Innovation of the Circular Transaction Service Mode of Furniture Products Oriented by User Demand

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In the context of global carbon neutrality and circular economy, this study proposes a circular furniture trading service model driven by user needs to address the underutilization of furniture waste, promote resource efficiency, and support carbon peaking and neutrality goals. Drawing on SIVA theory, circular economy principles, the Kano model, and Analytic Hierarchy Process (AHP), this study establishes a research framework to obtain, classify, and prioritize user needs through surveys, interviews, and mixed qualitative-quantitative methods. Based on these analyses, an optimized recycled furniture service system was designed to enhance information access, value perception, and the purchasing process. The Kano and AHP analyses identified price, environmental friendliness, and service convenience as core priorities. The model integrates green and information technologies to deliver a convenient, efficient, and eco-friendly service *via* trade-in, refurbishment, and one-stop solutions, thereby significantly enhancing user satisfaction and resource utilization efficiency. The findings provide a reference for green transformation of the furniture industry and the development of a low-carbon economy.

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INTRODUCTION

Global climate change has become a critical issue in contemporary society, presenting challenges that seriously threaten human survival and development. China currently stands at the intersection of economic growth and peak carbon emissions (Dai *et al*. 2024). In the face of this challenge, China officially pledged at the 75th session of the United Nations General Assembly the ambitious goals of "carbon peaking and carbon neutrality" (Li *et al*. 2024), aiming to promote a comprehensive green transformation of the economy and society by optimizing the energy structure and fostering green technological innovation.

In the context of these "dual carbon" goals, consumers are increasingly prioritizing green and environmentally friendly products (Li *et al*. 2024). In 2021, China's furniture industry output reached 1.12 billion pieces; in 2023, furniture manufacturing enterprises above the designated size generated a combined operating income of 655.57 billion yuan, indicating strong market development. However, it is estimated that Chinese cities produce approximately 90 million tons of waste wood materials annually, derived from discarded furniture, renovation debris, and construction projects (Zhao *et al*. 2024). China's domestic recycling of discarded furniture is still in the exploratory stage, and a systematic and efficient industrial chain has yet to be formed. Product Service Systems (PSS) can promote sustainable development, reduce resource waste and environmental impact, and improve the life cycle value of products (Li *et al*. 2021). Therefore, constructing a circular furniture service system guided by user needs offers a valuable reference for service innovation.

In the context of this study, it is imperative to clarify that the term "recycling service" extends beyond mere material reclamation. Instead, it encompasses a comprehensive range of value-restoration processes designed to render used items marketable again. These interventions include structural reinforcement such as regluing wooden components, aesthetic refurbishment involving scratch repair and surface refinishing, and functional restoration such as reupholstering fabric elements. By addressing physical defects including breakage or wear, these services effectively extend the product lifecycle and enhance reuse value.

The Conceptual Basis of the Study

Current research on vertical second-hand trading platforms primarily focuses on business model innovation, marketing strategy, and consumer behavior identification. Zhang (2022) explored the application of the 4R marketing model in online second-hand book platforms, emphasizing that competitiveness can be bolstered by responding flexibly to market demands. The study highlighted the importance of enhancing customer interaction, user engagement, and profit optimization, while also noting that integrating green concepts improves market efficiency. Qi and Yang (2021) compared user experiences on two second-hand luxury e-commerce platforms - Idle Fish and Plum. By analyzing design impacts across scope, structure, frame, and display layers, they concluded that vertical e-commerce platforms offer more efficient transaction experience for second-hand luxury goods than comprehensive platforms. Consequently, they suggested that functional and interaction designs on such platforms should prioritize user needs and psychological factors. Fan (2021) underscored the pivotal role of e-commerce in promoting the circular economy, advocating for improved supporting services to standardize second-hand commodity trading. The promotion can significantly reduce the overall acquisition costs, with e-commerce playing a crucial facilitation role.

The replacement of household products is increasingly driven by seasonal shifts and fashion trends. Consumers frequently update items to satisfy individualized needs, reflecting a pursuit of quality of life and market dynamism. Furthermore, personal values and social environmental factors significantly influence trust-building on second-hand platforms, a key differentiator from first-hand e-commerce (Mu and Xu 2024). As individual needs critically impact the furniture industry, user-centric analysis is essential. Wang and Li (2024) integrated the KANO model and AHP to analyze interaction needs for an immersive shopping APP, establishing a design model centered on basic and expectation needs to optimize user experience. Similarly, Mo *et al*. (2025) utilized the KANO model to filter core requirements *via* Better-Worse coefficients. Subsequently, they constructed an AHP model and transformed requirements into design parameters using Quality Function Deployment (QFD), creating a systematic solution for youth vision protection hardware and software. In the specific context of furniture, Zhang *et al*. (2023) investigated user experience optimization for mobile furniture shopping in the post-epidemic era. Using a mixed-methods approach combining qualitative interviews and quantitative questionnaires, they identified key user concerns, including authentic experience sharing, product matching, and after-sales service. Based on these findings, they proposed optimizations for interface functions, information presentation, and navigation to enhance user satisfaction and platform efficiency.

Framing of the Study

The SIVA model, proposed by Schultz and Dev in 2005 (Hsu *et al*. 2022), represents a paradigm shift from a product-oriented to a consumer-centered approach. It redefines the four distinct elements of the marketing mix from the user's perspective: Solutions, Information, Value, and Access. Within this framework, consumers are positioned as the active drivers of the decision-making process, replacing the traditional passive role.

The Kano model, introduced by Noriaki Kano in 1984, serves as a qualitative tool for analyzing user needs (Kano 1984). It categorizes product quality attributes into five distinct types: Must-be Quality (M), One-dimensional Quality (O), Attractive Quality (A), Indifferent Quality (I), and Reverse Quality (R). Regarding the prioritization of functions, the Kano theory generally suggests a hierarchical order of "M > O > A > I" to maximize user satisfaction effectiveness (Yu and Cheng 2022).

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making method developed by Saaty in the 1970s that integrates qualitative and quantitative analyses (Yu *et al*. 2021). It enables decision-makers to decompose complex multi-objective problems into a hierarchy and rank alternatives based on pairwise comparisons to identify the optimal solution (Ortiz-Barrios *et al*. 2017).

This study employed a structured framework focusing on the acquisition, screening, and satisfaction of user requirements. First, in the acquisition phase, the SIVA theory was utilized as a guiding macro-framework to capture initial system requirements across its four dimensions. Second, in the screening phase, the Kano model was applied to classify these requirements; following the elimination of "Indifferent" attributes, the remaining validated requirements were weighted and prioritized using the AHP method. Finally, in the satisfaction phase, the circular furniture transaction service model was optimized based on these prioritized demands, ensuring that user needs were effectively addressed across the solution, information, value, and access dimensions.

EXPERIMENTAL

Construction of Recycled Furniture Integration System Based on SIVA Theory and User Demand Acquisition

User group segmentation serves as the foundational basis for constructing the service system. Currently, China's second-hand furniture circular service sector is in a nascent stage, characterized by an underdeveloped user demand identification mechanism. Adopting a user-demand orientation, this study conducted an exploratory analysis to categorize typical user groups and define their specific requirements. This study collected primary data from 76 participants located in representative urban areas of China, employing a purposive sampling strategy. The recruitment process involved both physical channels, comprising brick-and-mortar second-hand furniture markets and trading towns, and digital channels *via* dominant online second-hand transaction platforms. Participant selection was strictly based on the inclusion criterion of possessing prior experience in purchasing or browsing second-hand furniture to ensure the validity and relevance of the demand data.

To mitigate potential bias arising from an unbalanced sample structure, a scenario-centric framework was adopted for user segmentation. This approach eliminates interference from confounding demographic variables such as age or identity. By combining contextual induction with motivation identification techniques, core demand characteristics were extracted from user interviews and usage scenarios to hierarchically categorize typical users. The primary classification was based on user identity, while sub-profiles were further refined by integrating consumption concepts and usage contexts. Consequently, five representative core user groups were delineated. Through analyzing the primary concerns, behavioral patterns, and value preferences of each category, distinct demand characteristics were refined. To ensure the validity and reliability of this classification, a data triangulation approach was employed. Findings were cross-verified from three distinct sources: field observations in physical markets, in-depth interviews with potential users, and behavioral analysis on digital platforms. The classification results are presented in Table 1.

Table 1. Classification and Characteristics of Target User Groups

User Category	Specific Profile	Key Requirement Characteristics
Young Users	Student Renters	Price-sensitive; seek personal style and practicality; require furniture that is easy to move and assemble
	Early-career Individuals	
Family Users	Three-person Families	Emphasize multifunctionality and safety; focus on eco-friendly materials and spatial adaptability; prefer durable yet lightweight designs
	Families with Young Children	
Office Users	Small and Micro Enterprises	Emphasize cost-performance; want one-time procurement that is comprehensive and supports multiple users; tend to choose clear-function, simple-form products
	Startups	
Elderly Users	Home-based Elder Care Users	High requirements for safety and comfort; prefer stable structures, easy-to-maintain furniture; attentive to healthy materials
Value-driven Users	Environmental Advocates	Have eco-awareness; value reuse value and lifecycle of furniture; tend to support certified or quality-assured second-hand products
	Resource-saving Consumers	

The SIVA theory anchors the system in a consumer-centric perspective for comprehensive need acquisition, while circular economy principles underpin the service model. Relying on the 3R principles (Reduce, Reuse, Recycle), the system aims to maximize resource utilization and ensure service professionalism and accessibility, thereby providing consumers with eco-friendly, sustainable solutions. A schematic diagram of this integrated circular furniture service system is illustrated in Fig. 1.

The satisfaction of user needs significantly influences the willingness to purchase second-hand furniture; therefore, precise identification of these needs is critical. In this study, user requirements were initially acquired from a four-dimensional perspective using the SIVA theory, synthesizing data from questionnaires and offline interviews. Crucially, to address the common limitation of the traditional Kano model regarding unstructured requirement screening, the SIVA framework was employed as a strict filtering mechanism. The collected raw items were mapped against the four SIVA dimensions (Solution, Information, Value, and Access). Requirements that failed to align with these consumer decision-making drivers were defined as "irrelevant" to the service model and were eliminated. Subsequently, semantically identical items were merged to ensure distinctiveness. The final refined list of user requirements is collated in Table 2.

Table 2. Initial List of User Requirements Based on SIVA Theory

SIVA Dimension	ID	Requirement Description
S: Solutions	S1	Trade-in service
	S2	Second-hand furniture purchase service
	S3	Second-hand furniture rental service
	S4	Second-hand furniture recycling service
	S5	Favorable pricing
	S6	Second-hand furniture refurbishment service
	S7	One-stop service from purchase to installation
I: Information	I1	Detailed product origin information
	I2	Clear furniture categorization
	I3	Educational content on advantages of buying second-hand furniture
	I4	Case studies showcasing high-quality furniture
	I5	User Q&A for common issues
	I6	Preliminary online valuation for selling furniture
	I7	Objective description of furniture condition
	I8	Transparent review/rating system
V: Value	V1	More economical second-hand furniture
	V2	Professional after-sales service
	V3	Buying second-hand furniture supports environmental protection
	V4	Second-hand furniture meets usage requirements
	V5	Second-hand furniture is healthier
	V6	Clear carbon-reduction data
A: Access	A1	Offline warehouse advantages
	A2	Online selection and purchase
	A3	Detailed guidance on purchase process
	A4	Conduct furniture maintenance workshops
	A5	Convenient payment methods

User Requirements Classification Based on Kano Model with Better-Worse Coefficient Analysis

To accurately classify user needs, a standardized Kano questionnaire was developed, the structure of which is explicitly declared in Table 3. This instrument employs a paired-question mechanism for each service attribute, comprising a functional question to assess user sentiment when the feature is provided, and a dysfunctional question to evaluate the reaction when the feature is absent. For each item, respondents selected one of five standardized options: "Like it," "Expect it," "Neutral," "Can tolerate it," and "Dislike it." These specific response alternatives were selected to maximize respondent convenience while strictly adhering to the Kano evaluation logic. By cross-referencing the responses to the functional and dysfunctional inquiries, each requirement was systematically classified into one of six categories: Must-be, One-dimensional, Attractive, Indifferent, Reverse, or Questionable."

Table 3. Specific Items and Question Format of the Standardized Kano Questionnaire

If available, what is your attitude?					Service Requirement Description	If not available, what is your attitude?				
Like it	Expect it	Neutral	Can tolerate it	Dislike it		Like it	Expect it	Neutral	Can tolerate it	Dislike it
					Trade-in service					
					Second-hand furniture purchase service					
					Second-hand furniture rental service					
					Second-hand furniture recycling service					
					Favorable pricing					
					Second-hand furniture refurbishment service					
					One-stop service from purchase to installation					
					Detailed product origin information					
					Clear furniture categorization					
					Educational content on advantages of buying second-hand furniture					
					Case studies showcasing high-quality furniture					
					User Q&A for common issues					
					Preliminary online valuation for selling furniture					
					Objective description of furniture condition					
					Transparent review/rating system					
					More economical second-hand furniture					
					Professional after-sales service					
					Buying second-hand furniture supports environmental protection					
					Second-hand furniture meets usage requirements					
					Second-hand furniture is healthier					
					Clear carbon-reduction data					
					Offline warehouse advantages					
					Online selection and purchase					
					Detailed guidance on purchase process					
					Conduct furniture maintenance workshops					
					Convenient payment methods					

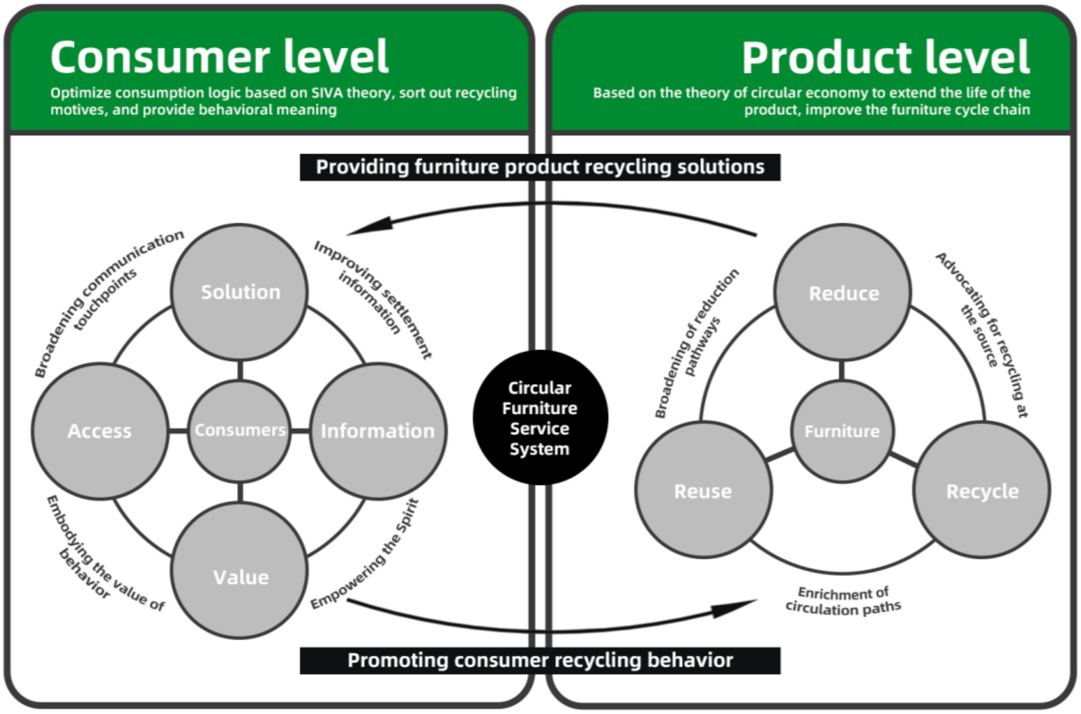

Fig. 1. Schematic diagram of the integrated circular furniture service system based on SIVA and 3R principles

The survey was distributed *via* both online and offline channels. A total of 100 questionnaires were distributed, yielding 96 valid responses. The study population was primarily comprised of the five typical user groups identified earlier. The demographic profile, including gender composition and age structure, is presented in Table 4.

Table 4. Demographic Profile of Survey Respondents

Category	Subgroup	Frequency (N)	Percentage (%)
Gender	Male	42	43.75
	Female	54	56.25
Age	Under 18	7	7.29
	18 to 25	36	37.50
	26 to 35	25	26.04
	36 to 45	18	18.75
	46 to 60	9	9.38
	Over 60	1	1.04

The demographic distribution shown in Table 4 indicates a significant concentration of users aged 18 to 35, accounting for 63.5% of the total sample. This aligns with the primary consumer base of the contemporary digital second-hand economy, who typically possess higher environmental awareness and acceptance of online transaction models. The gender balance further ensures that the collected data reflects a comprehensive perspective, minimizing gender-based bias in demand identification.

Reliability and validity analyses were conducted using SPSS 27 software, with results presented in Table 5.

Table 5. Reliability and Validity Analysis Results

Indicator	Statistical Value
Cronbach's α for positively worded items	0.853
Cronbach's α for reverse-coded items	0.948
Overall questionnaire Cronbach's α	0.925
KMO value	0.880
p-value	0.000
Cumulative variance explained after rotation	62.828%

Table 6. Aggregated Results and Classification of User Requirements

ID	A	O	M	I	R	Q	Kano Category	Better Coefficient	Worse Coefficient
S1	45	15	19	16	0	1	A	63.16%	-35.79%
S2	25	16	30	23	2	0	M	43.62%	-48.94%
S3	29	9	16	40	2	0	I	40.43%	-26.60%
S4	28	24	20	21	2	1	A	55.91%	-47.31%
S5	10	54	20	11	0	1	O	67.37%	-77.89%
S6	52	13	8	20	2	1	A	69.89%	-22.58%
S7	37	30	10	18	0	1	A	70.53%	-42.11%
I1	12	37	38	7	1	1	M	52.13%	-79.79%
I2	27	19	23	24	1	2	A	49.46%	-45.16%
I3	37	16	4	38	0	1	I	55.79%	-21.05%
I4	40	10	6	39	0	1	A	52.63%	-16.84%
I5	22	25	30	18	0	1	M	49.47%	-57.89%
I6	28	29	13	24	1	1	O	60.64%	-44.68%
I7	15	41	21	18	0	1	O	58.95%	-65.26%
I8	14	33	30	18	0	1	O	49.47%	-66.32%
V1	13	40	36	6	0	1	O	55.79%	-80.00%
V2	13	52	26	4	0	1	O	68.42%	-82.11%
V3	36	28	4	26	1	1	A	68.09%	-34.04%
V4	15	34	35	10	0	2	M	52.13%	-73.40%
V5	20	44	13	18	0	1	O	67.37%	-60.00%
V6	41	10	4	39	1	1	A	54.26%	-14.89%
A1	48	9	7	31	0	1	A	60.00%	-16.84%
A2	24	42	17	11	1	1	O	70.21%	-62.77%
A3	31	28	23	11	1	2	A	63.44%	-54.84%
A4	41	8	6	39	1	1	A	52.13%	-14.89%
A5	12	43	24	14	1	2	O	59.14%	-72.04%

The Cronbach's alpha coefficients for forward questions, reverse questions, and the overall questionnaire all exceeded 0.9, indicating high internal consistency reliability. The Kaiser-Meyer-Olkin (KMO) value was 0.880 ($p < 0.000$), surpassing the 0.6 threshold, which confirmed the suitability of the data for factor analysis. Furthermore, the cumulative variance explained after rotation reached 62.828%, demonstrating that the items effectively capture the research constructs and that the overall validity of the questionnaire is robust. The aggregated Kano classification results for each requirement are summarized in Table 6.

Traditional Kano model classification relies on the frequency maximization principle, often overlooking the distribution of other attributes (Li *et al*. 2023). To address this, the Better-Worse coefficient analysis proposed by Berger *et al.* (1993) was employed. This method assesses the importance of a product or service feature by quantifying customer satisfaction and dissatisfaction. It calculates two key indicators: the Better coefficient, representing the potential increase in satisfaction when a feature is provided, and the Worse coefficient, reflecting the potential increase in dissatisfaction when it is absent. The specific calculation method is:

$$Better = (A+O)/(A+O+M+I) \tag{1}$$

$$Worse = -1\times(O+M)/(O+A+M+I) \tag{2}$$

The distribution of user requirements based on the Better-Worse coefficients is visually synthesized in Fig. 2, with the detailed categorization presented in Table 7. As illustrated in the quadrant analysis, requirements located in the first quadrant, characterized by high Better and high Worse values, represent One-dimensional qualities serving as competitive factors directly proportional to user satisfaction. The identified "Must-be" qualities, such as S2, S4, and I8, constitute the system's non-negotiable baseline for safety and transparency, the absence of which would render the service unviable. Conversely, the "Attractive" qualities, including S1 and S6, underscore the unique value propositions of this circular model, specifically the trade-in and refurbishment services. These features distinguish the proposed system from generic second-hand platforms and function as "delighters" to exceed user expectations.

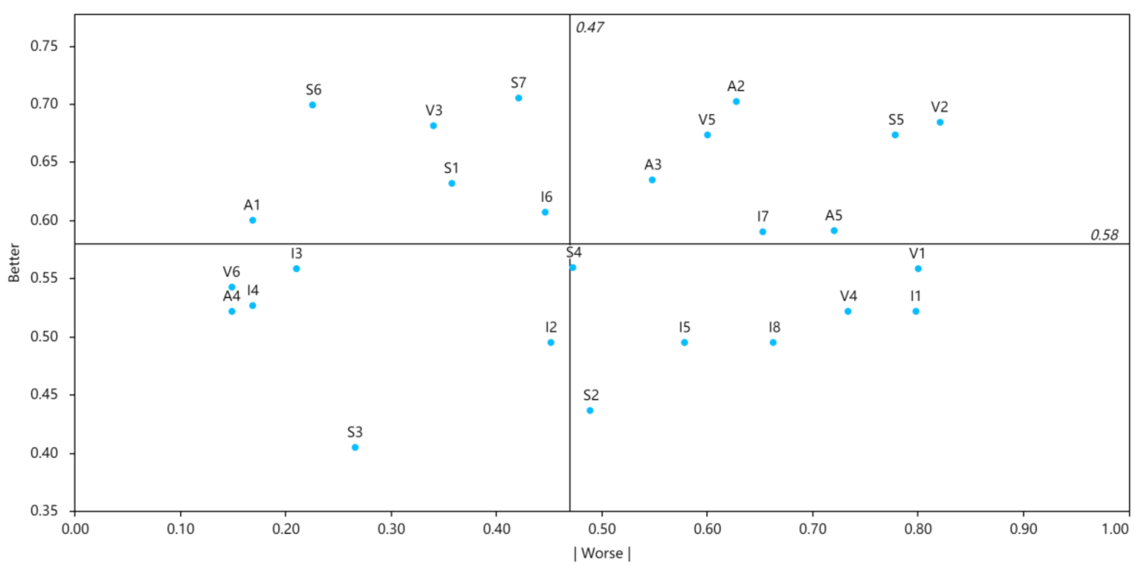

Fig. 2. Quadrant distribution of user requirements based on Better-Worse coefficient analysis

Table 7. Final Categorization of User Requirements based on Better-Worse Analysis

Attribute Category	ID	Requirement Description
Must-be Quality	S2	Second-hand furniture purchase service
	S4	Second-hand furniture recycling service
	I1	Detailed product origin information
	I5	User Q&A for common issues
	I8	Transparent review/rating system
	V1	More economical second-hand furniture
	V4	Second-hand furniture meets usage requirements
One-dimensional Quality	S5	Favorable pricing
	I7	Objective description of furniture condition
	V2	Professional after-sales service
	V5	Healthier second-hand furniture
	A2	Online selection and purchase
	A3	Detailed guidance on purchase process
	A5	Convenient payment methods
Attractive Quality	S1	Trade-in service
	S6	Second-hand furniture refurbishment service
	S7	One-stop service from purchase to installation
	I6	Preliminary online valuation for selling furniture
	V3	Buying second-hand furniture supports environmental protection
	A1	Offline warehouse advantages
Indifferent Quality	S3	Second-hand furniture rental service
	I2	Clear furniture categorization
	I3	Educational content on advantages of buying second-hand furniture
	I4	Case studies showcasing high-quality furniture
	V6	Clear carbon-reduction data
	A4	Conduct furniture maintenance workshops

Acquisition of Demand Weights of Recycled Furniture Transaction Service Model Based on AHP Hierarchical Analysis Method

AHP model construction

While the Kano model effectively categorizes the service attributes of the circular furniture system, it does not quantitatively determine the priority of specific demands. To address this limitation, the AHP was employed to accurately calculate the relative weight of each user requirement (Wang and Fan 2024). Based on the Kano classification results, six requirements identified as "Indifferent Quality" were excluded from the subsequent AHP weight calculation, as their contribution to user satisfaction is negligible. These eliminated items include: Second-hand furniture rental service (S3), Clear furniture categorization (I2), Educational content on advantages (I3), Case studies (I4), Clear carbon-reduction data (V6), and Furniture maintenance workshops (A4). Consequently, the AHP hierarchy for the circular furniture service system was constructed using the remaining validated requirements. The structural model is illustrated in Fig. 3.

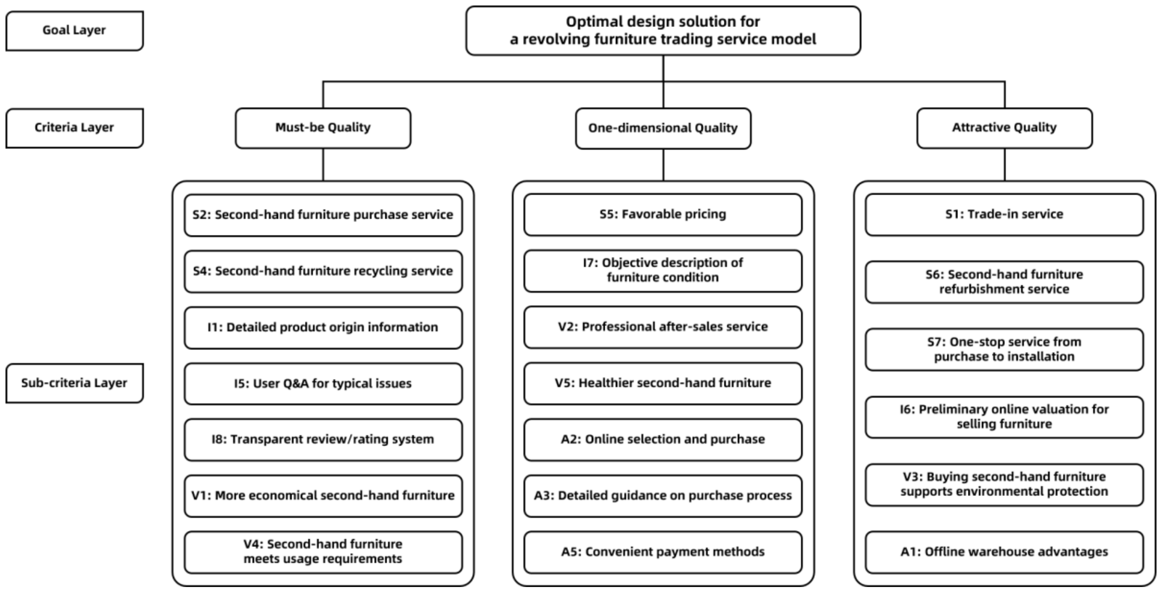

Fig. 3. Hierarchical structure model for the Analytic Hierarchy Process

Calculation of service model demand weights

To ensure objectivity and scientific rigor in the quantification process, Thomas L. Saaty's 1–9 scale was utilized. For *m* factors, the judgment matrix X was constructed as an *m*-order positive reciprocal matrix, where X_{ij} represents the relative importance of factor *i* compared to factor *j*, satisfying the condition $X_{ji} = 1/X_{ij}$ for all $i,j \in \{1,2,\ldots m\}$(Cang *et al*. 2022). The definitions of the scale values are presented in Table 8.

Table 8. The Saaty Rating Scale for Pairwise Comparisons

Intensity of Importance	Definition
1	Factor *i* and factor *j* are equally important
3	Factor *i* is slightly more important than factor *j*
5	Factor *i* is noticeably more important than factor *j*
7	Factor *i* is strongly more important than factor *j*
9	Factor *i* is absolutely more important than factor *j*
2, 4, 6, 8	Intermediate values between the two adjacent judgments

A panel of ten experts was invited to score the requirements of the circular furniture service model. The collected data were aggregated using the geometric mean method to construct the judgment matrices, which are detailed in Tables 9 through 12.

Table 9. Pairwise Comparison Matrix and Weights for the Criterion Layer

Factor	M	O	A	Local Weight	Consistency Test Result
M	1	4	5	0.683	λ_max = 3.025
O	1/4	1	2	0.200	CR = 0.024
A	1/5	1/2	1	0.117	Consistency check passed

Table 10. Pairwise Comparison Matrix for "Must-be" Qualities

M	S2	S4	I1	I5	I8	V1	V4	Local Weight	Consistency Test Result
S2	1	3	2	3	2	1/2	1/2	0.178	
S4	1/3	1	1	3	2	1	1	0.143	
I1	1/2	1	1	2	1/2	1/2	1/3	0.091	λ_max =7.402
I5	1/3	1/3	1/2	1	1/3	1/3	1/3	0.054	CR=0.049
I8	1/2	1/2	2	3	1	1/2	1/2	0.113	Consistency check passed
V1	2	1	2	3	2	1	1	0.205	
V4	2	1	3	2	1	1	1	0.217	

Table 11. Pairwise Comparison Matrix for "One-dimensional" Qualities

O	S5	I7	V2	V5	A2	A3	A5	Local Weight	Consistency Test Result
S5	1	2	2	3	1	4	4	0.264	
I7	1/2	1	2	2	2	3	4	0.217	
V2	1/2	1/2	1	3	1	3	3	0.164	λ_max=7.321
V5	1/3	1/2	1/3	1	1/2	2	2	0.091	CR=0.039
A2	1	1/2	1	2	1	1	2	0.138	Consistency check passed
A3	1/4	1/3	1/3	1/2	1	1	1	0.068	
A5	1/4	1/4	1/3	1/2	1/2	1	1	0.059	

Table 12. Pairwise Comparison Matrix for "Attractive" Qualities

A	S1	S6	S7	I6	V3	A1	Local Weight	Consistency Test Result
S1	1	3	1	2	2	3	0.270	
S6	1/3	1	1/3	2	1	2	0.130	
S7	1	3	1	2	2	4	0.283	λ_max = 6.312
I6	1/2	1/2	1/2	1	1/3	2	0.098	CR=0.050
V3	1/2	1	1/2	3	1	1	0.142	Consistency check passed
A1	1/3	1/2	1/4	1/2	1	1	0.078	

Step 1: Compute the product of the factors in each row of the judgment matrix:

(3)

Step 2: Calculate the geometric mean:

$$\overline{w_i} = \sqrt[n]{M_i} \quad (4)$$

Step 3: Perform normalization to calculate relative weights:

$$W_i = \frac{\overline{w_i}}{\sum_{i=1}^{n} \overline{w_i}} \tag{5}$$

Step 4: Compute the largest eigenvalue of the matrix:

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^{n} \frac{A_{W_i}}{W_i} \tag{6}$$

Step 5: Conduct the consistency test:

$$CI = \frac{\lambda_{max} - n}{n-1} \tag{7}$$

$$CR = \frac{CI}{RI} \tag{8}$$

A Consistency Ratio (CR) of less than 0.1 indicates acceptable consistency. Conversely, if CR > 0.1, the judgment matrix is deemed inconsistent, necessitating adjustments to the pairwise comparisons. This iterative correction process continues until the CR threshold is met, ensuring the validity of the decision analysis. As shown in Tables 9 through 12, all judgment matrices in this study passed the consistency test.

By synthesizing the weights from the criterion and sub-criterion layers, the global weights for each demand factor were calculated and ranked. The final results are presented in Table 13.

For this integrated online-offline system, the results indicate a distinct prioritization compared to traditional offline models, reflecting a dual user focus on both foundational functionality and innovative experience. According to Table 13, the criterion layer was ranked as Must-be Quality > One-dimensional Quality > Attractive Quality, aligning with the theoretical prioritization of the Kano model. Specifically, Must-be Quality held the highest weight. The top eight sub-criteria included: V4 (Usage Requirements), V1 (Affordability), S2 (Purchase Service), S4 (Recycling Service), I8 (Transparent Evaluation), I1 (Detailed Origin), S5 (Favorable Pricing), and I7 (Objective Description). These findings suggest that the users primarily prioritized basic utility and system transparency. Consequently, these elements should be emphasized as critical focal points in the system design.

RESULTS

Synthesizing the empirical findings from the SIVA-Kano-AHP analysis, this section proceeds to the practical construction of the circular furniture service system. The design process followed three logical steps: first, translating the high-priority qualities identified in the previous section into core functional modules; second, designing a service blueprint to visualize the synergistic interaction flow between online platforms and offline service nodes; and third, developing the user interface to ensure system accessibility. The ultimate goal of this construction was to establish a closed-loop transaction mode that effectively eliminates trust barriers, optimizes resource efficiency, and maximizes user satisfaction throughout the furniture lifecycle.

Table 13. Global Weights and Ranking of User Requirements

Criterion Layer	Weight	ID	Requirement Description	Local Weight	Global Weight	Rank
Must-be Quality	0.683	S2	Second-hand furniture purchase service	0.178	0.122	3
		S4	Second-hand furniture recycling service	0.143	0.098	4
		I1	Detailed product origin information	0.091	0.062	6
		I5	User Q&A for typical issues	0.054	0.037	9
		I8	Transparent review/rating system	0.113	0.077	5
		V1	More economical second-hand furniture	0.205	0.140	2
		V4	Second-hand furniture meets usage requirements	0.217	0.148	1
One-dimensional Quality	0.200	S5	Favorable pricing	0.264	0.053	7
		I7	Objective description of furniture condition	0.217	0.043	8
		V2	Professional after-sales service	0.164	0.033	10
		V5	Healthier second-hand furniture	0.091	0.018	14
		A2	Online selection and purchase	0.138	0.028	13
		A3	Detailed guidance on purchase process	0.068	0.014	17
		A5	Convenient payment methods	0.059	0.012	19
Attractive Quality	0.117	S1	Trade-in service	0.270	0.032	12
		S6	Second-hand furniture refurbishment service	0.130	0.015	16
		S7	One-stop service from purchase to installation	0.283	0.012	18
		I6	Preliminary online valuation for selling furniture	0.098	0.017	15
		V3	Buying second-hand furniture supports environmental protection	0.142	0.009	20
		A1	Offline warehouse advantages	0.078	0.033	11

Service System Construction

Based on the demand acquisition and prioritization results, the construction of the circular furniture service system is illustrated in Fig. 4.

The user demand-driven service model innovation essentially represents the terminal mapping of multi-party synergy within the circular economy. Although this study focused on optimizing user experience, the underlying logic of the service system aligned with the interests of multiple stakeholders through preset operational rules. For example, the high-priority user demand for a "transparent evaluation system" (I8, Table 7) relied on the synergistic guarantee of supplier access audits and logistics time commitments. Interconnected data and dynamic pricing mechanisms ensure sustainable partner engagement while enhancing user trust. This design utilizes user demand not to overlook other stakeholders, but as a lever to drive the efficiency restructuring of the industry chain. The improvement of user satisfaction will, in turn, drive process upgrades on the production side and optimize responses on the logistics side, ultimately forming an ecological closed loop of "demand traction–resource integration–value sharing."

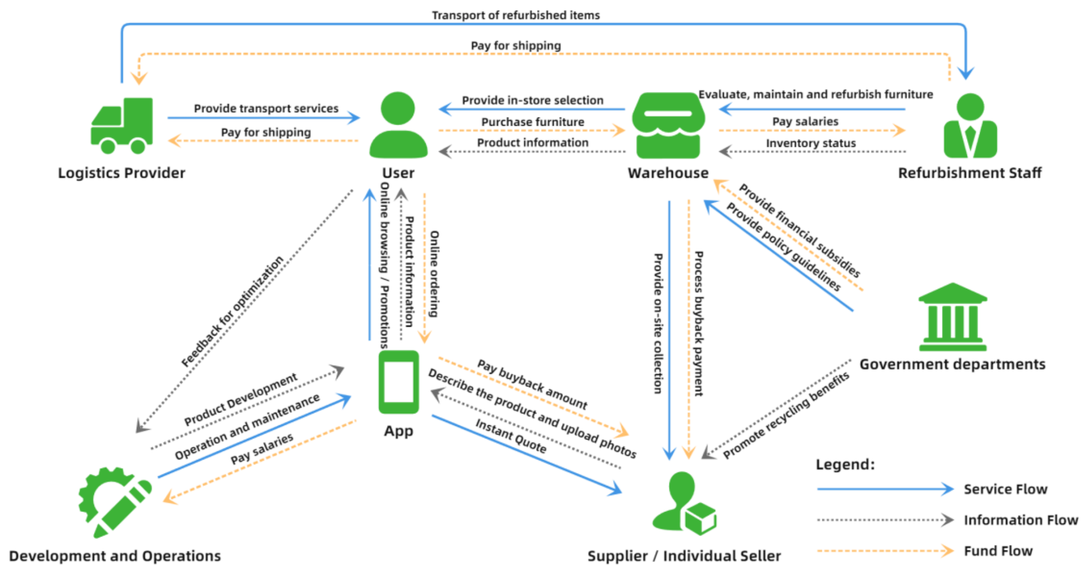

Fig. 4. Operational framework of the constructed circular furniture service system

For furniture buyers, the system has revolutionized the acquisition mode of second-hand furniture, reshaping the purchase path by integrating online and offline experiences for greater convenience and efficiency. The online platform integrates inventory data from offline warehouses and delivers this information to the buyer via the app, significantly improving the experience of basic needs. The system introduces a professional recycling and processing team, which not only ensures the transparency and credibility of the source but also cleans and refurbishes used items to extend their lifecycle and enhance product attractiveness. Through detailed and objective condition descriptions, the system provides consumers with an intuitive basis for purchasing, thereby simplifying the decision-making process.

For furniture sellers, the system establishes a rapid and accurate recycling channel, avoiding resource stagnation caused by the difficulty of finding buyers. The system is embedded with online pre-valuation tools to facilitate the recycling process. Compared with traditional platforms, this system deeply optimizes the service process based on user needs and market objectives, creating a closed-loop service that synergizes online and offline channels to provide a one-stop, highly trustworthy solution. The service blueprint of the system is shown in Fig. 5.

To clarify the operational logic, the blueprint delineates the interconnections across two critical boundaries: The boundary line of user interaction and Content interaction boundary line. The core proposal centers on a seamless Online-Merge-Offline flow, where user actions, ranging from digital browsing to one-click valuation, trigger immediate frontstage responses *via* the interface. Crucially, vertical interconnection is established as Backstage.

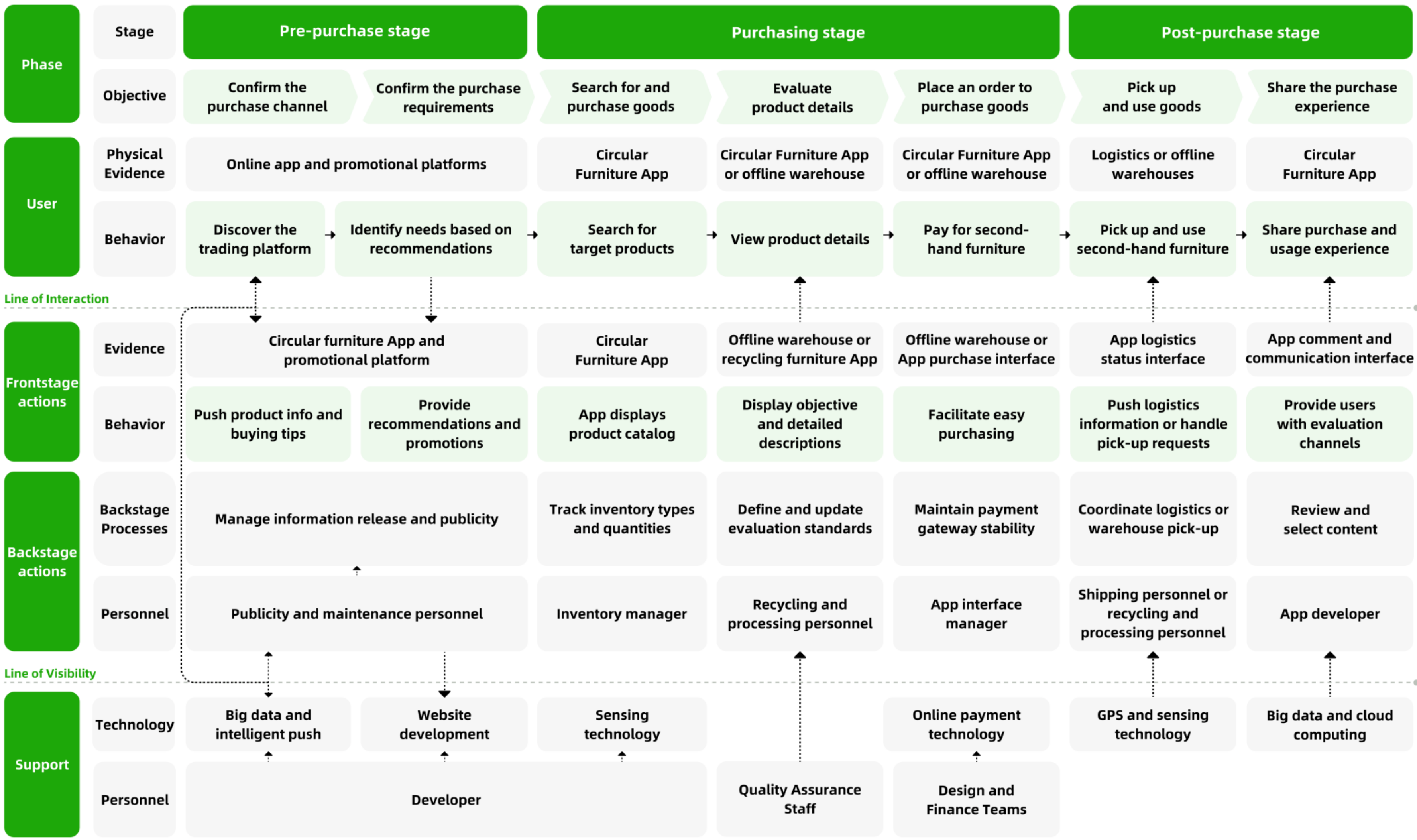

Fig. 5. Service blueprint illustrating the Online-Merge-Offline (OMO) synergy flow

Contact employees coordinate with Support Processes, specifically the professional testing and refurbishment teams. This internal collaboration ensures that the physical condition of the furniture is accurately quantified and synchronized with visible online data, thereby eliminating the information asymmetry typical of traditional transactions.

The core innovation of the recycled furniture service system is that it reconstructs the value chain of traditional second-hand furniture transactions through a specialized division of labor and data-driven processes. Compared with the free-market model led by "user self-description and independent negotiation" on comprehensive platforms, this system focuses on the specific characteristics of the furniture category. It builds a new logic of professional testing intervention and closed-loop service to address the pain points of non-standardization, cumbersome user experience, and high barriers to eco-friendly disposal.

While traditional platforms rely on subjective information provided by buyers and sellers, this system introduces a professional testing team to quantitatively assess material safety, structural stability, and refurbishment potential, generating a visual evaluation report. This upgrades the traditional random transaction of "one price for one item" to a standardized process of "data guidance - transparent and controllable." In addition, through the closed-loop design of "online decision-making—offline verification" (refer to the interaction flow in Fig. 6), the system transforms the storage center into a value-aware node, thus eliminating trust barriers.

This model innovation not only solves the problem of inefficient circulation but also embeds user behavior into the macro-value network of the circular economy through the visualization of carbon footprints, realizing the paradigm leap from "transaction aggregation" to "value co-creation."

Platform Interface Design

Next, the system interface was optimized to ensure that the design solution effectively meets core user needs. The functionality and professionalism of the interface were enhanced to address the two highest-priority demand factors, V4 and V1 (as quantified in Table 13), enabling users to better understand the actual condition of the furniture.

The interface design was simplified to highlight core functions and optimize the interaction process, reducing operational complexity. Product attributes such as color, material, and condition are clearly labeled to enhance information clarity and streamline the selection process. These improvements elevate the functionality and professionalism of the interface while enhancing the overall user experience. The interface design is presented in Fig. 6.

Service System Validation

As the contact point for user interaction, the functional modules and interface logic of the app strictly correspond to the core processes in the service architecture. From a systems theory perspective, the interface is not only a carrier of interaction but also the explicit expression of back-end processes. Usability testing and user feedback analysis are essential to verify the synergistic effectiveness of the system nodes (information flow, service flow, and value flow).

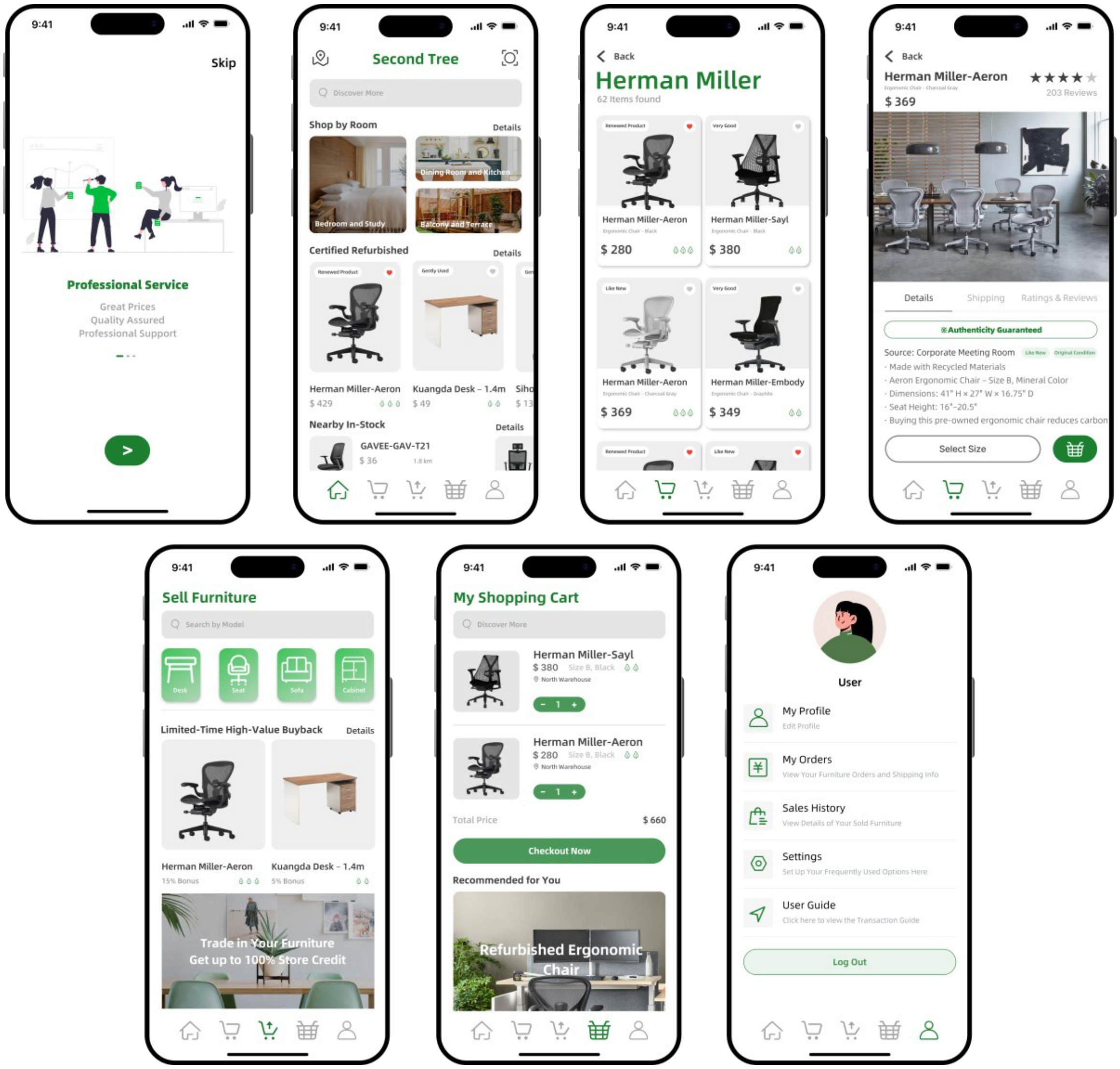

Fig. 6. Key user interface (UI) designs of the service platform

To empirically verify the effectiveness and feasibility of the proposed circular furniture service system, the System Usability Scale (SUS) was selected as the primary validation instrument. The specific items and response options of this questionnaire are explicitly presented in Table 14. The instrument comprises ten specific statements, alternating between positive and negative sentiments to minimize response bias. Participants evaluate each item using a five-point Likert scale ranging from “Strongly Disagree” (1 point) to “Strongly Agree” (5 points). Regarding the scoring algorithm, raw scores for positive, odd-numbered items are transformed by subtracting one from the user rating, whereas negative, even-numbered items are calculated by subtracting the user rating from five.

The cumulative sum of these transformed values is multiplied by a factor of 2.5 to derive a final composite score ranging from 0 to 100, providing a standardized index of global system usability.

Table 14. Items and Response Scale of the System Usability Scale (SUS)

Item No.	Statement	Response Scale				
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I think that I would like to use this system frequently.					
2	I found the system unnecessarily complex.					
3	I thought the system was easy to use.					
4	I think that I would need the support of a technical person to be able to use this system.					
5	I found the various functions in this system were well integrated.					
6	I thought there was too much inconsistency in this system.					
7	I would imagine that most people would learn to use this system very quickly.					
8	I found the system very cumbersome to use.					
9	I felt very confident using the system.					
10	I needed to learn a lot of things before I could get going with this system.					

A total of 37 valid SUS questionnaires were collected from typical users. The calculated mean SUS score was 82.86 (Grade A), surpassing 90% to 95% of benchmark samples in the database. These results indicate a high level of design quality and system usability, empirically validating the feasibility of the proposed service model and its alignment with user expectations.

DISCUSSION

Adopting a user-demand orientation, this study integrated SIVA theory, the Kano model, and the Analytic Hierarchy Process to construct an innovative framework for a circular furniture trading service model. Through demand classification and prioritization, the core driving factors - economy, environmental protection, and convenience were clarified. Consequently, differentiated functions, including trade-in, refurbishment, and one-stop services, were designed to establish a closed-loop system with online-offline synergy. The system usability validation demonstrated that the model effectively improves user trust and resource recycling efficiency, providing both theoretical insights and practical support for the low-carbon transformation of the furniture industry.

While this study constructed an empirically validated closed-loop service system, opportunities for further optimization remain. Given the fashion-sensitive nature of the furniture industry, it is acknowledged that the "refurbishment" module within the system should ideally extend beyond functional repair to include "aesthetic modernization."

Although the current study establishes the service framework, specific upcycling protocols to adjust the "fashion statement" of used items to align with changing trends require further exploration. Therefore, the next step will be to explore the stakeholder synergy mechanism, expand the empirical tests in different regions and scenarios, and investigate standardized aesthetic upgrading strategies. Future work will also optimize the demand classification through long-term data tracking and continuously improve the evaluation indexes in real application environments. These efforts aim to gradually upgrade the service model from "demand-oriented" to "ecological co-construction," thereby contributing to the development of the circular economy.

CONCLUSIONS

1. User-Centered Circular Service Model: This research developed a circular furniture trading service model grounded in SIVA theory, emphasizing trade-in, refurbishment, transparent evaluation, and one-stop solutions. By aligning green and information technologies, the model enhances convenience, efficiency, and eco-friendliness, directly responding to core user priorities such as affordability, environmental benefits, and service ease.
2. Rigorous Needs Identification and Prioritization: The employment of mixed qualitative-quantitative methods, specifically Kano classification and AHP weighting, ensures that basic (Must-be), expected (One-dimensional), and attractive user demands are systematically captured and ranked. This rigorous approach validates that critical features such as purchase and recycling services, transparent sourcing, and clear condition descriptions are addressed primarily to secure user trust and satisfaction.
3. Alignment with Sustainability Goals: The proposed system not only satisfies user requirements but also advances circular economy and carbon neutrality objectives by maximizing reuse, extending product lifecycles, and visualizing carbon reductions. This demonstrates how user-driven design can catalyze broader industry shifts toward low-carbon, resource-efficient practices.
4. Practical and Future Implications: The findings offer actionable guidance for second-hand furniture platforms and service designers. To enhance platform competitiveness, future circular ecosystems should prioritize specific attributes that address information asymmetry and transaction efficiency. Recommended features include the implementation of standardized quality assessment protocols to generate visualized condition reports, and the integration of seamless logistics services to ensure a consistent fulfillment experience. Furthermore, a critical direction for future development is to establish a product reclaim expectation at the initial point of sale, thereby embedding a "return-to-cycle" protocol into the consumer mindset. Future work should also expand user segments and explore hardware–software synergies to further optimize user experience and reinforce sustainable transformation in the furniture sector.

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