

RESEARCH ARTICLE

Impacts of Service Scenarios on Consumer Recycling Behavior: A Chain Mediation Model Involving Consumer Immersion and Recycling Intention

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ABSTRACT

Grounded in the Theory of Planned Behavior and the Stimulus-Organism-Response Theory, this study constructs a chain mediation model comprising "service scenario—consumer immersion—recycling intention—recycling behavior," while incorporating perceived policy effectiveness as a pivotal variable to elucidate its mechanistic role in mobile phone recycling. Using SPSS and AMOS software questionnaire data (N=483) from Shandong, China. Findings confirm a significant chain path: service scenarios enhance consumer immersion, which in turn boosts recycling intention, ultimately driving recycling behavior. However, perceived policy effectiveness did not significantly moderate the relationships between immersion and intention, or between service scenarios and intention. These results provide theoretical foundations and practical implications for optimizing recycling service scenarios and strengthening policy communication.

Keywords: Service scenario; consumer immersion; recycling intention; recycling behavior; perceived policy effectiveness

1. Introduction

From the advent of the First Industrial Revolution onward, the rapid industrial expansion and overconsumption has precipitated a cascade of environmental repercussions. The United Nations, in 2015, endorsed Transforming Our World: The 2030 Agenda for Sustainable Development, thereby outlining a framework of sustainable development objectives aimed at charting a course for sustainability in every nation, incorporating dimensions of economic expansion, societal integration, and ecological safeguarding^[1,2]. In the ensuing period, scholarly attention has increasingly converged on circular economy concerns, including the fusion of digital technologies with circular practices, the reclamation of waste, the reutilization of materials, the extension of product durability, and the facilitation of pre-owned exchanges^[3-6]. Notwithstanding the heightened awareness among diverse stakeholders regarding the critical role of—and the eventual risk of their complete depletion—has grown ever more apparent, thus necessitating immediate strategies for recycling and reutilization. Embedded within China's "13th Five-Year Plan" is a clear directive to "proactively advance the 2030 Agenda for Sustainable Development." The opportunity to leverage "urban mines"—these latent reservoirs of value—as a pivotal asset in recycling and reutilization endeavors holds substantial promise.

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During 2016, the official portal of the Chinese government integrated nine classifications of electronic devices, encompassing smartphones, personal computers, and tablet devices, into the Catalogue of Waste Electrical and Electronic Equipment Disposal, which was collaboratively issued by the National Development and Reform Commission, the Ministry of Environmental Protection, the Ministry of Industry and Information Technology, among others. This initiative denotes the formal initiation of efforts to manage the recycling and treatment of obsolete electronic goods in China, further emphasizing the essential need to refine the infrastructure for reclaiming such waste. Over the past several years, China has introduced an assortment of policies supporting green development to enhance the efficacy of recycling processes; while advancements in the recovery of electronic items have materialized, a considerable volume continues to languish unused within domestic settings. As indicated in Huawei's 2023 Sustainability Report, the worldwide recycling infrastructure has broadened to include 2,000 centers, extending across approximately 50 nations and territories, with more than 200 situated within China. Engagements with recycling-related details remain infrequent in Huawei's retail outlets for mobile devices. Hence, the amalgamation of recycling programs with brick-and-mortar establishments for electronic merchandise emerges as a matter of considerable import.

Existing investigations into consumer engagement in recycling have largely drawn upon the Theory of Planned Behavior, which maintains that individuals' recycling conduct is shaped by their underlying motivations, driven in turn by psychological and perceptual elements including dispositions, normative expectations, and appraisals of behavioral feasibility^[7,8]. More recently, an expanding body of researchers has argued that the Theory of Planned Behavior inadequately accounts for the role of particular situational influences on consumer actions, positing that contextual cues can substantially mold and transform personal behavioral trajectories^[9,10]. In the high-tech consumption environment, there is little exploration into how digital situational service cues such as interactive screens, AR navigation or personalized push notifications are effectively transformed into consumers' willingness to recycle through psychological mechanisms. The ambiguity of this influence path not only constitutes a research gap in academia but also makes it difficult for retailers to precisely design digital strategies that can promote environmentally friendly behaviors, thus limiting the potential of technology in driving sustainable development. This study takes environmental stimuli as the background antecedents of intention formation through the S-O-R model, thereby expanding the explanatory scope of the Theory of Planned Behavior (TPB). Under this integrated framework, external situational factors (S) are no longer regarded as interfering variables but as key elements that trigger an individual's internal cognitive and emotional responses (O). These internal states further shape the core constructs of TPB - attitude, subjective norms and perceived behavioral control, ultimately influencing the formation of behavioral intent (R). This expansion not only makes up for the insufficiency of TPB in considering the external environment, but also constructs a more comprehensive behavioral prediction path.

By conducting a thorough scrutiny of five principal facets—service scenarios, consumer immersion, recycling intentions, recycling behavior, and perceived policy effectiveness—this analysis fully illuminates the interrelations among these elements and their consequent effects on personal behaviors concerning the recycling of discarded electronic products.

First, over the past several years, scholarly inquiries in the field of marketing have progressively emphasized the role of service scenarios and contextualized marketing strategies in shaping consumer actions. Contextual marketing emerges as a novel tactical approach derived from conventional promotional methods, prioritizing the distinctiveness inherent in patterns of consumer conduct^[11]. By leveraging the Stimulus-Organism-Response (S-O-R) framework, the investigation highlights the essential function of service scenarios throughout the developmental trajectory of personal conduct. Functioning as an environmental variable, service scenarios demonstrably exert a profound effect on personal recycling practices. This

observation not only broadens the theoretical applicability of the Theory of Planned Behavior but also substantiates additional propositions regarding the Theory of Planned Behavior posited by select researchers: the orthodox Theory of Planned Behavior disproportionately concentrates on instigating actions^[12-15].

Second, the concept of "immersion" encapsulates intense absorption in the immediate context, during which individuals forfeit self-perception and become insensible to temporal progression^[16]. Upon achieving elevated levels of involvement, consumers develop a profound sense of engrossment in the commodities or offerings they engage with—specifically, becoming captivated by the experiential aspects of consumption or seamlessly integrating into the milieu delineated by the commodity or offering. As a result, this process generates consumption encounters that are more memorable and captivating for participants, thereby intensifying their predispositions or impulses toward dissemination. The notion of recycling intention precedes recycling conduct, serving as the immediate determinant that precipitates action. Investigations into the nexus between predispositions and transformations in conduct chiefly examine the capacity of predispositions to drive alterations in actions and the cultivation of novel routines, alongside methodologies for advancing constructive shifts in conduct via targeted interventions^[17,18]. Hence, by designating consumer immersion and recycling intention as intermediary constructs, this analysis delves into the potential of superior service scenarios to provoke consumers' captivation within designated environments, consequently heightening predispositions or instigating actions.

Third, the level of policy perception occupies a central position in inquiries concerning consumer conduct. When persons maintain optimistic appraisals of policy potency—that is, recognizing the availability of more efficacious and potent policy tools—this awareness typically activates endogenous drives, thus motivating the pursuit of designated actions with greater determination^[19]. These appraisals not only delineate a precise pathway for personal endeavors but also imbue such pursuits with enhanced vigor, leading to amplified degrees of involvement and dedication in tangible executions^[20]. At present, awareness among consumers regarding directives for the reclamation of electronic goods remains restricted; accordingly, the question emerges whether, in conjunction with particular environmental prompts, augmented policy awareness in persons might escalate the frequency of conduct.

Therefore, the present inquiry activates perceptual and responsive mechanisms in consumers via contextual components, including layout configurations and environmental enhancements, thereby expanding the spectrum of determinants affecting conduct within the Theory of Planned Behavior paradigm. This revelation introduces fresh viewpoints on sustainable consumption: in one respect, it enhances the insight and anticipation of personal ecologically oriented actions; in another, it reveals the untapped capabilities of consumers in partaking in reclamation practices, thereby offering conceptual foundations for the crafting and deployment of policies.

2. Literature review

2.1. Theory of planned behavior and S-O-R framework

Building on Fishbein and Ajzen (1975), the Theory of Reasoned Action conceptualizes behavior as intention-driven and, in turn, lays the groundwork for the Theory of Planned Behavior (TPB). Despite TPB's widespread adoption in consumer research, scholars have noted its over-reliance on purely cognitive antecedents, with insufficient attention to non-cognitive determinants^[21]—including habitual patterns^[22], affective states^[23], and situated contexts^[24]. By contrast, the Stimulus–Organism–Response (S-O-R) paradigm explicitly articulates how environmental stimuli precipitate internal states that culminate in behavioral responses. Although TPB remains a canonical account of individual decision processes and is frequently

applied to explain pro-environmental consumption and related actions^[25,26], it under-specifies the direct influence of environmental cues on psychological states. The S-O-R model effectively remedies this omission.

Existing studies mostly combine planned behavior theory with value-belief-norm theory, etc., focusing on exploring the influence of individual subjective factors on behavior^[27,28]. This study innovatively integrates the S-O-R theory and shifts the research perspective to external environmental stimuli, aiming to reveal the key role of situational factors in behavioral driving, thereby compensating for the insufficiency of existing studies in focusing on environmental factors. The present study synthesizes TPB and S-O-R by theorizing “specific environmental contexts” as the operative stimuli that shape TPB’s psychological constructs and, thereby, foster recycling behavior. Concretely, we argue that both the physical environment (e.g., spatial configuration of collection points, facility convenience) and the technological environment (e.g., user-interface architecture of online recycling platforms) heighten consumer immersion. This elevated immersion modifies psychological states in ways that reinforce recycling intention and, ultimately, convert intention into observable recycling behavior.

2.2. Research hypotheses

2.2.1. Direct hypothesis

Building on Kotler’s (1974) notion of store atmospherics as the deliberate engineering of retail spaces to shape cognition and affect^[29], targeted sensory stimulation can elicit favorable emotions^[30] and attitudes^[19]. Symbolic components of the servicescape—signage, icons, and artifacts—such as images, music, logos, and crafts, carry socially embedded meanings; as elements of a group’s symbolic universe, they possess particular salience for members and can trigger autobiographical recall^[31,32]. Given that service production and consumption often co-occur, consumers are effectively present “on site,” experiencing the service within the very environment that can modulate their attitudes and behaviors (Bitner, 1992)^[33]. Hence, in-store cue management is inherently multilevel and complex; integrating diverse impression-formation cues more effectively catalyzes engagement and augments experiential quality^[34,35].

Accordingly, the service scenario functions as a pivotal environmental lever shaping consumer experience and affect. By diagnosing and orchestrating environmental cues and atmospherics, managers can more precisely steer consumer responses. Hence, we posit:

H1: The service scenario positively affects consumer immersion.

Immersion is closely tied to sensory input and sustained attentional focus. Fornerino et al. (2008) conceptualize immersion as a psychological state in which individuals perceive themselves to be surrounded by, embedded within, and interacting with a continuously stimulating environment^[36]. Elevated immersion tends to strengthen behavioral intentions^[37,38]; critically, technology-related stimuli shape intention primarily through immersion rather than directly. Thus, immersion constitutes a key driver of sustainable behavioral adoption^[39,40].

Collectively, the literature suggests that recycling engagement entails economic, temporal, and cognitive-emotional costs while also offering potential economic and psychological gains; how these trade-offs are appraised depends substantially on immersive experience. We therefore hypothesize:

H2: Consumer immersion positively affects recycling intention

Evidence indicates that clearly articulated recycling intentions translate into enacted recycling behaviors (Schultz et al., 1995)^[41]. Within an extended Theory of Planned Behavior, adolescent recycling intentions in India are positively associated with actual recycling behavior^[42]. Synthesizing affective, rational, contextual, and behavioral-economic perspectives, similarly identify intention as a robust predictor of realized recycling^[43].

Taken together, these findings underscore intention's centrality in forecasting and shaping recycling behavior. Strengthening intention should, therefore, increase behavioral enactment. Accordingly:

H3: Recycling intention positively affects recycling behavior

Within bricks-and-mortar contexts, technological affordances bolster consumers' trust in recycling channels, thereby instantiating a durable sequence from "convenience of technology" to "behavioral commitment" and "ongoing participation." Scenario-embedded symbols—such as eco-labels and visible corporate social responsibility initiatives—can engender value alignment, heighten affective arousal, and catalyze favorable recycling intention^[20]. Concomitantly, socially configured service scenarios shape recycling choices through normative climates and emotional bonding; environmental campaigns and community-based interactions act as normative cues that evoke conformity and a sense of environmental duty^[44].

From a psychological standpoint, the S-O-R framework elucidates the layered pathways by which service scenarios shape intention. Exogenous physical stimuli precipitate cognitive appraisal and, via emotional arousal, modulate the intensity of behavioral intention^[45]. In parallel, social-interactional features amplify commitment through normative pressure and socio-emotional support. Empirical studies further demonstrate that configurations combining high logistical convenience with robust social support yield substantially larger gains in recycling intention than conventional settings^[46]. Accordingly, Hypothesis 5 is proposed:

H5: Service scenarios positively influence recycling intention

The retail milieu comprises physical infrastructure, ambient qualities, and interpersonal exchanges; these facets jointly configure consumers' affective states^[47]. Comfort and courteous service elevate pleasure, while aversive environments precipitate negative affect. Leveraging the S-O-R lens, Zheng et al. (2019) show that, in virtual shopping contexts, situational stimuli reliably elicit emotional reactions that, in turn, precipitate impulsive purchases^[48], underscoring the pivotal role of calibrated stimuli in activating target behaviors. Complementarily, Whitmarsh et al. (2018) demonstrate that clear signage and convenient facilities across domestic, occupational, and public spaces materially increase the likelihood of recycling^[49]. As a multifaceted exogenous stimulus, the service scenario—via physical settings, social interaction, and symbolic markers—meaningfully shapes both the formation and enactment of recycling intention^[32]. Moreover, social-service scenarios influence recycling decisions through group norms and affective bonds; for example, social-normative elements such as environmental-protection campaigns and interactions within environmental communities trigger consumers' conformity tendencies and sense of environmental responsibility^[47].

Taken together, these arguments support a robust positive linkage between service scenarios and recycling behavior. By curating supportive contexts and cultivating pleasant atmospheres, institutions can substantively amplify real-world recycling. We therefore state:

H7: Service scenarios positively influence recycling behavior

2.2.2. Mediation hypothesis

The service scenario demonstrably shapes immersive experience and downstream conduct. Asghar et al. (2023) argue that physical setting and psychological ambience jointly structure consumer perceptual processing^[50]. Two mechanisms predominate. First, physical design—layout, décor, and facility adequacy—directly stimulates the senses, amplifying immersion^[51]. Second, socio-emotional ambience—employee demeanors, other customers' conduct, and nonverbal cues (e.g., music, scents)—modulates emotional states, further deepening immersion. Heightened immersion, in turn, fosters favorable recycling intentions by intensifying cognitive and affective engagement with recycling, sensitizing individuals to environmental concerns and the social consequences of personal action^[52]. Immersion can also elevate satisfaction,

reinforcing willingness to participate and generating a positive feedback loop. Optimizing the service scenario to enhance immersion should, therefore, bolster recycling intentions and, ultimately, behavior.

In brief, environmental cues and atmospheric design operate through sensory and psychological channels to heighten immersion, thereby increasing the propensity to engage in recycling. Hence, we propose:

H4: Consumer immersion and recycling intention jointly constitute a sequential (chain) mediator between the service scenario and recycling behavior

Functioning as an exogenous cue, the service environment stimulates perceptions of normative endorsement and practical convenience, thereby fostering recycling intention^[53]. Design refinements—process simplification, pecuniary incentives—diminish perceived costs, amplify outcome expectancies, and consolidate intention formation^[46].

Recycling intention represents the pivotal psychological conduit through which the service milieu translates into enacted behavior. Once activated, individuals craft concrete plans, surmount temporal and habitual impediments, and transform motivation into sustained action. Social identity theory corroborates this mechanism: normative signals embedded in the environment are internalized, aligning behavior with collective expectations and materially elevating recycling incidence^[54]. Thus arises Hypothesis 6:

H6: Recycling intention mediates the effect of the service scenario on recycling behavior

2.2.3. Moderating hypothesis

Perceived Policy Effectiveness is central to explaining Recycling Behavior. When citizens perceive and endorse recycling policies to a greater extent, high-quality Service Scenarios are leveraged more effectively, thereby more robustly catalyzing recycling behavior^[55]. Specifically, where policy support is unambiguous and implementation is stringent, a favorable environmental ambience elicits stronger recycling intention^[56]. Heightened Perceived Policy Effectiveness cultivates trust in recycling measures and, by optimising contextual atmosphere, augments their impact on recycling intention^[57,58,59].

Accordingly, perceived policy effectiveness functions as a salient moderator linking service scenario to recycling intention. Elevated perceptions amplify the beneficial influence of service scenario on recycling behavior, such that supportive atmospheres more readily translate into pro-recycling conduct. Enhanced policy transparency and efficacy strengthen public trust, thereby intensifying the ambience-to-behavior pathway. Hence, the study advances Hypothesis 8:

H8: Perceived policy effectiveness positively moderates the relationship between service scenario and recycling intention

Conceptualized as consumers' subjective assessment of policy aims, instruments, and utility, perceived policy effectiveness critically conditions the consumer immersion–recycling intention nexus. When policy support is strongly perceived (e.g., clarity of dual-carbon targets, incentivizing subsidies), the hedonic facets of immersion convert into confidence in policy tools; the resulting environmental empathy and conative tendencies consolidate into durable recycling intention, thereby increasing expected behavioral returns^[60]. Moreover, embedding policy signals (e.g., eco-certification marks) within immersive settings can, via embodied cognition, heighten consumers' sense of social responsibility^[61]. Incentive-oriented instruments (e.g., trade-in subsidies, points schemes) elevate perceived economic value and markedly reinforce immersion's positive effect on recycling intention—especially among price-sensitive cohorts^[62]. By contrast, constraint-oriented instruments (e.g., mandatory sorting) leverage social-norm pressure to magnify moral activation within immersion, thereby motivating recycling intention, though clear execution guidelines are essential to avert react^[63].

In waste-electronics contexts, stronger perceived enforcement (e.g., higher violation-penalty likelihood) augments the contribution of interactive immersive elements (e.g., recycling-process simulation games) to recycling intention. Therefore, the study posits Hypothesis 9:

H9: Perceived policy effectiveness positively moderates the relationship between service scenario and recycling intention

Guided by the Theory of Planned Behavior and the S-O-R framework, the model adopts a consumer-centered lens to delineate how Service Scenario shapes Consumer Immersion, Recycling Intention, and downstream Recycling Behavior. External environmental stimuli are mobilized to intensify immersion and actual behavior. Given intention's primacy as a behavioral predictor, Recycling Intention is specified as the second mediator. As current policies are largely enterprise-oriented and consumer perceptions are heterogeneous, Perceived Policy Effectiveness is theorized as the moderator.

The conceptual framework for this study is presented in **Figure 1**.

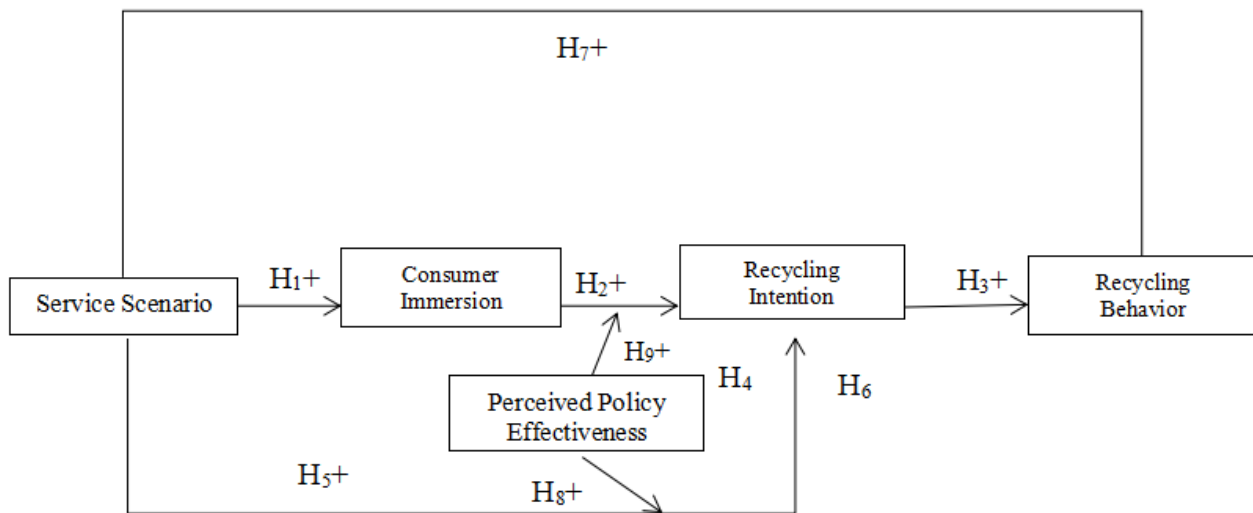


Figure 1. Research Framework

3. Research methods and design

3.1. Questionnaire design and target population

The questionnaire comprises a title page, a preface, basic demographic information, and the main item set. Personal-information section: Guided by statistical demographic characteristics, five items—gender, age, occupation, income, and educational attainment—were included to collect respondents' basic profiles; in addition, one screening item concerning prior recycling experience was set. Main questionnaire section: This is the core component, containing measurement items for the constructs of service scenario, consumer immersion, recycling intention, recycling behavior, and perceived policy effectiveness. The instrument is divided into six sections, with a total of 45 items.

The research targets Chinese consumers who demand electronic products and have engaged in recycling behavior. Because age and income levels determine whether consumers replace electronic products^[5], relevant items were included in the demographics section; because occupational category and educational level affect the strength of recycling awareness and the likelihood of recycling behavior^[64], corresponding items were also

included. Its function is to control variables. Control variables are factors that remain constant in scientific research, with the aim of eliminating the influence of these factors to more accurately study the impact of a single variable (independent variable) on another variable (dependent variable).

The questionnaire was primarily administered and collected in Shandong Province. According to data from China's national statistics department, Shandong's GDP in 2024 reached 9,856.6 billion yuan, ranking third in the country. According to the list of green manufacturing demonstration projects released by the Ministry of Industry and Information Technology, Shandong Province has had a total of 567 projects selected, ranking among the top in the country. Shandong has established an effective system for the recycling and dismantling of waste electrical and electronic products. There are four waste electrical appliance dismantling enterprises that have obtained the subsidy qualification from the National Waste Electrical Appliance Treatment Fund, with an annual dismantling and processing capacity of 7.3105 million units.

3.2. Measurement of variables

All scales adopted in this study were previously published and validated in international journals. All items were rated on a five-point Likert scale from 1 ("strongly disagree") to 5 ("strongly agree"). To ensure the rigor and content validity of the questionnaire, this study adopted the expert evaluation method. Firstly, mature scales at home and abroad are selected as the sources of the items; Subsequently, in light of the Chinese cultural context and research situation, multiple rounds of discussions were held with experts in relevant fields to optimize the translation, adjust the semantics and revise the localization of the items, in order to enhance their clarity and adaptability. Ultimately, the pre-test test (n=95) was passed to ensure that the questionnaire could comprehensively and accurately measure core constructs such as "service scenarios" and "consumer immersion".

For service scenario, we employed the 22-item scale from Tian (2021), which examined how service scenarios in physical retail settings influence consumer participation; measurement encompassed the in-store physical environment, product display, recycling signage, and staff interactions^[65]. Consumer immersion referenced the 4-item scale in Hamilton et al. (2016), which investigated how immersion in social-media brand–consumer interactions shapes customer value^[66]. Recycling behavior referenced the 5-item scale used by Ben et al. (2023) in studying the effects of data security and perceived benefits on mobile-device recycling^[67]. Recycling intention referenced the 4-item scale in Zhang et al. (2020), which analyzed how sense of responsibility and risk acceptance influence consumers' behavioral intentions regarding smartphone recycling^[68]. Perceived policy effectiveness referenced the 4-item scale in Wang and Mangmeechai (2021), which examined environmental intentions and pro-environmental behavior in waste sorting under Chinese regulatory policies^[56].

3.3. Questionnaire administration and sampling

Lingard and Rowlinson (2006) recommend that the minimum valid sample size for a formal survey be at least ten times the number of items in the longest scale and, as a rule, exceed 100^[69]. In this study, with 45 items in total, the tenfold benchmark was 450 questionnaires. Accounting for invalid responses—specifically, questionnaires from individuals without recycling experience, completion time under three minutes^[70], or $\geq 80\%$ identical answers within a single questionnaire—the final valid sample comprised 483 cases. Data collection was conducted via the Wenjuanxing platform to facilitate timely and efficient acquisition. Administration combined online and offline modes: online distribution used common communication apps such as WeChat, QQ, and DingTalk; offline distribution occurred at electronic-product specialty stores and brick-and-mortar recycling service outlets.

This study primarily adopted purposive sampling. First, within selected cities, consumers exhibiting recycling awareness were identified at electronic-product specialty shops, recycling stations, or other recycling-enabled venues (e.g., mobile-phone retailers and repair shops). Simultaneously, online questionnaires were collected using tools such as Wenjuanxing until the target number was achieved. Finally, based on analytic needs, a secondary wave of questionnaire administration was determined as necessary.

4. Research results and analysis

4.1. Reliability assessment and diagnosis of common method bias

The total sample size for this study was 483 participants. In terms of gender distribution, males accounted for 249 individuals (51.6%). Regarding age, 442 participants (91.5%) were adults aged 18 or above. In terms of occupational sectors, enterprise employees and professionals constituted the largest groups, representing 24.2% and 24.6% of the sample, respectively. Educational attainment showed that 69.9% of respondents held a bachelor's degree or higher. For income levels, the largest proportion (39.1%) reported a monthly income between 6,001 and 9,000 RMB. Since recycling experience was a screening criterion, all valid samples had prior engagement in recycling activities. Notably, 316 participants (65.4%) had participated in recycling within the past year.

To ensure measurement quality, the study first conducted reliability testing for each construct. The results indicate that Service Scenario ($\alpha = 0.962$), Consumer Immersion ($\alpha = 0.861$), Recycling Intention ($\alpha = 0.912$), Recycling Behavior ($\alpha = 0.883$), and Perceived Policy Effectiveness ($\alpha = 0.923$) all exhibited Cronbach's α coefficients greater than 0.80; therefore, all variables demonstrate strong internal consistency.

This study adopted the single-factor test proposed by Harman (1976) to conduct a comprehensive examination of all variables. First, all variables were entered into an exploratory factor analysis model. The unrotated factor solution was then inspected to ensure that the obtained factor structure is relatively stable and reliable. The results show that the variance explained by the first principal component before rotation is 36.853%, which is less than the 40% threshold, indicating that the common method bias test is passed^[71]; in other words, no single factor accounts for a majority of the variance.

4.2. Descriptive statistics and correlation analysis

When the absolute value of kurtosis does not exceed 10 and the absolute value of skewness does not exceed 5, the data may be regarded as meeting the criterion of normal distribution. Smaller absolute values of kurtosis and skewness suggest that the distribution's shape approximates the bell curve of a normal distribution, which facilitates more accurate statistical analyses and tests^[67]. In this study, Pearson's correlation coefficients were used. Judgement is based on the p-value: if the p-value is less than the pre-specified significance level ($p < .05$), the correlation is deemed significant^[24]. The results, as shown in Table 2, satisfy the normality requirements. Based on the correlation analyses among all variables, **Table 1** shows that each pairwise association is significantly positive.

Table 1. Table of Variable Correlation Analysis

	1	2	4	5	6
SS	1				
CI	0.519**	1			
RI	0.152**	0.095*	1		
RB	0.311**	0.286**	0.153**	1	
PPE	0.375**	0.279**	0.328**	0.265**	1

Table 2. Means and Standard Deviations of Variables

	Minimum	Maximum	Mean	SD	Skewness		Kurtosis	
	Stats.	Stats	Stats	Stats	Stats	SE	Stats	SE
SS	2.14	5.00	3.4964	0.80764	-0.06	.111	-1.220	0.222
CI	1.75	5.00	3.4094	0.81286	-0.03	.111	-0.806	0.222
RI	1.25	5.00	3.6718	0.90109	-0.50	.111	-0.336	0.222
RB	1.60	5.00	3.6830	0.74520	-0.36	.111	0.072	0.222
PPE	1.00	5.00	3.4798	1.05979	-0.33	.111	-1.176	0.222

4.3. Confirmatory factor analysis

To evaluate the validity of the measurement model, this study conducted a confirmatory factor analysis (CFA). A five-factor measurement model was specified with Service Scenario, Consumer Immersion, Recycling Behavior, Recycling Intention, and Perceived Policy Effectiveness as latent constructs. The results indicated satisfactory model fit: $\chi^2/df = 2.281$, GFI = 0.862, AGFI = 0.844, NFI = 0.886, CFI = 0.932, RMSEA = 0.052, and SRMR = 0.038. The comprehensive data supporting these fit indices are meticulously detailed in **Table 3**.

Table 3. Indices of model fit.

Index	χ^2	df	χ^2/df	RMSEA	SRMR	GFI	AGFI	NFI	CFI
Values			<3	<0.08	<0.05	>0.80	>0.80	>0.80	>0.80
	1578.360	692	2.281	.052	.038	.862	.844	.886	.932

As shown in **Table 4**, the convergent validity was supported. All standardized factor loadings ranged from 0.511 to 0.868, exceeding the recommended threshold of 0.50. Composite reliability (CR) values fell between 0.862 and 0.963, well above the critical value of 0.60. The average variance extracted (AVE) ranged from 0.544 to 0.759, surpassing the 0.50 criterion. Collectively, these indicators provide evidence of strong convergent validity for the measurement model.

Table 4. Convergent Validity Table

Variables	Items	Estimate	CR	AVE
SS	SS1	0.781	0.963	0.544
	SS2	0.716		
	SS3	0.780		
	SS4	0.783		
	SS5	0.699		
	SS6	0.755		
	SS7	0.853		
	SS8	0.755		
	SS9	0.610		
	SS10	0.754		
	SS11	0.773		
	SS12	0.848		
	SS13	0.848		
	SS14	0.817		
	SS15	0.667		
	SS16	0.736		
	SS17	0.729		
	SS18	0.693		
	SS19	0.511		
	SS20	0.541		
	SS21	0.811		
	SS22	0.634		
CI	CI1	0.794	0.862	0.609
	CI2	0.763		
	CI3	0.766		
	CI4	0.797		
RI	RI1	0.838	0.908	0.711
	RI2	0.801		
	RI3	0.864		
	RI4	0.868		
RB	RB1	0.787	0.887	0.611
	RB2	0.685		
	RB3	80.786		
PPE	RB4	0.817	0.887	0.611
	RB5	0.824		
	PPE1	0.881		
	PPE2	0.834		
	PPE3	0.863		
	PPE4	0.906		

Note: This table presents the results for convergent validity. All factor loadings reported above are standardized coefficients. Compiled by the present study.

4.4. Direct hypothesis testing

This study employed linear regression analyses to examine the direct effects; the analytical results are presented in **Table 5**. The findings indicate that, in Model 1, the service scenario exerted a significant and

positive effect on consumer immersion ($\beta = 0.520$, $p < 0.001$). This model explained 27.2% of the variance ($R^2 = 0.272$, $F = 44.703$, $p < 0.001$), thereby supporting Hypothesis H1. In Model 2, the service scenario significantly and positively influenced recycling intention ($\beta = 0.152$, $p < 0.001$). This model explained 2.8% of the variance ($R^2 = 0.028$, $F = 3.500$, $p < 0.001$), supporting Hypothesis H5. In Model 3, consumer immersion had a significant and positive effect on recycling intention ($\beta = 0.096$, $p < 0.05$). This model explained 1.5% of the variance ($R^2 = 0.015$, $F = 1.774$, $p < 0.05$), supporting Hypothesis H2. In Model 4, the service scenario significantly and positively affected recycling behavior ($\beta = 0.311$, $p < 0.001$). This model explained 10.2% of the variance ($R^2 = 0.102$, $F = 13.548$, $p < 0.001$), supporting Hypothesis H7. In Model 5, recycling intention significantly and positively influenced recycling behavior ($\beta = 0.154$, $p < 0.001$). This model explained 2.9% of the variance ($R^2 = 0.029$, $F = 3.524$, $p < 0.001$), supporting Hypothesis H3. The variance inflation factors (VIF) for all models were far below the critical threshold of 10, indicating no multicollinearity concerns.

This study empirically examines the influence mechanism of service scenarios on consumers' recycling behavior. The results show that the service scenario not only directly and positively affects the recycling behavior, but also has an indirect impact by enhancing consumers' immersion and recycling intention. Carefully designed scenarios foster immersive experiences by reducing cognitive load and stimulating positive emotions, and reinforce the intention to recycle by providing convenience and conveying social norms. The core contribution of this research lies in extending the service scenario theory from the business field to the environmental protection and public welfare field, and confirming that it can effectively bridge the "intention-to-behavior gap". Service scenarios are not only "boosters" for behavior, but also "converters" that connect intentions with actions, providing new practical paths for promoting sustainable development.

Table 5. Table of Hypothesis-Testing Analyses for Direct Effects

Model	CI	RI			RB
	M1	M2	M3	M4	M5
	β	β	β	β	β
	(t)	(t)	(t)	(t)	(t)
	(VIF)	(VIF)	(VIF)	(VIF)	(VIF)
IV	-0.004	0.017	0.016	0.015	0.007
Sex	(-0.089)	(0.378)	(0.343)	(.338)	(0.156)
	(1.029)	(1.029)	(1.029)	(1.029)	(1.029)
	-0.049	0.031	0.036	0.058	0.055
Age	(-1.245)	(0.688)	(0.797)	(1.335)	(1.210)
	(1.006)	(1.006)	(1.008)	(1.006)	(1.007)
	0.008	0.068	0.066	-0.032	-0.044
Monthly Income	(0.203)	(1.481)	(1.439)	(-0.732)	(-0.973)
	(1.023)	(1.023)	(1.023)	(1.023)	(1.027)
	0.520***	0.152***		0.311***	
SS	(13.312)	(3.372)		(7.176)	
	(1.000)	(1.000)		(1.000)	
			0.096*		
CI			(2.121)		
			(1.002)		
					.154***
RI					(3.405)
					(1.005)
R ²	8.272	0.028	0.015	0.102	80.029

Model	CI	RI		RB	
	M1	M2	M3	M4	M5
ΔR^2	0.266	0.020	0.006	0.094	0.021
F	44.703***	3.500**	1.774*	13.548***	3.524***

Table 5. (Continued)

Note 1: * $p < 0.05$, ** $p < 0.01$

Note 2: CI: Consumer Immersion; RI: Recycling Intention; RB: Recycling Behavior; SS: Service Scenario; IV: Independent Variable

4.5. Mediation hypothesis testing

Regression analysis is a common practice in top journal research in fields such as social sciences, environmental behavior, and marketing. Hierarchical regression is more flexibly applied in complex mediation models and is suitable for demonstrating chain mechanisms^[72,73]. This study employed the causal steps approach (Baron & Kenny, 1986) to analyse the mediating effects. Treating the service scenario as the independent variable and recycling behavior as the dependent variable, with gender, age, and monthly income as control variables, we conducted linear regression using hierarchical regression in quantitative statistical analysis software to obtain the results, service scenario exerts a partial mediating effect on recycling behavior through consumer immersion and recycling intention. In addition, the service scenario exhibits a partial mediating effect on recycling behavior through recycling intention alone, as shown in **Table 6**.

This study deepens the understanding of the mechanism of action of service scenarios, revealing that they function through a chain reaction of "experience - internalization - behavior", elevating the role of service scenarios from "behavior supporters" to "experience guides and motivation catalysts". Research has confirmed that the influence of immersive experiences can spill over from the business field to the field of social responsibility. Therefore, to promote recycling behavior, it is necessary to shift from a "function-oriented" approach to an "experience-oriented" one. By designing immersive scenarios, consumers' emotions and cognition can be activated, making recycling a "warm and story-filled" choice.

Table 6. Table of Hypothesis-Testing Analyses for Mediation Effects

Model	Recycling Behavior				
	M1	M2	M3	M4	M5
	β	β	β	β	β
	(t)	(t)	(t)	(t)	(t)
	(VIF)	(VIF)	(VIF)	(VIF)	(VIF)
IV	0.015	0.015	0.014	0.015	0.013
	(0.338)	(0.356)	(0.316)	(0.338)	(0.297)
Sex	(1.029)	(1.029)	(1.029)	(1.029)	(1.029)
	0.058	0.067	0.063	0.058	0.055
Age	(1.335)	(1.547)	(1.474)	(1.335)	(1.263)
	(1.006)	(1.009)	(1.010)	(1.006)	(1.007)
	-0.032	-0.033	-0.041	-0.032	-0.039
Monthly Income	(-0.732)	(-0.773)	(-0.940)	(-0.732)	(-0.902)
	(1.023)	(1.023)	(1.028)	(1.023)	(1.028)
	0.311***	0.220***	0.205***	0.311***	0.295***
SS	(7.126)	(4.387)	(4.084)	(7.176)	(6.751)
	(1.000)	(1.371)	(1.391)	(1.000)	(1.024)
CI		0.175***	0.173***		
		(3.485)	(3.452)		

Model	Recycling Behavior				
	M1	M2	M3	M4	M5
		(1.374)	(1.375)		
RI			0.106*		0.109*
			(2.447)		(2.490)
R ²	.102	.124	0.135	0.102	0.005
ΔR ²	.094	.115	0.124	0.094	-0.001
F	13.548***	13.520***	12.382*	13.548***	12.196*

Table 6. (Continued)

Note 1: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Note 2: CI: Consumer Immersion; RI: Recycling Intention; SS: Service Scenario; DV: Dependent Variable

4.6. Test of the moderation hypothesis

This study employed the causal steps regression approach (Baron & Kenny, 1986) to analyse the moderating effect. In the quantitative statistical software, hierarchical regression was selected to conduct linear regression analyses. The resulting data analysis, as presented in **Table 7**, indicates that the moderating effect of perceived policy effectiveness is not significant.

Table 7. Table of Hypothesis-Testing Analyses for Moderation Effects

Model	Recycling Intention					
	M1	M2	M3	M4	M5	M6
	β	β	β	β	β	β
IV	(t)	(t)	(t)	(t)	(t)	(t)
	(VIF)	(VIF)	(VIF)	(VIF)	(VIF)	(VIF)
	0.017	0.031	0.029	0.016	0.031	0.031
Sex	(0.378)	(0.708)	(0.661)	(0.343)	(0.708)	(0.712)
	(1.029)	(1.031)	(1.032)	(1.029)	(1.031)	(1.031)
	0.031	0.030	0.031	0.036	0.031	0.032
Age	(0.688)	(0.703)	(0.725)	(0.797)	(0.708)	(0.733)
	(1.006)	(1.006)	(1.006)	(1.008)	(1.008)	(1.009)
	0.068	0.083	0.079	0.066	0.083	0.086
Monthly Income	(1.481)	(1.907)	(1.030)	(1.439)	(1.913)	(1.972)
	(1.023)	(1.026)	(1.023)	(1.023)	(1.026)	(1.028)
	0.152***	0.032	0.018			
SS	(3.372)	(0.686)	(0.387)			
	(1.000)	(1.164)	(1.206)			
				0.096*	0.004	0.179
CI				(2.121)	(90.086)	(1.199)
				(1.002)	(1.087)	(1.047)
		0.321***	0.309***		0.332***	0.556
PPE		(6.898)	(6.555)		(7.384)	(2.963)
		(1.169)	(1.202)		(1.089)	(1.086)

Model	Recycling Intention					
	M1	M2	M3	M4	M5	M6
SS*PPE			-0.070			
			(-1.551)			
			(1.105)			
CI*PPE						-0.325
						(-1.230)
						(1.089)
R ²	0.028	0.117	0.121	0.015	0.116	0.119
ΔR ²	0.020	0.107	0.110	0.006	0.106	0.107
F	3.500***	12.589***	10.922	1.774	12.484***	10.667

Table 7. (Continued)

Note 1: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note 2: CI: Consumer Immersion; RI: Recycling Intention; SS: Service Scenario; PPE: Perceived Policy Effectiveness; IV: Independent Variable

5. Conclusions and recommendations

Anchored in the S-O-R paradigm and the Theory of Planned Behavior, this inquiry advances an integrative model that explicates how service scenarios shape recycling behavior by interlinking service scenario, consumer immersion, recycling intention, perceived policy effectiveness, and observed recycling behavior. The evidence indicates, first, that high-quality service scenarios exert a dual influence: they directly facilitate recycling conduct and, indirectly, amplify intentions by cultivating an immersive consumer experience. Second, service environments transmit normative cues that recycling is both endorsed and anticipated, thereby recalibrating cognitions and attitudes in subtle yet systematic ways. In consequence, the intention-to-action pathway can be reliably activated within thoughtfully engineered service contexts. Third, the analyses demonstrate that service scenarios mobilize recycling through a sequenced chain of psychological processes. Fourth, whereas service scenarios deliver immediate sensory —*abstract, distal, and predominantly cognition-driven*. Consistent with this conceptualization, the moderating influence of perceived policy effectiveness is not statistically salient in our data.

5.1. Research conclusions

Situated at the intersection of sustainability and public policy, this study proposes a theoretically integrated account that unites service scenario, consumer immersion, recycling intention, and perceived policy effectiveness to illuminate the layered psychological and behavioral dynamics of consumer recycling. By confirming that immersive design can effectively stimulate circular behaviors, the key role of the "organism" (O) stage as an emotional participation channel in the S-O-R theory is highlighted. This discovery directly responds to and Bridges the inherent "cognitive gap" in the theory of Planned Behavior (TPB). The TPB model focuses on cognitive factors such as attitudes and subjective norms, but often neglects the power of emotions in driving behavioral decisions^[13,15]. This study demonstrates that immersive experiences can effectively bridge the gap between perception and behavior by activating consumers' emotional resonance, transforming abstract environmental perceptions (" I should recycle ") into intrinsic, emotionally driven behavioral motivations (" I'm willing to recycle because it makes me feel good ").

5.2. Theoretical contributions

This work contributes conceptually by transcending the conventional emphasis on individual cognition in recycling research and, instead, systematically integrating external context (service scenario) with internal experience (consumer immersion). The resulting “context–experience–decision–behavior” architecture broadens the explanatory reach of the Theory of Planned Behavior within environmental behavior research. While the Theory of Planned Behavior foregrounds attitudes, subjective norms, and perceived behavioral control as proximal determinants of intention, it typically sidelines the dynamic coupling of environmental affordances and experiential depth. By specifying the service scenario—encompassing the convenience of recycling infrastructure, clarity of informational visualization, and professionalism of service personnel—as an antecedent contextual driver, we then delineate how external conditions precipitate deeper experiential states that energize decision processes and culminate in action. Collectively, the model traces a coherent pathway from physical environment to psychological state and onward to behavioral manifestation.

5.3. Practical implications

Government, as both the catalyst for sustainability and the rule-setting authority, is instrumental in cultivating a societal climate that favors recycling. Effective recycling policy must be not only substantively sound but also readily perceivable and intelligible to the public.

Firms, which orchestrate service scenarios and connect consumers to the circular economy, should frame recycling as a strategic lever for brand enhancement and corporate social responsibility. Utilize digital technology to lower the threshold for recycling, develop mobile apps or mini-programs, and provide functions such as "one-click appointment for door-to-door recycling", "navigation to nearby recycling points", and "tracking of recycling progress"^[74,75]. By means of digital incentives such as points and coupons, the recycling behavior is linked to the consumers' immediate interests to achieve immediate feedback, thereby strengthening their recycling behavior and enhancing perceived behavioral control.

Consumer capability and awareness remain the bedrock of sustainable recycling. Priority actions include (a) just-in-time, context-specific education in malls, supermarkets, and residential communities via posters, videos, and trained facilitators; (b) the cultivation of pro-recycling social norms and community culture by publicizing exemplary recyclers and positioning recycling as both honorable and fashionable; and (c) communications that foreground the tangible consequences of individual and collective efforts, thereby reinforcing self-efficacy, perceived behavioral control, and the motivation to persist.

5.4. Research limitations

First, regional constraints on sample representativeness may weaken the generalizability of the conclusions. The data were collected exclusively in Shandong Province. Although this province is economically significant and typical in terms of consumer scale and the advancement of environmental policies, China exhibits pronounced regional heterogeneity. Inferring national regularities from a Shandong-only sample may overlook the influence of key contextual variables.

Second, a cross-sectional design is ill-suited to capture the dynamic evolution of behavior. The present study employed single time-point data collection, which can validate static associations among variables but cannot reveal the temporal sequencing through which recycling behaviors form. Dynamic regularities are prone to simplification as linear relations within a static framework, potentially leading to misjudgments about the mechanisms underpinning behavioral persistence.

Third, the theoretical framework does not yet fully encompass the drivers of behavior. Although this study verified the role of consumer immersion and recycling intention based on the theory of planned behavior and SOR theory, recycling behavior is actually the result of the interweaving of multi-level factors. However,

external interference mechanisms such as different cultural backgrounds and AI immersive systems also lack explanatory power in the existing framework. Moreover, research on the circular economy highlights the competitive influence of “informal recycling practices” (e.g., private purchase by small peddlers), and such external interference mechanisms also lack explanatory coverage in the current framework.

In sum, future research should enhance sample representativeness through multi-region sampling designs, employ longitudinal tracking to parse behavioral dynamics, and integrate additional theoretical models to extend the framework’s boundaries, thereby constructing an explanatory system for recycling behavior that is more aligned with real-world complexity.

5.5. Future research agenda

In response to the aforementioned limitations, future studies may proceed along the following lines:

First, enrich questionnaire design and modes of administration. Questionnaire construction should more finely consider the characteristics of different consumer groups, add explicit distinctions between current and potential consumers, and include a broader array of response options to ensure that data comprehensively reflect the research questions. At the same time, researchers may adopt mixed administration modes (e.g., combining online and offline) to expand sample diversity and representativeness and to reduce sampling bias arising from a single delivery mode.

Second, this study investigated the electronics sector, while prior scholarship indicates that products differ by attribute and category. Consequently, future research can conduct empirical comparisons between functional and hedonic products and broaden product choices to additional categories such as household appliances and electric vehicles.

Third, this study found that the moderating effect of policy perception was not significant. Policy perception, essentially, is a cognitive assessment of macro institutional arrangements. It is an abstract, distant, cognitively driven judgment that cannot instantly guide consumers' thinking^[76]. Future research can incorporate moderating variables such as environmental trust, policy transparency, moral perception^[77], employee perception^[78,79], and industry standards^[80] and environmental awareness—to construct a more comprehensive theoretical model and to generate more encompassing theoretical insights.

Conflict of interest

The authors declare no conflict of interest

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