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# Offshore Wind Farms and Tourism Development Relationship to Energy Distribution Justice for the Beibu Gulf, China

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**Abstract:** Energy distribution justice is of primary concern within the energy justice framework and it is crucial to increase public acceptance of offshore wind energy and further advance its development. The rapid development of offshore wind energy in China has inevitably impacted the livelihoods of coastal vulnerable groups (CVGs) engaged in fisheries and tourism in the coastal zone. While current policies often compensate for livelihood losses through cash payments, the fiscal strain caused by COVID-19 renders this approach unsustainable. Consequently, this research pioneers the exploration of Chinese tourist groups' landscape preferences towards offshore wind farms (OWFs). This study proposes a new approach to enhance OWF landscapes for tourism development, thereby balancing the distribution of costs and benefits between CVGs and tourists. The research focuses on Beihai City in the Beibu Gulf Economic Region, utilizing a combination of Q-methodology and choice experiments that incorporates cut-offs. Answers to eighty Q-methodology questionnaires and 1324 choice experiment questionnaires are obtained. The findings indicate that this region can achieve energy distribution justice by compensating for the livelihood losses of CVGs through tourism. Contrary to traditional assumptions about wind farm noise preferences, Chinese tourists prefer proximity to OWFs, as an appropriate coastal acoustics landscape can enhance their tourism experience. In light of these findings, this paper presents policy recommendations towards energy distribution justice.

**Keywords:** offshore wind energy; energy distribution justice; tourist groups; coastal vulnerable groups; modified choice experiment; Q-methodology



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## 1. Introduction

By 2021, China's offshore wind energy had amassed an installation capacity exceeding 26 GW, ranking first in the world [1]. While offshore wind energy contributes to the development of clean energy, it has also resulted in energy injustices, including cost–benefit imbalances and imbalances in space allocations. As the world's largest developing country, China's approach to achieving energy justice in the expansion of offshore wind energy critically influences the acceptance of offshore wind farms (OWFs) by stakeholders [2,3]. The utilized approach is also vital for the welfare of 1.4 billion people, including coastal vulnerable groups (CVGs) and tourists nationwide. Distributive justice, a key goal of recognition and procedural justice, is of paramount concern in energy justice [4–6].

Energy injustices, mainly related to landscape degradation and livelihood losses, are the reason why CVGs often resist OWFs [7–9]. To still achieve energy distribution justice, current energy policies typically compensate for these losses through measures such as financial compensation, electricity fee reductions, community welfare funds, and joint ownership [10–12]. However, these modes of compensation are perceived by CVGs as evidence of the high negative externalities of OWFs, thus further diminishing their willingness to accept them [13]. As a result of the COVID-19 pandemic, economies worldwide are facing fiscal challenges [14,15], limiting their ability to provide large-scale compensations for OWFs and hindering the further advancement of offshore wind energy. For both governments and businesses, compensation implies higher costs [16–18]. In today's post-pandemic era, realizing distributive justice for offshore wind energy urgently requires a new avenue for loss compensation.

The impact of OWFs on tourism remains an unresolved issue to date. Different groups may perceive the externalities of OWFs differently, and a landscape that may appear negative to CVGs are potentially attractive to tourists [19]. Moreover, according to the exposure cumulative effect [20], tourists' short-term exposure to such externalities may not equate to the long-term exposure of residents, offering a potential route for compensating the losses of CVGs through tourism and achieving distributive justice through this pathway. Existing research primarily focused on developed countries and regions such as Europe and the USA [21]. Most relevant studies suggest that an OWF landscape could harm tourism, recommending that they should be located further out to sea, far from coastlines [22–24]. However, it has also been suggested that the impact on tourism is neutral, or may even be positive [25,26]. Nevertheless, how OWFs landscape influence tourism in developing countries such as China and whether these countries can simultaneously achieve both the development of clean energy infrastructure and energy distributive justice is still underexplored.

This study aims to address the two following research questions: (1) Can the tourism landscape development of OWFs effectively contribute to energy distribution justice? (2) What are the factors that affect the realization of distributive justice in offshore wind energy? To address these two questions, this paper presents two Q-methodology studies and two choice experiment studies. The Q-methodology studies are used to derive the attributes for the choice experiments, ensuring that the attributes considered are of the utmost concern to both CVGs and tourist groups. The two-choice experiment studies are employed to measure the marginal willingness to accept (MWTA) and marginal willingness to pay (MWTP) of both CVGs and tourist groups. In assessing the MWTP of tourist groups, cut-offs are incorporated to enhance measurement accuracy. Based on these four studies, this paper answers the two questions posed and offers pertinent policy recommendations to achieve energy distributive justice. This paper is structured as follows: Section 2 presents a literature review on energy distributive justice, CVGs, the impact of OWFs on tourism, and the modified choice experiment. Section 3 introduces the research area, the Q-methodology, the modified choice experiment method and model selection, as well as data sources and methodologies including the design of choice experiments. Section 4 details the results of the choice experiments, followed by Sections 5 and 6, which present the discussion and conclusion of this paper, respectively.

## 2. Literature Review

### *2.1. Energy Distribution Justice*

Energy distributive justice is the element most focused on within energy justice research, and it is key to addressing energy poverty [27]. Among the three principles of energy justice—distributive justice, procedural justice, and recognition justice—injustices in recognition and decision-making processes exacerbate unfairness in distribution [6,28–31].

How can energy distribution justice be achieved? Current research focuses on the four following aspects: cost allocation, benefit allocation, space allocation, and energy acquisition. In OWF projects, acquiring economic benefits can effectively enhance the acceptance of wind energy facilities by citizens [32–34]. However, the contrast between negative externalities such as noise and landscape damage imposed on local areas, and the outward flow of most income and economic benefits to non-local participants, is a key reason why citizens often resist OWFs [11,35]. Thus, equitable allocation of costs and benefits is of primary concern towards increasing OWF acceptance and achieving distributive justice [5,36]. Additionally, since the introduction of the concept of spatial justice into the field of energy justice [37], research has shown that the public prefers the consumption of electricity near its place of production, leading to regionalism and further emphasizing geographical disparities in energy poverty [38]. Finally, low-cost access to energy services is often used to offset the negative externalities of energy facilities and enhance community acceptance [33,39]. This is an inherent part of energy distributive justice.

### *2.2. Coastal Vulnerable Groups*

In coastal fishing communities, CVGs are pivotal participants for achieving energy justice. The coastal ecosystem, which is fragile and unstable, is predominantly inhabited by fishermen who are engaged in fishing and marine tourism. Their livelihoods are heavily reliant on the local marine environment, making them highly susceptible to coastal disasters, climate change [40–43], and human activities that alter this ecosystem [41,44–47]. Recent advancements in offshore energy projects, especially the development and construction of OWFs, have sparked competition for livelihood resources among CVGs, thus further exacerbating the fragility of this ecosystem [48–51]. Residents living near wind turbines are particularly prone to the externalities of energy facilities [3,13]. Unlike developed areas such as Europe and the USA, which focus on the destruction of landscape aesthetics, developing countries such as China place greater emphasis on the impacts on farmers' livelihoods [51–53].

Coastal fishing communities in China have optimized their household livelihood structures through tourism models such as "Fisherman's Family Tourism", thus enhancing family income and reducing vulnerability [54]. However, this will inevitably be affected by the externalities of OWFs, and the closer the Fisherman's Family Tourism operator is to the coastal zone, the greater the impact (vision, noise, etc.), as tourists are often willing to rent accommodation closer to the coast in order to reduce their transportation costs [47,54].

### *2.3. Impact of Offshore Wind Farms on Tourism*

Tourism is a substantial source of revenue for coastal nations and regions, with global earnings amounting to billions of dollars. In today's post-pandemic era, the previously suppressed potential of tourism is gradually being unlocked [55,56], wind energy facilities are predominantly located in areas of scenic beauty [57]. Thus, examining the relationship between OWFs and the tourism industry, as well as tourists' actual preferences towards OWFs, is of vital importance for the further development of marine wind energy.

The impact of OWFs on tourism, whether positive or negative, remains a subject of debate. Research focusing on the negative aspects often centers on the construction distance and layout of OWFs. Such research argues that OWFs should be built far from the coast to reduce their visual and acoustic impact, although this substantially increases energy costs. Meanwhile, OWFs have two opposing views of the vacation rental market. A stated preference study in coastal North Carolina showed that rental value losses are likely to be as high as 10% when OWFs are within eight miles of the coast [8], but Block Island's difference-in-differences study found that OWF construction significantly increased nightly bookings, occupancy, and monthly income [58]. Regarding layout, certain scholars suggested that, to minimize ecological damage and maintain local community attachment to the coastline, protected areas and scenic islands that provide recreational services should be avoided. However, such avoidance limits the tourism potential [59]. Other researchers posited that wind energy facilities can enhance recreational fishing and that OWFs, as novel landscapes, provide an appealing aspect [25,60–62]. As offshore wind technology advances and tourists' prior experience with OWFs increases, tourists are likely to pay more for locations where they can see the turbines [63]. The negative impacts of OWFs on the tourism industry will become more manageable and, with the help of certain management measures, will gradually turn into positive impacts [21].

When analyzing the causes underlying the heterogeneous outcomes observed, group characteristics and blurred boundaries between tourists and the general public emerge as decisive factors. Studies have shown that the acceptance of offshore wind projects varies across age groups. For instance, Vanja Westerberg et al. (2013) employed a latent class logit to examine the impact of socio-economic characteristics on OWF preferences; they found that younger tourists exhibited higher acceptance than older tourists [26]. This finding has been echoed by several other studies [64,65]. Additionally, factors such as energy preferences, the urgency of climate issues, and the coherence of environmental policies have been incorporated as explanatory variables in tourists' choice of destination, thereby imposing excessive moral elements on these choices [66,67]. Tourists primarily focus on the travel experience [68,69]; therefore, placing energy-related topics at the forefront of interviews or surveys can distort the identity of respondents, commonly leading to an underestimation of their welfare level. Current studies may also overestimate the overall welfare level. For example, treating the general public as tourists overlooks the gap between contingent and actual behaviors [24]. Not all tourists who express a preference for OWFs will also visit beaches, as this behavior is influenced by subjective, economic, and physiological factors [68]. Such imprecision in measuring tourist welfare levels impacts the assessment of the effect of OWFs on tourism in the existing literature.

Broadly speaking, current studies demonstrate ambiguity between tourists and the broader populace and tend to explore tourism compartmentalized. Neither positive nor negative stances have formulated a balanced pathway for distributing externalities concerning the effects of OWFs.

### 2.4. Modified Choice Experiment

The assessment of justice in energy distribution relies on comparing the overall MWTA and MWTP of CVGs and tourist groups. As a form of stated preference method, choice experiments offer the advantage of simulating real decision-making processes, and evaluating both preferences and trade-offs. This approach is extensively applied in fields such as product pricing, healthcare, and natural resource management.

The choice of attributes in choice experimental designs influences the overall measure of MWTA and MWTP. Scholars from developed countries have systematically reviewed the externalities of OWFs [70]. However, the prioritization of these externalities and the focus on these externalities in developing countries such as China remains unexplored. Selecting the attributes most valued by respondents becomes a critical factor for determining the scientific rigor of choice experiments. Current choice experimental studies primarily derive attributes from literature reviews, interviews, and surveys. Yet, these methods may be influenced by the subjectivity of researchers, thus introducing uncertainty [71].

The Q-methodology can circumvent this uncertainty in the attribute selection of traditional choice experiments. Compared with traditional attribute selection methods, the Q-methodology employs rigorous quantitative examination, providing objective analysis and understanding of subjective communication, and resulting in more impartial and objective research outcomes obtained through data analysis [72,73]. Additionally, the Q-methodology scientifically categorizes and ranks the viewpoints of stakeholders, comprehends their behaviors, and delves into subjective preferences. Ultimately, the Q-methodology generates representative research results that are aligned with the genuine psychology of stakeholders, thus overcoming the uncertainty of attribute selection [74,75].

Choice experiments present respondents with a series of decision scenarios and derive preference information based on their selections. However, when confronted with extensive choice data, limited by cognitive capacities, respondents frequently resort to non-compensatory strategies to reduce decision-making costs [76]. Traditional choice models that are grounded in linear compensatory principles do not account for the likelihood of respondents using non-compensatory strategies, possibly compromising the accuracy of estimation outcomes. Given this logic, Swait proposed to incorporate respondents' attribute cut-offs into the analysis [77]. While cut-offs in choice experiments concerning the externalities of renewable energy facility landscapes have been integrated [78], such considerations are absent in OWF research, which could affect the precision of choice experiment measurements.

In general, the current choice experiment research on OWFs has two problems: the selection of scheme attributes is highly arbitrary, and the accuracy of experimental measurements needs to be improved. To address these issues, this paper employs the Q-methodology to define the scheme attributes and incorporate cut-offs in the choice experiments.

## 3. Data Sources and Research Methods

### *3.1. Overview of the Research Area*

This study focuses on Beihai City in the Beibu Gulf Economic Region (BGER), which is located in the South China Sea and neighbors the countries of the Association of South East Asian Nations (see Figure 1). This region is one of China's least developed coastal regions. Moreover, this region is also the starting port of China's Maritime Silk Road. By using this region as the research area, the conclusions drawn have implications for realizing energy distribution justice in other coastal areas of China and nations of Southeast Asia. Guangxi's 14th Five-Year Plan includes a proposal for offshore wind energy projects in this area. Unlike the Guangdong and Hainan regions of BGER, Guangxi has no precedents for OWF construction. The CVGs lack prior experience with OWFs, making the selection of this area particularly forward-looking [79]. Beihai City boasts a relatively mature tourism and fishing industry, identifying it as a fitting representation of the coastal regions in BGER that combine both fisheries and tourism. Additionally, as indicated by the obtained data (see Section 4.1), tourists in Beihai City come from all over China, ensuring that the obtained tourist samples are nationally representative.

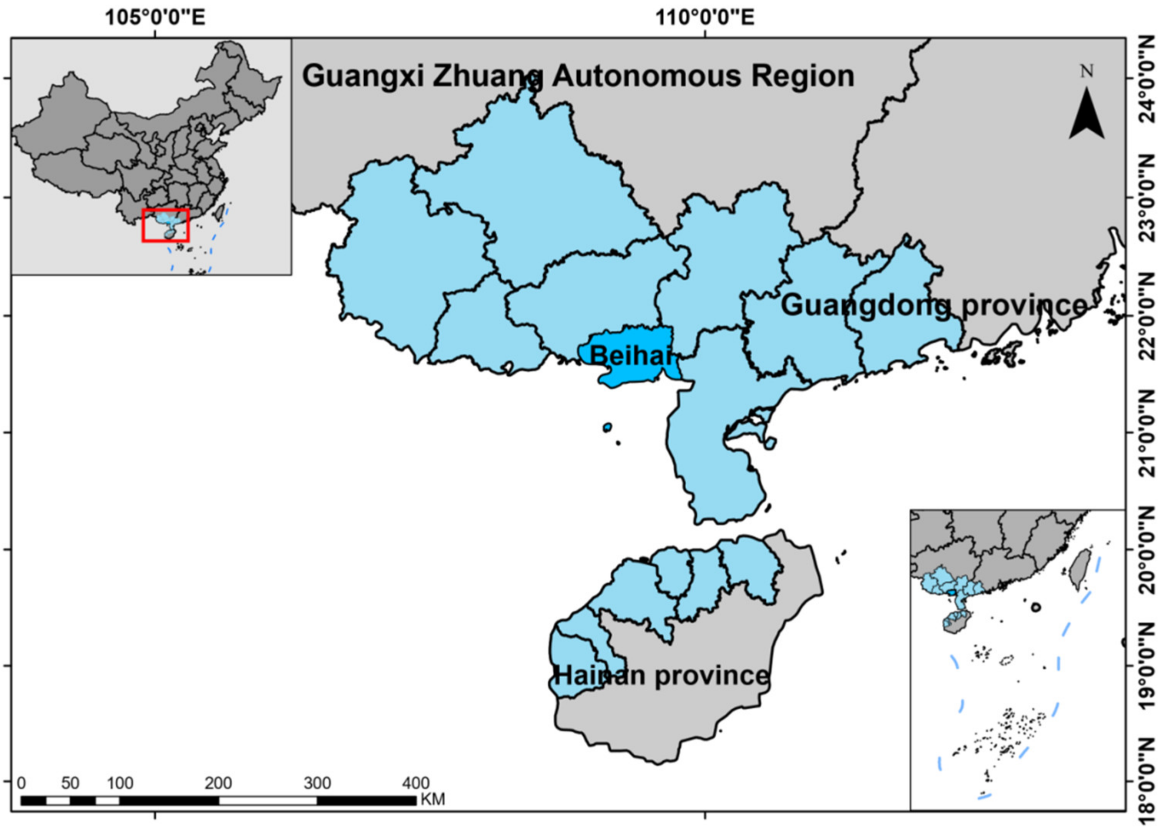


**Figure 1.** Research area.

### *3.2. Q-Methodology*

To mitigate the uncertainty associated with selecting scheme attributes and to discern the OWF external factors prioritized by China's CVGs and tourist groups, this paper initially adopts the Q-methodology to collect preferences on these factors from both groups [80]. The Q-methodology is a subjective research method with strong operability. Later, researchers inherited and developed the Q-methodology, proposed a series of specific operational steps, and formed a set of systematic subjective research procedures [81].

#### 3.2.1. Research Process

Adopting the foundational procedures of the Q-methodology [82,83], the forced rankings of the Q-statements of participants were employed to discern the preferences of CVGs and tourist groups regarding the establishment of OWFs. Based on the results, attributes for subsequent choice experiments are defined. Q-statements were initially designed. The Q-statements used in this paper encapsulate the external aspects of OWFs, gleaned from existing literature and interviews, conforming to principles of representativeness and pertinence. The gathered Q-statements for the CVGs were divided into four dimensions, centered on energy distribution justice. In contrast, the Q-statements for tourist groups were segmented into biodiversity, sensory perception, the aesthetic of wind energy installations, and landscape consonance. The accumulated Q-statements can be found in Tables A1 and A2. P-samples were chosen next. For the formal experiment, 40 samples of CVGs and 40 samples of tourist groups were selected to form P-samples. Finally, Q-sorting was completed [84].

#### 3.2.2. Data Analysis and Results

This study used the Ken-Q Analysis online tool to input results and calculate correlation matrices; subsequently, data were processed using principal component analysis and the maximum variance rotation method [85,86]. Following the Kaiser criterion, factors with eigenvalues greater than one were retained [87]. The results indicate that two factors among tourists had eigenvalues exceeding one, accounting for a cumulative explained variance of 87%, which is considerably high. The standard values reflect the degree of preference towards factors among the different categories of respondents. Based on the Q-sort results, the standard values of 20 secondary factors across the selected factors were computed. These values serve as the foundational data for preference attributes in the choice experiment.

Drawing from data analysis outcomes and concrete interviews conducted via the Q-methodology, the research pinpointed the foremost indicators among the 20 listed indicators. The aggregate Q-sort outcomes emerge from summing standard values across varied factors for all P-sample types, sequentially ordered based on their respective scores. Figure 2 shows the results. Prioritizing the thoroughness and inclusivity in attribute selection, and amalgamating score ranks with statement characteristics, ultimately, scale, offshore distance, fish count, and coastal acoustics were designated as attributes for the tourist groups' choice experiment. Conversely, the risk of fish count reduction, tourist volume, offshore distance, and power obtainability were designated as attributes for CVGs.

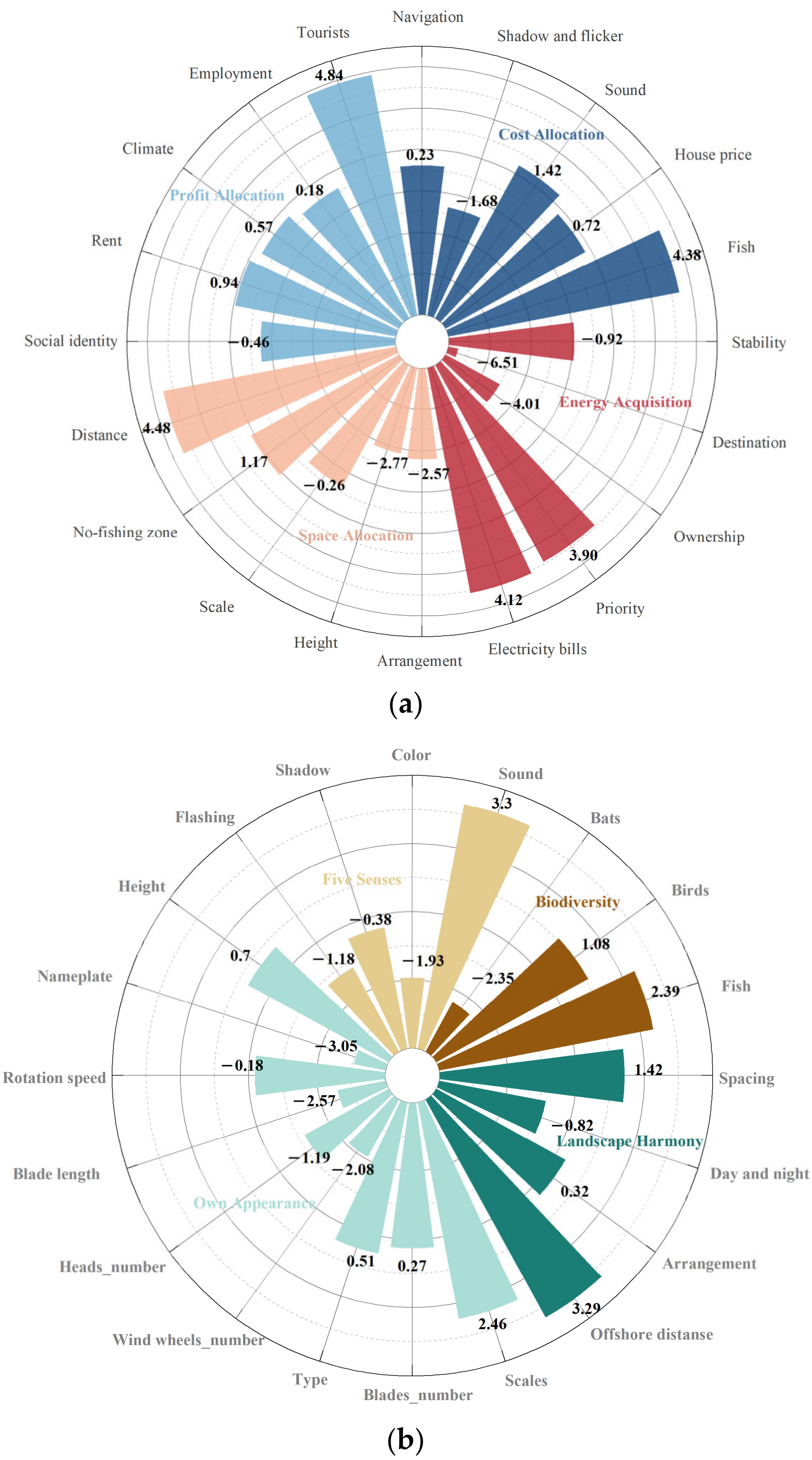


**Figure 2.** Results of the Q-methodology: (**a**) Q-methodology results for coastal vulnerable groups; and (**b**) Q-methodology results for tourist groups. The scores represent the relative importance of corresponding Q-statements.

### 3.3. Modified Choice Experiment and Research Design

The choice experiment (CE) is grounded in attribute value theory and random utility theory [88,89]. By translating the consumer's choices in the choice set into a comparison of utilities, the researcher can obtain the consumer's utility maximization and thus estimate the model parameters [90]. Therefore, both CVGs and tourist groups can select a combination of OWFs attributes based on the principle of maximizing their utility.

Traditional choice models assume that respondents are rational agents, who achieve maximum utility by choosing within a finite choice set $C$:

$$[Max]\sum_{i\in C}\delta_i U(X_i) \quad (1)$$

$$s.t. \sum_{i\in C}\delta_i = 1, \delta_i \in \{0,1\}, \sum_{i\in C}\delta_i p_i \leq Y, \forall i \in C \quad (2)$$

In Equations (1) and (2), $U$ represents the utility function; $X_i$ is a k-dimensional vector describing the attributes of OWFs; $\delta_i$ is an indicator variable for choosing or not choosing, which is represented by 1 and 0, respectively; $C$ is the set of alternative choice options; $p_i$ represents the price variable, denoting the price of $i$, and $Y$ represents the respondent's income.

Traditional choice models overlook the violation of cut-offs. Swait accounted for these cut-offs in the model and amended the conventional choice model accordingly [75], arriving at the following modified choice model:

$$[Max]U = \sum_{i\in C}\delta_i U(X_i) + \sum_{i\in C}\sum_k \delta_i(w_k\lambda_{ik} + v_k\kappa_{ik}) \quad (3)$$

$$s.t. \sum_{i\in C}\delta_i = 1, \delta_i \in \{0,1\}, \sum_{i\in C}\delta_i p_i \leq Y, \forall i \in C \quad (4)$$

$$\delta_i\left(\theta^L - Z_i\right) - \lambda_i \leq 0 \quad (5)$$

$$\delta_i\left(Z_i - \theta^U\right) - \kappa_i \leq 0 \quad (6)$$

$$\lambda_\mathrm{i} \geq 0, \kappa_\mathrm{i} \geq 0; \forall i \in C \quad (7)$$

In Equations (3)–(7), $\theta^L$ and $\theta^U$ represent the minimum and maximum cut-offs, respectively, for OWF attributes that respondents can accept. $Z_i$ is a $k$ + 1 dimensional vector that characterizes the attributes and price of OWFs. The penalty coefficients for violating the minimum and maximum cut-offs are represented by $w_k$ and $v_k$, respectively, signifying the marginal disutility after breaching the cut-offs. $\lambda_{ik}$ and $\kappa_{ik}$ are used to measure the extent to which respondents violate the minimum and maximum cut-offs, respectively, for the kth attribute of the OWF, quantitatively satisfying $\lambda_{ik} = \max\left(0, \theta_k^L - Z_{ik}\right), \kappa_{ik} = \max\left(0, Z_{ik} - \theta_k^U\right)$. $\lambda_{ik} = \kappa_{ik} = 0$ indicates that the respondent's choice does not violate any cut-offs, and subsequent processing is the same as in the traditional CE model.

The modified model assumes that respondents have specific minimum and maximum acceptable cut-offs, represented by $\theta^L$ and $\theta^U$, respectively, for the attributes of OWFs. This model permits respondents to exceed their personally set cut-offs, which, in turn, generates a corresponding marginal disutility. For example, the maximum amount that a tourist is willing to pay for OWFs is CNY 100; however, the long interview and a series of choice sets caused cognitive fatigue for the respondent, leading him to choose the option of paying CNY 150 in the choice set, which clearly exceeds his maximum willingness to pay and will result in a biased final estimate. Essentially, the new model amends observable effects through the cut-offs and recalibrates them into a composite of two components: one is the utility respondent n derives from the combination of OWF attributes, and the other is the negative utility stemming from the breach of attribute cut-offs. That is:

$$V_{ni} = \sum k(\beta_k X_{ik} + w_k\lambda_{nik} + \nu_k k_{nik}) \quad (8)$$

In Equation (8), $V_{ni}$ represents the utility respondent n derives from the ith option; $\beta_k$ is the estimated parameter; $X_{ik}$ denotes the level of the kth attribute combination of the OWF for the ith option; $\lambda_{nik}$ and $k_{nik}$ quantify the extent to which respondent n violates the minimum and maximum cut-offs for attribute $k$, respectively.

The modified CE model aligns more closely with reality. The total marginal utility of the respondents not only encompasses the marginal utility derived from the original attributes but also includes the negative marginal utility resulting from breaches of attribute cut-offs. Under this framework, assuming that the utility function $U_i(Z)$ is a linear function of attribute $Z_{ik}$, the total marginal utility in the revised model can be represented by the following equation:

$$\frac{\partial U_i}{\partial Z_{ik}} = \delta_i \begin{cases} \beta_k - w_k & Z_{ik} < \theta_k^L \\ \beta_k & \theta_k^L \leq Z_{ik} \leq \theta_k^U \\ \beta_k + v_k & Z_{ik} > \theta_k^U \end{cases} \tag{9}$$

In Equation (9), $\theta_k^L$ and $\theta_k^U$ represent the lowest and highest cut-offs for attribute k respondents can accept, respectively.

Based on the modified random utility function, the actual marginal value of OWF attributes can be expressed as:

$$MWTP_k(MWTA_k) = -\frac{\beta_k}{\beta_p} \tag{10}$$

The payment surplus can be expressed as:

$$CS \ = -\frac{1}{\beta_p}(V^0 - V^1) \tag{11}$$

In Equations (10) and (11), $MWTP_k$ represents the actual marginal value of attribute k; $CS$ is the compensation/payment surplus after cut-offs correction; $\beta_k$ and $\beta_p$ denote the actual marginal utilities of attribute k and the compensation amounts/payment, respectively; using Equation (9) for numerical adjustments, $V^0$ and $V^1$ indicate the welfare utility levels of respondents without and with OWFs, respectively.

This study did not incorporate cut-offs into the CVG model but instead employed the traditional CE model to gauge the willingness to be compensated among CVGs. Three reasons underpin this approach. Firstly, the MWTA results tend to be several times higher than the MWTP results [91]. If tourists' MWTP can offset their MWTA, it can also offset MWTP. Furthermore, the accuracy enhancement for welfare outcomes because of cut-offs lies within 30–50% [92], implying that including cut-offs will not substantially improve the precision of WTA measures. Secondly, during field examinations, the research team discovered that CVGs opt for extreme cut-offs to maximize benefits, such as the highest compensations, lowest fishery losses, and maximum tourist influx. Thirdly, there was an attempt to transition from gauging MWTA to MWTP for the sake of using cheap talk in research (which represents a way of talking that can elicit more accurate information about respondents' preferences), but respondents were reluctant to pay for projects that impact their livelihoods. The tourist groups cohort utilized the CE model with integrated cut-offs to enhance the accuracy of MWTP measurements.

### *3.4. Choice Experimental Design and Data Collection*

The crux of the CE lies in identifying the attributes of schemes and their combinations. Based on the Q-methodology and the results of the pre-survey, we derive the OWFs attributes and compensation amounts/payments that are of most concern to CVGs and tourists are shown in Table 1. Notably, the fish count levels indicated by CVGs differ from those indicated by tourist groups. The impact of OWFs on fish count remains inconclusive and varies with the different phases of OWF construction and operation under governmental marine spatial management. However, in general, OWFs have a positive effect on recreational angling activities for tourists but potentially have negative implications for the fishing activities of CVGs [59,93–95]. The decisions of CVGs that affect their livelihoods are influenced by both objective and subjective risk preferences, prompting to consider risk preferences in the setup of fish count levels for this group [96]. Unlike previous studies where wind turbine sounds were defined as noise [97–99], this study adopted a more neutral expression, allowing respondents to make their judgements using various audio formats.

**Table 1.** Description of each attribute level and index.

| | Attribute | Levels | Indicators/Description |
|---|---|---|---|
| Coastal vulnerable groups (CVGs) | Offshore distance | 3 km |  |
| | | 15 km |  |
| | | 50 km |  |
| | Tourist volume | Reduced |  |
| | | Unchanged |  |
| | | Increased |  |
| | Risk of fish count reduction | Low risk<br>Risk<br>High risk | The influence of radiation and sound waves from offshore wind farms (OWFs)<br>Impacts of closed fishing areas |
| | Power obtainability | Unchanged<br>Small increases<br>Large increases | Power tariff reduction; power supply priority; power supply stability; |
| | Compensation amounts (CNY/person/month) | 50, 100, 150 | The amount of compensation each person receives per month |

**Table 1.** *Cont.*

| Attribute | | Levels | Indicators/Description |
|---|---|---|---|
| Tourist groups | Offshore distance | 3 km |  |
| | | 15 km |  |
| | | 50 km |  |
| | Scale | Small |  |
| | | Medium |  |
| | | Large |  |
| | Fish count | Unchanged<br>Small increase<br>Substantial increase | Coral reef-like enrichment effect, can be used for leisure fishing |
| | Coastal acoustics landscape | Low turbine sound<br>Medium turbine sound<br>Loud turbine sound | Turbine sound;<br>waves sound;<br>seabirds sound; |
| | Payments (yuan/person) | 50, 100, 150 | The amount each person receives every time |

Utilizing SPSS 26.0 for orthogonal experimental design and considering the lack of prior experience among CVGs, the research team divided the generated eight choice sets into four versions. Each choice set consists of three alternative schemes and one status quo scheme, and each CVG member received one such version. However, for the tourist groups, which have higher prior experience and education levels, the research team presented all choice sets at once.

To ascertain the tourists' cut-offs for the attributes of OWFs, in this section of the questionnaire, a series of supplementary questions related to cut-offs were incorporated [100]. Examples are as follows: "What is the maximum distance from OWFs you are willing to accept in km?" and "What is the loudest sound from the OWF you are willing to tolerate?". Respondents were provided with pre-determined cut-off levels in the questionnaire and were asked to select the category closest to their limit. Depending on the attribute, tourists were queried about the maximum cut-offs for the offshore distance, scale, and coastal acoustics landscape of OWFs, as well as the minimum cut-off for fish count. Furthermore, we added cheap talk during the CE process, which improved the precision of the measure by giving full disclosure, providing a free discussion environment, and conducting multiple response confirmations to make the respondents' MWTA/MWTP closer to the true value [71,101,102].

The experimental questionnaire consists of four sections: basic attitudes towards OWFs, fundamental preferences and cut-offs for OWFs, selection sets for OWFs, and the socioeconomic characteristics of respondents. Given the availability of data, the CVG samples were obtained in Beihai City using stratified random sampling, and the tourist samples were obtained through cooperation with Beihai City Scenic Spots using convenience sampling. Each tourist receives a souvenir of Beihai's specialties as a questionnaire reward, while each CVG receives necessities such as laundry detergent and paper towels. To ensure the representativeness of samples from CVGs and tourist groups, the research team visited the study area four times during the peak tourist seasons between May 2022 and June 2023. All researchers who conducted interviews in all four phases were from relevant fields. They underwent extensive training before the survey to ensure familiarity with the questionnaire and acquisition of necessary research skills. During the four phases of the experimental selection, 314 valid questionnaires were retrieved from CVGs and 1010 from the tourist groups, totaling 1324 responses.

## 4. Results and Analysis

### *4.1. Descriptive Statistical Results of Respondents*

The socio-economic characteristics, gender ratio, age structure, educational level, and household income of CVGs and the tourist groups are provided in Table 2. Overall, the income level of the tourist groups is higher than that of CVGs, and tourists are younger and more educated. A total of 95.1% of tourists support the development of offshore wind energy, 81.9% are attracted to OWF landscapes, and 81.3% claim they would be willing to pay to view OWFs. The geographical spread of tourists largely mirrors the population distribution percentages across China, guaranteeing that the sampled tourist groups are fairly representative.

**Table 2.** Sociodemographic profile of survey respondents.

| Characters | CVGs | Tourist Groups |
|---|---|---|
| Sample size | 314 | 1010 |
| Sex distribution | | |
| Female | 49.68% | 50.50% |
| Male | 50.32% | 49.50% |
| Age distribution | | |
| 18–30 | 26.11% | 64.75% |
| 31–40 | 19.43% | 22.18% |
| 41–50 | 21.34% | 8.71% |
| 51–60 | 18.79% | 2.67% |
| Over 61 | 14.44% | 1.68% |
| Highest level of education | | |
| Primary school and below | 20.70% | 1.09% |
| Middle school | 35.67% | 1.68% |
| High school/secondary school | 20.06% | 8.81% |
| Junior college | 11.15% | 10.30% |
| Bachelor's degree or above | 12.42% | 78.12% |
| Household income (CNY/year) | | |
| Less than 50,000 | 8.60% | 11.98% |
| 50,000–100,000 | 45.54% | 23.56% |
| 100,000–150,000 | 29.62% | 26.63% |
| 150,000–200,000 | 10.51% | 18.42% |
| Over 200,000 | 5.73% | 19.41% |
| Regions | | |
| East China | | 29.70% |
| South China | | 14.55% |

**Table 2.** *Cont.*

| Characters | CVGs | Tourist Groups |
| --- | --- | --- |
| Central China | | 16.14% |
| Southwest | | 15.25% |
| North China | | 10.50% |
| Northeast | | 6.63% |
| Northwest | | 7.23% |
| Attitude | | |
| Attitude to offshore wind power | | 4.61 |
| Willingness to visit OWFs or beaches | | 4.23 |
| Willingness to pay for OWF views | | 3.43 |

Note: The attitude part is scored from 1 to 5, where the higher the score, the greater the support and the stronger the willingness.

### 4.2. Marginal Willingness to Accept of Coastal Vulnerable Groups

For CVGs, Stata 17.0 software was used to estimate and analyze the model without considering attribute cut-offs. Utilizing the results from the model estimation and Equation (10), the marginal values for the OWF attributes were determined, as detailed in Table 3. Through the application of Equation (10), the monthly compensatory willingness of CVGs is derived as CNY 61.21 for offshore distance, CNY 225.22 for tourist volume, CNY 396.72 for risk of fish count reduction, and CNY 111.44 for power obtainability, amounting to a total of 794.59 CNY/month.

**Table 3.** Random parameter Logit model estimation results for coastal vulnerable groups.

| Variable | CVG | |
| --- | --- | --- |
| | Coefficient | Standard Error |
| Offshore distance | 0.2060 * | 0.1215 |
| Tourist volume | 0.7580 *** | 0.2135 |
| Risk of fish count reduction | −1.3352 *** | 0.3689 |
| Power obtainability | 0.3751 * | 0.2059 |
| Compensation amounts | 0.0337 ** | 0.0016 |
| Log likelihood | −556.2949 | |

Note: ***, **, and * indicate that the estimated value is significant at the level of 1%, 5%, and 10%, respectively.

### 4.3. Marginal Willingness to Pay of Tourist Groups

The analysis of tourist groups integrated statistical results from both choice models, one with and one without cut-offs. Judging by the fit of the model, the Log-likelihood indicates that the model considering attribute cut-offs achieves a better fit and more accurately reflects the real choices of tourist groups. This result is consistent with the findings of Nie et al. [100]. From the perspective of model robustness, the direction and significance of various attributes, except for the scale attribute, do not change before and after the incorporation of cut-offs, indicating that the model is overall robust. The change in the significance of the scale attribute before and after suggests that the utility tourists derive from the scale attribute of OWFs is more composed of the negative utility generated by the violation of cut-offs.

Based on the coefficients of OWF attributes, the effects of offshore distance and coastal acoustics landscape on utility are negative, whereas the fish count has a positive impact on utility. The preference for OWFs in close proximity reflects the uniqueness of Chinese tourists. Existing studies generally perceive nearshore OWFs as negative landscape attributes [24]. This distinctive space allocation preference for wind farms allows China to achieve energy distribution justice through tourism. Tables 4 and A3 show that the overall utility of the coastal acoustics landscape for tourists is negative, and surprisingly, tourists do not desire the absence of the OWF sound, and the effect is positive when the OWF sound is at a low level. This implies that the OWFs sound can be a positive experience for tourists when it is appropriate, contrary to the common view of noise [99]. As one tourist remarked, "The sound of the turbines, combined with the waves and seabirds, gives me a romantic feeling—it's like white noise".

**Table 4.** Random parameter Logit model estimation results for tourist groups.

| Variable | Model without Cut-Offs | | Model with Cut-Offs | |
|---|---|---|---|---|
| | **Coefficient** | **Standard Error** | **Coefficient** | **Standard Error** |
| Scale | −0.0467 ** | 0.0219 | −0.0023 | 0.0302 |
| Offshore distance | −0.2120 *** | 0.0203 | −0.1001 *** | 0.0313 |
| Fish count | 0.0961 *** | 0.0285 | 0.0703 ** | 0.0346 |
| Coastal acoustics landscape | −0.2044 *** | 0.0191 | −0.0780 ** | 0.0358 |
| Payments | −0.0065 *** | 0.0005 | −0.0029 *** | 0.0006 |
| Scale_cutoff | | | −0.1835 *** | 0.0479 |
| Offshore distance_cutoff | | | −0.2323 *** | 0.0493 |
| Fish count_cutoff | | | −0.2043 *** | 0.0545 |
| Coastal acoustics Landscape_cutoff | | | −0.3089 *** | 0.0651 |
| Payments_cutoff | | | −0.0079 *** | 0.0010 |
| Log likelihood | −6365.3996 | | −6299.2261 | |

Note: *** and ** indicate that the estimated value is significant at the level of 1% and 5% respectively.

Using the estimations from the model and employing Equation (10), the marginal values of OWF attributes can be ascertained under the two model scenarios. The findings demonstrate that in the traditional model, tourists are willing to pay CNY 7.14, CNY 32.43, 14.70, and CNY 31.26 for the attributes of scale, offshore distance, fish count, and coastal acoustics landscape, respectively; when considering the attribute cut-offs in the choice model, these values change to CNY 16.99, CNY 30.78, CNY 12.41, and CNY 35.82, respectively. By considering the attribute cut-offs, the amended model more accurately reflects the actual situation and presents an enhanced model fit. From the estimations derived from the model and using Equation (11), a per capita payment surplus for the tourist groups of CNY 96.00 can be deduced.

Similarly, applying the model that incorporates cut-offs to tourist groups from different geographical regions allows one to derive the space allocation of MWTP across China, as shown in Figure 3. The results indicate that tourists from north China, northeast China, and central China exhibit a higher MWTP. In contrast, tourists from northwest China and southwest China exhibit a relatively lower MWTP. The MWTP for tourists across the country varies widely, ranging from CNY 50.88 to CNY 328.12.

This research has pinpointed the factors that affect energy distribution justice for CVGs and tourist groups by applying Q-methodology and CEs. The most critical of these factors have been identified, thus answering the second research question.

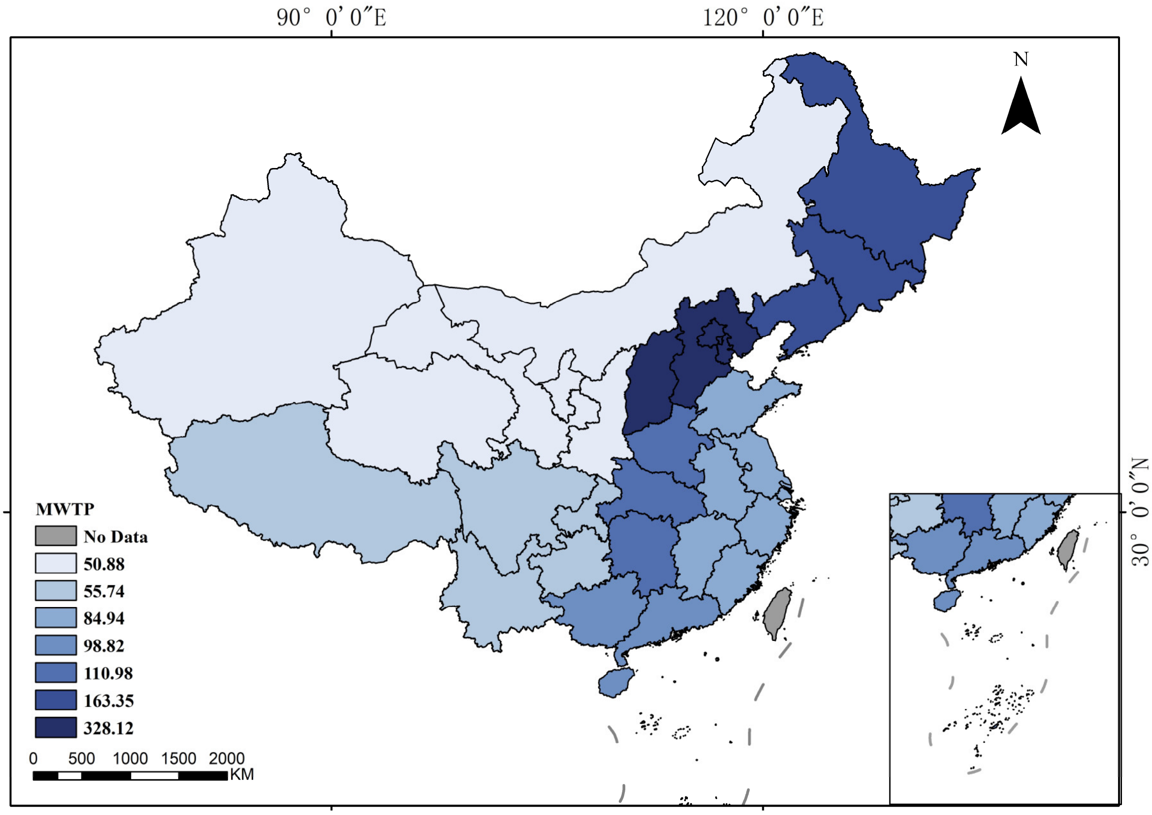


**Figure 3.** Marginal willingness to pay (MWTP) for tourist groups from various regions in China.

### 4.4. Cost and Benefit Allocation Balance

According to the Beihai City Economic and Social Development Statistical Bulletin, the total number of tourists in Beihai City in 2020 reached 41.2 million. These tourists generated a tourism revenue of CNY 514.27 billion. By multiplying the per capita MWTP with the number of tourists and subtracting the 18.7% of tourists with zero MWTP, the total payment intention amounts to CNY 32.16 billion per year. This suggests that the construction of OWFs could lead to a 6.25% increase in tourism revenue for Beihai City.

According to the Guangxi Statistical Yearbook, in 2020, Beihai City boasted a standing population of 1.8 million. Among the residents, about 200,000 were CVGs, primarily subsisting on manual fisheries and tourism. By excluding the tourist volume compensation from the per capita MWTA and then multiplying it by the count of these CVGs, the total compensation intent reaches CNY 1.366 billion annually. This indicates that basing tourism on OWFs could compensate for the likely livelihood deficits these CVGs face. In addition, OWFs present a potential yearly income augmentation of CNY 9250 for CVGs. This figure represents 55.08% of the annual disposable income for Beihai's rural dwellers and 24.37% for its urban populace. A comparison of MWTA and MWTP data can be found in Table 5.

**Table 5.** Comparison of MWTA and MWTP data.

| | CVG | Tourist |
|---|---|---|
| MWTA(CNY/person/year) | 6832.44 | |
| MWTP(CNY/person) | | 96.00 |
| Number of people | 200,000 | 33,495,600 |
| Total amount | 1,366,488,000 | 3,215,577,600 |
| Income growth | 1,849,089,600 | |

In the tourism industry, tourists can enhance their travel experience by paying for the opportunity to closely observe OWFs, engage in reef fishing, and enjoy romantic soundscapes. This increases the attractiveness of coastal areas for tourism. Additionally, tourists compensate for the negative externalities imposed on CVGs due to the development of OWFs by paying for their visits. This approach effectively addresses the concerns of local OWF protesters, who question why the benefits of clean energy are shared by the public while the costs are borne solely by them.

At this point, the study answers the first question posed in the introduction, that MWTP by tourists has the potential to compensate for the loss of livelihoods of CVGs. By paying for it, tourists can have a better tourist experience while promoting energy distribution justice centered on a balanced distribution of costs and benefits.

## 5. Discussion

The use of the Q-methodology ensures that the attributes of the plans are the most valued by both groups, and that the derived MWTA/MWTP better represent the core desires of both communities. The MWTA for CVGs in Beihai City is 9535.08 CNY/year, while the MWTP for Chinese tourists regarding OWF landscapes is 96.00 CNY/visit. This implies that the development of the OWF tourism landscape has the potential to contribute to a balanced distribution of costs and benefits in offshore wind development.

The proper space allocation of wind energy facilities can help balance costs and benefits between these two groups. Contrary to the research in Europe, the USA, and other parts of Asia [61,103], this study shows that tourists prefer OWFs that are closer in proximity. Departing from traditional assumptions about wind farm noise, the results of this research indicate that appropriate sounds from OWFs can enhance the tourist experience, which is related to the harmony of the soundscape [104,105].

Improving the energy acquisition for CVGs can increase their willingness to accept OWFs. The stability of energy supply in coastal areas is significantly affected by extreme weather events such as typhoons [40]. CVGs expect a higher priority for energy supply. Given the hot climate of the BGER and the associated use of air conditioning units, the electricity demand of these CVGs is also higher. Reducing electricity fees can enhance their acceptance of OWFs.

Although most studies have negative conclusions, this research shows that tourists have a positive preference for OWFs. This positivity is due to the fact that previous studies have overly moralized the options available to tourists, overlooking that the primary demand of tourists is the travel experience itself. The study reveals that changes in fish populations have varying impacts on tourists and CVGs. OWFs lead to an increase in fish populations due to the enrichment effect, while the establishment of no-fishing zones results in a decline in fishing yields. It is important to note that these impacts are not uniform and affect different groups differently. The study recorded and simulated coastal soundscapes, finding that the sounds of waves, wind turbines, and seabirds can create a harmonious soundscape, increasing tourists' MWTP.

This article's contributions are three-fold: (1) It is the first to apply the Q-methodology to the selection of experimental scheme attributes, overcoming the issue of randomness in attribute selection. (2) The choice experiment model incorporates cut-offs, which enhances the precision of measuring tourists' MWTP. (3) The study revisits the differences between tourists, the public, and CVGs. It finds that the core reason for the low acceptance of OWFs by CVGs is the underexplored potential of the OWF tourism landscape.

Because of ethical and privacy considerations, this paper could not obtain the precise geographical locations and related characteristics of tourists, and hence, analysis was restricted to large-scale geographical divisions within China. Moreover, the appeal of OWFs to tourists might be due to their "novelty". It remains uncertain whether the attractiveness of OWF landscapes will persist in the long run [25,62]. This study also did not measure the potential increase in tourist numbers induced by OWFs; hence, the total amount tourists are willing to pay may even be higher than identified in this study. Further research is needed on the sustainability of this appeal and dynamic changes in tourists' MWTP. From the perspective of external validity, future research could also continuously focus on the impact of the offshore wind farm tourism industry on energy distribution justice in regions with similar economic, social, and geographical conditions, such as Goa in India, Da Nang in Vietnam, and Boracay in the Philippines. Overall, this study concludes that OWFs tourism landscape development has the potential to contribute to energy distribution justice, but how CVGs can fully exploit the potential of offshore wind tourism still deserves further research.

## 6. Conclusion and Policy Implications

### 6.1. Conclusions

This paper employs a modified CE to measure both the MWTP of tourist groups, which is CNY 96.00 per visit, and the MWTA of CVGs, which amounts to CNY 9535.08 per year. The following findings can be summarized as follows: (1) The tourism industry can achieve a balance among the allocation of costs and benefits. Furthermore, the equitable distribution of energy resources can be realized through the space allocation of nearby OWFs, the optimization of coastal acoustics landscape, and enhancing the power obtainability for CVGs. (2) The impact of OWFs on fish count and tourist volume is the most concerning factor for CVGs. For tourists, the distance of OWFs and the coastal acoustics landscape are the primary factors affecting their landscape experience. Realizing energy distribution justice necessitates a considering of the cost allocation, benefit allocation, space allocation, and energy acquisition. Based on the obtained research findings, this paper proposes policy recommendations revolving around these four perspectives.

### 6.2. Policy Recommendations

In light of these findings, this paper presents policy recommendations towards energy distribution justice from four perspectives.

(1) For CVGs, OWFs should be constructed away from traditional fishing grounds to mitigate adverse effects on fishing navigation and potential risks to fish count. For tourist groups, attention should be directed to aesthetics and overall visual harmony when planning OWFs, thus transforming the potential negative costs into benefits. In general, CVGs bear livelihood cost losses, while tourists incur no direct costs when enjoying the positive externalities of clean energy.

(2) For CVGs, the government should guide them to optimize their livelihood structures by introducing policies that encourage integration with the tourism industry. This integration ensures that tourism revenue from OWFs directly benefits CVG communities. Furthermore, the government can identify groups or segments of the livelihood conversion process that are unable to realize offsets and compensate them monetarily accordingly, and the MWTA derived from this study can be used as a reference. For tourist groups, attractions should incorporate recreational activities linked with OWFs, such as leisure fishing and promoting clean energy awareness. The direct benefits from OWFs mainly manifest in tourism growth, with tourists paying for the enjoyed positive externalities.

(3) For CVGs, no-fishing zones associated with OWFs should not overlap with traditional fishing grounds. For tourist groups, proximity to and a smaller scale of OWFs can enhance their experience and willingness to pay. Balancing the preferences of both groups, OWFs are best constructed 3–15 km off the coast in non-fishing areas. Furthermore, regional adaptations can be made based on historical visitor geographic distribution and varying MWTP to adjust the placement of OWFs.

(4) For CVGs, that are substantially impacted by climate and experience energy instability, the electricity produced by OWFs should be prioritized for their consumption. Appropriate tariff reductions should be granted to alleviate energy poverty. For tourist groups, the government should promote transnational tourism reliant on OWFs, thus advancing regional energy distribution justice.

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## Appendix A

**Table A1.** Q statement for coastal vulnerable groups.

| Label | Statement | Dimensionality | Explanation |
|---|---|---|---|
| Fish | Fish | Cost Allocation | I care about the impact of offshore wind on fish populations |
| House price | Housing price | Cost Allocation | I care about the impact of offshore wind on surrounding house prices |
| Sound | Sound | Cost Allocation | I care about offshore wind sounds |
| Shadow and flicker | Shadow and flicker | Cost Allocation | I care about the shadows and flicker from offshore wind. |
| Navigation | Fishing boat navigation | Cost Allocation | I care about the impact on fishing vessel navigation |
| Tourists | Tourists | Profit Allocation | I care about the impact of offshore wind on tourist numbers |
| Employment | Employment opportunities | Profit Allocation | I care about the increase in jobs from offshore wind farms |
| Climate | Impact on climate | Profit Allocation | I care about the climate impact of offshore wind |
| Rent | Impact on rent | Profit Allocation | I think offshore wind has an impact on rents |
| Social identity | Social identity | Profit Allocation | I think offshore wind improves the social identity of the area for others |
| Distance | Distance | Space Allocation | I care about offshore wind distance |
| No-fishing zone | Establishment of prohibited fishing areas | Space Allocation | I care about the setting of closed areas (generally 1–4 km around) |
| Scale | Scale | Space Allocation | I care about the scale of offshore wind power |
| Height | Height | Space Allocation | I care about the height of offshore wind. |
| Arrangement | Arrangement | Space Allocation | I care about offshore wind alignment |
| Electricity bills | Electricity bills | Energy Acquisition | I want my electric bill to go down. |
| Priority | Power priority supply right | Energy Acquisition | I want to have first right of refusal to supply electricity from offshore wind. |
| Ownership | Ownership | Energy Acquisition | I care about offshore wind ownership (state, business, community joint venture) |
| Destination | Electric energy destination | Energy Acquisition | I care about where offshore wind power goes (domestic, foreign/transnational trade in power) |
| Stability | Stability of energy supply | Energy Acquisition | I think offshore wind enhances the stability of local energy supply |

**Table A2.** Tourist's Q statement.

| Label | Statement | Dimensionality | Explanation |
|---|---|---|---|
| Fish | Effect on fish | Biodiversity | I care more about offshore wind power impacts on fish |
| Birds | Effect on birds | Biodiversity | I am more concerned about the impacts of offshore wind on birds than I am about offshore wind |
| Bats | Effect on bats | Biodiversity | I care more about the impact of offshore wind on bats |
| Sound | Sound | Five Senses | I care more about offshore wind sound |
| Color | Color | Five Senses | I care more about offshore wind colors |
| Shadow | Shadow | Five Senses | I care more about offshore wind generated shadows |
| Flashing | Flashing | Five Senses | I care more about offshore wind generated flicker |
| Height | Height | Own Appearance | I care more about offshore wind heights |
| Nameplate | Nameplate | Own Appearance | I care more about offshore wind nameplates |
| Rotation speed | Rotation speed | Own Appearance | I care more about the offshore wind speed |
| Blade length | Blade length | Own Appearance | I care more about offshore wind power blade length |

**Table A2.** *Cont.*

| Label | Statement | Dimensionality | Explanation |
| --- | --- | --- | --- |
| Heads_number | Number of heads | Own Appearance | I care more about the number of offshore wind turbine heads |
| Wind wheels_number | Number Of wind wheels | Own Appearance | I care more about the number of wind turbines for offshore wind power |
| Type | Type | Own Appearance | I care more about the type of offshore wind power construction |
| Blades_number | Number of fan blades | Own Appearance | I care more about the number of fan blades in offshore wind power construction. |
| Scales | Scales | Own Appearance | I care more about offshore wind power offshore distance |
| Offshore distance | Offshore Distance | Landscape Harmony | I care more about offshore wind power scale (number) |
| Arrangement | Arrangement | Landscape Harmony | I care more about offshore wind power arrangement. |
| Day and night | Day and night | Landscape Harmony | I care about the different landscape of offshore wind by day and by night. |
| Spacing | Spacing distance | Landscape Harmony | I care more about the distance between the offshore wind power construction. |

**Table A3.** Random parameter Logit model of coastal acoustics landscape.

| Variable | Tourist | |
| --- | --- | --- |
| | **Coefficient** | **Standard Error** |
| Scale | −0.1258 *** | 0.0254 |
| Offshore distance | −0.2128 *** | 0.0202 |
| Fish count | 0.0903 *** | 0.0285 |
| Coastal acoustics landscape_medium | 0.1940 *** | 0.0652 |
| Coastal acoustics landscape_loud | −0.5344 *** | 0.0433 |
| Payments | −0.0074 *** | 0.0005 |
| Log likelihood | −6344.8687 | |

Note: *** indicate that the estimated value is significant at the level of 1%.

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