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A Comparative CVM-Based Evaluation of Non-Use Values for the Zhongjieshan and Liuheng Marine Ranches in China

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Abstract

This study uses the Contingent Valuation Method (CVM), a quantitative approach, with interval regression and Ordinary Least Squares (OLS) models to assess the non-use values of the Zhongjieshan and Liuheng Marine Ranches. The aim of the study is to quantify the monetary value of non-market benefits, examine socioeconomic influences on stakeholders' Willingness to Pay (WTP), and provide a basis for ecological compensation mechanisms. Zhongjieshan's annual non-use value is estimated at 28.99–30.81 million CNY (Chinese Yuan) (median WTP 74.33–78.99 CNY per person), while Liuheng's value is higher at 108–111 million CNY (median WTP 150.20–153.89 CNY per person), suggesting greater ecological and recreational potential at Liuheng. The results show robust model performance, with minimal WTP differences. WTP for Liuheng is primarily influenced by income and environmental awareness, while Zhongjieshan shows a distance-decay effect. Visitor profiles reveal that Zhongjieshan attracts younger, moderately educated visitors, while Liuheng draws more highly educated, economically diverse groups. These findings suggest that Zhongjieshan should prioritize community-based co-management, while Liuheng should focus on high-quality, technology-driven ecological leisure development. The study also emphasizes the need for targeted awareness campaigns and supports the creation of diversified ecological compensation mechanisms beyond government funding.

Keywords: marine ranching; China; contingent valuation method; Ordinary Least Squares regression; willingness to pay

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1. Introduction

Marine ranching is an important means of promoting the sustainable use of marine resources and a key measure for enhancing coastal fisheries output, improving the ecological environment, and protecting biodiversity [1]. As a major maritime country, China has a long coastline and abundant marine resources, providing exceptional conditions for the development of marine ranching. In recent years, the Chinese government has attached great importance to the construction of marine ranches, investing substantial funds and resources to promote their rapid development nationwide. Marine ranching refers to an ecosystem constructed in suitable sea areas through habitat restoration and population enhancement, which adheres to ecological principles, maximizes natural productivity, and integrates modern engineering technologies with systematic management [2]. This system simultaneously delivers environmental remediation, resource conservation, and sustainable fishery production and is widely recognized as a critical approach for rehabilitating marine

fishery resources and an effective strategy for improving marine ecological conditions. However, despite this rapid expansion, there remains limited empirical evidence on how the public values the ecological and fishery benefits generated by marine ranching and to what extent they are willing to contribute to its construction and maintenance. In particular, the willingness-to-pay (WTP) for the non-market ecological services of marine ranches, as well as the socio-economic, cognitive, and spatial factors that shape this WTP, are still insufficiently understood.

The economic valuation methods for marine ranching primarily include the Contingent Valuation Method (CVM) [3], cost–benefit analysis [4] and the travel cost method [5] to evaluate the economic effectiveness of marine ranching. However, the capitalization method faces challenges in accurately forecasting future biological resource yields due to significant environmental fluctuations affecting marine biomass, leading to unreliable data. Meanwhile, the replacement cost method struggles to identify equivalent artificial substitutes for quantifying ecological service values, resulting in substantial estimation errors. The CVM serves as a robust toolkit for economic valuation of non-market environmental resources. By directly eliciting public WTP for intangible assets through structured surveys, it addresses the inherent limitations of conventional market-based pricing approaches. Owing to its quantifiability, contextual adaptability, and operational feasibility, CVM has been extensively adopted in international environmental economics research [6]. The resultant evidence base critically informs evidence-based policy formulation, implementation efficacy assessment, and iterative optimization of resource management strategies.

CVM has been used in revealing the economic value of biodiversity conservation and ecological restoration. Studies [1,7] on coral reef restoration in the northern Adriatic Sea of Italy found that the public's willingness to pay (WTP) for active restoration measures, such as removing abandoned fishing gear, was significantly higher than for maintaining the status quo. Thapa et al. [8], evaluating the non-consumptive value of the Hilsa fishery in West Bengal, discovered a spatial decay effect in the willingness to pay for resource restoration among fishermen, highlighting the influence of livelihood dependence on value perception. Imamura et al. [9], through discrete choice experiments, found that 60% of high-income groups showed a strong WTP for coral reef protection, but his study focused solely on a single ecosystem, lacking a trade-off analysis between multiple ecosystem services. Shan et al. [10], when assessing the value of biodiversity conservation in Pingtan Island, improved the reliability of willingness-to-pay estimates by using a grouped data model to correct for the hot-spot effect bias. Scholars [8,11] analyzed the economic benefits of the Dokdo seal restoration project using a peak model, providing a quantitative basis for the protection of endangered species. Additionally, studies [9,12] using a sample selection model to control for protest zero-payment responses verified the public's WTP for deep-sea ecosystem restoration, emphasizing the importance of non-market benefit evaluation.

Recent studies have advanced the quantification of recreational service values in marine protected areas (MPAs) through integrated applications of the CVM and discrete choice experiments (DCE). However, significant limitations persist in spatial scalability and multi-service trade-off analysis. For example, Rojas-Nazar et al. [12] revealed stronger WTP among households with children for MPA conservation, yet neglected intergenerational transmission mechanisms of non-use values. Chen et al. [13] combined the travel cost method (TCM) and CVM to estimate the annual economic value of Penghu artificial reefs at $89 million but failed to analyze the marginal effects of tourist experience quality on WTP. Malinauskaite et al. [14] indicated explicit support for whale sanctuary expansion among 29.7% of respondents, though cultural identity variables were excluded from WTP models. A Russian study of Glass Beach revealed non-use values constituting 93% of total value, yet the unique assessment context limited generalizability to other artificial restoration

landscapes [15]. Most existing research relies on static WTP data, lacking longitudinal tracking of policy responsiveness and community engagement dynamics. Hindsley et al. [16] demonstrated that introducing attribute non-attendance (ANA) mechanisms in three-stage analysis of Florida diver preferences significantly improved model goodness-of-fit, with their hybrid RP/SP model providing decision support for artificial reef siting optimization. This innovative approach corrected attribute oversimplification biases by segregating revealed and stated preference data, though its applicability remains confined to single-use recreational scenarios without comparative valuation across marine activities. Regarding protest response mitigation, O'Connor et al. [11] required specialized model adjustments for public WTP toward unfamiliar environmental goods. While underscoring the necessity of non-market benefits in marine restoration assessments, their analysis remained limited to single projects without comparative frameworks across MPA management strategies. Schuhmann's research [17] on Barbados tourists identified WTP for marine conservation fees ranging from USD 36 to 52 per visit among non-Caribbean visitors, reflecting economic constraints imposed by regional development levels.

In summary, existing research has made notable progress in the economic evaluation of marine systems, particularly in establishing methodological foundations for biodiversity conservation valuation, recreational service quantification, and resource utilization innovation analysis. However, significant gaps remain in studies of marine ranching as complex ecosystems: First, most research focuses on single ecosystem services or localized case studies, lacking quantitative analysis of synergistic benefits across multiple services. This limits understanding of trade-off mechanisms among ecological restoration, resource proliferation, and recreational services in marine ranching contexts. Second, WTP studies predominantly rely on static cross-sectional data, neglecting temporal dynamics such as intergenerational changes, community participation evolution, and policy responsiveness elasticity, thereby reducing the applicability of findings for long-term management decisions. Third, cross-cultural heterogeneity in WTP remains underexplored, particularly regarding socio-cultural contexts specific to China's coastal fishing communities, which constrains the practical applicability of valuation models in regional settings. Fourth, while some studies integrate CVM and the travel cost method (TCM), these applications often remain at superficial technical combination levels without developing systemic analytical frameworks tailored to marine ranching's multi-stakeholder and multi-service characteristics, thereby diminishing the policy relevance of economic evaluations. Consequently, empirical research quantifying non-market benefits of marine ranching remains scarce. Without a comprehensive understanding of these economic values, policymakers face challenges in determining optimal expenditure and investment levels for marine ranching conservation and management.

To address this gap, the primary objective of this study is to quantitatively assess the non-use values of ecological resources in the Zhongjieshan and Liuheng Marine Ranches using the contingent valuation method (CVM). Specifically, this study aims to (1) quantify the monetary value of these non-market benefits; (2) examine the influence of socioeconomic and related factors on stakeholders' WTP; and (3) provide a scientific basis for establishing ecological compensation mechanisms. Given that many countries and blue-economy industries face similar challenges in justifying long-term investments in managed coastal ecosystems with multiple non-market benefits, the integrated valuation approach developed here is transferable to contexts such as artificial reefs, habitat restoration, eco-tourism planning, and aquaculture–fisheries enhancement, thereby strengthening the evidence base for budgeting, compensation, and sustainable management. The findings can also serve as a useful reference for decision-makers and analysts concerned with island biodiversity conservation and restoration, particularly in cost–benefit analysis.

2. Materials and Methods

2.1. Study Area

In this study, two National Marine Ranches in Zhoushan City, Zhejiang Province, China—the Zhongjieshan Islands Marine Ranch and the Liuheng Islands Marine Ranch—were selected as research sites (Figure 1).

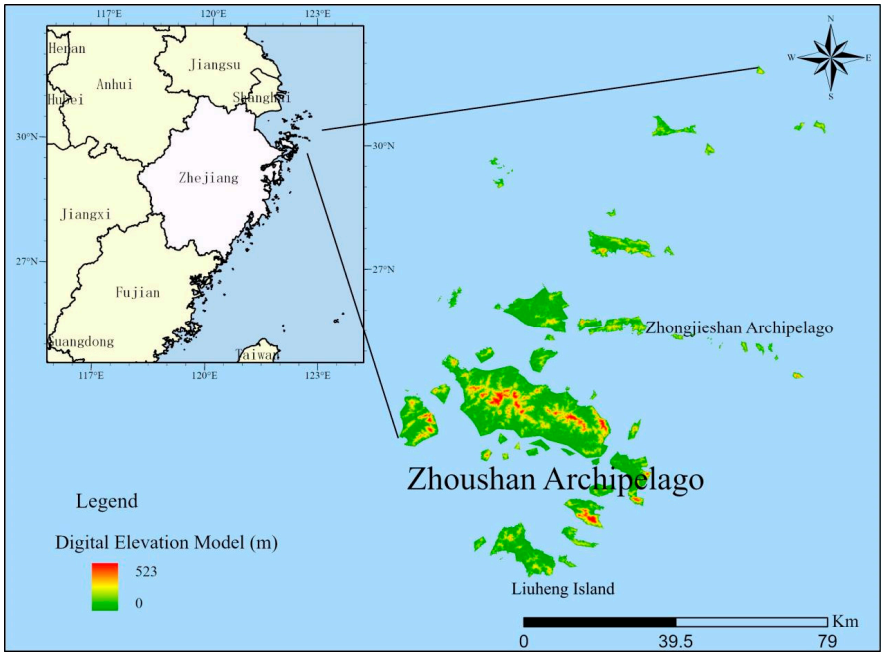

Figure 1. Location of the study area.

The Zhongjieshan Islands Marine Ranch, located at the southern junction of the Yangtze, Qiantang, and Yongjiang estuaries, lies in the southeastern Zhoushan Archipelago, about 45 km from Shenjiamen Fishing Port. The area includes 151 islands and reefs, with five inhabited islands (Miaozihu, Qingbang, Huangxing, Xifushan, and Dongfushan) covering 10.22 km^2 of land. Characterized by complex currents, rich nutrients, and high biodiversity, Zhongjieshan serves as an important spawning, feeding, and migratory habitat for commercial fish species, earning it the name "Granary of the East China Sea." Its local economy integrates fisheries and tourism, with a fishery output exceeding 100,000 tons and annual tourist arrivals of about 390,000 people.

The Liuheng Marine Ranch, located on Liuheng Island in the southern Zhoushan Archipelago, covers 121.5 km^2 and serves as a national-level demonstration zone. The ranch has a 500-hectare core area and a planned sea area of over 3000 hectares, forming a large-scale ecological and industrial complex. In 2023, Liuheng hosted 720,000 tourists, generating CNY 865 million in tourism revenue and producing 136,500 tons of fishery output valued at CNY 1.708 billion. Liuheng integrates "fishery + tourism" and "fishery + renewable energy" models, promoting ecological restoration, leisure fisheries, and marine carbon-neutral initiatives, positioning it as both an ecological base and a driver of green marine economic growth.

The selection of these two cases is based on three main considerations. First, both are located in the Zhoushan Sea area, sharing a similar policy context and development stage, which provides an ideal foundation for comparative analysis. Second, their development orientations differ markedly: Zhongjieshan focuses on ecological protection and marine habitat restoration, while Liuheng emphasizes integrated development of ecology, fisheries, and tourism. Third, their geographical contexts vary—Zhongjieshan is situated in a tradi-

tional fishing ground with strong ecological functions, whereas Liuheng is adjacent to the Yangtze River Delta economic zone, benefiting from a large tourism market.

These shared foundations and distinct differences make Zhongjieshan and Liuheng exemplary comparative cases for analyzing how development models and location factors influence the non-use value of marine ranch ecosystems.

2.2. Research Method and Hypotheses

In this study, the contingent valuation method (CVM)—a stated preference technique that uses questionnaires to elicit individuals' WTP for hypothetical environmental improvements or conservation measures [12]—is employed. Grounded in the principle of utility maximization, CVM simulates market behavior by directly asking respondents either their WTP for improved environmental quality or their willingness to accept (WTA) compensation for environmental degradation, thereby quantifying the economic value of ecological gains or losses. It allows for the valuation of both use values and non-use values (existence, bequest, and option values) associated with ecosystem services [7].

To analyze the WTP data obtained from the payment-card questionnaire, we employed two econometric approaches: Ordinary Least Squares (OLS) regression and interval regression. In the OLS specification, the midpoint of each selected payment interval is treated as the respondent's point estimate of WTP and used as the dependent variable [18,19]. By contrast, interval regression directly uses the lower and upper bounds of the interval within which the respondent's true WTP is assumed to lie; parameters are estimated via maximum likelihood. This approach is therefore particularly well suited to WTP data elicited using payment-card formats [18–20]. Although interval regression is generally more appropriate for payment-card data, we also estimate OLS models in parallel for comparison and to assess the robustness and consistency of our findings. To further strengthen the methodological robustness of this dual-model strategy, we draw on Liu et al. [21], who highlight the value of hybrid multi-model decision-making for validating empirical results. Using two complementary econometric models is consistent with this perspective and enhances the credibility of our WTP estimates. Moreover, to examine heterogeneity across demographic and spatial groups, we follow the econometric strategy proposed by Yang et al. [22], which emphasizes capturing latent group heterogeneity to derive more nuanced policy implications.

Although CVM is widely acknowledged for its theoretical contribution to environmental valuation, its empirical reliability remains contested, particularly under preference uncertainty. Conventional CVM applications, rooted in neoclassical economics, assume stable, well-defined preferences and treat WTP as a fixed value [12]. However, since the 1990s, scholars such as Cameron and Huppert [23] have argued that preferences are dynamically constructed through learning, and respondents often indicate broad acceptable value ranges rather than precise WTP points.

Building upon the theoretical framework of the CVM and economic principles of individual decision-making, this study posits four core hypotheses:

H1: *Respondents' socioeconomic attributes significantly influence their willingness-to-pay (WTP), with personal income level exhibiting a positive correlation with WTP. Higher-income groups, possessing greater economic capacity, demonstrate a stronger propensity to support marine ranching development.*

H2: *Within the public cognition domain, awareness of marine ranching's ecological functions and economic values positively reinforces WTP, as enhanced environmental understanding fosters ecological responsibility consciousness and stimulates payment behavior.*

H3: *Spatial-demographic factors exert modulating effects: geographical distance negatively moderates WTP, with residents farther from marine ranching sites exhibiting reduced payment inclination due to diminished perceived benefit relevance.*

H4: *Age progression may negatively impact WTP through generational disparities in environmental attitudes or income constraints, resulting in relatively lower payment propensity among elderly cohorts compared to younger demographics.*

2.3. Sample Size Determination and Questionnaire Design

2.3.1. Questionnaire Design

The CVM questionnaire was developed in accordance with the survey principles recommended by NOAA [24], employing the payment card contingent valuation method to estimate the WTP for non-use value protection among residents and tourists near the Zhongjieshan and Liuheng National Marine Ranches. The questionnaire contained 15 bid intervals (0–400 CNY), requiring respondents to select the maximum annual ecological compensation they could afford based on their ecological awareness and payment ability.

Given the potential biases of the payment card method—such as initial anchoring, interval gradient effects, and limitations inherent to declarative preference approaches—this study established a multi-dimensional bias control framework covering questionnaire design, interviewer selection, and field implementation. Before the formal survey, a pilot study of at least 30 respondents was conducted in representative coastal communities [25], and the results were used to refine the questionnaire structure, measurement scales, and guiding language.

The final instrument ensured anonymity, incorporated multiple payment options, and applied contextualization measures to enhance perceived payment realism. During data collection, face-to-face interviews were carried out using tablets displaying questionnaire content, ecological service diagrams, and animated payment scenarios. Interviewers applied income-constrained reminders and hierarchical WTP confirmation procedures to reduce misperception and strategic bias, thereby improving data reliability.

The questionnaire comprised three modules. The first introduced the study background and objectives. The second collected demographic information—including gender, age, occupation, education, and income—to construct respondents' socio-economic profiles for subsequent WTP analysis. The third module focused on tourism experience and ecological value perception through a three-tier question chain covering (1) cognitive familiarity with marine ranches; (2) behavioral metrics such as visitation frequency and tourism motivations; and (3) value assessment, including satisfaction ratings, WTP verification, payment scheme preferences, and public-welfare participation intentions. By integrating tourism expenditure items with ecological compensation motivations, the questionnaire established a coherent framework linking "consumption behavior–value perception–compensation willingness," providing robust evidence for monetizing the ecological value of marine ranches.

2.3.2. Sample Size Determination

This study determined the minimum sample size n for questionnaire distribution based on the formula for simple random sampling, which is expressed as follows:

$$n = \frac{Z^2 \times p \times (1 - p)}{e^2} \quad (1)$$

where Z represents the Z-score corresponding to the confidence level (1.96 for a 95% confidence level). The confidence level (95%) and Z-score (1.96) adhere to conventions in

social science research, where a 95% confidence level indicates the sample results have a 95% probability of encompassing the true population value, with the *Z*-score determined through a two-tailed test of the standard normal distribution. The parameter p denotes the expected proportion, conservatively estimated at 0.5 (maximum variance assumption to ensure adequate sample size). This application of $p = 0.5$ follows the maximum variance assumption (where variance is maximized when $p = 0.5$), preventing underestimation of sample size due to insufficient prior information. The parameter e denotes the allowable error margin (set at 5%, balancing research precision with implementation costs). The 5% error margin represents a compromise between resource constraints and statistical precision, aligning with the accuracy requirements for non-market valuation studies in contingent valuation method (CVM) research. Substituting the parameters into Equation (1) yields: $n = \frac{1.96^2 \times 0.5 \times 0.5}{0.05^2} \approx 384$. Further, the finite population correction is applied based on the total number of visitors to Dongji Town in 2024 (N = 390,000) and Liuheng Island in 2023 (N = 721,000): $n_{adjusted} = \frac{n}{1+\frac{n-1}{N}} \approx 383$, and $n_{adjusted} = \frac{n}{1+\frac{n-1}{N}} \approx 721$. To address the challenges of low response rates and invalid entries, 470 and 750 questionnaires were distributed for the Zhongjieshan and Liuheng Marine Ranches, respectively. After data cleaning, 454 and 734 successful responses were obtained, meeting the requirements for empirical analysis. The definitions and explanations of the variables used in this study are provided below (see Table 1).

Table 1. Explanation of defined variables.

Variable Numbering	Variable Description	Variable Symbol	Variable Assignment
X1	Gender	Gender	Male = 1; Female = 2
X2	Age	Age	Under 18 = 1; 18–25 years old = 2; 26–35 years old = 3; 36–45 years old = 4; 46–60 years old = 5; 60 years old and over = 6
X3	Age squared divided by 100	Ages	
X4	Occupation		Administrative organ = 1; Enterprise = 2; Other = 3; Subsistence fishermen = 4; self-employed entrepreneur = 5; Public Institution = 6
X5	Education Level	Edu	Junior High School or Below = 1; Senior High School/Secondary Vocational School = 2; Junior College/Bachelor's Degree = 3; Graduate Student = 4
X6	Income	Income	1000 yuan or below = 1; 1000–3000 yuan = 2; 3000–5000 yuan = 3; 5000–8000 yuan = 4; 8000–10,000 yuan = 5; 10,000–30,000 yuan = 6; 30,000 yuan or above = 7
X7	Respondent Classification	Distance	Inside the City = 0; Outside the City = 1
X8	Number of Visits to Marine Ranch	Vmr	No = 1; 1 time = 2; 2 times = 3; Three times or more = 4
X9	Knowledge of Marine Ranch	Komr	Never Heard = 1; Know Little = 2; Basic Knowledge = 3; Know Well = 4; Very Familiar = 5

2.3.3. Stratified Sampling Optimization

To enhance sample representativeness, a stratified sampling approach was employed by integrating the visitor demographic characteristics of two study sites (70% peak season, 30% off-peak season). During peak season (April–October), 70% of questionnaires were distributed (allocated proportionally to daily visitor volumes across wharf, homestays, and other key nodes). In the off-peak season (November–March), 30% of questionnaires were administered (concentrated at scenic area entrances and transportation hubs).

3. Empirical Results and Analysis

3.1. Basic Statistical Characteristics of the Sample

This section presents the basic characteristics of these questionnaires. Among both resident and tourist samples, males slightly outnumbered females, with the majority of respondents being middle-aged adults. Personal monthly incomes were predominantly concentrated in the CNY 5000–10,000 range, and most participants had attained secondary or higher levels of education, which to some extent enhances the validity and reliability of the questionnaire data. Given the study area's identity as a tourism-oriented island, resident respondents were primarily engaged in leisure fisheries, while tourist respondents mainly comprised private business owners and public sector employees.

The percentage distribution of respondents' educational attainment from the questionnaire survey across the two study sites is presented in Figure 2, revealing notable differences. For the Zhongjieshan Archipelago, respondents with junior college or bachelor's degrees accounted for 61%, forming the core of the sample population. Respondents with junior high school education or below accounted for 16.6%, while those with high school or technical secondary education represented 16.2%, with both proportions being relatively similar. Respondents holding a graduate degree constituted the smallest group, at 6.2%. This distribution indicates that the overall educational level of respondents in Zhongjieshan Archipelago is relatively high, with those holding junior college and bachelor's degrees likely playing a dominant role in the assessment of the marine ranch's economic value. Meanwhile, the relatively small proportion of highly educated respondents provides baseline data for further analysis of how educational background influences perception differences.

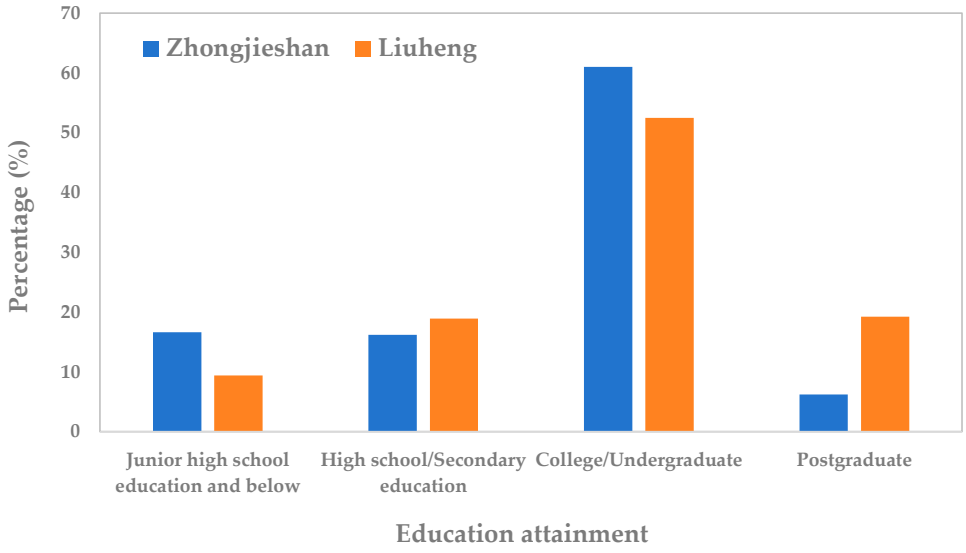

Figure 2. Percentage distribution of respondents by education attainment from the questionnaire survey for Zhongjieshan and Liuheng sites.

On the other hand, for Liuheng, respondents with junior college or bachelor's degrees also constituted the main group, accounting for 52.5% of the total. Respondents with high school or technical secondary education accounted for 18.9%, those with junior high school education or below accounted for 9.4%, and respondents with graduate degrees made up 19.2%. Overall, the educational level of respondents in Liuheng is high, with those holding junior college degrees and above comprising more than 70% of the total, indicating that higher-educated individuals play an important and representative role in the evaluation of marine ranch economic value.

In comparison, respondents from Liuheng generally exhibited a higher level of education than those from the Zhongjieshan Archipelago, with a notably larger proportion of individuals holding graduate degrees. This suggests that the Liuheng sample group possesses a stronger knowledge base and cognitive capacity. In contrast, the Zhongjieshan group was dominated by respondents with junior college and bachelor's degrees, showing a more concentrated but moderately lower educational structure. The observed differences in educational levels between the two regions may lead to distinct patterns in value perception and willingness-to-pay in subsequent analyses, providing valuable insights into the influence of educational background on the perceived economic value of marine ranches.

As shown in Figure 3, the age structure of respondents from the questionnaire survey at the two marine ranches exhibits clear contrasts, reflecting differences in visitor composition and engagement patterns. At Zhongjieshan, the respondent population is strongly youth-dominated. Individuals aged 18–25 account for 42.4%, the largest share, followed closely by those aged 26–35 at 39%. Together, these two groups comprise 81.4% of the total sample, indicating that participation in the valuation survey is largely driven by younger respondents. Middle-aged groups are comparatively underrepresented, with respondents aged 36–45 comprising only 10.2%, and those aged 46–60 representing a mere 8.4%. This distribution, as illustrated in Figure 3, suggests that younger individuals show stronger interest in or connection to Zhongjieshan's ecological and cultural resources, forming the primary evaluators of its non-use value.

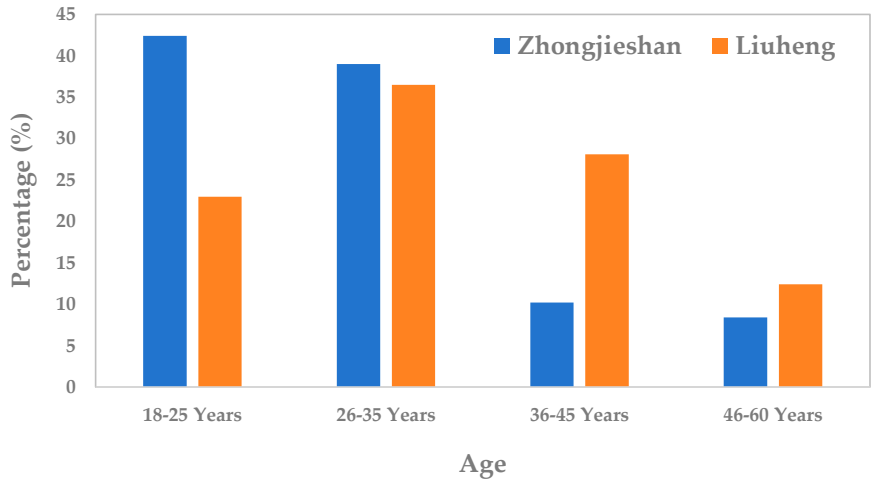

Figure 3. Percentage distribution of respondents by age from the questionnaire survey for Zhongjieshan and Liuheng sites.

In contrast, the age distribution at Liuheng is more balanced and suggests broader appeal across life stages. Respondents aged 26–35 represent the largest group (36.5%), followed by those aged 36–45 at 28.1%, indicating stronger participation from economically stable middle-aged adults who may be motivated by family-oriented or quality leisure activities. The proportion of respondents aged 18–25 (23.0%) remains significant but is notably lower than at Zhongjieshan, suggesting that Liuheng attracts a comparatively older

and more diverse visitor base. Additionally, the 46–60 age group accounts for 12.4%, a higher share than in Zhongjieshan, reflecting Liuheng's appeal to visitors seeking comfort, relaxation, or health-oriented experiences.

Overall, the comparative analysis reveals that Zhongjieshan is characterized by a younger respondent profile, dominated by students and early-career individuals, whereas Liuheng exhibits a wider age span, with strong participation from both young adults and middle-aged groups. These differences underscore the distinct positioning of the two marine ranches: Zhongjieshan appears to resonate more with youthful, experience-seeking visitors, while Liuheng attracts a broader demographic with more diverse recreational and family-oriented motivations.

3.2. Reliability and Validity Test

Before incorporating key latent variables into the regression models, specifically the "Knowledge of Marine Ranching" (Komr), we verified their measurement reliability using Cronbach's Alpha coefficient. As shown in Table 2, the Corrected Item-Total Correlations for all items range from 0.558 to 0.631, exceeding the recommended threshold of 0.5, which indicates a strong correlation between individual items and the overall scale. Furthermore, the Cronbach's Alpha coefficients (if item deleted) range from 0.650 to 0.731, suggesting acceptable internal consistency. These results confirm that the measurement of respondents' awareness is reliable and suitable for subsequent econometric analysis.

Table 2. Reliability Analysis of the Variable "Knowledge of Marine Ranching".

Variable	Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Knowledge of Marine Ranching (Komr)	Item 1	5.39	2.737	0.631	0.650
	Item 2	5.39	2.873	0.610	0.674
	Item 3	4.80	3.008	0.558	0.731

Note: The overall Cronbach's Alpha for this latent variable is 0.766. Source: Calculated by the authors based on the survey data.

3.3. Descriptive Analysis

After examining the basic characteristics of the sample, a descriptive analysis was conducted to explore the influence of occupation on WTP. Table 3 presents the OLS regression results for the Zhongjieshan Archipelago, showing that only government employees exhibited a significantly higher WTP compared with other occupational groups (Beta = 0.472, t = 6.180, p = 0.000). The constant term was also significant (B = 8.206, p = 0.000), indicating that the model has explanatory power.

Table 3. (**a**) Impact of Different Occupations on Payment Levels: An OLS Regression: Zhongjieshan. (**b**) Impact of Different Occupations on Payment Levels: An OLS Regression: Liuheng.

(a)

	Standardized Coefficients	t	Statistical Significance p
	Beta		
(Constant)		8.206	0.000
Government agencies	0.472	6.180	0.000
Enterprise	0.000	−0.001	0.999
Fishermen	0.019	0.243	0.808
Self-employed entrepreneur	−0.054	−0.609	0.543
Public Institution	−0.048	−0.612	0.541
Other	0		

Table 3. *Cont.*

(**b**)			
	Standardized Coefficients	**t**	**Statistical Significance *p***
	Beta		
(Constant)		5.480	0.000
Government agencies	0.191	2.243	0.025
Enterprise	0.239	2.676	0.008
Fishermen	0.257	3.032	0.003
Self-employed entrepreneur	0.228	2.675	0.008
Public Institution	−0.031	−0.499	0.618
Other	0		

Other occupational categories did not show statistically significant effects: enterprise employees (Beta = 0.000, p = 0.999), livelihood fishermen (Beta = 0.019, p = 0.808), private business owners (Beta = −0.054, p = 0.543), and public institution employees (Beta = −0.048, p = 0.541) all had coefficients close to zero. These results suggest no significant differences in WTP between these groups and the reference category.

For Liuheng (see Table 3), several occupational groups showed significantly higher WTP than the reference group. Government employees (Beta = 0.191, t = 2.243, p = 0.025), enterprise employees (Beta = 0.239, t = 2.676, p = 0.008), subsistence fishermen (Beta = 0.257, t = 3.032, p = 0.003), and private business owners (Beta = 0.228, t = 2.675, p = 0.008) all had positive and significant effects. In contrast, public institution employees showed no significant difference (Beta = −0.031, t = −0.499, p = 0.618).

Overall, the results indicate that occupation type has a measurable influence on WTP. Respondents working in government agencies, enterprises, fisheries, and private businesses exhibit stronger payment intentions than those in the reference group, while the effect of public institution employees remains statistically insignificant.

To gain a deeper understanding of the relationships between variables, the following section applies econometric models for analysis.

3.4. Econometric Analysis Using OLS Regression Model

This section employs an OLS regression model to further analyze the influence of various variables on WTP. Based on the OLS estimation, the empirical analysis of respondents' WTP for Zhongjieshan and Liuheng reveals that economic conditions, environmental awareness, and spatial location are the core factors influencing WTP for non-use value. By constructing an econometric model, this study systematically examines the impact mechanisms of multiple variables—including demographic characteristics and levels of environmental awareness—on WTP (see Table 4).

In terms of economic capacity, annual household income (variable: Income) shows a significant positive association with WTP, with a coefficient of 48.607 (p < 0.01) and 20.791 (p < 0.01) for Zhongjieshan and Liuheng. This confirms that income level is a key determinant of WTP, suggesting that respondents' economic capacity forms a critical foundation for their willingness to contribute to environmental protection. These findings support Hypothesis 1, which posits that higher-income groups exhibit a stronger inclination to support marine ranch development due to their greater financial resilience.

Within the dimension of environmental cognition, the coefficient for marine ranching awareness (variable: Komr) passes the 1% significance test with a coefficient of 16.152 and 37.888 for Zhongjieshan and Liuheng, indicating a positive and reinforcing relationship between public awareness of marine ranching and their WTP. This supports Hypothesis 2,

which suggests that enhanced environmental awareness fosters a stronger sense of ecological responsibility, thereby stimulating payment behavior.

Table 4. OLS Regression of Respondent Samples from Zhongjieshan and Liuheng.

	Zhongjieshan	Liuheng
Variables	**Respondents**	**Respondents**
Income	48.61 ***	20.791 ***
	(9.81)	(2.810)
Vmr	−1.182	−0.197
	(−1.06)	(1.452)
Komr	16.15 ***	37.888 ***
	(8.41)	(2.070)
Distance	8.481 ***	2.212
	(4.49)	(3.119)
Edu	0.245	1.844
	(0.19)	(1.546)
Ages	2.477 *	7.478 ***
	(2.53)	(1.418)
Age	−2.035 **	−0.111
	(−2.95)	(0.143)
Gender	−2.811	4.863 *
	(−1.36)	(2.621)
_cons (constant)	−385.8 ***	−207.002 ***
	(−8.63)	(22.371)
N	451	734
R^2	0.810	0.821
adjusted R^2	0.806	0.819

Note: The values in brackets are the standard error, and the following table is the same. ***, **, and * indicate $p < 0.001$, $p < 0.01$, and $p < 0.05$, respectively. N denotes sample size, and R represents the correlation coefficient.

For Zhongjieshan, the coefficient for geographical distance (variable: distance) is 8.481 ($p < 0.01$), revealing a negative moderating effect of spatial separation on WTP. This suggests that the accumulation of environmental knowledge and spatial proximity act synergistically to reinforce public ecological protection responsibility. This result supports Hypothesis 3, which holds that residents living farther from marine ranch sites tend to exhibit lower payment willingness due to a weaker perceived relevance of the benefits. However, for Liuheng, the geographical distance (coefficient = 2.212, $p > 0.1$) did not pass the statistical significance test.

Notably, age exhibits a nonlinear relationship with WTP. For Zhongjieshan, the combined effect of the quadratic term (variable: Ages) coefficient (2.477, $p < 0.05$) and the linear term (variable: Age) coefficient (−2.035, $p < 0.01$) suggests variation in WTP across age groups. On the contrary, the combination of the quadratic term (variable: Ages) with a coefficient of 7.478 ($p < 0.01$) and the linear term (variable: Age) with a coefficient of −0.111 (non-significant) reveals the middle-aged group has a relatively stronger WTP. The directional trend lends partial support to Hypothesis 4, which posits that increasing age may negatively influence WTP. Future research could further investigate the underlying mechanisms, such as intergenerational differences in environmental values or constraints related to fixed income structures.

With respect to control variables, neither gender (coefficient = −2.811, $p = 0.166$) nor education level (coefficient = 0.245, $p = 0.840$) achieves statistical significance. This suggests that demographic characteristics have limited explanatory power for WTP within the sampled population.

Using the OLS regression model, the median WTP for the non-use value of Zhongjieshan and Liuheng was calculated as 78.99 and 150.20 CNY per person, with a mean value of 78.38 and 121.86 CNY per person. Through analysis via the OLS regression model, we gained insights into the influence of various variables on WTP. Subsequently, an interval regression model will be employed to further validate these findings.

3.5. Econometric Analysis of Interval Regression Model

Applying the interval regression model to analyze survey data from respondents at Zhongjieshan and Liu Heng marine ranches, this study calculates the WTP for the preservation and sustainability of the marine ranches' non-use value. The results, presented in Table 5, demonstrate significant differences in the impact of various variables on WTP.

Table 5. Interval Regression of Respondent Samples from Zhongjieshan and Liuheng.

Variables	Zhongjieshan	Liuheng
Age	−0.517	−0.163
	(−1.73)	(−1.20)
Income	20.73 ***	22.074 ***
	(9.06)	(4.05)
Gender	−1.063	3.744
	(−1.19)	(1.39)
Ages	0.625	5.783 ***
	(1.49)	(3.89)
Edu	0.360	1.129
	(0.64)	(0.73)
Distance	17.38 ***	0.661
	(14.45)	(0.23)
Komr	10.07 ***	38.254 ***
	(10.78)	(9.58)
Vmr	0.293	−0.553
	(0.56)	(−0.46)
_cons (constant)	−175.6 ***	−207.205 ***
	(−8.43)	(−5.64)
lnsigma	2.104 ***	3.340 ***
_cons	(34.04)	(46.88)
N	451	734

Note: The values in brackets are the standard error, and the following table is the same. *** indicate $p < 0.001$. *N* denotes sample size, and *R* represents the correlation coefficient.

In the analysis of Zhongjieshan marine ranch, the income variable (Income) has a significantly positive regression coefficient (20.73, t = 9.06), indicating that for every unit increase in annual household income, the WTP increases by approximately CNY 20.73. This effect is highly significant at the 0.1% level, highlighting the core driving role of economic ability in WTP. The geographic distance (Distance, 17.38, t = 14.45) and the level of understanding of marine ranches (Komr, 10.07, t = 10.78) also show significant positive effects, indicating that geographic factors and policy awareness reinforce the WTP. However, the effects of gender and age are weaker, with the gender variable having a negative coefficient (Gender, −1.063, t = −1.19), which is not statistically significant, suggesting that the direction of gender's effect on WTP should be interpreted cautiously. The age variable has a negative coefficient (Age, −0.517, t = −1.73), but it does not reach statistical significance, indicating that age has a weak impact on WTP. On the other hand, in the analysis of the Liu Heng marine ranch, the income variable (Income) has a regression coefficient of 22.074 (t = 4.05), confirming that economic foundation is a key determinant of WTP. The level of understanding of marine ranches (Komr, 38.254, t = 9.58) has a strong

positive effect on WTP, while the quadratic term for age (Ages, 5.783, t = 3.89) reveals that WTP follows a U-shaped trend, decreasing first and then increasing with age. Although the linear terms for age (Age, −0.163, t = −1.20) and gender (Gender, 3.744, t = 1.39) do not pass the significance test, suggesting that these demographic variables have relatively weak explanatory power for WTP when controlling for core factors.

The validity tests of the model show that both the intercept term and the error term are significant at the 1% level, validating the model's specification. Overall, the economic foundation and environmental awareness form a dual driving mechanism for WTP, while the impact of traditional demographic variables weakens after controlling for core factors. This provides an important theoretical basis for the precise design of environmental protection policies.

3.6. Heterogeneity Analysis

Based on tourist samples from the Zhongjieshan and Liuheng marine ranches, this study applies CVM to analyze the heterogeneity of factors influencing visitors' WTP and employs OLS regression models to explore the differentiated characteristics of visitor groups from different regions. As shown in Table 6, tourists are classified into three categories according to their place of origin—local (within the city), intra-provincial (outside the city but within the province), and inter-provincial (outside the province). The results reveal significant heterogeneity in both the direction and significance of core explanatory variables across groups.

Table 6. OLS Regression Heterogeneity Analysis.

Location	**Zhongjieshan**			**Liuheng**		
Category	**Within-City Tourists**	**Intra-Provincial Out-of-City tourists**	**Extra-Provincial Tourists**	**Within-City Tourists**	**Intra-Provincial Out-of-City Tourists**	**Extra-Provincial Tourists**
	WTP	WTP	WTP	WTP	WTP	WTP
Income	51.771 ***	34.003 ***	10.248 ***	9.494 ***	31.843 ***	9.494 ***
	(8.72)	(7.18)	(2.92)	(2.316)	(3.286)	(2.316)
VMR	−2.995	0.203	1.993	−0.949	0.002	−0.949
	(−0.97)	(0.16)	(1.39)	(0.636)	(1.348)	(0.636)
Komr	21.198 ***	10.637 ***	11.533 ***	8.653 ***	16.059 ***	8.653 ***
	(5.38)	(5.98)	(6.05)	(1.533)	(2.081)	(1.533)
Edu	2.100	−1.778	2.321 **	1.458 **	−0.860	1.458 **
	(0.89)	(−1.59)	(2.08)	(0.611)	(1.432)	(0.611)
Ages	4.504 **	1.487 *	−1.355	0.106	1.111	0.106
	(2.36)	(1.69)	(−1.21)	(0.680)	(1.381)	(0.680)
Age	−3.778 ***	−0.990	0.856	−0.044	−0.015	−0.044
	(−2.76)	(−1.56)	(1.11)	(0.065)	(0.146)	(0.065)
Gender	−2.908	0.203	−1.369	0.939	−7.020 ***	0.939
	(−0.76)	(0.11)	(−0.66)	(1.299)	(2.652)	(1.299)
Career	−1.620	−0.242	−1.149 *	2.570 *	0.075	−0.794 **
	(−1.30)	(−0.39)	(−1.72)	(1.541)	(0.897)	(0.385)
Constant	−374.806 ***	−250.055 ***	−95.301 ***	−63.107 ***	−228.659 ***	−63.107 ***
	(−6.03)	(−5.74)	(−3.15)	(17.453)	(26.775)	(17.453)
Observations	208	137	106	403	164	167
Adjusted R^2	0.625	0.577	0.384	0.467	0.710	0.321

Note: The values in brackets are the standard error, and the following table is the same. ***, **, and * indicate $p < 0.001$, $p < 0.01$, and $p < 0.05$, respectively. N denotes sample size, and R represents the correlation coefficient.

From the perspective of income effects, the Income variable exhibits a significant and positive influence ($p < 0.01$) across all groups but demonstrates distinct spatial patterns. In the Zhongjieshan sample, a "distance-decay" trend is evident, with coefficients of 51.771, 34.003, and 10.248, indicating that the effect strength declines as geographic distance increases. Local residents show the highest income elasticity—about five times that of out-of-province visitors—suggesting that geographic proximity enhances perceived resource value and payment capacity. In contrast, the Liuheng sample shows a "middle-high, both-sides-low" pattern (coefficients of 9.494, 31.843, and 9.494), where intra-provincial

non-local visitors demonstrate the strongest income effect, approximately 3.4 times that of local or out-of-province tourists. This suggests that medium-distance visitors possess both strong use and nonuse value recognition of marine ranching ecosystem services, leading to higher WTP.

In terms of environmental cognition, the Komr variable consistently shows a significant positive effect ($p < 0.01$) in all models, underscoring its universal role as a driving factor in payment decisions. The magnitude of this effect ranges from 10.637 to 21.198 in the Zhongjieshan sample, while in Liuheng it peaks among intra-provincial visitors (16.059), suggesting that environmental cognition plays a more pronounced role for medium-distance tourists rather than varying monotonically with distance. Conversely, the Vmr (visitation frequency) variable fails to achieve statistical significance in all models, indicating limited explanatory power for WTP.

The influence of demographic characteristics also exhibits marked heterogeneity. In the Zhongjieshan sample, Age exerts a significant negative effect (-3.778, $p < 0.01$), while Age (the squared term) is positive and significant (4.504, $p < 0.05$), implying that younger to middle-aged local tourists demonstrate higher WTP—likely linked to their more frequent use of ecological services. In the Liuheng sample, Education (Edu) shows significant positive effects for local and out-of-province visitors (coefficients = 1.458, $p < 0.05$), but an insignificant negative coefficient (-0.860) for intra-provincial tourists, indicating that educational attainment strengthens environmental responsibility primarily among nearby and distant visitors. Moreover, Gender exhibits a notable regional divergence in Liuheng, being significantly negative among intra-provincial tourists (-7.020, $p < 0.01$) but positive and insignificant for the other two groups, possibly reflecting differences in gender roles and social norms across regions. Similarly, Career shows a marginally significant negative effect (-1.149, $p < 0.1$) among out-of-province tourists in the Zhongjieshan sample, suggesting that occupational structure may shape WTP preferences for non-local visitors.

Regarding model explanatory power, the results reveal substantial regional variation. In the Zhongjieshan sample, the adjusted R^2 for local tourists reaches 0.625, considerably higher than that of out-of-province tourists (0.384), indicating that the determinants of local visitors' WTP are more readily captured by observable variables. In contrast, in the Liuheng sample, the intra-provincial group achieves the highest adjusted R^2 (0.710), suggesting that medium-distance tourists' decision-making mechanisms are more systematic and consistent. Collectively, the findings highlight two distinct spatial patterns: the "distance-decay effect" identified in Zhongjieshan and the "medium-distance peak effect" observed in Liuheng.

Overall, the results demonstrate that tourists' WTP for marine ranching ecosystem services is jointly influenced by geographic distance, income, environmental cognition, and socio-demographic factors, with significant spatial heterogeneity. These findings suggest that ecosystem compensation and value realization policies should be tailored to regional characteristics, enhancing local residents' resource perception and ecological responsibility while targeting medium-distance visitors with cognitive incentives and experiential innovations. Such differentiated strategies can effectively improve both the efficiency and equity of marine ranch ecological product value realization.

3.7. Multicollinearity Test

In this section, systematic multicollinearity diagnostics were conducted to ensure the robustness of the model estimations for Zhongjieshan and Liuheng marine ranches. Overall, both models are statistically significant and exhibit good fitting performance, with multiple key variables showing significant impacts on payment behavior as provided in Tables 7 and 8.

Table 7. (**a**) Heterogeneity Analysis of Factors Influencing WTP for Zhongjieshan marine ranch. (**b**) Heterogeneity Analysis of Factors Influencing WTP for Liuheng marine ranch.

(a)							
Coefficient [a]							
Model	**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Significance**	**Collinearity Statistics**	
	β	**Standard Error**	***β***			**Tolerance**	**VIF**
(Constant)	−407.523	28.091		−14.507	0.000		
Gender	−2.811	2.026	−0.029	−1.387	0.166	0.983	1.017
Age	−0.568	0.160	−0.109	−3.560	0.000	0.458	2.186
Age squared divided by 100 (centered)	2.477	1.029	0.074	2.408	0.016	0.451	2.215
Post-categorization occupation	−0.680	0.722	−0.020	−0.942	0.347	0.982	1.018
Level of Education	0.245	1.209	0.004	0.202	0.840	0.980	1.021
Tourists' Residence	8.481	2.347	0.141	3.614	0.000	0.283	3.533
Level of Awareness about Marine Ranching	16.152	1.962	0.418	8.234	0.000	0.167	5.986
Number of Visits to Marine Ranching Sites	−1.182	1.509	−0.026	−0.783	0.434	0.386	2.589
Logarithmic Transformation of Monthly In-come	48.607	3.239	0.443	15.006	0.000	0.494	2.024
(**b**)							
Coefficient [a]							
Model	**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Significance**	**Collinearity Statistics**	
	β	**Standard Error**	***β***			**Tolerance**	**VIF**
(Constant)	−209.603	22.834		−9.179	0.000		
Gender	4.773	2.627	0.029	1.817	0.070	0.940	1.064
Age	−0.108	0.143	−0.013	−0.757	0.450	0.864	1.157
Age squared divided by 100 (centered)	7.399	1.425	0.092	5.191	0.000	0.791	1.265
Post-categorization occupation	0.539	0.938	0.009	0.575	0.566	0.928	1.078
Level of Education	1.994	1.569	0.021	1.271	0.204	0.877	1.140
Tourists' Residence	2.123	3.124	0.012	0.679	0.497	0.817	1.224
Level of Awareness about Marine Ranching	37.833	2.073	0.674	18.250	0.000	0.181	5.519
Number of Visits to Marine Ranching Sites	−0.182	1.453	−0.002	−0.125	0.900	0.937	1.068
Logarithmic Transformation of Monthly In-come	20.900	2.818	0.271	7.418	0.000	0.185	5.399

[a] Dependent Variable: Payment Level.

Among the core variables, income and environmental cognition emerged as the strongest positive drivers of WTP in both sites. In the Zhongjieshan model, the standardized coefficients of logarithmic monthly income (β = 0.443, t = 15.006, $p < 0.001$) and level of understanding of marine ranching (β = 0.418, t = 8.234, $p < 0.001$) were the highest, indicating their dominant positive predictive roles in explaining payment levels. Similarly, in the Liuheng model, understanding of marine ranching (Komr, β = 0.674, t = 18.250, $p < 0.001$) and household annual income (Income, β = 0.271, t = 7.418, $p < 0.001$) were the most influential variables. These findings confirm that environmental cognition and economic capacity jointly form the dual-core mechanism driving tourists' WTP.

Table 8. (**a**) Collinearity Diagnostics Assessment for Willingness-to-Pay Regression Mode for Zhongjieshan marine ranch. (**b**) Collinearity Diagnostics Assessment for Willingness-to-Pay Regression Model for Liuheng marine ranch.

(a)

Collinearity Diagnostics [a]													
				Variance Proportion									
Model	Dimension	Eigenvalue	Condition Index	(Constant)	Gender	Age	Age Squared/100 (Centered)	Post-Categorization Occupation	Educational Attainment	Tourist Residence	Level of Understanding of Marine Ranching	Number of Visits to Marine Ranching	Logarithm of Monthly Income
1	1	8.692	1.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.733	3.443	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00
	3	0.240	6.013	0.00	0.04	0.01	0.00	0.02	0.04	0.02	0.02	0.06	0.00
	4	0.098	9.396	0.00	0.05	0.00	0.00	0.57	0.32	0.00	0.00	0.00	0.00
	5	0.092	9.743	0.00	0.77	0.01	0.00	0.02	0.27	0.00	0.00	0.00	0.00
	6	0.061	11.978	0.00	0.05	0.31	0.22	0.24	0.27	0.00	0.00	0.00	0.00
	7	0.045	13.937	0.00	0.01	0.00	0.00	0.02	0.00	0.26	0.03	0.74	0.00
	8	0.021	20.232	0.02	0.07	0.63	0.32	0.12	0.08	0.04	0.00	0.02	0.02
	9	0.017	22.675	0.00	0.00	0.04	0.04	0.00	0.01	0.68	0.77	0.17	0.00
	10	0.001	118.775	0.98	0.00	0.00	0.00	0.02	0.02	0.00	0.17	0.01	0.98

(b)

Collinearity Diagnostics [a]													
				Variance Proportion									
Model	Dimension	Eigenvalue	Condition Index	(Constant)	Gender	Age	Age Squared/100 (Centered)	Post-Categorization Occupation	Educational Attainment	Tourist Residence	Level of Understanding of Marine Ranching	Number of Visits to Marine Ranching	Logarithm of Monthly Income
1	1	8.715	1.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.553	3.970	0.00	0.00	0.00	0.65	0.00	0.00	0.00	0.01	0.00	0.00
	3	0.222	6.271	0.00	0.01	0.00	0.16	0.31	0.02	0.04	0.04	0.02	0.00
	4	0.164	7.292	0.00	0.03	0.00	0.02	0.55	0.00	0.07	0.03	0.10	0.00
	5	0.103	9.201	0.00	0.53	0.00	0.01	0.01	0.00	0.00	0.00	0.46	0.00
	6	0.092	9.739	0.00	0.29	0.08	0.03	0.00	0.02	0.31	0.01	0.26	0.00
	7	0.073	10.917	0.00	0.00	0.09	0.00	0.03	0.37	0.33	0.09	0.00	0.00
	8	0.061	11.985	0.00	0.01	0.54	0.09	0.01	0.45	0.07	0.00	0.01	0.00
	9	0.017	22.609	0.08	0.13	0.28	0.03	0.06	0.12	0.18	0.14	0.11	0.04
	10	0.001	80.718	0.92	0.00	0.00	0.00	0.02	0.02	0.01	0.69	0.04	0.96

[a] Dependent Variable: Payment Level.

With respect to age effects, both models revealed significant relationships. In the Zhongjieshan sample, Age had a significant negative effect (β = −0.109, t = −3.560, $p < 0.001$), whereas in the Liuheng model, the squared term of age (Ages, β = 0.092, t = 5.191, $p < 0.001$) showed a significant positive impact. Together, these results indicate a U-shaped relationship between age and WTP, suggesting that middle-aged tourists exhibit relatively higher payment intentions. Additionally, tourist residence (β = 0.141, t = 3.614, $p < 0.001$) was significant in the Zhongjieshan model, implying that geographic origin plays an important role in shaping payment behavior.

For the control variables, gender showed marginal significance ($p \approx 0.07$), while education level ($p = 0.204$), geographical distance ($p = 0.497$), number of visits ($p = 0.900$), and occupation ($p = 0.566$) were statistically insignificant. This suggests that, after accounting for key economic and cognitive factors, these demographic attributes contribute limited additional explanatory power to tourists' payment willingness.

The multicollinearity diagnostics indicate that both models are free from serious multicollinearity issues. In the Zhongjieshan sample, most variables had VIF values ranging between 1.017 and 3.533, well below the strict threshold of 10, with only understanding of marine ranching (VIF = 5.986) showing a moderate but acceptable level of collinearity. In the Liuheng sample, the majority of VIF values ranged from 1.064 to 1.265, while Komr (VIF = 5.519) and Income (VIF = 5.399) showed moderate collinearity within acceptable bounds (VIF < 10). The condition index diagnostics further support these findings: the tenth-dimension indices (118.775 for Zhongjieshan; 80.718 for Liuheng) indicate that variance proportions were mainly concentrated in the intercept term (92–98%), suggesting that potential multicollinearity primarily affects the constant term rather than the explanatory variables.

Moreover, the age and age-squared variables, after mean-centering and polynomial transformation, yielded VIF values of 2.186 and 2.215 (or 1.157 and 1.265, respectively), effectively mitigating nonlinear collinearity. Although Komr and Income exhibit moderate correlation, both are theoretically distinct constructs and statistically significant; therefore, both variables were retained in the final models.

In summary, the regression results demonstrate that the models are well-specified, parameter estimates are stable, and findings are statistically reliable. Economic capacity and environmental cognition consistently act as the primary determinants of tourists' WTP, while age and regional factors exert structured and secondary effects. These results provide robust empirical support for developing differentiated ecological compensation and value realization strategies in marine ranch management.

3.8. Analysis of Willingness to Pay Distribution Characteristics and Estimation of Non-Use Value

This section presents the frequency distribution of respondents' WTP levels for marine ranching ecological services. The distribution shows how different payment levels are represented within the sample population, highlighting the proportion of respondents willing to contribute at various payment thresholds. Based on the empirical results of the Contingent Valuation Method (CVM), this study estimates the non-use value of the Zhongjieshan Marine Ranch as the following formula:

$$\text{Non-use value} = \text{per capita WTP} \times \text{annual number of visitors.} \quad (2)$$

As illustrated in Figure 4, 98.47% of respondents for the Zhongjieshan Marine Ranch expressed a WTP, with payment levels primarily concentrated at 55, 70, and 90 CNY/person·year, and 70 CNY/person·year being the most frequently chosen value. Respondents who reported zero WTP were mostly individuals employed in unrelated industries and lacking knowledge about marine ranching. In contrast, 98.37% of respondents

for the Liuheng Marine Ranch indicated a WTP, with payment levels mainly distributed around 90, 110, and 120 CNY/person·year, and the majority choosing 110 CNY/person·year. This suggests that most participants were willing to make relatively higher payments in support of ecological conservation and sustainable marine development.

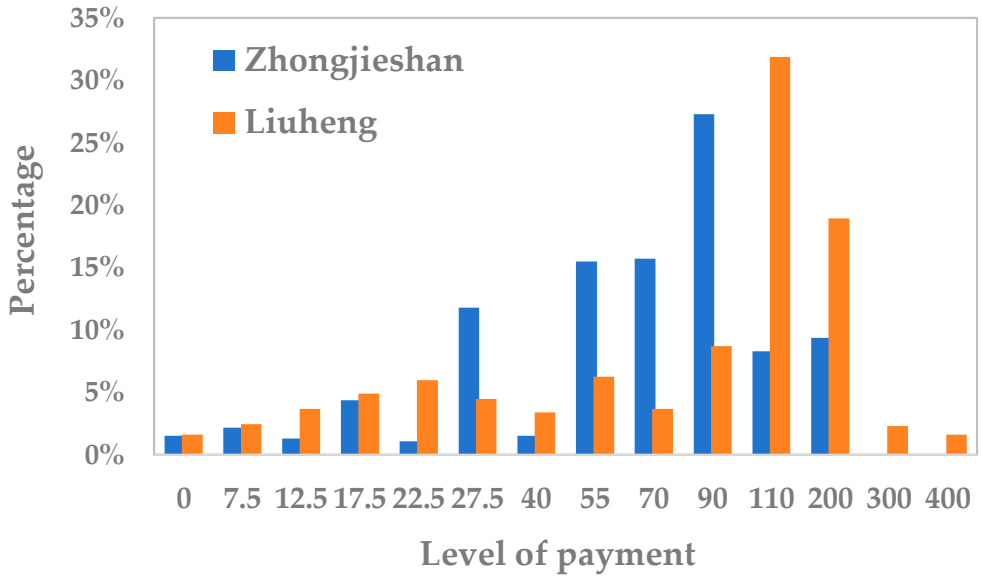

Figure 4. Percentage Distribution of Respondents' WTP Levels for Zhongjieshan and Liuheng marine ranches.

For the Zhongjieshan Marine Ranch, the OLS model yielded a WTP median of 78.99 CNY/person and a mean of 78.39 CNY/person, while the interval regression model estimated a median of 74.33 CNY/person and a mean of 73.32 CNY/person. The minor differences between the two models suggest strong robustness of the estimation results. The slightly higher mean relative to the median indicates a right-skewed distribution, meaning that a small proportion of respondents were willing to pay substantially higher amounts to support marine ranch ecological protection and sustainable development. The median WTP values obtained from both models were used to estimate the non-use value. According to the OLS model, the annual non-use value is 30.8061 million CNY. Based on the interval regression model, the estimated value is 28.9887 million CNY. The results from the two models are highly consistent, jointly indicating that the non-use value of the Zhongjieshan Marine Ranch lies within the range of 28.99–30.81 million CNY per year.

For the Liuheng Marine Ranch, the interval regression model estimated a WTP median of 153.89 CNY/person and a mean of 124.85 CNY/person, while the OLS model produced a median of 150.20 CNY/person and a mean of 121.86 CNY/person. Similarly to the Zhongjieshan sample, the Liuheng data also exhibit a right-skewed distribution, with a few high-WTP individuals elevating the overall mean. In both cases, the median provides a more representative measure of the typical respondent's payment intention. The annual visitor volume of 7.21 million person-times for Liuheng as the baseline. The interval regression model yields a median WTP of 153.89 CNY per person, corresponding to a non-use value of 1109.527 million CNY. The OLS regression model produces a median WTP of 150.20 CNY per person, resulting in a non-use value of 1082.942 million CNY. The two estimates are highly consistent, jointly indicating that the annual non-use value of the Liuheng Marine Ranch is approximately 1.08–1.11 billion CNY.

Overall, the mean and median WTP values from the two models fall within comparable ranges, reinforcing the stability and consistency of the estimation results. The observed differences mainly stem from the methodological assumptions of the two approaches: the

OLS model assumes that WTP follows a normal distribution, whereas the interval regression model incorporates a probability density function corresponding to discrete payment intervals, thereby capturing respondents' choice behavior more accurately. Despite these methodological nuances, the two models yield statistically and economically consistent results, providing a reliable empirical basis for formulating marine ecological compensation standards and designing value realization pathways.

In summary, the CVM-based estimations for both sites demonstrate strong explanatory power and robustness. The higher WTP for the Liuheng Marine Ranch indicates a greater perceived economic and ecological value, reflecting stronger public recognition of its ecological and cultural service functions. These findings provide empirical support for differentiated marine ecological compensation standards and contribute to developing region-specific value realization strategies for sustainable marine ranch management.

4. Discussion

4.1. Comparisons Between

The most direct difference between the two sites is reflected in the absolute level of WTP. The median WTP for the Liuheng Marine Ranch (interval regression: 153.89 CNY/person; OLS: 150.20 CNY/person) and its mean values (interval regression: 124.85 CNY/person; OLS: 121.86 CNY/person) are both significantly higher than those for the Zhongjieshan Marine Ranch (median: approximately 74–79 CNY/person; mean: approximately 73–78 CNY/person). This indicates that respondents assign nearly twice the economic value to Liuheng compared with Zhongjieshan.

The primary reason for the difference in WTP between the two marine ranches stems from the fundamentally distinct socioeconomic structures of their visitor groups. The occupational distribution of respondents for the two sites is shown in Figure 5.

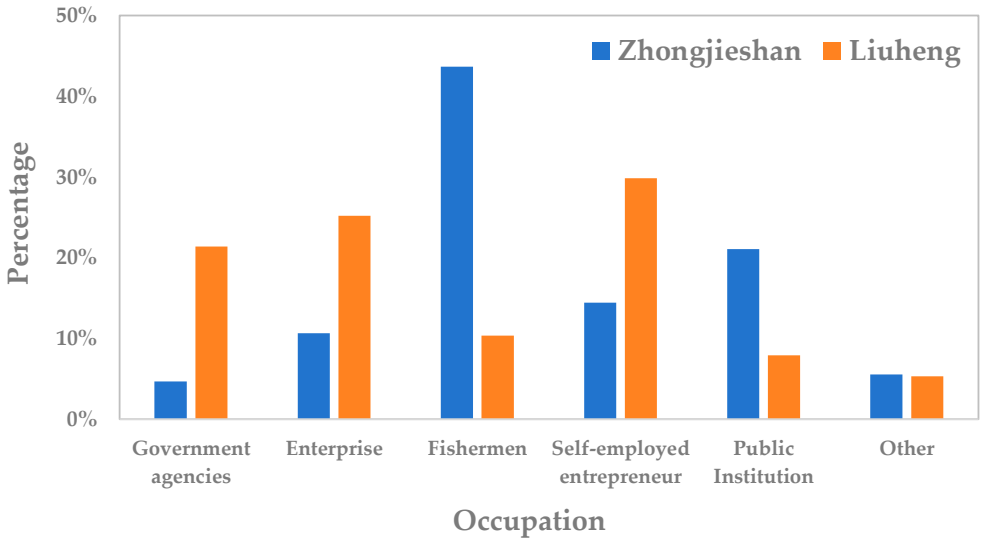

Figure 5. The occupational distribution of respondents for Zhongjieshan and Liuheng marine ranches.

At the Zhongjieshan Marine Ranch, fishers (43.7%) and public institution employees (21.1%) constitute the dominant user segments. Fishers, although highly dependent on marine resources, generally possess limited discretionary income, while many public-sector visitors travel to Zhongjieshan for administrative inspections or research-related tasks rather than self-funded leisure. This structural composition reflects Zhongjieshan's positioning as a traditional fishing ground and national marine ranch demonstration site—characterized by a "community + research" functional orientation and resulting in an overall lower WTP.

In contrast, the Liuheng Marine Ranch attracts a visitor profile dominated by self-employed entrepreneurs (29.8%) and entrepreneur employees (25.2%), groups with significantly stronger purchasing power and a higher propensity for leisure spending. For these individuals, Liuheng functions as an appealing destination for weekend getaways, social gatherings, and recreational fishing, aligning with its modern "market + recreation" development model. This socioeconomic composition directly contributes to the substantially higher WTP observed in Liuheng compared with Zhongjieshan.

Spatial characteristics further underscore these differences. Zhongjieshan displays an atypical positive distance gradient, with WTP increasing as visitors originate farther away—likely because long-distance visitors tend to be purpose-driven actors such as investors or government officials engaged in targeted inspections. Liuheng, by contrast, shows no distance effect, consistent with its integration into the leisure economy of the Yangtze River Delta, where convenient access and strong tourism demand mean that travel distance is no longer a deterrent for its primary visitor groups. Age patterns also diverge: Zhongjieshan's weak age effect reflects the stability of its community-based visitor composition, whereas Liuheng's strongest WTP is found among middle-aged individuals at the peak of income and family leisure demand.

These findings offer important implications for marine ranch management in China. Effective strategies must be aligned with each site's socioeconomic context. For Zhongjieshan, the priority should be establishing a "protection–benefit" cycle through community co-management mechanisms, ensuring that ecological conservation outcomes translate into tangible benefits for local fishers, thereby sustaining their livelihood- and identity-based willingness to support marine protection. For Liuheng, management should emphasize a dual engine of "environmental awareness + value realization," leveraging ecological knowledge dissemination and value communication to further stimulate payment willingness among economically capable urban visitors.

4.2. Comparison with Domestic and International Studies

To contextualize the significance of our findings within the broader literature, we compared our WTP estimates with those from other marine protected areas (MPAs) worldwide. Our results (CNY 74–154 per year) are broadly consistent with domestic studies; for example, Yu et al. [25] reported a WTP of CNY 172–216 for MPAs in Zhejiang, indicating regional coherence in valuation patterns.

From an international perspective, our estimates reveal notable economic disparities. Thur [26], for instance, reported a substantially higher WTP (approximately CNY 397–871, adjusted for inflation) for marine parks in the Caribbean (Bonaire), likely reflecting higher income levels and more mature ecotourism markets in developed economies relative to the developing context of our study area. Conversely, our findings are comparable to those of Pascoe et al. [27] in Southeast Asia (approximately CNY 65–260), suggesting similar valuation patterns across developing regions. Despite these differences in economic context, the persistent demand for non-use values across diverse geographical settings highlights a broadly shared public recognition of the ecological benefits provided by marine environments.

4.3. Interpretation of Determinants

In this study, the econometric analysis revealed distinct driving mechanisms underlying stakeholders' WTP, providing theoretical justification for the observed behaviors. Consistent with economic theory (H1), income emerged as a primary determinant. The observed positive correlation indicates that financial resilience is a prerequisite for non-use value payments, in line with the "ability-to-pay" principle. With respect to cognitive

drivers, the significant positive effect of marine knowledge (Komr) supports the "information deficit model" (H2), suggesting that familiarity with ecological functions acts as a catalyst that converts latent environmental awareness into active payment behavior.

In terms of spatial and demographic dynamics, the results provide nuanced insights. Contrary to the traditional distance-decay hypothesis, our findings for geographical distance (H3) in the Zhongjieshan sample reveal a positive correlation. This pattern can be interpreted as a "scarcity effect," whereby non-local tourists—having incurred higher sunk travel costs—attach greater value to the unique island experience than local residents, who have relatively easy access. Furthermore, the negative linear and positive quadratic age terms indicate a U-shaped preference pattern (H4). This is consistent with recent studies suggesting that younger generations, who are often exposed to more systematic environmental education, tend to exhibit a stronger sense of intergenerational responsibility for ecological conservation.

4.4. Methodological Insights and Limitations

Methodologically, this study demonstrates the usefulness of the interval regression model, which effectively addresses several limitations of the traditional CVM median approach. In addition, the survey results indicate that 67% of respondents are willing to contribute to maintenance through volunteer services. This suggests that future ecological value assessment systems should evolve from a purely monetary framework to a composite value assessment system that integrates both monetary payments and public participation. Combining CVM with choice experiment (CE) methods in future research could help capture a more comprehensive picture of the public's perceptions of ecological value.

Despite these contributions, it is important to acknowledge limitations related to the temporal dimension. Although the introduction emphasizes intergenerational dynamics, the empirical analysis is based on cross-sectional data, which provides a static snapshot rather than evidence of longitudinal evolution. Consequently, the "dynamics" discussed in this study refer to cross-generational differences observed at a single point in time and thus serve only as a proxy for intergenerational change. While our results reveal significant heterogeneity across age cohorts (e.g., the U-shaped WTP pattern), this design does not allow us to track how individual preferences change as people age. Future research should therefore prioritize longitudinal tracking systems to follow cohorts over time and verify whether the observed generational disparities persist or shift in the context of socio-economic development.

Furthermore, several sources of preference uncertainty must be recognized. Difficulties in defining and quantifying ecological–economic benefits—such as fisheries enhancement and carbon sequestration—complicate precise estimation of the overall value of the ranch. Additional uncertainty arises regarding the actual benefits to individuals, as unpredictable fluctuations in fishing yields can induce variability in WTP. Potential response biases may also weaken WTP estimates if respondents misunderstand or oversimplify complex ecosystem services. Finally, unforeseen changes in socio-demographic conditions, such as income volatility, may reshape perceived benefits; for example, fishermen facing unstable incomes may exhibit more conservative investment behavior. Taken together, these uncertainties underscore the need for continued and more refined investigation in future research.

5. Conclusions

This study used the CVM, combined with interval regression and OLS models, to assess the non-use values of the Zhongjieshan and Liuheng Marine Ranches. The annual non-use value of Zhongjieshan is estimated at 28.99–30.81 million CNY (median WTP 74.33–78.99 CNY per person), while Liuheng reaches 108–111 million CNY (median WTP

150.20–153.89 CNY per person), indicating greater economic potential in ecological services and recreation at Liuheng. Accordingly, Zhongjieshan should prioritize ecological value communication and community co-management, whereas Liuheng should focus on high-quality ecological leisure development.

Cross-validation shows strong model robustness, with median WTP differences below 4.7 CNY for Zhongjieshan and 3.7 CNY for Liuheng. Heterogeneity analysis indicates that WTP for Liuheng is mainly driven by income and environmental awareness, while Zhongjieshan exhibits a distance-decay effect and lower cognitive coefficients, revealing distinct value perception mechanisms.

Respondent profiles further support these differences: Zhongjieshan mainly attracts younger visitors with medium education levels, while Liuheng draws younger and more middle-aged, highly educated visitors, with a higher share of private business owners and enterprise employees. These patterns suggest that Zhongjieshan should strengthen community-based co-management and localized interpretation, while Liuheng should develop more technology-oriented and interactive eco-leisure products tailored to its visitor base.

Based on these findings, several implications emerge. The gap between high latent interest and only moderate WTP indicates the need for targeted public awareness campaigns to convert "passive attention" into "active contribution." Moreover, the substantial non-use value identified in this study supports the development of diversified ecological compensation mechanisms beyond sole reliance on government funding, such as establishing dedicated conservation funds or composite value assessment systems that integrate both monetary and non-monetary contributions.

However, there are some limitations for the study. The reliance on cross-sectional data confines the analysis of temporal dynamics to static cross-generational comparisons. In addition, preference uncertainties associated with biological fluctuations remain difficult to fully resolve. Future research should therefore prioritize the establishment of longitudinal tracking systems to monitor the evolution of public value perceptions over time and incorporate choice experiments (CE) to more precisely capture trade-offs among multiple ecosystem services.

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