits of an action; a *normative goal* deals with the appropriateness of actions in social settings; and a *hedonic goal* stresses individual pleasure and satisfaction (Soliman and Tuunainen, 2022).

Instrumental Affordances

Instrumental affordances refer to the system's functionalities—such as tools, points, information, and so on—that enable users to accomplish certain goals or act upon tasks more efficiently and effectively (Grgecic *et al.*, 2015). In the present study, instrumental affordances are conceptualized into three key subdimensions: autonomy support, achievement and reward, and informational feedback. Autonomy support refers to the extent to which a system offers flexibility in terms of personal choices (Du *et al.*, 2020). Achievement and reward mechanisms include points and badges that recognize and induce desired behaviors (Shen *et al.*, 2020). Informational feedback provides real-time updates for customers to better understand their performance and facilitates decision-making (Hassan *et al.*, 2019). These subdimensions of instrumental affordances enhance user motivation and engagement by aligning system functionalities with user needs.

Social Affordances

Social affordances refer to the capabilities of a system to support interaction, exert peer influence, and facilitate social comparison (e.g., leaderboards, team challenges, etc.). In this study, we conceptualize social affordances into three key subdimensions: interactivity, competition/cooperation, and social feedback (Du *et al.*, 2020; Xu *et al.*, 2022). Interactivity facilitates user communication and interaction (Xu *et al.*, 2022). Competition allows users to compare their performance with that of others, whereas cooperation fosters teamwork and collective effort to achieve goals (Aebli, 2019; Suh and Wagner, 2017). Social feedback refers to opportunities to provide and receive comments, praise, or even criticism from the user community within a system (Hamari and Koivisto, 2015). These social affordances foster a sense of connectedness and leverage social interactions to motivate users to engage in the gamified system.

Hedonic Affordances

Hedonic affordances refer to system features that enhance user satisfaction by providing opportunities for enjoyable and entertaining experiences, such as aesthetic design and personalization, allowing users to engage in ways that reflect their individual preferences and desires (Wang *et al.*, 2022). We identified three subdimensions of hedonic affordances: self-expression, affective feedback, and narrative. Self-expression refers to the extent to which users can express their values and identities by creating their own avatars and personalized progress (Shi *et al.*, 2022). Conversely, affective feedback refers to the users' enjoyment and positive experiences derived from the recognition of their own achievements (Xu *et al.*, 2022). Narrative refers to compelling storytelling messages that motivate users to engage in behavioral contexts (Zhang *et al.*, 2023). These affordances complement instrumental and social affordances by offering emotional experiences desired by users.

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Appendix B - Extended Discussion of Autonomous and Controlled Motivation

Autonomous Motivation

Autonomous motivation refers to individuals' internal motives, including intrinsic motivation, integrated regulation, and identified regulation (Ma and Shen, 2024). Intrinsic motivation refers to the inherent satisfaction and enjoyment individuals derive from engaging in specific behaviors; integrated regulation highlights how these behaviors align with personal interests and values; identified regulation reflects the perceived importance of these behaviors (Deci and Ryan, 2000; De Groot and Steg, 2010). For example, when an individual chooses to find ways to recycle a piece of second-hand clothing, he/she is motivated by a personally rewarding experience (i.e., intrinsic motivation), the alignment with own environmental values (i.e., integrated regulation), and the perceived importance of recycling for environmental protection (i.e., identified regulation). Overall, autonomous motivation emphasizes how individuals are motivated by internal motives that guide their behaviors.

Controlled Motivation

Individual behaviors are also influenced by controlled motivation, in which individuals engage in behaviors to achieve external goals and meet social expectations (Luqman *et al.*, 2018). Controlled motivation refers to external motives, including introjected regulation (Masson and Otto, 2021) and external regulation (Ma and Shen, 2024). Introjected regulation involves engaging in behaviors to avoid guilt or anxiety, whereas external regulation pertains to performing behaviors to obtain rewards or fulfill external requirements (Mills and Allen, 2020; Zhang *et al.*, 2015). In the context of pro-environmental behaviors, an individual who recycles regularly is motivated by alleviating guilt associated with the negative environmental impact (i.e., introjected regulation) and demonstrating the social recognition for the sustainable practices (Adams *et al.*, 2020; Caniëls *et al.*, 2021). Therefore, controlled motivation clarifies how people engage in behaviors driven by external influences.

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Appendix C – Survey Administration and Data Cleaning Procedures

A purposive sampling technique was used to select the sample for this study to reduce non-response bias (Tan, 2018). To ensure relevance, respondents were included if they had used the Xianyu app in the past three months and had sold at least one used item on the app during that period. Respondents were excluded if they were under 18 years of age or had not engaged in selling activity on Xianyu in the past three months. Eligible participants were invited to complete the survey. When participants were invited to complete the survey, they were first informed about the purpose of the study, which explores how the gamified elements of the Xianyu app influence pro-environmental behaviors and consumption patterns. These gamified elements were defined and described to participants, such as rewards, leaderboards, social feedback, progress tracking, interactivity, competition and cooperation, self-expression, and narrative engagement. This ensured that the participants had a clear understanding of the concepts before proceeding with the survey. The survey was conducted between 13 and 27 March 2025. We received 628 responses. To ensure reliability, a thorough data cleaning process was performed to define missing data before analysis. Of the 628 responses, 12 were excluded because they were incomplete, specifically when participants did not provide answers to the main constructs in our research model (i.e., gamification affordances, pro-environmental motivations and behaviors, warm glow, moral licensing, and overconsumption behaviors).

The average response time required to complete the questionnaire was 7.13 minutes. To ensure data quality, an expected minimum response time of 3 minutes was established, and responses completed in under 2 minutes were considered to contain fictitious answers (Steelman *et al.*, 2014). By adopting a more conservative approach, participants who completed the survey in less than 3 minutes were excluded from the analysis. We identified three respondents who completed the survey in less than 3 minutes; therefore, they were excluded from the study. A total of 613 valid responses were collected. The demographic information of respondents is presented in Table 1.

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Appendix D – Pre-Test Procedures and Measurement Validation

All items used in this study were adapted from previous literature, tested for reliability and validity, and adjusted to fit the research context. A seven-point Likert scale (1 = strongly disagree, 7 = strongly agree) was employed to measure the influence of gamification affordances, motivations, warm glow, and moral licensing on user behaviors. Additionally, a seven-point scale (1 = never, 7 = always) was used to assess pro-environmental behaviors and three overconsumption behaviors: over-purchase, hedonic consumption, and impulse purchase. A forward-back translation was adopted to translate the original measurement items from English into Chinese to ensure accuracy (Douglas and Craig, 2007). Three independent researchers and two industry practitioners were invited to assess the clarity and relevance of the measurement items. Moreover, a pre-test was conducted to ensure the comprehensibility of the measures. We invited 20 participants who had experience in using a secondary marketplace app and had made purchases over the past 3 months to participate in the pre-test. According to the feedback from the participants, some sentences were perceived as repetitive, such as 'The gamified elements of the Xianyu app offer me the possibility to make independent decisions about my selling activities to support environmental protection' and 'The gamified elements of the Xianyu app offer me the possibility to make contributions of my selling activities to environmental protection visible to others'. To address the repetitive issue, we simplified the measurement items to ensure accuracy and ease of understanding. Furthermore, to enhance readability, some wording was modified for consistency and conciseness, such as replacing 'environmental sustainability' with 'environmental protection'. The pre-test was subsequently analyzed, and the results indicated that all constructs exceeded a Cronbach's alpha of 0.7.

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Appendix E – Measurement Items

The items for autonomy support, interactivity, competition/cooperation, and self-expression were adapted from Xu *et al.* (2022). Achievement/reward was adapted from the measurement items established by Shi *et al.* (2022). Informational, social, and affective feedback were modified from Hassan *et al.* (2019). Narrative was measured using the measurement items developed by Zhang *et al.* (2023). The items for autonomous and controlled motivation were measured based on the measurement items by Koo and Chung (2014) and Ng *et al.* (2024). Warm glow and moral licensing were measured using the measurement items developed by van Doorn and Kurz (2021) and Xu *et al.* (2020) respectively. Finally, the constructs of pro-environmental behaviors adapted the measurement items from Liu *et al.* (2024), over-purchase from Mathur (2024), hedonic consumption from Liapati *et al.* (2015), and impulse purchase from Shen and Khalifa (2012). Additionally, to account for potential social desirability bias, we included items from the Social Desirability Scale-17 (Stöber, 2001). These items assessed the extent to which participants responded in a socially acceptable rather than truthful manner. Following the procedure recommended by Larson (2019), items were administered in a True/False format and aggregated into a total score (0 = False; 1 = True). The composite score was included as a control variable.

Construct	Measurement Items	Source
Instrumental Affordances		
Autonomy support (AUS) [1]	The gamified elements of the Xianyu app offer me the possibility to: • AUS1 make independent selling decisions to support environmental protection. • AUS2 decide for myself how to support environmental protection through my selling activities. • AUS3 experience a sense of choice and freedom in selling to support environmental protection.	Xu *et al.* (2022)
Achievement/ Reward (ACH) [1]	The gamified elements of the Xianyu app offer me the possibility to: • ACH1 obtain rewards in recognition of my selling efforts toward environmental protection. • ACH2 achieve good selling performance that contributes to environmental protection. • ACH3 gain financial benefits through my selling activities that help protect the environment.	Shi *et al.* (2022)
Informational feedback (INF) [1]	The gamified elements of the Xianyu app offer me the possibility to: • INF1 understand how my selling activities contribute to environmental protection. • INF2 access useful information about the environmental impact of my selling activities. • INF3 make informed decisions on how my selling activities can support environmental protection. • INF4 track useful statistics on the environmental benefits of my selling activities.	Hassan *et al.* (2019)
Social Affordances		

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Interactivity (INT) [1]	The gamified elements of the Xianyu app offer me the possibility to: • INT1 interact with other users for supporting environmental protection. • INT2 connect with other users on environmental protection through my selling activities. • INT3 participate in dialogues with other users about environmental protection.	Xu *et al.* (2022)
Competition/ Cooperation (COM) [1]	The gamified elements of the Xianyu app offer me the possibility to: • COM1 compete with other sellers in contributing to environmental protection. • COM2 compare the environmental benefits of my selling activities with others. • COM3 influence others' status rankings in environmental protection through my participation.	
Social feedback (SOC) [1]	The gamified elements of the Xianyu app offer me the possibility to: • SOC1 receive comments and likes from other users on my environmental protection efforts. • SOC2 feel good when others recognize the impact of my selling activities on environmental protection. • SOC3 make the environmental impact of my selling activities visible to others. • SOC4 pay attention to the environmental impact of others' selling activities on the platform.	Hassan *et al.* (2019)
Hedonic Affordances		
Self-expression (SEE) [1]	The gamified elements of the Xianyu app offer me the possibility to: • SEE1 express my environmental identity. • SEE2 express my contributions to environmental protection in my own way. • SEE3 present my contributions to environmental protection in a unique manner.	Xu *et al.* (2022)
Narrative (NAR) [1]	The gamified elements of the Xianyu app offer me the possibility to: • NAR1 engage with narratives that highlight real-world environmental protection. • NAR2 connect with narratives that promote environmental protection. • NAR3 feel involved in a story advocating for environmental protection and resonate with its characters.	Zhang *et al.* (2023)
Affective feedback (AFF) [1]	The gamified elements of the Xianyu app offer me the possibility to: • AFF1 feel satisfied when seeing how my selling activities contribute to environmental protection. • AFF2 have fun while browsing my activity reports on environmental protection. • AFF3 feel good when reviewing my statistics on environmental protection.	Hassan *et al.* (2019)

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	• AFF4 feel enjoyment when viewing the environmental benefits resulting from my selling history.	
Autonomous Motivation		
Intrinsic motivation (INM) [1]	• INM1 I find pleasure in learning new ways to help the environment through the Xianyu app. • INM2 I find pleasure in enhancing environmental quality by using the Xianyu app. • INM3 I feel good about taking pro-environmental actions through the Xianyu app.	Koo and Chung (2014)
Integrated regulation (INR) [1]	• INR1 Being environmentally responsible through the Xianyu app is an integral part of my life. • INR2 Using the Xianyu app to protect the environment has become fundamental to my identity. • INR3 Using the Xianyu app to support environmental protection has become a key part of my lifestyle. • INR4 By using the Xianyu app, I take care of both myself and the environment.	
Identified regulation (IDR) [1]	• IDR1 Using the Xianyu app is a sensible way to contribute to environmental protection. • IDR2 I choose to use the Xianyu app as a way to contribute to environmental protection. • IDR3 Using the Xianyu app is a reasonable choice for contributing to environmental protection.	
Controlled Motivation		
Introjected regulation (IJR) [1]	• IJR1 I would regret not using the Xianyu app to help the environment and support future generations. • IJR2 I would feel guilty if I did not use the Xianyu app to help the environment and future generations. • IJR3 I would feel ashamed if I did not use the Xianyu app to help the environment.	Koo and Chung (2014)
External regulation (EXR) [1]	• EXR1 Others will be upset if I don't use the Xianyu app to help protect the environment. • EXR2 I use the Xianyu app to gain recognition from others for my contributions to environmental protection. • EXR3 I use the Xianyu app to avoid criticism for not being committed to environmental protection.	Ng *et al.* (2024)
Global Single-item Criterion Measure		
Instrumental Affordances [1]	Overall, the gamified elements of the Xianyu app offer me the possibility to use tools that help me accomplish tasks related to environmental protection.	Cheah *et al.* (2018)
Social Affordances [1]	Overall, the gamified elements of the Xianyu app offer me the possibility to interact with others in order to support environmental protection.	
Hedonic Affordances [1]	Overall, the gamified elements of the Xianyu app offer me the possibility to enjoy my experience of supporting environmental protection.	

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Autonomous Motivation [1] Controlled Motivation [1]	Overall, I use the Xianyu app because supporting environmental protection is inherently important to me. Overall, I use the Xianyu app because I feel compelled by external pressures to do so.	
Pro-environmental behaviors, Warm Glow and Moral Licensing		
Pro-environmental behaviors (PEB) [2]	• PEB1 I engage in pro-environmental behaviors through my use of the Xianyu app. • PEB2 I reduce resource waste by using the Xianyu app. • PEB3 I make no efforts to reduce my waste production by using the Xianyu app. [R]	Liu *et al.* (2024)
Warm glow (WAG) [1]	• WAG1 I feel positive about using the Xianyu app to engage in pro-environmental behaviors. • WAG2 I would feel bad about myself if I decided to use Xianyu app to engage in pro-environmental behaviors. [R] • WAG3 I would feel positive about my decision to use the Xianyu app to engage in pro-environmental behaviors.	van Doorn and Kurz (2021)
Moral licensing (MOR) [1]	• MOR1 Using the Xianyu app for pro-environmental actions justifies doing less environmentally friendly things. • MOR2 When I recycle or sell items on the Xianyu app, I feel entitled to waste resources elsewhere, like using more energy. • MOR3 Selling used products on the Xianyu app compensates for the environmental harm caused by buying new items. • MOR4 Reducing waste on the Xianyu app does not compensate for environmental impacts elsewhere. [R]	Xu *et al.* (2020)
Over-consumption		
Over-purchase (OVP) [2]	• OVP1 After selling items on the Xianyu app, I buy more products than I actually need. • OVP2 After selling items on the Xianyu app, I purchase items in larger quantities than necessary. • OVP3 After selling items on the Xianyu app, I buy more than I need for daily use.	Mathur (2024)
Hedonic consumption (HEC) [2]	• HEC1 After selling items on the Xianyu app, I feel curious about exploring new products to purchase. • HEC2 Selling items on the Xianyu app makes me eager to seek out other new and exciting shopping experiences. • HEC3 After selling items on the Xianyu app, I enjoy discovering unique items to buy.	Liapati *et al.* (2015)
Impulse purchase (IMP) [2]	• IMP1 After selling items on the Xianyu app, I feel sudden urges to buy things that I hadn't planned for. • IMP2 After selling items on the Xianyu app, I purchase items that are not on my prepared shopping list.	Shen and Khalifa (2012)

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	• IMP3 Selling items on the Xianyu app triggers my impulse to make other unplanned purchases. • IMP4 After selling items on the Xianyu app, I find myself buying things I hadn't intended to purchase.	
Control Variables		
Social desirability [3]	• I sometimes litter. [R] • I always admit my mistakes openly and face the potential negative consequences. • In traffic I am always polite and considerate of others. • I always accept others' opinions, even when they don't agree with my own. • I take out my bad moods on others now and then. [R] • There has been an occasion when I took advantage of someone else. [R] • In conversations I always listen attentively and let others finish their sentences. • I never hesitate to help someone in case of emergency. • When I have made a promise, I keep it—no ifs, ands, or buts. • I occasionally speak badly of others behind their back. [R] • I would never live off other people. • I always stay friendly and courteous with other people, even when I am stressed out. • During arguments I always stay objective and matter-of-fact. • There has been at least one occasion when I failed to return an item that I borrowed. [R] • I always eat a healthy diet. • Sometimes I only help because I expect something in return. [R]	Stöber (2001); Larson (2019)

[1] Items are measured in a 7-point scale (from 1 = strongly disagree to 7 = strongly agree)
[2] Items are measured in a 7-point scale (from 1 = never to 7 = always)
[3] Items are measured in a dichotomous true or false question (0 = false and 1 = true)
[R] reverse-code items

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Appendix F – Justifications and Modeling Details for PLS-SEM

Justifications for Using PLS-SEM

There are five main reasons for using PLS-SEM in this study. First, PLS-SEM is suitable for effectively handling reflective-formative constructs (Hair *et al.*, 2022; Sarstedt *et al.*, 2019). Constructs such as instrumental affordances, social affordances, hedonic affordances, autonomous motivation, and controlled motivation are formatively modeled at the high-order formative level. Previous studies have also used PLS-SEM to analyze complex models with hierarchical component structures and assess the relationships between latent constructs in various contexts, such as gamification, technology adoption, and customer engagement (Hina *et al.*, 2024; Hollebeek *et al.*, 2023; Hou *et al.*, 2024; Lim *et al.*, 2022; Luo *et al.*, 2025). Second, PLS-SEM is well suited for handling complex models but requires fewer stringent assumptions, such as a small to moderate sample size and relaxed normality conditions (Hair *et al.*, 2022). Our study involves complex relationships, including higher-order constructs, lower-order constructs, and moderating effects, with a sample size of 613 (Sarstedt *et al.*, 2019). Third, compared to covariance-based SEM , PLS-SEM demonstrates favorable convergence behavior that provides higher levels of statistical power, resulting in the maximization of the explained variances of the endogenous constructs, such as overconsumption, hedonic consumption, and impulse purchase (Hair *et al.*, 2019; Hair *et al.*, 2017). Fourth, PLS-SEM is particularly suitable for studies with exploratory objectives that aim to predict and explain the variance in dependent constructs. While our study is grounded in theory, it also seeks to explore under-examined pathways, specifically, the psychological mechanisms linking pro-environmental behaviors to the unintended consequences of overconsumption through warm glow and moral licensing. Given the model's complexity and partially exploratory nature, PLS-SEM is an appropriate choice for predicting such behaviors within a multifaceted research framework. Fifth, PLS-SEM has been widely applied in information system disciplines, particularly to investigate technology adoption, user behavior, and complex models involving formative and reflective constructs. Lim *et al.* (2025) used PLS-SEM to examine the adoption of facial recognition payment systems, emphasizing the roles of service enhancement, technology security, and trust in driving continued technology adoption. Similarly, Pandit *et al.* (2024) used PLS-SEM to investigate continued engagement intention (CEI) with social media influencers (SMI), focusing on how homophily attitudes toward SMI moderate the relationship between SMI experience and CEI.

Reflective-Formative Model and Higher-Order Constructs

We adopted a reflective-formative model to assess the relationships between lower- and higher-order constructs (Becker *et al.*, 2012). The lower-order constructs, including autonomy support, achievement/reward, and informational feedback under instrumental affordances; interactivity, competition/cooperation, and social feedback under social affordances; and self-expression, narrative, and affective feedback under hedonic affordances, are treated as reflective constructs. Similarly, intrinsic, integrated, identified, introjected, and external regulations are reflective constructs. This is because the measurement items for each of these lower-order constructs share a common theme and reflect the dimensions of gamification affordances and user motivations (Coltman *et al.*, 2008). These reflective constructs collectively form broader affordance (instrumental, social, and hedonic) and motivation categories (autonomous and controlled) at the higher-order formative level (Finn and Wang, 2014).

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To model the higher-order formative constructs, we used the disjoint two-stage approach recommended by Becker *et al.* (2012) and Sarstedt *et al.* (2019) to ensure the accurate estimation of hierarchical models. In the first stage, the lower-order constructs were modeled and estimated independently (e.g., autonomy support, achievement/reward, and informational feedback), providing latent variable scores that represent the relationships between the indicators and their respective constructs (e.g., instrumental affordances). In the second stage, these latent variable scores were used as indicators to form the higher-order constructs, such as instrumental affordances, social affordances, and hedonic affordances, while autonomous motivation and controlled motivation contributed to the higher-order formative constructs. This approach ensures a clear separation between lower- and higher-order constructs, thereby reducing collinearity issues (Sarstedt *et al.*, 2019).

Model Estimation Settings

For model estimation settings, we employed the path weighting scheme in SmartPLS with initial weights set to 1.0. To assess the significance and stability of path coefficients, we conducted non-parametric bootstrapping with 10,000 subsamples The bias-corrected and accelerated (BCa) bootstrap method was used to estimate confidence intervals, which are preferred in PLS-SEM due to their computational efficiency and narrower interval width (Hair *et al.*, 2022). This approach allowed us to assess both the significance and stability of the coefficient estimates, with confidence intervals that did not contain zero, indicating significant relationships.

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Appendix G – Assessment of the Measurement Model

We first assessed indicator reliability using indicator loadings, and all item loadings exceeded the recommended threshold of 0.70. In terms of internal consistency reliability, we assessed Cronbach's alpha and composite reliability using the threshold value of 0.7. All our latent variables met these requirements. Then, we evaluated convergent validity of items within the same construct using the average variance extracted (AVE) value. All the AVE values were greater than the acceptable level of 0.5 (Hair *et al.*, 2017).

Construct	Item	Loadings	Cronbach's alpha	Composite reliability (CR)	Average variance extracted (AVE)
Autonomy Support	AUS1	0.811	0.722	0.789	0.585
	AUS2	0.736			
	AUS3	0.746			
Achievement/ Rewards	ACH1	0.756	0.702	0.766	0.524
	ACH2	0.765			
	ACH3	0.838			
Informational Feedback	INF1	0.771	0.752	0.811	0.589
	INF2	0.745			
	INF3	0.812			
	INF4	0.764			
Interactivity	INT1	0.780	0.755	0.860	0.672
	INT2	0.806			
	INT3	0.870			
Competition/ Cooperation	COM1	0.867	0.853	0.910	0.772
	COM2	0.879			
	COM3	0.890			
Social Feedback	SOC1	0.785	0.769	0.813	0.521
	SOC2	0.726			
	SOC3	0.796			
	SOC4	0.784			
Self-expression	SEE1	0.824	0.705	0.835	0.628
	SEE2	0.752			
	SEE3	0.801			
Narrative	NAR1	0.835	0.738	0.851	0.656
	NAR2	0.785			
	NAR3	0.808			
Affective Feedback	AFF1	0.753	0.744	0.834	0.573
	AFF2	0.733			
	AFF3	0.828			
	AFF4	0.760			
Intrinsic Motivation	INM1	0.789	0.721	0.832	0.610
	INM2	0.779			
	INM3	0.785			
Integrated Regulation	INR1	0.826	0.805	0.873	0.633
	INR2	0.819			
	INR3	0.837			
	INR4	0.744			
Identified Regulation	IDR1	0.823	0.718	0.821	0.605
	IDR2	0.799			
	IDR3	0.811			
Introjected Regulation	IJR1	0.922	0.908	0.942	0.844
	IJR2	0.942			
	IJR3	0.919			
External Regulation	EXR1	0.889	0.865	0.918	0.788
	EXR2	0.861			
	EXR3	0.913			
Pro-environmental Behaviors	PEB1	0.796	0.713	0.838	0.584
	PEB2	0.811			
	PEB3	0.842			
Warm Glow	WAG1	0.833	0.725	0.837	0.601

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	WAG2	0.746			
	WAG3	0.829			
Moral Licensing	MOR1	0.857	0.881	0.917	0.719
	MOR2	0.871			
	MOR3	0.839			
	MOR4	0.833			
Over-purchase	OVP1	0.877	0.849	0.908	0.768
	OVP2	0.924			
	OVP3	0.825			
Hedonic Consumption	HEC1	0.957	0.915	0.941	0.839
	HEC2	0.912			
	HEC3	0.884			
Impulse Purchase	IMP1	0.906	0.920	0.944	0.807
	IMP2	0.894			
	IMP3	0.904			
	IMP4	0.890			

Source: Author's own work

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Appendix H – Discriminant Validity using HTMT

The HTMT values should be less than 0.85 (Henseler *et al.*, 2015) and our results satisfied the requirement.

Constructs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Autonomy Support (AUS)																			
2. Achievement/ Rewards (ACH)	0.794																		
3. Informational Feedback (INF)	0.790	0.641																	
4. Interactivity (INT)	0.418	0.546	0.523																
5. Competition/ Cooperation (COM)	0.537	0.682	0.541	0.604															
6. Social Feedback (SOC)	0.485	0.618	0.748	0.664	0.606														
7. Self-Expression (SEE)	0.699	0.712	0.788	0.638	0.741	0.502													
8. Narrative (NAR)	0.841	0.730	0.712	0.576	0.638	0.697	0.613												
9. Affective Feedback (AFF)	0.712	0.715	0.702	0.513	0.689	0.478	0.647	0.661											
10. Intrinsic Motivation (INM)	0.639	0.641	0.601	0.501	0.765	0.551	0.539	0.673	0.693										
11. Integrated Regulation (INR)	0.722	0.751	0.696	0.456	0.673	0.552	0.678	0.704	0.697	0.797									
12. Identified Regulation (IDR)	0.639	0.623	0.793	0.558	0.617	0.601	0.608	0.715	0.546	0.723	0.684								
13. Introjected Regulation (IJR)	0.406	0.549	0.585	0.603	0.645	0.610	0.518	0.773	0.775	0.488	0.647	0.591							
14. External Regulation (EXR)	0.740	0.611	0.524	0.546	0.607	0.632	0.633	0.603	0.530	0.712	0.566	0.505	0.644						
15. Pro-Environmental Behaviors (PEB)	0.749	0.593	0.656	0.511	0.638	0.419	0.576	0.618	0.508	0.786	0.755	0.840	0.521	0.631					
16. Warm Glow (WAG)	0.585	0.539	0.695	0.512	0.643	0.729	0.502	0.719	0.611	0.488	0.585	0.379	0.642	0.724	0.621				
17. Moral Licensing (MOR)	0.598	0.765	0.696	0.652	0.750	0.706	0.615	0.724	0.606	0.772	0.732	0.601	0.495	0.621	0.597	0.632			
18. Over-purchase (OVP)	0.663	0.489	0.720	0.630	0.755	0.627	0.492	0.555	0.628	0.638	0.503	0.636	0.501	0.601	0.723	0.622	0.794		
19. Hedonic Consumption (HEC)	0.629	0.803	0.756	0.533	0.639	0.770	0.612	0.790	0.708	0.738	0.712	0.832	0.576	0.613	0.632	0.620	0.640	0.785	
20. Impulse Purchase (IMP)	0.710	0.723	0.671	0.460	0.564	0.674	0.549	0.575	0.754	0.532	0.628	0.741	0.539	0.501	0.801	0.663	0.665	0.589	0.766

Note: HTMT < 0.85 (Henseler *et al.*, 2015)
Source: Authors' own work

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Appendix I - Assessment of the Formative Measurement Model

For the formative measurement model, we examined convergent validity using global single-item measures to ensure that the formative constructs were adequately represented by their indicators, variance inflation factor (VIF) values to ensure the absence of multicollinearity. The significance and relevance of outer weights were also examined to verify the relevance of the formative indicators. The VIF values for all formative indicators were below the threshold of 5 (Hair *et al.*, 2017), indicating no multicollinearity issues. The significance of the outer weights was evaluated (Appendix I) and all indicators demonstrated significant contributions to their respective constructs. In addition, each formative construct showed an adequate correlation of at least 0.70 with its corresponding global single-item measure, supporting convergent validity as recommended by Hair *et al.* (2022). These results confirm the validity of the formative constructs.

Formative construct	Reflective construct	VIF	Weights	Correlation with global single-item measure
Instrumental affordances (INA)	AUS	1.503	0.420***	0.757
	ACH	1.498	0.352**	
	INF	1.584	0.445***	
Social affordances (SOC)	INT	1.617	0.285*	0.788
	COM	1.269	0.518***	
	SOF	1.633	0.390**	
Hedonic affordances (HEA)	SEE	1.813	0.394**	0.802
	NAR	1.702	0.388**	
	AFF	1.668	0.400**	
Autonomous motivation (AMO)	INM	1.658	0.402**	0.801
	INR	1.419	0.393**	
	IDR	1.912	0.388**	
Controlled motivation (CMO)	IJR	1.419	0.581***	0.704
	EXR	1.522	0.331*	

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$
Source: Author's own work

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