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Sustainable Tourism and Its Environmental and Human Ecological Effects

Edited by
Luc Hens and An Thinh Nguyen

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Contents

About the Editors

Luc Hens is a Belgian human ecologist who has been performing and supporting research on sustainable development and climate change policy instruments in Vietnam for over 25 years. He worked at the "Flemish Institute for Technological Research (VITO)", which is Belgium's largest environmental research organization. Professor Hens has published over 130 papers in international peer-reviewed journals. He has also published in local Belgian and Dutch scientific journals, and (co-)edited over 40 books with international distribution. He is "Editor in Chief" of "Environment, Development and Sustainability", a journal paying ample attention to sustainable tourism contributions.

An Thinh Nguyen is the Dean of the Faculty of Development Economics at VNU University of Economics and Business, Hanoi, Vietnam. He also currently acts as the Vice-President of the International Association of Landscape Ecology in the Vietnamese region (VN-IALE). His research focuses include the geography of Vietnam, human geography, environmental economics, and tourism economics.

Preface to "Sustainable Tourism and Its Environmental and Human Ecological Effects"

The book "Sustainable Tourism and Its Environmental and Human Ecological Effects" addresses the increasing interest in sustainable and related forms of tourism, with a focus on the environmental and human ecological impacts. The social and economic impacts of sustainable tourism are addressed, along with its effects on the physical environment. A series of case studies on the friction between tourism development and environmental quality is presented. Specific topics are: the development of sustainable tourism, sport tourism, e-travel services and e-tourism; environmental and human ecological effects of tourism on island and inland destinations; impacts of historic district built environment to recreation, leisure and sports; evaluation of low-carbon scenic spots; current crisis experienced by the tourism industry caused by COVID-19. The book covers a wide range of tourism destinations worldwide, mainly in Asia and Europe (Vietnam, Taiwan, China, South Korea, and Spain). The book offers opportunities, including policy papers, not only focusing on the instruments to alleviate environmental impacts, but also on methods for the efficient involvement of stakeholders.

Luc Hens, An Thinh Nguyen
Editors

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Article

Hierarchical Variance Analysis: A Quantitative Approach for Relevant Factor Exploration and Confirmation of Perceived Tourism Impacts

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Abstract: The issue of tourism impacts is one that has plagued the tourism industry. This study develops a quantitative approach using hierarchical variance analysis, which deals with the exploration of the relevant factors and the confirmation of their significant contribution to analyze the residents' perception of tourism impacts. Hierarchical variance analysis includes three mathematical procedures: Cronbach's alpha tests, the exploration of relevant factors, and a hierarchical factor confirmation. Data are collected using a structured questionnaire completed by 452 surveyed residents living in Ly Son Island, Vietnam. The significant effects of socio-demographic variables on the overall impact assessment are observed. The bilateral and simultaneous relationships are analyzed using a one-factor ANOVA. A two-factor ANOVA shows the significant contribution of each socio-demographic variable on the economic, socio-cultural, and environmental impacts. Interaction between factors such as "Education level", "Type of work", etc. are hierarchically confirmed. The findings allow a better understanding of the residents' perception of the effects of tourism on society, the economy, and the environment. This provides a scientific basis to help define problems and promote legal regulations for community participation in tourism planning in a small island destination.

Keywords: hierarchical variance analysis; residents' perceptions; socio-demographic variables; ANOVA; linear regression model; perceived tourism impacts; overall impact assessment; Ly Son Island; Vietnam

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1. Introduction

Tourism development impacts the local economy and residents' lives socially, economically, and environmentally [1,2]. A stakeholder approach is used to assess the impacts of tourism [3,4]. Local residents link tourism development with the challenges of sustainable development, which affect their support for further tourism development [5,6], more hospitality, and for the sustainability of tourism [7]. Perceived environmental pollution reduces the support of residents for tourism development [5]. Perceived economic benefits increase the support of residents towards tourism development [8–11] because it provides opportunities for employment for local residents in general, and for women in particular. This enables them to be more independent, raises local land prices [1], and provides increased income opportunities [11,12]. Perceived social impacts, such as changes in the life styles and customs of local residents, decrease local social moral standards [1]. The perceived environmental impacts include generating municipal solid waste and carbon dioxide, degenerating the quality of the environment, disturbing the regular life of residents, and destroying the peaceful character of villages [1,13,14]. Perceptions differ between households on the socio-demographic characteristics and on the stages of local tourism development [7,15,16]. A better balance between the socio-economic impacts and environmental considerations in residents' perceptions is needed [5].

2. Literature Review

Residents' perception of tourism impacts has been quantitatively studied in depth. Combining socio-psychological theories with mathematic models such as Cronbach's alpha tests, Fisher test, ANOVA, Structural Equation Modeling (SEM), multi-level factor, and regression analysis provides theoretical and practical insights allowing us to understand the impacts of the stressors and beneficiaries in tourism communities [17–21]. A series of aspects of residents' support towards tourism development are quantified using a triple bottom line approach [22] involving the following: a two-dimensional informedness–involvement tourism grid [23], self-perception theory [24], social exchange theory [25–28], social exchange theory combined with identity theory [29], and the cognitive appraisal theory [30]. Tourists' safety is analyzed by the Rimal and Real's risk perception attitude framework [31]. The item response theory measures the sustainability perception of residents [32]. The du Cros model assesses tourism potential [33]. A comprehensive resilience model assesses overall community resilience for tourism [34]. Structural Equation Modeling (SEM) has the advantage of being able to assess the overall support of residents for tourism development [35,36]. The relationships between tourism impacts, emotions, and stress are tested by the Partial Least Squares Structural Equation Modeling (PLS-SEM) [37].

This study develops the hierarchical variance analysis, a mathematical approach using Cronbach's alpha tests, ANOVA, and linear regression analysis to analyze the socio-demographic composition of surveyed residents according to their perception on tourism impacts. Socio-demographic composition is expressed by variables such as gender, age, marital status, the condition of being native, foreign participants' years of residence in the city, parental status, education level, participation in local associations and neighborhood groups, and the type of work in relation to tourism [7]. Analyzing socio-demographic variables supports research that recognizes existing conditions, needs, and expectations of a given population [38–40]. Taking into account the impacts of tourism, a combination of mathematics procedures is definitely worth additional empirical research. Pearson correlations, ANOVA analyses, and hierarchical multiple regression analyses using socio-demographic variables shows significant variance in the overall attitudes [7]. Descriptive statistics was combined with a series of independent sample t-tests to assess statistically significant differences caused by socio-demographic characteristics of residents living in a tourism destination [41]. The two-level hierarchical linear model using the fixed effects model, random intercept empty model, random coefficients model, and Cook's distance test was used to assess the impacts of tourism conducted from perceptions of residents [42]. However, there are still few quantitative studies which mix mathematics procedures to examine how socio-demographic variables affect the residents' perception on social, economic, and environmental impacts of tourism. The proposed hierarchical variance analysis is a vindication of our efforts to solve two main problems in the field of tourism impacts: the first is to examine the link between relevant factors and the confirmation of their significant contribution; and the second is to analyze the residents' perception of tourism impacts according to each socio-demographic variable.

The paper is organized as follows: Section 2 introduces the mathematic procedures of the hierarchical variance analysis methodology; the results of a case analysis in a Vietnamese island destination are described in Section 3; and a conclusion and policy implication are drawn up in Section 4.

3. Methodology

3.1. Problem

The hierarchical variance analysis combines three mathematic procedures: Cronbach's alpha tests (to assess the reliability of independent variables), the exploration of relevant factors (to measure the effect of independent variables on the perceived impacts), and a hierarchical factor confirmation (to find the one that explains most of the contribution of the relevant variables on the perceived impacts and to confirm the likely interaction). Perceived tourism impacts are expressed by dependent variables, while socio-demographic characteristics are expressed by independent variables. To process the model, dependent variables of tourism impacts Y were selected: Economic impacts (Y_1), Socio-cultural impacts (Y_2), and Environmental impacts (Y_3) (Table 1). The six independent variables of socio-demographic are: Gender (X_1), Marital status (X_2), Education level (X_3), Age (X_4), Type of work (X_5), and Social network (X_6). In the first step, Cronbach's Alpha test verifies the relevance of X for each tourism impact Y. In the next steps, an ANOVA compares the positive, negative, and overall variance of each perceived impact on tourism development. A linear regression analysis measures the effect of socio-demographic variables on three impacts confirming the result of the exploration step. By the end of the analysis, a two-factor ANOVA confirms the likely interaction between "Education level" and "Type of work" while predicting three impacts.

Table 1. Dependent variables of tourism impacts.

Economic Impacts (Y_1)			**Socio-Cultural Impacts (Y_2)**			**Environmental Impacts (Y_3)**		
Y_1^+ Positive	Y_1^- Negative	Y_1 Overall	Y_2^+ Positive	Y_2^- Negative	Y_2 Overall	Y_3^+ Positive	Y_3^- Negative	Y_3 Overall

3.2. Cronbach Alpha's Test

Cronbach Alpha's test estimates the reliability of independent variables X_i in each question. Suppose that we are interested in the relevance of variables $X_i, i = \overline{1, K}$, let Z be the total test score in each question:

$$Z = X_1 + X_2 + \ldots + X_K \tag{1}$$

The Cronbach Alpha is defined as [43]

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum_{i=1}^{K} \sigma_{X_i}^2}{\sigma_Z^2}\right) \tag{2}$$

where σ_Z^2 is the variance of the total observed test scores, and $\sigma_{X_i}^2$ is the variance of the variable X_i.

Cronbach Alpha varies from 0 to 1. The greater value of α, the more acceptable the internal consistency among variables X (Table 2).

Table 2. The common usage of Cronbach Alpha [44].

Cronbach Alpha	**Internal Consistency**
$0.9 \leq \alpha$	Excellent
$0.8 \leq \alpha < 0.9$	Good
$0.65 \leq \alpha < 0.8$	Acceptable
$0.5 \leq \alpha < 0.65$	Poor
$\alpha < 0.5$	Unacceptable

3.3. Exploration of Relevant Factors

A one-factor ANOVA is used to explore the relationship between an impact and a variable by measuring the effect of the socio-demographic background of the residents on the perceived economic, socio-cultural, the environmental impacts of tourism.

Suppose that the factor X consists of k treatments $T_1, \ldots, T_k$, and there are n_i observations $Y_{i1}, \ldots, Y_{in_i}$ of the dependent variable Y with respect to the treatment T_i $\left(i = \overline{1,k}\right)$. The following denotations are used:

$\mu_{i.} = \frac{1}{n_i} \sum_{j=1}^{n_i} Y_{ij}$, is the treatment mean;

$E\left(Y_{ij}\right) = \frac{1}{n} \sum_i \sum_j Y_{ij} = \mu$ ($n = \sum_j n_j$), is the grand mean;

$$\alpha_i = \mu - \mu_{i.}$$

ε_{ij}: the error terms.

The impact of X on variable Y is tested using the significant difference between the k treatment means:

$H: \mu_1 = \mu_2 = \ldots = \mu_k$ vs. $K:$ at least one mean differs.

With the assumption that ε_{ij} are independent normally distributed random variables with $E\left(\varepsilon_{ij}\right) = 0,\ \mathrm{Var}\left(\varepsilon_{ij}\right) = \sigma^2$ (*), the random variables Y_{ij} can be written [45] as

$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}, i = \overline{1,k}, j = \overline{1,n_i} \tag{3}$$

The deviation of Y_{ij} can be separated in the variation between the treatments (α_i) and within the treatments (ε_{ij}):

$$\sum_{i=1}^{k} \sum_{j=1}^{n_i} \left(y_{ij} - \mu\right)^2 = \sum_{i=1}^{k} n_i(\mu_{i.} - \mu)^2 + \sum_{i=1}^{k} \sum_{j=1}^{n_i} \left(y_{ij} - \mu_{i.}\right)^2 \tag{4}$$

or

$$\text{SSTotal (total sum of square)} = \text{SST (sum of squared treatment)} + \text{SSE (sum of squared errors)}$$

The difference among the treatment means is tested as

$$H: \alpha_i = 0 (\forall i); K: \text{ At least one } \alpha \neq 0$$

Results from comparing SST with SSE, if the weight of SST is equal or less than that of SSE. There should be no difference among k treatments, otherwise, there is a significant disparity among the k means, which results from an impact of factor F on the dependent variable Y.

Because the values of μ and μ_i are unknown, they are replaced by an estimation of $\overline{y}.$ (sample grand mean) and $\overline{y}_i$ (sample treatment mean):

$$\sum_{i=1}^{k} \sum_{j=1}^{n_i} \left(y_{ij} - \overline{y}\right)^2 = \sum_{i=1}^{k} n_i\left(\overline{y}_{i.} - \overline{y}\right)^2 + \sum_{i=1}^{k} \sum_{j=1}^{n_i} \left(y_{ij} - \overline{y}_{i.}\right)^2 \tag{5}$$

By dividing SST and SSE by their corresponding degrees of freedom ($\nu_1 = k - 1$ and $\nu_2 = n - k$) to obtain MST (mean square of treatment) and MSE (mean square of error), the sampling distribution of the ratio $F = MST/MSE$ is a Fisher distribution with ν_1 and ν_2 degrees of freedom. If $F > F_\alpha$, the hypothesis H is rejected.

3.4. Hierarchical Factor Confirmation

3.4.1. Linear Regression Analysis

The multiple linear regression is

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p + \varepsilon$$

where ε is the random error, following the normal distribution with $E\varepsilon = 0, \mathrm{Var}\varepsilon = \sigma^2$.

The following linear regression equation is estimated:

$$EY = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p$$

Using either the least square method or the maximum likelihood estimation, one finds the estimators of the p coefficient β_i as b_i, following the estimated linear regression equation:

$$\hat{Y} = b_0 + b_1 X_1 + \ldots + b_p X_p$$

To further explore the bilateral relationship between a variable and an impact, a one-way ANOVA is used. Independent variables will be combined to find out about their simultaneous effect on the outcome. As a result, several hierarchical models are considered to find the one that explains most of the contribution of the relevant variables on the impacts.

Suppose that p independent variables affect variable Y, p models are used with 1, 2, ..., p predictors with respect to the largest $\hat{R}^2$ (adjusted R^2). Particularly, among p. linear models containing 1 predictor, i.e., $\hat{Y} = b_0 + b_i X_i$, the one providing the largest $\hat{R}^2$ will be selected; among $\frac{p(p-1)}{2}$ models containing two predictors, i.e., $\hat{Y} = b_0 + b_{i_1} X_{i_1} + b_{i_2} X_{i_2}$, the one with the largest $\hat{R}^2$ will be plotted, until the last one containing all p variables are used. After that, the model providing the largest $\hat{R}^2$ is selected.

Suppose the dataset consists of n sets $\left\{\left(y_i, x_{1i}, \ldots, x_{pi}\right)\right\}_{i=\overline{1,n}}$. Using a similar option as the one in Equation (5), the total sum of squared difference consists of two sources [40]:

$$\sum_{i=1}^{n} (y_i - \overline{y})^2 = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 + \sum_{i=1}^{n} (\hat{y}_i - \overline{y})^2 \quad (6)$$

where $\overline{y}$ is the sample grand mean of Y, and $\hat{y}_i$. are the estimated values of Y given the i$^{\text{th}}$ value of X.

Denoting $SSTotal = \sum_{i=1}^{n} (y_i - \overline{y})^2, SSE = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2, SSR = \sum_{i=1}^{n} (\hat{y}_i - \overline{y})^2$, Equation (6) can be rewritten as $SSTotal = SSE + SSR$. SSE measures the lack of fit of the regression model, and SSR measures the variation that can be explained by the regression model. The determination coefficient of R^2 is defined by the ratio SSR/SSE; the larger R^2 is, the better the model fits the data. However, when increasing the number of variables, R^2 also increases; therefore, it is inappropriate to use this number to assess how well the model fits the data. The adjusted R^2 is introduced to deal with this problem:

$$R^2_{adj} = 1 - \frac{\frac{SSE}{df_e}}{\frac{SSTotal}{df_t}} = 1 - \left(1 - R^2\right) \times \frac{n-1}{n-p-1} \quad (7)$$

Taking into account the degrees of freedom ($df_e = n - p - 1, df_t = n - 1$), the adjusted R^2 increases when the increase in R^2 is more than one would expect to see by chance.

Remarkably, the Fisher test is performed in a similar way to explore the relevant steps. The following test problem is considered:

$H : \beta_1 = \ldots = \beta_l = 0$ (reduced model);
$K :$ at least one β_i differs (full model).

Taking into account the Fisher test, the error between the estimators of coefficient and the observed values is evaluated [46]: the sum of the squared error of the two models: SSE(R) and SSE(F) (the reduced and the full one, respectively). While the estimator of y_i is $\hat{y}_i$ in the full model, deducing $(F) = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2$, the estimator in reduced model is $\overline{y}$ $(\forall i)$, deducing $SSE(R) = \sum_{i=1}^{n} (y_i - \overline{y})^2$. Because of Equation (6), $SSE(R) \geq SSE(F)$. The following cases are possible:

- In case SSE(F) is close to SSE(R), the full model does not reduce the total variance of SST and SSR (the variation explained by the regression model) is limited. The reduced model is selected;
- On the contrary, in case SSE(F) differs significantly from SSE(R), the full model reduces substantially and the total variance and the full model is selected.

The ratio (F) measures the difference between SSE(F) and SSE(R):

$$F = \frac{SSE(R) - SSE(F)}{df_r - df_f} : \frac{SSE(F)}{df_f} \tag{8}$$

In the case that the full model contains p variables, the degrees of freedom of SSE(F) is given as $n - p - 1$, and of SSE(R) it is given as $n - 1$. Take notice that in Equation (6) $SSE(R) - SSE(F) = SSTotal - SSE(F) = SSR(F)$ can be rewritten as

$$F = \frac{SSR}{p} : \frac{SSE(F)}{n - p - 1} = \frac{MST}{MSE} \tag{9}$$

If $F > F_\alpha$, which means the difference is significant, H is rejected and the full model is used for the prediction.

The Fisher test is used to compare the two models and allows the choice of the one with the smallest variance.

3.4.2. Two-Factor ANOVA

Supposing one wants to see the effect of factor A containing a levels and factor B containing b levels on the outcome variable Y, the problem can be formulated using the following symbols [47]:

y_{ijk} are the observations to the ith level of factor A and jth level in factor B where $k = \overline{1, n_{ij}}$, $\sum_{i,j} n_{ij} = n$ (but n_{ij} are commonly assumed to be the same as n/ab);

$\mu = EY = \frac{1}{n} \sum_{i,i,k} y_{ijk}$ is grand mean;

$\mu_{ij.} = \frac{1}{n_{ij}} \sum_k y_{ijk}$ is the mean at the ith level in factor A and jth level in factor B;

$\mu_{i..} = \frac{1}{b.\ n_{ij}} \sum_{j,k} y_{ijk}$ is the mean at the ith level of factor A, $\mu_{.j.} = \frac{1}{a.n_{ij}} \sum_{i,k} y_{ijk}$ is the mean of the jth level in factor B;

$\alpha_i = \mu - \mu_{i..}$ is the main effect of factor A, $\beta_j = \mu - \mu_{.j.}$ is the main effect of factor B;

ε_{ijk} are the random error variable satisfying $E(\varepsilon_{ijk}) = 0,\ Var(\varepsilon_{ijk}) = \sigma^2$.

Along the same idea as the one-factor ANOVA, the two-factor ANOVA can be written as

$$y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk} \tag{10}$$

where $(\alpha\beta)_{ij}$ is the effect of the interation between factor A and B. As a result, the total variance can be partitioned as

$$\sum_{i,j,k} \left(y_{ijk} - \mu\right)^2 = \sum_{i,j,k} \left(y_{ijk} - \mu_{ij.}\right)^2 + \sum_{i,j} n_{ij} \left(\mu_{ij.} - \mu\right)^2 \tag{11}$$

of notice $SSE = \sum_{i,j,k} \left(y_{ijk} - \mu_{ij.}\right)^2$ and

$$\sum_{i,j} n_{ij} \left(\mu_{ij.} - \mu\right)^2 = \sum_{i} b.n_{ij} (\mu_{i..} - \mu)^2 + \sum_{j} a.n_{ij} \left(\mu_{.j.} - \mu\right)^2 + \sum_{i,j} n_{ij} \left(\mu_{ij.} - \mu_{i..} - \mu_{.j.} + \mu\right)^2 \tag{12}$$

Therefore, $\sum_i b.n_{ij}(\mu_{i..} - \mu)^2 = SSA, \sum_j a.n_{ij}\left(\mu_{.j.} - \mu\right)^2 = SSB, \sum_{i,j} n_{ij}\left(\mu_{ij.} - \mu_{i..} - \mu_{.j.} + \mu\right)^2 = SS(AB)$, then

$$SS\ Total = SSA + SSB + SS(AB) + SSE \tag{13}$$

This means the total sum of square of variance can be partitioned into one source from factor A, one from factor B, one from their interaction, and one from the random error. Replacing the estimators for the unknown parameters in this model, Equation (14) can be written as

$$\begin{aligned} \sum_{i,j,k}\left(y_{ijk} - \overline{y}\right)^2 = \sum_i b.n_{ij}\left(\overline{y}_{i..} - \overline{y}\right)^2 + \sum_j a.n_{ij}\left(\overline{y}_{.j.} - \overline{y}\right)^2 + \sum_{i,j} n_{ij}\left(\overline{y}_{ij.} - \overline{y}_{i..} - \overline{y}_{.j.} + \overline{y}\right)^2 \\ + \sum_{i,j,k}\left(y_{ijk} - \overline{y}_{ij.}\right)^2 = SSA + SSB + SS(AB) + SSE \end{aligned} \tag{14}$$

At this point, the Fisher test assesses these sources of variance:

Problem 1: test the hypothesis: H: $\mu_{1..} = \mu_{2..} = \ldots = \mu_{a..}$ vs. K: at least one mean differs. The Fisher statistic is $F_A = \frac{SSA/df_a}{SSE/df_e} = \frac{MSA}{MSE}, df_a = a - 1$;

Problem 2: test the hypothesis: H: $\mu_{.1.} = \mu_{.2.} = \ldots = \mu_{.b.}$ vs. K: at least one mean differs. The Fisher statistic is written as $F_B = \frac{SSB/df_b}{SSE/df_e} = \frac{MSB}{MSE},\ df_b = b - 1$;

Problem 3: test the hypothesis: H: there is no interaction between both factors and K: The Fisher statistic is written as $F_{AB} = \frac{\frac{SS(AB)}{df_{ab}}}{\frac{SSE}{df_e}}, df_{ab} = (a-1)(b-1), df_e = df_t - df_a - df_b - df_{ab}$.

This complex process is performed using the R software, in which the *p*-value allows one to decide about the H. If the *p*-value is smaller than the critical value α, H is rejected.

4. The Case Analysis

4.1. The Ly Son Destination

Ly Son Island is the most attractive destination in Quang Ngai province, on the South Central Coast, Vietnam. Ly Son has substantial biodiversity on the land and in the sea. The biodiversity is well protected in the Ly Son Marine Protected Areas. The island can be categorized into four main areas: mountainous forest, farms, residential areas, and the coast (Figure 1). The most attractive tourist sites are the resorts in Hang Cau, Bac An Hai, and Nam An Vinh; other spots include the Sau volcanic cave, the garlic fields, and the beaches of Chua Duc, Bac An Hai, and Hang Cau. The island attracted about 95,000 visitors in 2015, and over 230,000 visitors in 2018. Tourism development contributes significantly to the local economy: the tourism revenue is estimated at USD 12 million in 2018. Some of the negative consequences of rapid tourism development on the island can be seen to have affected the master planning, fishing, social life, and environment. Massive motels and hotels have broken with the master plan and the overview of the total landscape. Near-shore seafood has been exhausted due to over-fishing. A number of shops and spontaneous tourist stalls have sprung up around the monuments and natural landscapes, making the island appear unsightly. The overbalance of tourists on the island at the weekend influences the normal life of residents. Environmental pollution has become a problem due to the increase in water use, waste, and sewage [48].

Figure 1. The total landscape and tourism areas on Ly Son Island (photo by authors, 2018). (**a**) Overview of Ly Son landscape; (**b**) mountainous forests; (**c**) farming tourism areas; (**d**) residential tourism recreations (R); (**e**) the sandy coasts of the island (C).

4.2. Data Collection

This study aimed to collect information on the socio-demographic background of residents and survey their perception of tourism impacts. The questionnaire was divided into two main parts: the first part entailed socio-demographic questions; the second part was about perceptions of the economic, socio-cultural, and environmental impacts of tourism. Finally, respondents were asked about their social network in yes/no questions. The socio-demographic information dealt with gender, marital status, education level, age, type of work, and social network. Marital status included two categories: "married" and "single". Education levels were classified into four groups: "Primary education or below", "Secondary school", "High school" and "Beyond high-school level". Four age groups were inventoried: "18–25 years", "26–42 years", "43–55 years" and "Older than 55 years". The type of work question included as alternatives: "Farmer", "Fishermen", "Trade and Tourism service", and "Free labor and Other". The questionnaires were completed during a field trip in September 2018. The sample includes 452 residents selected according to a stratified random sample design.

The perception scale used items on economic, socio-cultural, and environmental impacts, and an overall assessment. The items were quantified using a 5-point Likert scale, which expressed 'strong disagreement' as (1), 'disagreement' (2), 'neutral' (3), 'agreement' (4), and 'strong agreement' (5).

4.3. Descriptive Statistics

The Cronbach Alpha of the economic impacts group is 0.811, of the socio-cultural impacts group is 0.785, and of the environmental impacts group is 0.823. The results show that the questions in each group were relevant, and consequently, all questions could be used in the analysis.

4.3.1. Socio-Demographic Variables

Gender (X_1): almost two thirds of surveyed respondents were male.

Marital status (X_2): a majority of respondents (94.5%) were married.

Education levels (X_3): there were equal percentages among the surveyed residents' education levels: primary or below, secondary, high school or beyond; while the number of cases holding high school level and beyond high-school level were almost the same.

Age (X_4): over half of the respondents were over 43 years old, while young laborers (between 18 and 25 years old) accounted for 2%.

Types of work (X_5): almost half of residents were farmers, while about 14% of them went fishing for living; about 18% of cases worked in trade and tourism services, and a small proportion of residents were officials.

Social participation (X_6): a third of respondents admitted to participating in social activities in the community.

4.3.2. Tourism Impacts

The scale means and standard deviations were calculated in the positive and negative assessment on three impacts, and the mean of overall assessment was considered (Table 3).

Table 3. The (scale) mean and standard deviation of the assessment on three impacts.

	Economic Impacts (Y_1)			Socio-Cultural Impacts (Y_2)			Environmental Impacts (Y_3)		
	Y_1^+	Y_1^-	Y_1	Y_2^+	Y_2^-	Y_2	Y_3^+	Y_3^-	Y_3
(Scale) mean	3.7	3.5	3.8	3.8	2.8	3.8	3.8	3.1	3.1
Standard deviation	0.603	0.808	0.665	0.430	0.458	0.667	0.508	0.835	1.007

4.3.3. Correlations between Socio-Demographic Variables and Tourism Impacts

On the basis of the correlation coefficients, residents had a clear assessment of the negative economic impacts (with more pessimism among single, higher educated, younger, and free labor residents), and overall environmental satisfaction (with more pessimism among male, single, higher educated, farming–fishing, and non-participating residents) (Table 4).

Table 4. Correlations between socio-demographic variables and tourism impacts.

	Economic Impact			Socio-Cultural Impact			Environmental Impact		
	Y_1^+	Y_1^-	Y_1	Y_2^+	Y_2^-	Y_2	Y_3^+	Y_3^-	Y_3
X_1	−0.062	0.052	0.026	−0.097 (.)	−0.007	−0.022	0.003	−0.172 (***)	0.147 (**)
X_2	−0.058	0.159 (**)	−0.078	−0.004	0.079	−0.078	−0.117 (*)	0.042	−0.117 (*)
X_3	0.03	0.15 (**)	−0.032	−0.021	0.119 (*)	−0.05	−0.088 (.)	−0.103 (*)	0.133 (**)
X_4	−0.067	−0.118 (*)	0.037	0.014	−0.156 (**)	0.063	0.088 (.)	0.058	−0.053
X_5	0.047	0.115 (*)	−0.038	−0.047	−0.034	−0.002	0.092 (.)	−0.19 (***)	0.178 (***)
X_6	0.026	−0.04	−0.11 (*)	−0.087 (.)	0.011	−0.086 (.)	0.063	−0.148 (**)	0.33 (***)

Note: (.) $p < 0.10$; (*) $p < 0.05$; (**) $p < 0.01$; (***) $p < 0.001$.

4.4. Socio-Demographic Effects on Attitudes and Tourism

4.4.1. Effects of gender

No marked effect of gender on economic impacts was found. Male residents were more optimistic than the woman in terms of positive socio-cultural impacts ($F = 3.79,\ p = 0.052$). Men were more worried than the women about negative environmental impacts ($F = 12.35, p < 0.001$) and less satisfied in terms of the overall environmental impacts ($F = 8.87, p < 0.01$).

4.4.2. Effects of Marital Status

Economic impacts: married residents were more satisfied than singles ones about the positive impacts ($F = 4.32, p < 0.05$), less worried about negative impacts ($F = 10.65, p < 0.01$), and more optimistic in their overall assessment ($F = 5.43, p < 0.05$).

Socio-cultural impacts: married residents were more satisfied in their overall assessment than the single ones ($F = 5.0, p < 0.05$).

Environmental impacts: married residents were more satisfied than single ones on the positive impacts ($F = 12.7, p < 0.001$), and on the overall assessment ($F = 8.13, p < 0.01$).

4.4.3. Effect of Education Levels

Economic impacts: education levels had the main effects on negative economic impacts. Residents educated to a higher level worried more about the negative impacts than others ($F = 4.59, p < 0.01$). Residents who studied to a high-school level worried most, and those with a primary level or below worry least.

Socio-cultural impacts: education levels clearly affected negative socio-cultural impacts ($F = 4.07, p < 0.01$). Residents educated to a higher level worried more the ones educated to a lesser level, while the assessments of the others were not clear.

Environmental impacts: education levels affected the positive aspects most ($F = 7.17, p < 0.001$). The negative aspects ($F = 11.26, p < 0.001$) and the overall assessment ($F = 14.45, p < 0.001$) of the environmental impacts were less affected. Residents with primary level of education or below = and secondary school levels were optimistic about the positive assessments, while those with higher school educations showed more pessimism. Regarding the negative assessment, the higher the education level of the residents, the less they worry, except for those with a level above high school (who's assessment was unclear). Overall, the satisfaction of residents increased along with their education level regardless of the ideas from the group with the highest level of education.

4.4.4. Effects of Age

Economic impacts: age had significant effects on positive economic expectations from tourism ($F = 3.64, p < 0.05$). The youngest residents expressed less satisfaction while those between 26 and 42 year had the most positive expectations. The ideas of seniors were not as clear as those of the other age groups, although they were less satisfied than the age group of 26–42 ($t = 2.24, p < 0.05$).

Socio-cultural impacts: the main effects of age on the negative and overall assessment were found ($F = 6.76, p < 0.001$ and $F = 5.82, p < 0.001$, respectively). T-tests confirmed this effect: the most pronounced negative assessments were found for the age groups 18–25 and 43–55 ($t = 2.14, p < 0.05$), group 26–42 and 43–55 ($t = 4.14, p < 0.001$), group 26–42 and 55–81 ($t = 2.8, p < 0.01$).

Environmental impacts: a significant effect of age on the positive assessment ($F = 6.42, p < 0.001$) and overall assessment ($F = 4.52, p < 0.01$) were found. The t-test results include in following: 26–42 vs. 18–25 ($t = 1.90, p < 0.05$), 43–55 vs. 18–25 ($t = 2.07, p < 0.05$), over 55 vs. 18–25 ($t = 1.96, p < 0.05$). They show that the youngest residents expected the least positive aspects of environmental impacts, while residents between 43 and 54 years expected the most. No clear differences were found in terms of negative aspects. The overall satisfaction followed the same trend: the youngest group was less satisfied than the middle-aged group.

4.4.5. Effects of type of work

Economic impacts: a significant effect of the type of work on both the positive and negative aspects of the economic impacts was found ($F = 2.46, p < 0.05$ and $F = 5.82, p < 0.001$, respectively). T-tests indicated that residents working in trade and tourism services had the most positive expectation: farmer vs. trade and tourism ($t = -2.37, p < 0.01$), fishermen vs. trade and tourism ($t = -2.26, p < 0.05$), free labor vs. trade and tourism ($t = -2.56, p < 0.01$). Free laborers demonstrated the most pessimism on the negative impacts: farmer vs. free labor ($t = -4.13, p < 0.001$), fishermen vs. free labor ($t = -5.1, p < 0.001$), trade and tourism vs. free labor ($t = -4.22, p < 0.001$).

Socio-cultural impacts: types of work influenced negative effects ($F = 3.22, p < 0.05$). The t-test results showed that farmers are the most worried about the negative aspects of socio-cultural impacts: trade and tourism vs. farmer ($t = -2.01, p < 0.05$), fishermen vs. farmer ($t = -1.78, p < 0.05$), officials vs. farmer ($t = -1.34, p < 0.1$).

Environmental impacts: significant effects on the positive, negative, and overall assessment were found ($F = 2.95,\ p < 0.05; F = 4, p < 0.01$ and $F = 4.43, p < 0.01$, respectively). Results of the ANOVA and t-tests showed that farmers were the least satisfied in terms of the positive and overall assessment on environmental impacts; free labors worried least about the negative impacts and were most satisfied on the overall assessment.

4.4.6. Effects of Social Networks

Economic impacts: the ANOVA result showed a significant difference in the overall assessment ($F = 5.58, p < 0.05$): residents who participated in social organizations felt more satisfied.

Socio-cultural impacts: no effect was found.

Environmental impacts: significant effects on the negative and overall assessment were found ($F = 10.17, p < 0.01$ and $F = 55.34, p < 0.001$, respectively). Residents with a social network worried more and were less satisfied than those without a social network.

4.5. Socio-Demographic Effects Analyzed with a Linear Regression Model

The socio-demographic variables were put into the linear regression analysis to analyze their simultaneous effects on the perceptions of tourism development.

4.5.1. Economic Impacts

Table 5 shows the significant effects of some socio-demographic variables on the negative sides and overall assessment of the economic impacts. In particular, marital status, education level, type of work, and social network contributed 7.91% to the variability of negative impacts explained by the model. Single, higher educated, and socially participating residents felt more pessimistic about these negative impacts. Marital status, education level, type of work, and social network accounted for 2.7%

of the variability of the overall assessment score explained by the model. This shows that married, socially participating residents demonstrated a higher overall satisfaction in terms of economic impacts.

Table 5. Linear regression analysis for economic impacts and socio-demographic variables.

Impact	Predictors	β	SE_β	R^2	Adjusted R^2	F Test Value
Y_1^+	X_1-Female	−0.637	0.402	0.052	0.0273	2.102 (*)
	X_2-Single	−1.245	0.888			
	X_3-Secondary	1.142 (*)	0.479			
	X_5-Trade and Tourism	0.982 (.)	0. 55			
	X_6-Not participate	−0.449	0.42			
Y_1^-	X_2-Single	2.176 (.)	1.172	0.1	0.0791	4.749 (***)
	X_3-Secondary	1.446 (*)	0.631			
	X_3-High school	2.731 (***)	0.809			
	X_3-Beyond high school	2.019 (*)	0.946			
	X_5-Others	1.949 (*)	0.891			
	X_6-Not participate	−1.399 (*)	0.553			
Y_1	X_2-Single	−0.465 (**)	0.16	0.0575	0.0355	2.605 (**)
	X_6-Not participate	−0.194 (*)	0.079			

Note: (.) $p < 0.10$; (*) $p < 0.05$; (**) $p < 0.01$; (***) $p < 0.001$.

4.5.2. Socio-Cultural Impacts

Male and socially participating residents felt more optimistic about the positive aspects of tourism which contribute 2.24% to the variability of the positive scores explained by the model. Regarding the negative aspects, higher educated residents worried more than fishermen, official agents, and those working in trade and tourism. This explains the significant variance of 7.5% of the negative scores. Overall, married and socially participating residents were more satisfied in terms of the socio-cultural impacts of tourism development (Table 6).

Table 6. Linear regression analysis for socio-cultural impacts and socio-demographic variables.

	Predictors	β	SE_β	R^2	Adjusted R^2	F Test Value
Y_2^+	X_1. -Female	−1.215 (*)	0.766	0.0447	0.0224	1.998 (*)
	X_5-Official Agent	2.721 (.)	1.615			
	X_6. -Not participate	−2.064 (**)	0.796			
Y_2^-	X_1-Female	-0.727	0.707	0.0962	0.075	4.539 (***)
	X_3-Beyond high school	5.733 (***)	1.24			
	X_5-Fishermen	−1.791 (.)	1.035			
	X_5-Official Agent	−6.817 (***)	1.49			
	X_5-Trade and Tourism	−3.105 (**)	0.966			
	X_6-Not participating in a social organization	0.623	0.735			
Y_2	X_2-Single	−0.36 (*)	0.161	0.0353	0.0229	2.839 (*)
	X_3	0.001	0.003			
	X_6-Not participating in a social organization	−0.175 (*)	0.076			

Note: (.) $p < 0.10$; (*) $p < 0.05$; (**) $p < 0.01$; (***) $p < 0.001$.

4.5.3. Environmental Impacts

Socio-demographic variables explain the significant variances of the assessment scores on environmental impacts. Marital status, education level, and type of work explain 7.82% of the variability of positive scores; gender, education level, type of work, and social network explain 14.98% of the variability of negative scores; gender, marital status, education level, type of work, and social network explain 17.79% of the variability of overall scores. Married, lower educated residents, and free laborers felt more satisfied in terms of the positive aspects; female, secondary- and high-school educated, free laborers, and others who did not participate in social activities worried less about the negative aspects. In the overall assessment, female, married people, free laborers, and nonsocially participating residents felt more optimistic about the environmental impacts of tourism development (Tables 7 and 8).

Table 7. Linear regression analysis for environmental impacts and socio-demographic variables.

	Predictors	β	SE_β	R^2	Adjusted R^2	F Test Value
Y_3^+	X_2-Single X_3-Beyond high school X_5-Fishermen	−1.07 (***) −0.721 (*) 0.481 (*)	0.371 0.3 0.031	0.0971	0.0782	5.147 (***)
	X_5-Others	0.757 (**)	0.281			
	X_5-Trade and Tourism	0.428 (.)	0.224			
Y_3^-	X_1-Female X_3-Secondary X_3-High school	−3.1 (***) −2.824 (**) −2.26 (***)	0.752 0.894 1.148	0.1693	0.1498	8.694 (***)
	X_5-Official Agent	−2.709 (.)	1.585			
	X_5-Others	−3.305 (**)	1.228			
	X_6-Non socially participating	−3.156 (***)	0.781			
Y_3	X_1-Female X_2-Single X_3-High school	0.377 (***) −0.652 (**) 0.623 (**)	0.101 0.224 0.155	0.1988	0.1779	9.506 (***)
	X_5-Others	0.381 (*)	0.17			
	X_6-Non socially participating	0.413 (***)	0.106			

Note: (.) $p < 0.10$; (*) $p < 0.05$; (**) $p < 0.01$; (***) $p < 0.001$.

Table 8. Relevant factors influencing Ly Son residents' perceptions on tourism's impacts.

	More Favorable	Less Favorable
Economic impacts	Married Secondary Trade and Tourism Social network	Single High-school level or Beyond Free labor No Social network
Socio-cultural impacts	Male, Married Social network Trade – Tourism service, Officials, Fishermen	Female, Single No social network Beyond High-school level
Environmental impacts	Married Female No social network Secondary, High school Free labors, Fishermen	Single Male Social network Beyond high-school level

4.6. Interaction Effects on Three Tourism Impacts Analyzed Using a Two-Factor ANOVA

Types of work and education levels are two important factors in predicting the satisfaction of the residents. The two-factor ANOVA confirmed the interaction plots of the tourism attitude dimensions on education levels by different types of work, controlling the effects of the variables related to tourism attitudes (i.e., gender, marital status, age, social network). The two-factor ANOVA results show a significant interaction for "Education level" × "Type of work" and on negative and overall economic scores (Figure 2), on positive and overall socio-cultural scores (Figure 3), and on negative and overall environmental scores (Figure 4). The effects of “Education level” on tourism impacts are moderated by “Type of work”.

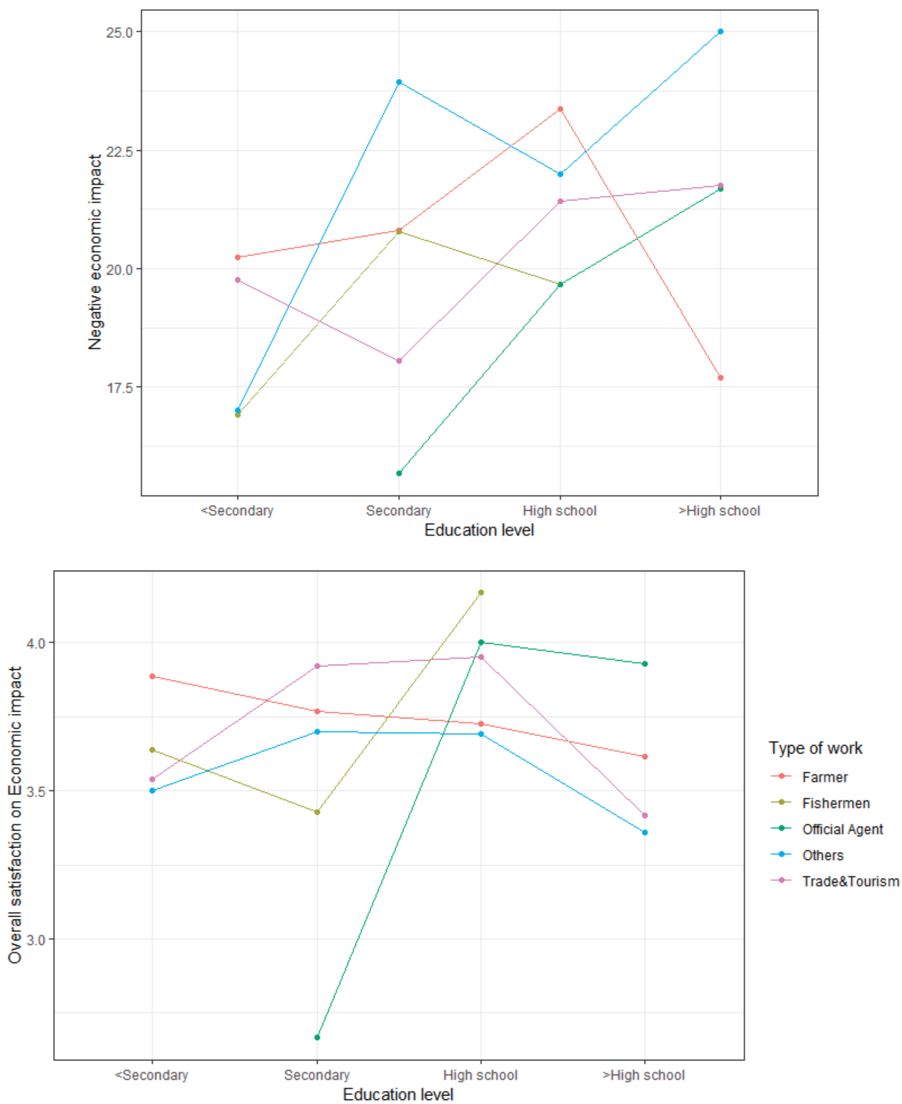

Figure 2. Effect of the interaction between education level and type of work on the economic impacts.

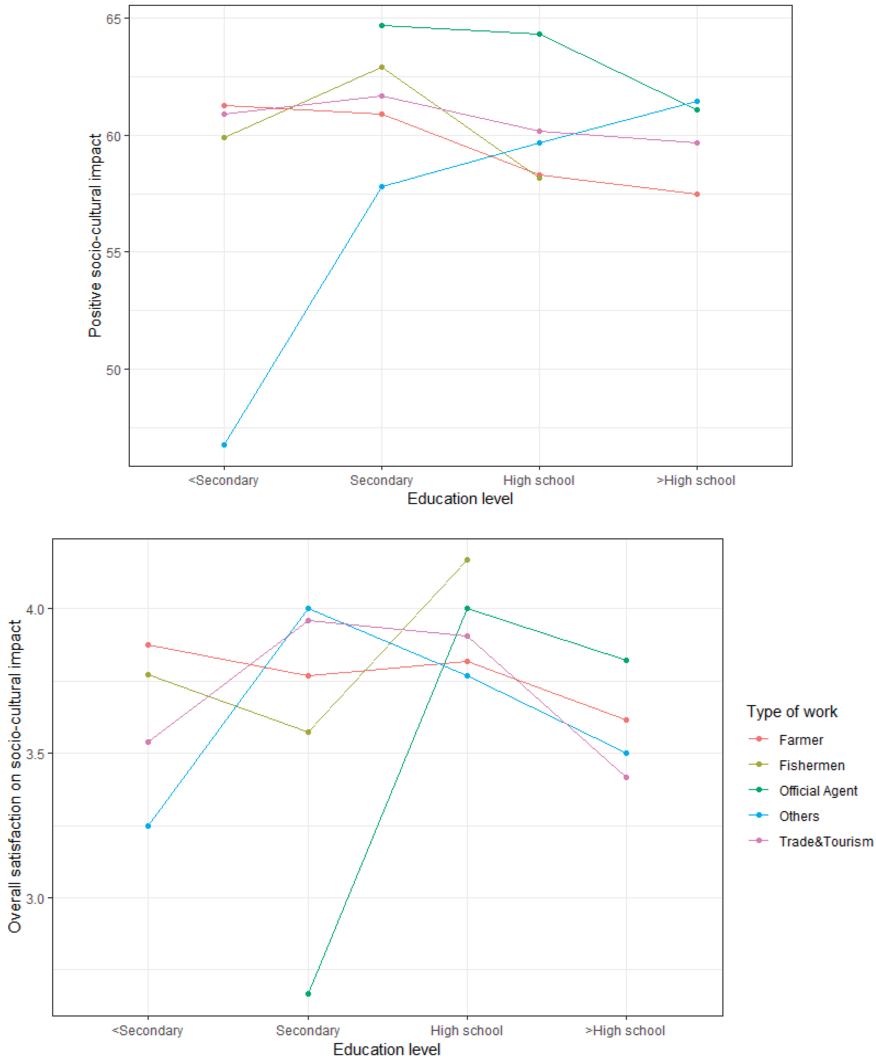

Figure 3. Effect of interaction between "Education level" and "Type of work" on the socio-cultural impacts.

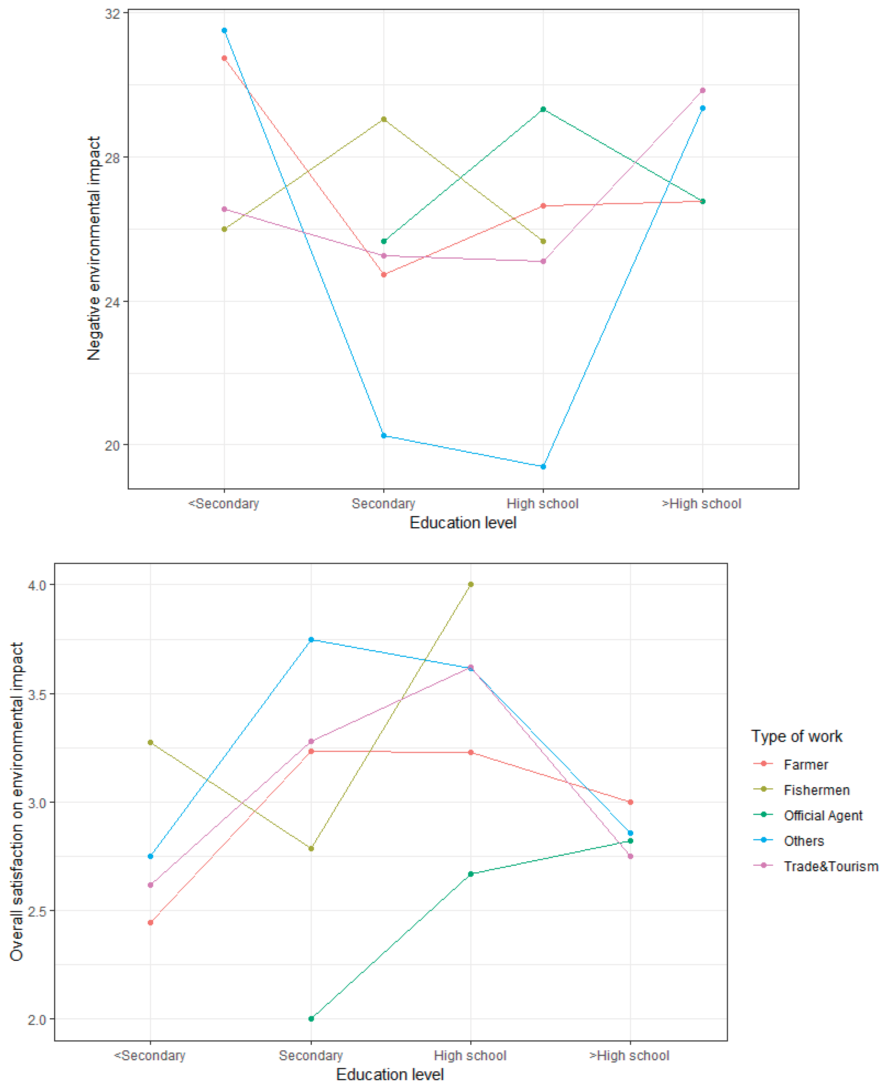

Figure 4. Effect of interaction between "Education level" and "Type of work" on the environmental impacts.

Significant effects of the interaction between "Education level" and "Type of work" exist in terms of the negative economic impacts and overall assessment. For the negative economic impact, dramatic changes were observed between the group of "Beyond high-school level" and "Primary level or below"; free laborers with primary level or below had the smallest negative scores, while those with a level above high school showed most pessimism. Farmers with a primary level of education or below showed the largest negative scores; on the contrary, those with the highest level of education demonstrated the smallest. On the overall assessment, fishermen and officials with secondary level of education felt the least satisfied, but those with a high-school level of education felt most satisfied compared with the two others. Adding the interaction increases the adjusted R-squared to 10.76% in the negative model (nearly 3% more than without interaction) and by 4.6% in the overall model (1% higher than without interaction).

The interaction between "Education level" and "Type of work" is a significant predictor of the positive aspects and overall socio-cultural impact. Free laborers with primary level of education or below felt least pessimistic, while those with above a high-school level worried the most in terms of the socio-cultural impacts of tourism. Farmers with a primary level of education or below ranked first in scores but those with highest educated level worried least. Officials worried more than other groups. In the overall socio-cultural satisfaction, a difference is seen between the "Secondary" group and the "High school" group: officials and fishermen with a secondary level of education were the two least satisfied groups, while those with a high-school level became the two most satisfied groups out of the five. The interaction increases the adjusted R-squared in the positive model by 3.44% and confirms the additive effect in the negative model.

A two-factor ANOVA showed the significant contribution of the interaction between "Education level" and "Type of work" on the environmental impact. Regarding negative environmental scores, for residents with primary level of education or below, farmers ranked first, free labors ranked second, and trade and tourism services were the least. This comparison changes a lot for residents who obtained a higher education level: farmers worried the least (together with officials), those belonging to trade and tourism services worried most, followed by free laborers. Regarding overall environmental scores, a difference was observed between the primary education or below group and the higher education level: farmers in the first group felt least satisfied but most satisfied in the second one; those working in the trade and tourism service ranked third for satisfaction but fell down to the last. The interaction and these two factors explain 13.58% of the total variance in the negative model and 14.2% in the overall model, which is a substantial contribution to the whole model.

5. Discussion

Hierarchical variance analysis is a combination mathematical procedures that allows one to assess the perceived tourism impacts. It provides quantitative procedures to analyze the variance hierarchically, as well as explaining it using the factors or the regression model in the total variance, making it feasible and straightforward to apply. The approach entails two steps: (i) exploration of the relevant factors; and (ii) confirmation of their significant contribution and the effect of their interaction in explaining the residents' assessment. The model is comprehensive and requires uncomplicated calculation compared with other mathematics models such as the Exploratory Factor Analysis (EFA) and Confirmation Factor Analysis (CFA). Hence, it is applicable to the data collected by structured interviews. However, this approach has some limitations. When the questionnaire is not well designed, the independence between factors is violated. As a result, the regression model does not follow the additive rule. In other situations, the Fisher test does not produce a significant result, which means the linear regression model is invalid. Under these conditions, one has to apply other mathematical models such as a Structural Equation Model (SEM), a Bayesian network, or others.

The study's findings show that at the core of solving the negative impacts of tourism development is the promotion of sustainable tourism development. Particularly Vietnam, the findings suggest significant solutions for small islands, with their relative limited surface and their relatively limited natural resources. Firstly, tourism should be managed in an interdisciplinary manner. The government should plan to raise awareness of the noneconomic aspects of tourism development among the public, including environmental and socio-culture aspects. While tourism revenue continues be a most important priority, which can be improved by an increase in visitors and the development of tourism infrastructures, the control of natural resource degradation, environmental pollution, and some negative changes in the socio-cultural life of residents should be taken into account in tourism management and strategic tourism planning at both provincial and local levels. Secondly, community participation (CP) in tourism planning and development should be brought to the forefront. A socio-demographic survey provides the input data for the perception analysis of the local residents' support for tourism development, and their local participation in tourism planning. The findings provide a better understanding of residents' perceptions of the local economy, and the perceived impacts of tourism development on society, the economy, and environment. This offers a scientific basis to help deal with problems emerging during tourism development and also promote the participation of locals in tourism planning and development.

6. Conclusions

This study investigates the effects of socio-demographic variables on residents' perception towards tourism development in Ly Son Island, Vietnam: the bilateral and simultaneous relationships were assessed using a one-factor ANOVA to explore the relationships and then a linear regression analysis to confirm them. Furthermore, the interaction between two important factors ("Education level" and "Type of work") is also explored by a hierarchical confirmation.

The results show that no marked effect of gender on the impacts of tourism is found, while farmers, younger, higher educated, and socially participating residents have negative assessments in terms of tourism impacts. Married and socially participating residents demonstrate higher overall satisfaction in terms of the economic impacts, and are more satisfied on the socio-cultural impacts of tourism development. Female, married people, free laborers, and nonsocially participating residents feel more optimistic about the environmental impacts of tourism development. The interaction between "Education level" and "Type of work" contributes significantly to the economic, socio-cultural, environmental impacts, and the overall impact.

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Article

Sustainable Tourism as a Source of Healthy Tourism

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Abstract: Even though the World Tourism Organization described Sustainable Tourism as a tourism form that could contribute to the future survival of the industry, the current reality is quite different, since it has not been firmly established in society at expected levels. The present study analyzes which variables drive the consumption of this tourism type, taking tourist awareness as the key element. To this awareness, we must add the current crisis experienced by the tourism industry caused by COVID-19, since it can benefit Sustainable Tourism development, promoting less crowded destinations that favor social distancing. For this, the existing literature on Sustainable Tourism has been examined in order to create a model that highlights the relations among these variables. To determine the meaning of these relations, a sample of 308 tourists was analyzed through structural equation models using Partial Least Squares. The results show that there is a clear attitude on the part of the tourist to develop Sustainable Tourism, driven by the positive effects and motivation it entails, as well as the satisfaction the tourist perceives when consuming a responsible tourism type.

Keywords: sustainable tourism; attitude; positive effects; motivation; satisfaction

1. Introduction

The World Tourism Organization (UNWTO) in 2005 defined the concept of Sustainable Tourism as "one whose practices and principles can be applicable to all forms of tourism in all types of destinations, including mass tourism and the various niche tourism segments". Sustainability principles refer to the environmental, economic, and socio-cultural aspects of tourism development, and a suitable balance must be established among these three dimensions to guarantee its long-term sustainability [1]. In addition to international organizations, we also find many authors who have defined the concept of sustainable tourism [2–6]. Conversely, despite the fact that sustainable tourism has been recognized in business practice, the volume of academic research has not been as relevant as might be expected [7]. From the start, the development of sustainable tourism is based on environmental preservation, cultural authenticity and the profitability of the tourist activity in the destination [8]. In this tourism type, both social return and the reversed well-being index on the visited destinations are recognized, as well as the economic return—in other words, whether the tourist activity generates enough income for the local population in terms of employment, wealth and available resources [9].

This study aims to establish the factors that allow sustainable tourism development, which is really necessary for the industry in the context of the crisis caused by COVID-19. From a theoretical point of view, motivational factors, economic impact and satisfaction are analyzed as attributes that potentially influence the intention and attitude of choosing this type of tourism.

Hence, one of the possible solutions the tourism industry can find to help the current crisis that it faces as a consequence of COVID-19 could come from Sustainable Tourism. Finding solutions is more than necessary in those countries where the tourism industry plays an important role in the economy. Thus, in the case of Spain, it must be considered that it is a country highly dependent on tourism. In 2019, it was the second world destination in terms of international tourist arrivals (83.3 millions), with EUR 92.5 billion in tourism revenue, 2.8 million direct jobs and a contribution to GDP of 14.2% [10]. In this way, tourism is considered the main industry in the country. Therefore, in order to preserve this situation, it is essential to promote developing a sustainable industry over time and, perhaps more necessary than ever, this tourism type.

The contribution of this research is double-edged. Firstly, we present a model that relates a set of variables obtained from the literature and that must be considered for sustainable tourism development from the perspective of the tourist (applicant for tourist services). Secondly, we propose a hypothesis set that seeks to analyze both the level and strength of these relations as drivers of an attitude favorable to sustainable tourism development. The study begins with a review of the literature to consider the relation among the variables considered in the study. Next, the methodology used in the data collection is explained to later expose the results analysis, as well as the discussion and conclusions, which complete the final sections of this study.

2. Literature Review

2.1. Relation between Positive Impacts and Attitude towards Sustainable Tourism

According to [11], tourism impacts are the result of human behavior stemming from interactions between tourists and the subsystems of the territory where they come into play. Throughout the publications that take the study of sustainable tourism as a main topic, the doctrine that corroborates the effects of positive impacts is predominant, whose consequences affect residents, economy and environment [12]. Firstly, the main positive economic aspects are based on greater economic movement, contribution to GDP, job creation and income distribution in other local economic activities. Secondly, regarding residents, the well-being of the local and tourist population is taken into account meticulously, in addition to the respect and preservation of the culture and heritage of the host region. Thirdly, as sustainable tourism is closely related to the environment, due to its use of natural resources, it highly depends on having an attractive natural environment. This produces an increased environmental awareness in society, as well as the revaluation of the natural environment through the approval of environmental quality conservation, protection and improvement measures [13–16].

Sustainable tourism development is inherent to those tourists capable of showing a greater awareness of the sustainability problem [17], who are averse to mass tourism development and seek to contribute to destination protection when choosing. Sensitive to the negative impacts of tourism, they support the development of respectful sustainable tourism from an economic, social and environmental perspective [18,19]. In accordance with [20], that the positive impacts of awareness of the protection of natural resources, cultural resources and the increase in local recreational facilities and resources were considered. From the study of these authors, the following hypothesis is proposed:

Hypothesis 1 (H1). *The positive impact on tourists has a direct and positive influence on their attitude towards sustainable tourism development.*

2.2. Relation between Satisfactory Experience and Attitude towards Sustainable Tourism

Customer motivation is identified as a determinant factor in the success of all industries [21] and, homogeneously, in the case of the tourism sector, influences future intentions of purchase and visiting of the same destination [22]. The success of a global model of sustainable tourism requires achieving high levels of tourist satisfaction, thus increasing their awareness of the problems that sustainability encompasses and promoting more respectful practices. This long-term maintenance of the applicant's satisfaction guarantees the consolidation of the destination in the market and, at the same time, it favors an adequate demand according to its attractions [23]. This satisfaction is configured based on previous expectations and evaluation after finishing the tourist experience [24,25].

Recent studies have analyzed this direct relation between both constructs, linked to a given geographic environment [25–28]. This study covers a geographic area not detected in the literature review and, in line with the proposed authors, the second of the hypotheses is established:

Hypothesis 2 (H2). *Experiential satisfaction has a direct and positive influence on the attitude towards sustainable tourism.*

2.3. Motivation and Attitude Relation towards Sustainable Tourism

Motivation has been analyzed as an internal factor that guides and integrates the behavior of the individual. It is a psychological factor that leads people to act in a certain way to satisfy their desires and goals [29] and, therefore, a driver that motivates people to take vacations or visit destinations [4]. Motivation is related to the attitudes and intentions of tourists when choosing a destination [30,31], and the experience gained in situ is crucial to satisfy that motivation and increase the loyalty to a tourist destination [32]. Hence, tourist motivation is not only useful to explain tourist behavior, but also acts as a predictor of the visit intention [33].

The customer's profile of sustainable tourism involves a tourist committed to the environment and who is aware of sustainability. As tourist motivation has positive effects on the visit intention, various studies [34–37] confirm that the experience is more attractive to tourists when they participate in activities entailing more responsible behavior and greater involvement with the environment, the local community and society. In this way, a direct relation between motivation and attitude towards sustainable tourism is established. From the reading of these authors, the third hypothesis is proposed:

Hypothesis 3 (H3). *Motivation has a direct and positive influence on the attitude towards sustainable tourism.*

2.4. Moderating Effect of Motivation in the Relation between Positive Impacts and Attitude towards Sustainable Tourism

Most research concludes that the three basic categories of benefits and costs that affect a community which receives tourists are economic, environmental, and social [5,38–43], although [2] also incorporate institutional sustainability. Likewise, the sustainability principles imply a balance of these three dimensions: environment, economy and society [32]. Most studies report a positive relation between the attitude towards sustainable tourism development and the perception of its positive impacts [2,5,26,44–46].

In the tourism context, motivation is one of the most important values regarding behavioral intentions among revisiting a place, word of mouth and the search for alternative destinations [47]. This is why tourists more committed to the balance among sustainability dimensions show a higher motivation towards this tourism type and, on the other hand, there is a direct and positive relation between these two variables, as other authors have analyzed [36,37]. Therefore, research has focused on the direct relation between positive impacts and motivation with an implication towards sustainable tourism (hypotheses 1 and 3 of the model); however, the moderating effect that motivation can have on positive impacts and sustainable tourism has not been analyzed. Therefore, the following hypothesis is formulated:

Hypothesis 4 (H4). *Motivation has a moderating effect on positive impacts and the attitude towards sustainable tourism.*

2.5. Moderating Effect of Motivation in the Relation between Satisfaction and Attitude towards Sustainable Tourism

Understanding what factors influence tourist satisfaction is one of the most relevant research topics in the tourism sector, due to the impact it has on the success of any tourism product or service. Most tourists can compare the aspects of different destinations (such as services, attractions, etc.) according to their perceptions. A high level of tourist satisfaction fosters positive future behaviors, such as the intention to revisit and recommend a destination [48].

The relation of satisfaction and motivation with the attitude towards sustainable tourism has been analyzed in the scientific literature by various studies [36,37,49–51] to refer to the tourists' general evaluations of their experiences with environment respect and their expectations regarding the sustainable development of tourist destinations or services. Similarly, the moderating effect of satisfaction with sustainable tourism and other variables, such as the recommendation of a destination and emotional value, have also been analyzed [32]. However, the moderating effect that motivation can have on the relation between satisfaction and attitude towards sustainable tourism has not been examined. Consequently, we deduce from the collected studies that the higher the motivation of a tourist to visit ecological and sustainable environments is, the greater the impact of said relation is. Therefore, the following model hypothesis is suggested:

Hypothesis 5 (H5). *Motivation has a moderating effect between satisfaction and attitude towards sustainable tourism.*

All hypothesis are represented in Figure 1:

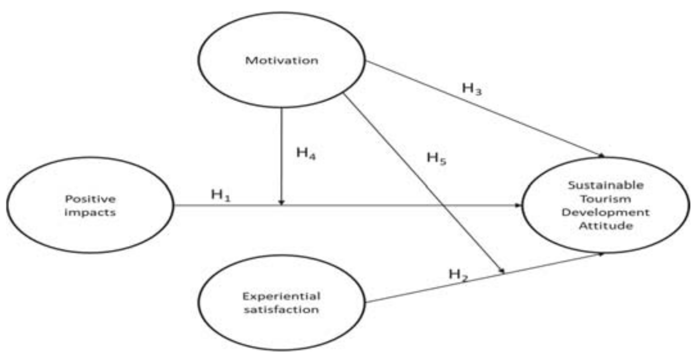

Figure 1. Conceptual model. Source: Own elaboration. While H1, H2 and H3 consider a direct influence between constructs, H4 and H5 include a moderator perspective.

3. Data and Methodology

3.1. Participants

The data were collected from tourists who visited the city of Córdoba (Spain) between the months of October and November 2019. Córdoba (a World Heritage city) is one of the main cities receiving tourism (both national and international). This means that one of the main challenges it faces is its massification and the problems associated. The measurement instrument was completed by a total of 308 subjects.

Table 1 shows the main aspects related to the respondents' profiles. It has to be emphasized that a relative equality is observed regarding the origin of the tourists surveyed. In general, these are tourists who came on holidays that they financed and, in a high percentage of cases, that were based on their own decisions. The questionnaire was personally distributed among the main tourist attractions located inside the old quarter. More than 60% of the travelers were 35 years old or more, had a stable partner (married and living as a couple), lived in households based on two or more people and earned a monthly income of between EUR 1000 and 2000. Although the majority of the respondents stated that they were visiting this city for the first time (62.7%), a high percentage (close to 40%) repeated their destination. On average, the tourists who participated in the study stayed in the city for 2–3 days.

Table 1. Respondent characteristics.

Descriptive Variables	Absolute Frequency	Percentage
Sex		
Male	142	46.1
Female	166	53.9
Nationality		
Spaniard	163	52.9
Other	145	47.1
Visit purpose		
Work	23	7.5
Vacancy	150	48.7
Visit friends	47	15.3
Family event	25	8.1
Independent journey	39	12.7
Others	24	7.8
Person who paid for the visit		
Myself	140	45.5
My company	29	9.4
My partner	63	20.5
Friends	10	3.2
Family	60	19.5
Others	6	1.9
Person who proposed the destination		
Myself	111	36.0
My company	31	10.1
My partner	55	17.9
Friends	36	11.7
Family	71	23.1
Others	4	1.3
Professional status		
Student	54	17.5
Freelance	43	14.0
Employed person	141	45.8
Unemployed person	16	5.2
Retired person	19	6.2
Homemaker	28	9.1
Lost	7	2.3
Age		
65 years old or more	21	6.8
55–64 years old	45	14.6
45–54 years old	79	25.6
35–44 years old	57	18.5
26–34 years old	43	14.0
18–25 years old	62	20.1
Lost	1	0.3

Table 1. *Cont.*

Descriptive Variables	Absolute Frequency	Percentage
Marital status		
Single	78	25.3
Married	135	43.8
Common-law relationship	60	19.5
Divorced	27	8.8
Widow/er	7	2.3
Lost	1	0.3
Household size		
Individual	37	12.0
2 people	126	40.9
3 people	73	23.1
4 people	58	18.8
5 or more people	14	4.5
Lost	2	0.6
Salary		
Less than EUR 999	71	23.1
EUR 1000–1499	96	31.2
EUR 1500–1999	72	23.4
EUR 2000 and over	60	19.5
Lost	9	2.9

Source: Own elaboration.

3.2. Measurements

In relation to the instruments used, special interest was placed on translating the original versions of the scales to the linguistic characteristics of the population. All variables were measured on a Likert scale from 1 to 5, where 1 = totally disagree and 5 = totally agree.

The items in the questionnaire were translated and adapted for the different constructs. The items of positive socio-cultural, economic and environmental impacts were extracted and adapted from [20]. The items related to experiential satisfaction were obtained from the research carried out by [51]. The items of Sustainable Tourism Development Attitude were adapted from the study of [26]. Finally, the construct of motivation was extracted and adapted from [4].

3.3. Data Analysis

The relations among the variables, with special emphasis on the moderating effect of the satisfaction experience, were analyzed with a structural equation model based on variance—the Partial Least Squares (PLS). Furthermore, the recommendations of various authors were followed: [52] and [53]. The computer software used was SmartPLS 3.2.8.

The use of a single instrument to collect data on constructs (latent variables) implies the need to check the existence of a common variance among them. Following the experts' opinions [54,55] on the design and execution process of questionnaires, we proceeded to separate the different measures, as well as to guarantee the anonymity of the respondents. The presence of common influence on responses was analyzed using the [56]. The exploratory factor analysis recorded the existence of 12 factors, where the largest of them explains 17% of the total variance. Therefore, there is no common factor of influence among the items included in the questionnaire [57].

The validation of the proposed model was carried out at a double level. Firstly, the measurement model. Once the validity of the model was checked, the structural model was validated.

4. Results and Discussion

4.1. Measurement Model

The mean and standard deviation values of each item, as well as the latent variables, are given in Table 2. In addition, this table includes the data required to perform the first step in the validation of the measurement model: determining the reliability of the individual items. It can be seen that the factorial loads of most of the items exceed the minimum criterion of 0.707 [58]. Only one item with a lower value has been maintained, although it is very close (0.692). This item was not eliminated after checking its significance level via bootstrapping (5000 subsamples) and in accordance with the suggestions of [59]. Finally, 22 elements of a total of 31 items related to the constructs of the model analyzed were removed.

Table 2. Mean, standard deviation, individual reliability, composed reliability and average variance extracted for constructs and indicators.

Construct and Indicator	Mean	SD	Loading	Composed Reliability	AVE
Global positive impacts (GPI)	3.35	1.110		0.885	0.719
Tourism promotes awareness of the protection of natural resources	3.13	1.237	0.807		
Tourism promotes awareness of the protection of cultural resources	3.44	1.324	0.877		
Tourism increases local recreational facilities and resources	3.46	1.366	0.858		
Sustainable Tourism Development Attitude (SUS)	3.43	0.991		0.800	0.668
I think the attitudes and behaviors of local tourists are satisfactory and do not disturb residents	3.25	1.106	0.743		
I think that the positive aspects of the development of Sustainable Tourism are greater than their negative aspects	3.61	1.306	0.885		
Experiential satisfaction (SAT)	4.02	0.803		0.765	0.622
It is worth visiting a sustainable city	4.07	1.062	0.692		
I feel that I contribute to environment protection and Sustainable Tourism	3.97	0.941	0.875		
Motivation (MOT)	4.46	0.585		0.749	0.600
I want to travel somewhere that offers an ecological environment	4.17	0.900	0.825		
I want to experience different cultures from mine	4.75	0.574	0.720		

Source: Own elaboration.

In order to set the construct's reliability, the composite reliability index (ϱ_c) was used [60]. All its values, included in Table 2, are above the minimum threshold: above 0.7 [61]. The previous table also shows the AVE value, which is used to determine the convergent validity, since it exceeds the minimum level of 0.5 in all latent variables [62].

To determine the discriminant validity of the model constructs, we used the Fornell–Larcker test and the corresponding values are shown in Table 3. These table data verify that all the constructs strictly meet the Fornell–Larcker criterion. In short, this allows us to affirm the existence of discriminant validity among the latent variables and the way of measuring them.

Table 3. Constructs discriminant validity (Fornell–Larcker criterion).

Constructs	GIP	MOT	SUS	SAT
GIP	**0.848**			
MOT	0.190	**0.774**		
SUS	0.646	0.215	**0.817**	
SAT	0.303	0.131	0.382	**0.789**

GIP: Global positive impacts; MOT: Motivation; SUS: Sustainable Tourism Development Attitude; SAT: Experiential satisfaction. Diagonal elements (bold figures) are the square root of the variance shared between the constructs and their measures. Off-diagonal elements are the correlations among constructs. For discriminant validity, diagonal elements should be larger than off-diagonal.

After validating the measurement model, it is necessary to validate the structural model.

4.2. Structural Model

Following the opinion of [63], this study should start with the analysis of the sign, size and significance of the path coefficients, the values of R^2 and the Q^2 test. [59] recommend the use of the bootstrapping technique with 5000 samples to calculate the t statistics and the confidence intervals, which will allow for establishing the significance of the relations. The two-step technique has been followed for the analysis of the moderating effects [59]. Table 4 shows the direct effects (path coefficients), the values of the t statistic, the corresponding confidence intervals (without bias) and the verification of whether the proposed hypotheses have been supported, without forgetting the values of R^2 and Q^2.

Table 4. Direct effects on endogenous variables.

Effects on Endogenous Variables	Path (β)	*t* Value (Bootstrap)	Confidence Interval	Explained Variance	Support
Sustainable Tourism Development Attitude Adj R^2 = 0.470/Q^2 = 0.297)					
H1: Global positive impacts	0.568 ***	14.393	(0.500; 0.627) Sig	36.69%	Yes
H2: Experiential satisfaction	0.212 ***	4.957	(0.137; 0.279) Sig	8.09%	Yes
H3: Motivation	0.064 ns	1.438	(−0.015; 0.133)	1.38%	No
H4: Global positive impacts x Motivation (interaction term)	−0.120 **	2.640	(−0.195; −0.046) Sig		Yes
H5: Experiential satisfaction x Motivation (interaction term)	0.073 *	1.872	(0.012; 0.140) Sig		Yes

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$; ns: not significant.; nd: not determined. t (0.05; 4999) = 1.645, t (0.01; 4999) = 2.327, t (0.001; 4999) = 3.092. One-tailed test.

In order to have a greater awareness of the attitude of the tourist (consumer of tourist services) towards sustainable tourism development, it is necessary to know what variables influence it. Based on previous work on Sustainable Tourism, this study designs a model where a set of variables that influence the attitude towards the development of Sustainable Tourism are described. The relations among them and the consistency of this relation have also been analyzed.

Not all the hypotheses presented have been validated. The hypothesis that relates positive economic impacts to attitude presents higher parameters (β, T-Student) than other variables (GIP ATT; β = 0.568; t = 14.393). Furthermore, the relation with satisfaction for the experience had developing this modality of tourism shows quite adequate levels (SAT ATT; β = 0.212; t = 4.957). This reveals the important role played by the tourist's awareness and their contribution so that Sustainable Tourism can be developed. Lower levels are found in the hypothesis that relates motivation to attitude (MOT ATT; β = 0.064; t = 1.438). This means that this relation is presented as "not significant".

However, the variable "motivation" also has a moderating effect on the relations shown in the model, both the one we observe in positive impacts and the one that appears in satisfaction on the attitude for sustainable tourism development. Thus, we find that, as motivation increases, the satisfaction effect on attitude also grows (β = 0.073; t = 1.852). However, the moderating effect of the variable "motivation" is the opposite in the relation between positive impacts and attitude (β = −0.120; t = 2.640). In other words, the less motivation there is, the less the impact effect on the attitude will be reduced (Figure 2).

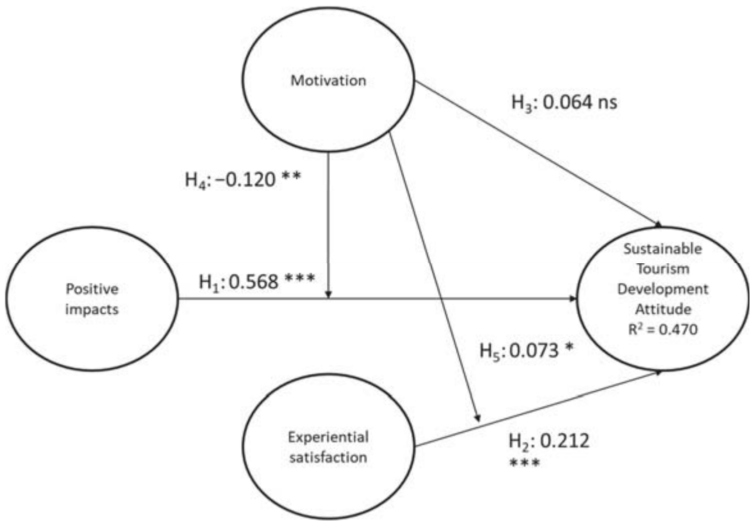

Figure 2. Structural model.

This study is in line with previous works that have highlighted the importance of tourist awareness for sustainable tourism development [12,24,25,28,37]. Similarly, it is in line with the recently published document "Covid-19: EU Guide to the progressive resumption of tourism services and health protocols in hotels" [64]. It is essential to develop Covid-19-related protocols for hotel establishments [65–67]. These protocols corroborate many of the guidelines that must be followed for sustainable tourism development, fundamentally related to environmental protection, based on a commitment to reduce destination massification in order to avoid tourist overcrowds. In this way, it will be possible to maintain a safe distance among people while consuming tourist services, which comprises the main concern of the health authorities. Nevertheless, we note that the health authorities have not clearly communicated these protocols yet. This lack of information will lead to a certain delay in the implementation of measures in tourist offers, which could help sustainable tourism development.

We believe that, as health authorities establish the protocols to responsibly and safely develop tourism, and as long as the tourists are aware of their implementation, it is quite probable that the level of the different variables of the proposed model (positive impacts, satisfaction and motivation towards the attitude for sustainable tourism development) will increase due to a greater knowledge on the part of the tourist. A higher level of awareness, fundamentally supported by the security that tourists need in the current context, can lead them to consume tourist services.

5. Conclusions

The development of sustainable tourism requires, mainly, an awareness on the part of the tourist services applicant (the tourist). According to the analysis of the literature, we find a series of factors that can contribute to increasing positive attitudes towards sustainable tourism development from the perspective of demand. Through this analysis and a methodology focused on personal surveys carried out on tourists using a questionnaire, the factors that make tourists have a favorable attitude towards sustainable tourism development have been determined. Based on this study and the results obtained from the fieldwork, in addition to the analysis of the tourist-industry situation after the health crisis, a series of conclusions are drawn from both theoretical and empirical perspectives.

5.1. Theoretical Perspective

Firstly, in the literature, we find three factors that lead to a favorable attitude for sustainable tourism development from the tourist's perspective. On the one hand are the positive effects perceived by the tourist with the consumption of sustainable tourism, whose consequences affect the resident's, economy and destination environment [12,16]. On the other hand, customer satisfaction is identified as a determinant of success in any industry [21] and, therefore, in the tourism industry [28]. Finally, motivation is related to the attitudes and intentions of tourists when choosing a destination [30,31]. However, this motivation plays a moderating (and different) role in the relation between the positive effects and the attitude towards sustainable tourism development and in the relation between satisfaction and the attitude towards sustainable tourism. Thus, motivation harms the positive impact and favors the satisfaction effects on the attitude of sustainable tourism development.

Secondly, after reviewing studies and reports on the current context of the tourism industry, it can be affirmed that there is a need to develop protocols (based on the perspective that tourist services offer) which reaffirm tourists' commitments to consume sustainable tourism. This perspective is not included in the model (which only analyzes the demand perspective); however, from a theoretical point of view, it does seem necessary to consider. In this scenario, the performance of the presented empirical study is one more reference to contemplate that the tourist (applicant for tourist services) becomes a fundamental element for sustainable tourism development. Nevertheless, for their safety, the tourist will demand tourist services that take into account hygiene and health factors [65] and aspects related to social distancing [68,69].

5.2. Empirical Perspective

Firstly, only two of the three main hypotheses regarding the direct effects are supported. The attitude towards sustainable tourism development is positively influenced by the global positive impacts perceived by the tourist and by the satisfaction experienced with the consumption of this tourism type. The value of R^2 indicates an appropriate predictive level for the "attitude towards sustainable tourism development" variable, which is reinforced by the value of Q^2.

Secondly, it is important to highlight that the "motivation" variable plays a moderating role regarding the impacts on the relations of the other two variables analyzed. In the case of positive global impacts, the incidence of motivation is negative—in other words, the less motivated a subject is, the lower the effect of global positive impacts on the attitude towards sustainable tourism development will be. On the other hand, motivation seems to increase the effect of the satisfaction experienced on the attitude towards sustainable tourism development.

In summary, sustainable tourism can build on the momentum provided by this context of health crisis to increase a favorable attitude towards sustainable tourism development. Achieving this attitude will allow for an increase in the tourist's awareness, translated as the tourist's perception of the positive impact and the satisfaction experienced with the consumption of this tourism type. Likewise, motivation is a factor that also favors the attitude towards sustainable tourism development. At the same time, a priori, the role played by the tourist offer (companies and authorities) to help increase this tourist awareness will also be important.

5.3. Limitations and Future Studies

The main limitation we find in the present work is that the study was carried out prior to the crisis caused by COVID-19; therefore, aspects such as changes in attitudes, motivations and perceptions related to and caused by this new situation were not considered at any time. However, the study focused on analyzing the importance of sustainable tourism. Without doubt, this relevance will be driven by this new situation. Therefore, it would be very convenient to replicate this work in the future when total mobility within national territories begins to be allowed and the circulation of tourists is allowed internationally. Thus, for example, an aspect that was not supported in the present work is the importance of positive impacts a destination could have, which did not suppose a motivation for its choice. Thanks to the different government campaigns that are being recently launched with the aim of achieving positive impacts from visiting certain destinations, we think that this aspect could change due to the increased sensitivity perceived by the tourist. In short, it is necessary to find formulas that boost the tourism industry. The development of sustainable tourism can help to mitigate tourists' perceived fears of visiting destinations with a large concentration of people.

Therefore, it would also be interesting to launch a study that considers the actions carried out by the tourism offer in order to verify its impact on the attitude towards sustainable tourism development.

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Study on the Impact of Historic District Built Environment and Its Influence on Residents' Walking Trips: A Case Study of Zhangzhou Ancient City's Historic District

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Abstract: Walking maintains an indisputable advantage as a simple transport mode over short distances. Various situations have shown that when staying in a walk-friendly built environment, people are more likely to walk and interact with their surroundings. Scholars have reported some evidence of the influence of neighbourhood environments on personal walking trips. Most existing studies of the correlation between the built environment and walking, however, have been conducted in the West and are cross-sectional, which leaves a gap in addressing the causality between built environments and walking under the intervention of regeneration measures. This study takes a historic district of a mid-sized city in China as the research area and reports the changes in the traditional residential district's built environment caused by the implementation of urban regeneration. In this paper, we use physical and perceptual indicators to measure the walkability of the built environment. We identify the changed content of the built environment's walkability and the change of residents' walking behaviour through longitudinal and quasi-longitudinal methods. The conclusion shows that the implementation of a regeneration project of the historic district has greatly changed perceived walkability, which has significantly promoted residents' recreational walking trips, especially among the population of middle-aged and elderly people in the district. The conclusion that the built environment's change promotes recreational walking is contrary to the research performed in sprawling Western contexts such as in the US, and it provides a meaningful supplement for research on the topic in an Asian context.

Keywords: built environment; walking behaviour; neighbourhood walkability; regeneration project

1. Introduction

Compared with other modes of transportation, walking is a very simple transport mode. It can improve personal physical activity, increase opportunities for informal contact, and promote neighbourhood relationships. Before the advent of major transformations in transport technology in the nineteenth century, walking was the common and traditional form of urban transport [1]. In contemporary society, especially within central areas, walking is also one of the fastest and most time-reliable transport modes for short-distance trips. However, car dependence with the development of large-scale urban motorisation has brought pervasive criticism upon unfriendly walking environments, such as single-function land, lack of service facilities, and poor sidewalk connectivity. This status is not conducive to public life, health, liveability, or economic improvement and could also frustrate pedestrians [2–5]. Consequently, researchers have started attaching importance to walkability, making the quality of the walking environment and the design of pedestrian precincts an essential element of urban planning in the past decade.

Reviewing previous research, there is enough evidence to prove a correlation between the built environment and walking behaviour [6–8]. The neighbourhood environment has been proven to at least partially affect individuals' physical activity and walking behaviour [9–15]. Pedestrian activities can be increased by the presence of a well-connected street, easily accessible facilities, varied land uses, and good experience in the neighbourhood environment [16,17]. As one of New Zealand's government entities, the New Zealand Transport Agency (NZTA) (2009) has offered an authoritative definition of walkability: "the extent to which the built environment is walking-friendly" [18]. In a pedestrian-friendly community environment, pedestrians prefer to interact with the surrounding environment more frequently, which is beneficial to creating a closer community network and a safer neighbourhood.

However, quantitative studies on the correlation between the built environment and walking have been focused on cross-sectional and easily raised causal attributions [19]. There is much less work focusing on longitudinal studies of built environments and walking behaviour under the influence of improvement measures. Besides this, on a neighbourhood environment scale, the sprawling Western context is different from the high-density and compact Asian context; those reports may not be applicable to Asia, including China [20]. Longitudinal research is helpful for improving the walking environment in China [21].

This paper provides new evidence for a longitudinal study of the relationship between the built environment and walking and helps to solve the problem of insufficient studies on this topic in Asian neighbourhood environments. The study measures "before" and "after" walkability of the built environment by indicators of three components and uses a quasi-longitudinal method to collect "before" and "after" information about residents' walking behaviour to clarify the built environment's impact on walking. This longitudinal report may help to provide some information for planners and managers who intend to optimise pedestrian environment quality to promote a more attractive, inclusive, and walking-oriented healthy city.

2. Literature Review

Reviewing the existing research, scholars have developed plentiful theoretical models to measure the extent to which the built environment is walking-friendly. Thus, the walkability index was generated [22,23]. The development of walkability measurement has gone through several stages. The earliest measurement indexes came from the 3Ds developed by Cervero and Kockelman (1997) [24]. Ewing et al. (2009) further extended this to a 5D layout, which included density, diversity, design, destination accessibility, and transit distance [25]. Frank (2010) calculated walkability by four walking indexes: intersection density, net residential density, retail floor area ratio, and land use mix [26]. All their measurement indexes are physical indexes. Pikora et al. (2003) and Cerin (2006) further developed the physical indexes, supplemented the measurement of aesthetics and pedestrian safety, and developed the theory of a neighbourhood environment walkability scale (NEWS) [27,28]. Jun and Hur (2015) emphasised perception and the walking experience in their model [29]. Moura (2017) adapted the 5C theory, which was developed by the London Planning Advisory Committee and proposed the latest 7C layout; "conspicuous" and "commitment" were added to the walkability indicators of "connected", "convenient", "comfortable", and "convivial", which makes the assessment more comprehensive within the expansion of the walking experience and perception [30]. Walking safety and experience indicators were also proved to be necessary and effective in measuring walkability [31].

In terms of types of research on correlations, scholars have provided multiple views to investigate the association between the built environment and walking, but the majority are cross-sectional. The existence of a small quantity of longitudinal studies generally concerns two categories: impact of event intervention or time sequence. The former refers to the implementation of an improvement plan or impact of a life event, such as a residential relocation or family or work changes, which involves a change of personal circumstances. The latter is based on the impact of different time periods at the same site. Regarding the impact of time, Hirsch et al. (2014) took five built environment factors as the measurement standard, inspected the same six locations in the United States four times over a decade, and found that the destination quantity and level of street connectivity were positively correlated with utilitarian walking. Rates of recreational walking increased under higher baseline levels of both lands zoned for retail and walking destinations but had no association with built environment features [32]. Regarding the impact of event intervention, based on changes in land use, bus support, pedestrian network, and population, which were caused by a natural experiment on Hong Kong's university campus, Sun et al. (2014) measured the change of students' walking behaviour. They found that the transformation of the campus environment led to a great change in students' walking behaviour, and students' walking distance and walking proportion were increased [33]. Carlson et al. (2019) studied the activity impact under a rapidly completed street-view improvement project in a northeast neighbourhood in Kansas City, MO. After recording "before" and "after" pedestrian activity at the same site, they found that the intervention with the street view increased pedestrian numbers [34]. Gao (2019) emphasised the impact of life-event induced change on walking. After collecting two-year travel records of 922 families in the Netherlands' 87 cities, they analysed their walking behaviour and found that life events were related to utilitarian walking but had no significant impact on recreational walking [35]. The majority of this longitudinal research is based on the case of Western countries, and these reports do not consider factors that can influence pedestrian perceptions and experiences when measuring the extent to which the built environment supports walking. At a community level, the social network in a neighbourhood is more closely connected with the environment than in general areas [36–42]. As the majority of studies have been performed in Western countries, supplementation with Asian cases is urgently needed.

3. Study Area

3.1. District Selection

The research area is the Zhangzhou ancient city's historic district in Fujian Province, China, with an area of about 0.5 hm^2 (Figure 1). According to the administrative division in Zhangzhou, the jurisdiction of the historic district belongs to the Xiqiao subdistrict, which includes four residential neighbourhoods. Although motorisation in Zhangzhou has developed rapidly in recent years, the main travel modes of this medium-sized city are still nonmotorised vehicles and walking (Table 1). The study's neighbourhood is a traditional living settlement located in an old urban area, with a highly built footprint, low and continuous buildings, mixed land use and dense street networks. The existing studies' summary concluded that within 500 m is a comfortable walking distance for most people. The plane morphology of the study neighbourhood is basically a structured grid square, and the straight-line distance from its geometric centre point to the boundary is at 300 to 500 m, which accords with the comfortable walking distance range, making it suitable for research.

Table 1. References for travel modes of similar medium-sized cities in China.

City	Walking Ratio (%)	Electric Vehicles Ratio (%)	Bike Ratio (%)	Public Transportation Ratio (%)	Car Ratio (%)	Year
Zhangzhou	21.17	25.50	6.84	6.08	13.46	2013
Huzhou [a]	24.20	33.70	5.00	4.40	26.10	2015
Ningpo [b]	4.53	22.28	18.27	34.38	15.06	2008
Fuzhou [c]	28.30	14.00	14.60	16.70	9.20	2008
Kunshan [a]	16.20	28.40	6.20	13.70	29.10	2017

[a] From Bi and Luo (2018) [4]. [b] From Teng and Chen (2009) [43]. [c] From Lin T (2012) [27].

(**a**) (**b**)

Figure 1. Location of study area: (**a**) Position of Zhangzhou municipality in China; (**b**) study area in Zhangzhou (2017 Google image).

3.2. Physical Intervention Descriptions of Phase I Regeneration Project

The ancient city's historic district has implemented several local renovations since 1988, such as the restoration and renewal of local building facades and some street pavements. The first phase of the regeneration project, started in 2015, is a comprehensive, integrated vision and action for the entire historic district. It aims to improve the economic, social, and environmental conditions of the district and create a comprehensive community for life, culture, and tourism. The physical intervention of Phase I of the project mainly included traffic system optimisation, environmental design, commercial planning, and architectural renovation (Figure 2).

Figure 2. Photos of the historic district.

The traffic system optimisation included an adjustment of the internal traffic mode and parking configuration. Previous vehicle lanes in the district were almost all adjusted to nonmotorised traffic use for pedestrian and nonmotor vehicle access (Figure 3). At the same time, the construction of an underground parking lot was carried out by using the idle land at the district boundary; a special entrance for vehicles and special connecting facilities for pedestrians were set up.

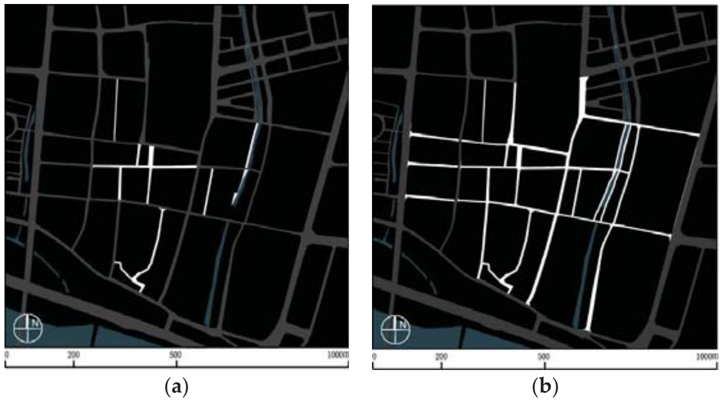

Figure 3. Neighbourhood traffic control (highlights show the streets are closed to motorised vehicles). (**a**) Before; (**b**) after.

The environmental design includes improvement of district infrastructure and green space, allocation of street furniture, design of three entrance squares, and restoration of historic open space. The restoration of historic open space provides more leisure and exercise locations for residents and visitors.

Surrounding vacant lands were redesigned as commercial stores after the restoration of the historic open space, and some style conflicts and declining buildings were renovated or rebuilt.

4. Research Design and Methods

4.1. Analysis Model Construction

4.1.1. Walkable Built Environment Model

This paper has summarised the development of measurement frameworks. As the physical calculation indexes were considered too incomprehensive to capture pedestrians' walkability perception of the environment [30], the measurement index in this paper includes not only a developed physical environment index but also pedestrians' perception and interaction indexes based on the characteristics of the built environment in the 7C index.

In the present case, we measured and collected 23 data sets to measure the "before" and "after" walkability. These data consist of three control components: Street Connectivity, Pedestrian Accessibility, and Perceived Walkability.

Street Connectivity. The measurement index was calculated by CAD based on the 1:2000 topographic file provided by the local government's surveying department in 2012 and supplemented by the field survey.

Pedestrian Accessibility. The measurement index was an extracted survey of land use and destinations. The local government's planning department's status investigation files (before), delay images of Tencent and Baidu online street view (before), and the field survey (after) were aggregated to form the distribution of destinations and the land use calculation. Generally, residents' pedestrian network in a neighbourhood incorporates formal and rich informal paths (in the study area, "informal paths" includes park paths that are used for transportation and other informal paths within the plot). Due to the accuracy of the topographic file, informal paths were able to be included in the calculation. As for the classification of destinations, according to the characteristics of traditional neighbourhood communities in Chinese cities, Yintao (2013) divided the neighbourhood destinations of Shanghai communities into 20 classes for measurement [44–47]. Alternatively, according to *The Shanghai Planning Guidance for 15-min Walkable Neighborhoods*, Weng et al. (2019) divided these into six categories and 15 subcategories, including education, medical care, municipal administration, finance and telecommunication, commercial service, and elderly care [45]. Considering the whole population of all ages, destinations were divided into four categories and nine subdivisions in this research. Table 2 shows the classification results of the trip destination statistics.

Table 2. Classification and statistics of nine types of trip destinations.

Destination Category	Subdivision Rules	Abbreviations
Commercial service destination	Retail store	RS
	Restaurant	R
Public facility destination	School	S
	Amenity facility	A
	Culture and recreation facility	CR
	Clinic	C
Transit destination	Bus stop	BS
	Parking lot	P
Green open space	——	GS

Perceived Walkability. Perception represents the extent to which people feel comfortable and safe walking. Although individuals have varied perceptions, there are also commonalities that can be tracked. In this research, we combined subjective evaluation data and objective data calculation for measurement. The aforementioned topographic file was used for the CAD calculation; questionnaire sampling survey statistics were used for measurement of subjective evaluation results.

4.1.2. Survey and Sampling

In this paper, a quasi-longitudinal design was used to resolve the difficulties associated with previous data. Respondents were asked about their walking experience before and after project implementation. This method is considered to be an effective way to improve causality between the environment and trip, and the control influence of variables like attitudes over time [18]. Different personal demographic characteristics, like age or income, always produce variable neighbourhood activities. Demographic information and walking experience were obtained by the questionnaire. The sampling survey was conducted with the help of subdistrict staff from 16 to 26 November 2018. We conducted random interviews with families of community residents to ensure that respondents were evenly distributed. Residents who relocated after project implementation were not eligible to participate, and all respondents were granted anonymous use of their data for academic purposes. Through the questionnaire, personal and family attributes were collected, including age, gender, education, career status, any children in the household, annual household income, and car and electric bicycle ownership.

Residents were also asked to review their walking experience, previous and present. Firstly, residents needed to report a self-assessment of the project implementation influence degree on the change of personal walking behaviour and a multiple response assessment of the subjective evaluation of destinations based on their improved or reduced accessibility. Secondly, information about walking behaviour was measured, including walking frequency per week before and after project implementation, "before" and "after" average single walking distance, and "before" and "after" walking frequency to destinations.

4.2. Calculation and Statistical Methods of Variables

4.2.1. Index Calculation

Calculation methods of the index measuring built environment walkability are as follows:

Group 1: Street connectivity index. (1) Block density: Number of blocks per unit area, indirect data were used to detect street connectivity; (2) Average length of street segments: Average length between two adjacent street intersections; (3) Street network density: Street length (km) on neighbourhood unit area (km^2); (4) Connected Node Ratio (CNR) [11]: The ratio of the number of street intersections to the number of street intersections plus the number of cul-de-sacs. A CNR less than 0.5 should be avoided as much as possible; (5) Link-Node Ratio (LNR) [11]: The ratio of the number of road sections connecting two nodes and the number of nodes. When the LNR is higher, the connectivity is better. On a block with good connectivity, the LNR value should be greater than 1.4.

Group 2: Pedestrian accessibility index. Average walking distance to the aforementioned nine destinations and degree of district's mixed land use, as follows.

(1) Average walking distance: Calculates the average walking distance of the nine classes' destinations. Because the research neighbourhood plan is regular and square, walking distance between the geometric centre and the boundary is within 300 to 500 m. Therefore, the distance is within the predetermined walking range, and the average shortest walking distance from the four community geometric centres to the nearest three of nine classes' destinations in the neighbourhood is calculated as follows to measure the average walking distance to a destination; the formula being $D_j = \frac{\sum_{i=1}^{3} D_i}{3}$.

(In the formula, D_j is the mean value of the shortest distance from each community geometric centre to the nearest three destinations of class *j*.)

(2) Degree of land use mix: Proportion of each class of land area of the following five categories within a unit area (km^2): Residential, Retail commerce, Public facility, Road traffic, and Green open space. Shannon's (1948) [40] information entropy theory was used for reference to express land-use structure and equilibrium degree by the results of entropy value (H) and equilibrium value (J), using the formula $H = -\sum_{i=1}^{n} p_i \ln p_i$, $J = H/H_{max} = -\sum_{i=1}^{n} p_i \ln p_i / \ln n$.

(In the formula, p_i represents the proportion of class *i* land area, and *n* represents the calculated land number.)

Group 3: Perceived walkability index. (1) Ratio of street walkable area: the ratio of walkable area to total neighbourhood area; (2) Proportion of green open space: the ratio between the area of green open space and total neighbourhood area; (3) Streetscapes' suitability and walking safety: Evaluation results of respondents (from 1 point being "very dissatisfied" to 5 points indicating "very satisfied") are used to qualitatively measure the index before and after project implementation; (4) Landmark visibility: 0–2 points are used to measure the visibility of landmarks like historic sites, characteristic buildings, squares, and parks, where 1 point is given to street segments that have a view of a landmark, 2 points are given to a situation where landmarks are located on street segments; otherwise, 0 points are given; (5) Interaction degree: The ratio of street segments with communication space to all street segments. The communication space here refers to open shops, restaurants, activity rooms, and other buildings that can initiate an interaction at night; (6) Regulatory enforcement degree: the ratio of street segments that have implemented current pedestrian-friendly regulations to all street segments, such as street segments with vehicle control, pavement arrangements, or crossing guidance interventions.

Walkability score of the built environment: Seven indicators of the above three components were weighted to get the results by weight function of an adult's utilitarian walking following Moura's 7C layout. The formula being

Walkability score = [(0.17 * *Connected node ratio*) + (0.06 * *Equilibrium degree*) + (0.17 * *Suitability of streetscape*) + (0.17 * *Interaction degree*) + (0.11 * *Landmarks visibility*) + (0.22 * *Walking safety*) + (0.11 * *Regulatory enforcement degree*)

4.2.2. Methods

Statistical analyses of built environment variables and the survey were conducted in SPSS 22, and the significance level was set at $p < 0.05$. Univariate analysis examined the basic distribution of data for the primary calculation of descriptive statistics. The analysis method consists of two steps. Firstly, we explored the built environment contexts before and after project implementation. A statistical test was used to compare the response distribution; a paired sample *t*-test examines whether significant changes have taken place before and after. Analysis of covariance (ANCOVA) was used to test the difference between the three groups' variables' effects on the built environment before and after project implementation.

Secondly, we take the self-assessment result of project implementation influence degree on the change in personal walking behaviour (self-assessment result) as a variable and use Spearman's correlation analysis to examine the statistical correlation between the self-assessment results and demographic characteristics. The purpose is to enable respondents to actively exclude possible subjective walking changes, so as to confirm that changes are caused by the implementation of the regeneration project. A chi-square test was used to further determine the classes of demographic variables with different changes. A paired *t*-test and Mann–Whitney–Wilcoxon test were investigated, respectively, for variables with a normal distribution (valid skewness and kurtosis thresholds were set between −2 and 2) and non-normal distribution. After comparing the visit frequency to destinations, walking frequency, and walking distance, the final results were used to explain the effective intervention of the built environment change on residents' walking trips.

5. Results

5.1. Calculation Result of Built Environment Walkability Variables

5.1.1. Elementary Analysis and Assumptions

Table 3 shows the calculation results of built environment factors under the implementation of the regeneration project.

Table 3. Calculation results of built environment variables.

Components		Built Environment Variable	Value (Before)	Value (After)
Street connectivity	C1	Block density	52	54
	C2	Average length of street segments	0.13	0.12
	C3	Density of street network	16.82	18.02
	C4	Connected node ratio (CNR)	0.98	1.00
	C5	Link-Node ratio (LNR)	1.51	1.56
Pedestrian accessibility	A1	Distance to RS	0.06	0.08
	A2	Distance to R	0.16	0.13
	A3	Distance to S	0.32	0.37
	A4	Distance to A	0.24	0.25
	A5	Distance to CR	0.45	0.45
	A6	Distance to C	0.29	0.29
	A7	Distance to BS	0.52	0.41
	A8	Distance to P	0.00	0.42
	A9	Distance to GS	0.38	0.24
	A10	Entropy	1.46	1.55
	A11	Equilibrium degree	0.91	0.96
Perceived walkability	W1	Ratio of street walkable area	0.05	0.11
	W2	Ratio of green open space	0.10	0.15
	W3	Suitability of streetscape	2.86	4.07
	W4	Walking safety	2.30	4.22
	W5	Landmark visibility	0.58	1.00
	W6	Interaction degree	0.67	0.81
	W7	Regulatory enforcement degree	0.25	0.62
Walkability score	**WS**		59.3	81.2

(1) Interpretation of street connectivity indicators. There were enough blocks (C1 = 52) in the district. Together with the average length of street segments (C2 = 0.13 kilometre, about 0.08 mile), these showed correspondence with the eligible dimension range (0.12–0.15 kilometre), which was put forward by Jacobs (1993) [21]. The value of CNR (C4 = 0.98) revealed that there were almost no cul-de-sacs in the district. Combined with the value of LNR (C5 = 1.51), it showed that the

district was composed of many small blocks and intersections with various paths between each block and consequently formed desirable street network connectivity.

(2) Interpretation of pedestrian accessibility indicators. Research points out that mixed-use of land is the key component of walkability, is linked with health, traffic, and environmental consequences, and is convenient for people to access on foot [16]. The equilibrium degree (A11 = 0.91) was close to 1, indicating the high mixed degree of land use belonging to a high-density residential neighbourhood. The distances between four centres of the research district grid and each of the nine types of facilities were almost all within 0.5 km. According to the international standard walking speed, the range that adults can reach in 5 min is 0.25 miles (about 0.4 kilometre), which shows that the neighbourhood has ideal walking accessibility to facilities [1,2,36].

(3) Interpretation of perceived walkability. Benefitting from the large area of an urban historical park (about 0.05 square kilometres) on its north side, the historic district had a high ratio of green open space. However, the walkable area outside the park was not desirable, and the engagement of local authorities in the pedestrian environment (W7 = 0.25) was insufficient. Therefore, the residents' evaluation of streetscape suitability and walking safety (W3 = 2.86, W4 = 2.30) tended to be negative (median = 3). A large number of street segments with visible landmarks can improve street attractiveness and differentiation. The visibility of landmarks (W5 = 0.58) in the study area was unsatisfactory; otherwise, the street interaction degree was acceptable because of the central location in the city.

5.1.2. Differences Analysis of Built Environment Variables among Groups

Table 4 reports the differences between "before" and "after" built environment variables. Both the correlation (p = 0.000) and t-test result (p = 0.032) were significant, which indicates that there is a significance difference. An analysis of covariance was further conducted to examine the intensity among three groups' indicators, which led to the significance change (Tables 5 and 6). The result of the test of homoscedasticity (F = 3.307, p = 0.059 > 0.05) was not significant, and there was no interaction (F = 0.359, p = 0.704 > 0.05). After removing the interaction terms, the result of tests of between-subject effects revealed a significant difference in the effects of three groups on the change of "before" and "after" built environment variables (Table 5). From the result of pairwise comparisons, we can confirm that the perceived walkability group has a greater impact function than the street connectivity group and pedestrian accessibility group (Table 6).

Table 4. Paired-samples test result of built environment walkability (before and after).

Built Environment Variable	Mean	SD	SE	t	Df	Sig. (2-Tailed)
Before	−0.221 [a]	0.728	0.031	−2.3	21	0.032
After	−0.151 [a]	0.72				

[a] Result of log transformation.

Table 5. Tests of between-subject effects from ANCOVA.

Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2923.003 [a]	3	974.334	5883.707	0.000
Intercept	0.712	1	0.712	4.302	0.052
Three groups of built environment variable	1.328	2	0.664	4.009	0.035
Before-After walkability	2146.077	1	2146.077	12,959.501	0.000

[a] R-squared = 0.999 (adjusted R-squared = 0.999).

Table 6. Pairwise comparisons analysis among three groups from ANCOVA.

Group of Variable		MD	SE	Sig [b]	95% Confidence Interval for Difference [b]	
					Lower Bound	Upper Bound
Group1	Group2	0.038	0.057	0.514	−0.082	0.159
	Group3	−0.212 *	0.059	0.002	−0.336	−0.088
Group2	Group1	−0.038	0.057	0.514	−0.159	0.082
	Group3	−0.250 *	0.045	0.000	−0.345	−0.156
Group3	Group1	0.212 *	0.059	0.002	0.088	0.336
	Group2	0.250 *	0.045	0.000	0.156	0.345

Based on estimated marginal means. * The mean difference is significant at the 0.05 level; [b] adjustment for multiple comparisons: least significant difference (equivalent to no adjustments).

After weighting seven indexes of three components corresponding to the 7C framework, the walkability score before project implementation was 59.3, which belongs to a moderately walkable district according to the Walkscore® standard. The walkability score (WS = 81.2) was greatly improved after project implementation. Based on the results of differences among the three groups of built environment variables, it can be concluded that the improvement of the walkability score is mainly due to the improvement of perceived walkability. Based on the above analysis results, we put forward a preliminary hypothesis that the changed built environment walkability mainly consists of walking perception and experience in the environment, which may promote the occurrence of recreational walking.

5.2. Analysis of Respondents' Walking Behaviour

5.2.1. The Report of All Respondents' Samples

Table 7 displays the population characteristics of respondents. Results showed that the samples were mainly composed of middle-aged and elderly people with a low education level. Those with a full-time job and self-employed and retired respondents were homogeneously distributed, and the family income was mostly middle level. (According to the comparison of citizens' income distribution from the *National Bureau of Statistics* and the economic indicators of personal capita income from the *Zhangzhou Statistical Yearbook 2017*, individuals with an annual income of more than ¥120,000 are classified as high-income citizens in the Zhangzhou municipality.) More than half of the families had children living in the home, and the proportion of those with a household car was not high. The sample represents the typical residents of the Zhangzhou ancient city's historic district, a long-standing residential area with the highest ageing population of all subdistricts of the city (according to subdistrict staff). Most modern young or middle-aged families with a high level of education separate from their elders and move from the historic district to newly-built middle or upscale residential areas in the city to live independently.

The walking frequency variable and the variable of visit frequency to destinations that reflected the walking behaviour of residents were investigated by measurement data. The walking distance variable was reported as seven grades: 0.4, 0.4–0.8, 0.8–1.2, 1.2–2, 2–3, 3–4, 4–5, and above 5 km. A paired t-test was investigated to report the correlation of walking behaviours between "before" and "after". The coefficient of correlation was significant (p = 0.000); the results of "before" and "after" walking frequency and walking distance were significantly different. The frequency of walking per week (M_t = −0.939) increased significantly after project implementation (Table 8).

Table 7. Characterisation of surveyed residents and their families.

Personal Attributes		N	Frequency (%)	Family Attributes		N	Frequency (%)
Gender	Male	45	54.88	Family size	1	5	6.10
	Female	37	45.12		2–3	43	52.44
Age	18–29 years old	4	4.88		4 or more	34	41.46
	30–39 years old	16	19.51	Annual household income	Less than ¥30,000	4	4.88
	40–49 years old	21	25.61		¥30,000–60,000	35	42.68
	50–59 years old	18	21.95		¥60,000–120,000	34	41.46
	60 years old or older	23	28.05		More than ¥120,000	9	10.98
Education	Basic first or second stage	39	47.56	Presence of children	0	33	40.24
	Secondary education or high school	27	32.93		1	37	45.12
	University	16	19.51		2 or more	12	14.63
	Master and above	0	0.00	Availability of a car	0	57	69.51
Career status	Student	3	3.66		1 or more	25	30.49
	Full time job	21	25.61	Availability of electric bicycles	0	21	25.61
	Self-employed	26	31.71		1	46	56.10
	No job	4	4.88		2 or more	15	18.29
	Retired	28	34.15				

Table 8. "Before" and "after" paired-samples test results of residents' walking behaviour.

Walking Behaviour Variable	Before		After		Paired-Samples Test			
	Mean	SD	Mean	SD	Mean	SE	*t*	sig
Walking frequency per week	7.35	3.567	8.29	3.977	−0.939	0.200	−4.70	0.000
Average single walking distance	3.12	0.908	3.63	1.083	−0.512	0.072	−7.11	0.000

5.2.2. Subgroup Analysis Results

Self-assessment data was investigated to three levels: no impact, certain impact, and great impact. A Spearman correlation analysis was run to test for socio-demographic variables and self-assessment data. The self-assessment results of four population attribute categories (age group, education group, career group, and car group) showed differences (Table 9). After a further chi-square test, despite the insignificant result on career groups, results were confirmed according to the adjusted residual (AR) value and the crosstab proportion of each class factor in the other three groups.

Table 9. "Before" and "after" correlation analysis between attribute variables and self-assessment variables.

Aspects	Variables	Correlation Coefficients	Sig (2-Tailed)
Personal attributes	Gender	0.002	0.987
	Age	0.363	0.001
	Education	−0.311	0.004
	Career status	0.281	0.011
Family attributes	Family population	−0.105	0.349
	Annual household income	−0.164	0.142
	Presence of children	−0.097	0.385
	Availability of a car	−0.248	0.025
	Availability of electric bicycles	−0.15	0.177

Residents aged 50 to 59 and over 60 in the age sub-group were more inclined to the following conclusion than other age groups—project implementation had a greater impact on their walking behaviour. The same results could be found in the "less than high school" class of the education group and the "no car" class of the car group.

Based on the above analysis conclusion, a paired *t*-test was run on subgroups to obtain results for "before" and "after" walking frequency and the walking distance of 57 samples without a car, 41 middle-aged and elderly samples, and 38 samples with less than a high school education background. Due to a large difference in the report result of each sample, the variable of visit frequency to destinations did not meet the valid threshold of skewness and kurtosis. A Wilcoxon signed rank test was consequently used to test the variables of the three subgroups. Only significant variables were shown in the final statistical results (Tables 10 and 11).

Table 10. "Before" and "after" paired-samples test results of three sub-groups' walking behaviours.

Group Branch	Variable	Before		After		Paired-Samples Test				
		Mean	SD	Mean	SD	Mean	SE	*t*	df	sig
Middle-aged and Elderly	Walking frequency	8.44	3.905	9.07	4.274	−0.634	0.246	−2.57	40	0.000
	Walking distance	3.17	1.052	3.66	1.146	−0.366	0.091	−4.03	40	0.000
No car	Walking frequency	7.44	3.784	8.05	4.121	−0.614	0.192	−3.20	56	0.002
	Walking distance	3.21	0.940	3.61	1.161	−0.404	0.086	−4.68	56	0.000
Less than high school	Walking frequency	8.13	4.408	8.79	4.515	−0.658	0.254	−2.56	37	0.015
	Walking distance	3.34	0.994	3.63	1.195	−0.289	0.092	−3.16	37	0.003

Table 11. "Before" and "after" Wilcoxon test results of three sub-groups' walking visits to destinations.

Group Branch	Variable	Related Samples Wilcoxon Test					
		Mean	SD	SE	*z*	*N* *	sig
Middle-aged and Elderly	Walking frequency to GS	3.82	2.46	5.852	2.392	38	0.017
No car	Walking frequency to RS	3.90	2.45	4.623	2.271	51	0.023
	Walking frequency to R	2.08	1.46	5.690	2.460	38	0.014
	Walking frequency to GS	2.83	1.91	15.652	3.354	48	0.001
Less than high school	Walking frequency to R	1.86	1.28	4.500	2.333	22	0.020
	Walking frequency to GS	3.97	2.58	5.852	2.392	31	0.017

* Samples with zero destination visits or no changes were removed.

(1) All three sub-groups reported increased walking frequency and walking distance. The increase in walking distance was significantly longer in the "no car" subgroup ($M = -0.404$), followed by the middle-aged and elderly subgroup ($M = -0.366$). The increase in walking frequency was significantly higher in the "less than high school" education subgroup ($M = -0.658$), followed by the middle-aged and elderly subgroup ($M = -0.634$).

(2) The report on visit frequency to destinations revealed specific contents of significant differences in the pedestrian behaviour of residents before and after project implementation. Among the

three destinations, only the differences in green open space have commonality. In summary, walking distance and travel frequency of middle-aged and elderly residents improved after project implementation, which is reflective of recreational walks to visit the green open space. Kim et al. (2014) [23] indicated that recreational walking is more sensitive to the walking environment. The difference between built environment factors, however, was the comprehensive result of three group variables: street connectivity, pedestrian accessibility, and perceived walkability. From the specific content of respondents' walking behaviour changes and the significant difference results of perceived walkability changes, at least one result could be measured: the change in the built environment brought about by the project has a significant relationship with the recreational walking promotion of middle-aged and older residents.

6. Discussion and Conclusions

Based on the change in the built environment brought by the implementation of the regeneration project, this study focuses on and evaluates the correlation of residents' walking trips before and after the change through a quasi-longitudinal method. We adopt comprehensive indicators to evaluate built environment walkability, including not only developed physical environment calculation indicators but also perceived walkability and interaction indicators in the 7C layout. The results show that the project has significantly improved perceived walkability in the environment, and residents have also reported a desirable walking safety and streetscape experience index. Although there may be some residents with individual constraints or other objective factors, results can still be obtained from this paper. As we assume the increase in recreational walking is significantly related to the implementation of this project, the preliminary assumption of the correlation between recreational walking and the built environment is valid. For utilitarian walking, only positive changes in residents' visits to retail venues and restaurants were observed, while the other content did not receive a strong data response in this study.

The first phase project of the Zhangzhou ancient city's historic district retained the original form of its streets and alleys, mainly implementing environmental design and traffic system optimisation. The design of entrance squares and arrangement of landscape increased many open activity spaces; the optimisation of the traffic system reduced nuisances from vehicle traffic and enlarged pedestrian space, broadening the visual field. Intervention in commercial areas and growth of the tourism industry have turned many monotonous household-daily-necessity retail stores into featured local restaurants and diversified commodity retail, which facilitates more visits. However, there are still some limitations to this study. Even though scholars have been committed to providing reports on walking behaviour changes in built environments and discovering reasons for the changes via longitudinal design, subjective motivation, and triggers for walking are complex and uncertain. In addition to individual constraints, trip purpose or preferences generally affect the choice of walking for a private trip. Besides this, the perceived indicators of BE, such as site quality, health, neighbourhood satisfaction, or social connectedness, also effect walking results. Especially for residents who are familiar with the surrounding neighbourhood environment, even the captured changes may only be temporary results. The sustainability of the positive impact is still unknown; sometimes, social activities are more influential than the built environment for residents' pedestrian behaviour [21]. Another limitation can be found in the content of pedestrian perception. Certain impacts on walking behaviour are found among the content of perceived walkability factors, but the specific pedestrian environment, community awareness, and detail factors (such as the architectural visual impact on both sides, street furniture, and street scale) that affect visual quality are not further captured.

Nevertheless, although objective and perceived environment measures have been proven to be important environmental correlates of walking in adults, most studies in this field are still conducted in the West [3]. The sprawling Western context is different from the compact Asian context; relevant research in China holds great significance, especially the evidence reported in this study that change of BE promotes the recreational walking of the middle-aged and elderly, which helps to improve their physical function, reduce the economic and social burden of NCDs, and improve individual quality of life [26].

The results support the hypothesis that changes in the built environment can effectively promote leisure walking behaviour, especially for the middle-aged and elderly. We believe this research has made a meaningful contribution to the literature on this topic. As our study is a case study that may involve the unique characteristics of a single city, this limits generalizability. More cross-sectional cases, combined with longitudinal exploration, need further research and the assembly of a catalogue. In addition, future research will need to take into account other trip modes like driving or cycling to contribute a comprehensive strategy of BE impact on travel behaviour.

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Article

The Role of Eco-Friendly Edible Insect Restaurants in the Field of Sustainable Tourism

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Abstract: The purpose of this study is to apply the concept of a green image in order to explore how to form behavioral intentions in the context of eco-friendly edible insect restaurants. This study analyzed 444 samples collected in South Korea in order to evaluate the theoretical model including 12 hypotheses. The data analysis results showed that a green image has a positive influence on attitude. In addition, attitude helps to increase desire, which in turn positively affects two sub-dimensions of behavioral intentions, such as intentions to use and word-of-mouth intentions.

Keywords: edible insect restaurants; eco-friendly; green image; behavioral intentions; attitude; desire

1. Introduction

The world's population is on a constant rise, and now it is approximately 7.7 billion, but will increase to about 9.7 billion by 2050 [1]. Such an increase in population causes severe food shortages because of limited resources [2]. Edible insects are receiving much attention as humans need new food sources to replace current food sources [3]. The Food and Agriculture Organization (FAO) also suggested that edible insects are the future food of mankind that can solve world hunger [4]. Edible insects are as high in protein, amino acids, and micronutrients, which are important nutrients for humans, as the meat of livestock [5]. Edible insects also have the advantage of not having a high-level entry barrier similar to that for livestock in terms of technology and monetary investment [6].

Green food can be defined as an organic and sustainable food in the restaurant industry [7], and previous studies have indicated that green food is regarded as pivotal for the sustainable development of the regional tourism [8]. In particular, in terms of the environmental aspect, edible insects aid to recycle animal waste, which leads to the protection of the environment [9]. In addition, Megido et al. also argued that compared to raising livestock, raising edible insects can reduce greenhouse gas, so it can be said that edible insects are green food [10]. According to Gössling and his colleagues [11], restaurant managers and the sustainable tourism service sector need to cooperate extensively in terms of environmental issues and global climate changes, and the industry should find ways to reduce carbon and waste for restaurant managers. In this sense, the eco-friendly role of edible insects is significantly related to the green image in the field of sustainable tourism since edible insect production not only has lower greenhouse gas emissions, but also higher feed-conversion efficiency because it requires less land and water when compared to livestock [12].

In recent years, consumers have a lot of interest in protecting the environment, so they try to purchase eco-friendly products/services, which fulfills their environmental needs [13]. For example, tourists actively enjoy involving themselves in sustainable food consumption including edible insects during their ecotourism holidays [12]. For this reason, restaurant companies make an effort to make their corporate image appear green to consumers [14]. If edible insect restaurants emphasize a green image based on their role of environmental protection, it will have a positive effect on consumer behavior. Although a green image of an edible insect restaurant is important in the context of sustainable tourism, there has been no research done on this subject.

To sum up, this study tried to explain how to form behavioral intentions in the context of eco-friendly edible insect restaurants. More specifically, this study examined the relationship between green image and attitude. In addition, this study investigated the effect of attitude on desire and two sub-dimensions of behavioral intentions including intentions to use and word-of-mouth intentions. In this situation, the results of this study will provide edible insect restaurant managers with important implications for developing effective green marketing strategies.

2. Literature Review

2.1. Eco-Friendly Edible Insect Restaurants

Although entomophagy, which means human consumption of insects, was first introduced by Bodenheimer [15], humans have been eating insects for thousands of years [16]. Currently, about two billion people around the world eat 1900 species of insects, such as crickets, buffalo worms, grasshoppers, ants, and cicadas as part of their food culture [17]. In addition, the market for edible insects in 2018 was approximately U.S. $400 million, and it is predicted to be approximately three times larger in 2023 [18]. According to Pliner and Hobden [19], food neophobia refers to a personal inclination to reluctance to try novel/unique foods. Thus, food neophobia and edible insects are highly correlated because edible insects can also seem disgusting to consumers. However, Olabi et al. [20] suggested that fear/negative emotions of novel/unique foods may gradually decrease with constant exposure. Therefore, in order to reduce the food neophobia of consumers, insect restaurant owners need to continuously promote edible insects, highlighting their merits.

These edible insects also play an important role in the restaurant industry. In the past, a small number of customers used edible insect restaurants, so they operated on a small scale. Nowadays, as more and more customers are looking for edible insect restaurants, their growth is exponential, and edible insect restaurants are operating even in five-star hotels [21]. For example, Linger restaurant, located in Denver, USA, uses insects as ingredients to provide a variety of menus to customers, and Sweet and Sour Crickets are the most popular [22]. In addition, Lardo, in Col. Condesa, an edible insect restaurant located in Mexico, is known for providing its customers with original menus, especially "huevo en torta", which means eggs on cake made using insects. In fact, Mexico has a number of edible insect restaurants that provide an "exotic" experience to tourists [23]. In Thailand, "Insects in the Backyard" serves food using insects such as crickets, grasshoppers, worms, and beetles [24]. In particular, the restaurant emphasizes the nutritional aspects of insects, and suggests that insects play an important role in human future food. China has a long history of edible insects, especially insect restaurants in Yunnan Province have become popular [25]. Furthermore, there are many edible insect restaurants in England, Japan, New Zealand, and Taiwan, and sales are increasing [12].

In recent years, as consumers' interest in environmental protection has increased in the restaurant industry, the eco-friendly role of edible insect restaurants has attracted attention [26]. Prior studies have consistently claimed that edible insects can play an important role in protecting the environment. First, it is widely known that many resources, such as grass and water, are used to raise livestock, which causes desertification [27]. On the other hand, edible insects are considered to be environmentally friendly because they require far fewer resources than livestock [28]. Second, greenhouse gas emissions from livestock have a negative impact on climate change [29], but edible insects have a very low level of greenhouse gas emissions, making a significant contribution to environmental protection [30]. Third, in terms of global warming potential (GWP), edible insects have lower levels of GWP compared to livestock such as beef and lamb [31].

In summary, edible insect restaurants are expected to play an important role in satisfying the eco-friendly needs of consumers, as edible insects are emerging as important new food sources that can replace traditional food sources in the environmental aspect. However, research on edible insect restaurants is insufficient.

2.2. Green Image

Human life has been enriched through several industrial revolutions, but on the contrary, these revolutions have caused environmental pollution [32]. In the late twentieth century, countries around the world recognized the seriousness of problems caused by environmental pollution, such as resource depletion and desertification, and governments have made efforts such as enacting laws on the protection of global environment [10]. As consumers' awareness of environmental protection increases, they are willing to pay more to buy eco-friendly products that are more expensive than general products in order to protect the environment [33]. For this reason, companies are making a lot of effort in various forms, such as green marketing and green management to make their images green [34].

The concept of a green image refers to "a set of perceptions of a firm in a consumer's mind that is linked to environmental commitments and concerns" [35]. Green includes the concept of natural environment and is also known as environmentally friendly or eco-friendly [36]. The green image of a company that satisfies consumers' environmental needs plays a major role in enhancing trust in the company, consequently creating strong brand equity [34]. In addition, green image helps to maximize consumers' intention to use and minimize consumers' switch intentions [37]. More importantly, since a green image of a company has a symbolic meaning that can represent the overall characteristics of the company, the green image plays a critical role in differentiating it from other competitive brands [34].

Prior research has examined the outcome variables of a green image in diverse fields. For instance, Lee et al. [38] examined how a hotel's green image affects behavioral intentions using 416 hotel guests. They found that the green image of the hotel favorably induces customers' behavioral intentions. In addition, Yusof, Musa, and Rahman [39] developed a research model, which focused on the relationship between a green image and loyalty in the retail industry. Their data analysis results indicated that there is a positive relationship between a green image and loyalty. In other words, when people have a green image of a certain brand, they have a high loyalty to that brand. Martínez [35] also explored the effect of a green image on loyalty and identified that a green image positively affects loyalty. That is, people have high levels of brand loyalty if the brand has a green image.

2.3. Effect of Green Image on Attitude

First, this study proposes how a green image plays a role in forming attitude. Although many scholars have suggested the definition of attitude, the definition proposed by Ajzen [40] is the most frequently cited. The author emphasized the importance of attitude in order to explain consumer behavior through the theory of planned behavior (TPB), and defined attitude as "the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior" [40]. In other words, attitude is a personal subject of an object or person, so the attitude is formed based on the values or beliefs that an individual seeks [41], which suggested that there is a positive association between green image and attitude. For instance, if consumers have strong beliefs about the protection of the natural environment, they will have a favorable attitude toward using eco-friendly products/services.

Existing studies have also supported the effect of green image on attitude. For example, Han, Yu, and Kim [42] explored the relationship between green image and attitude in the tourism industry, and they suggested that a green image is a vital predictor of attitude. That is, people have a favorable attitude to a certain brand when the brand has a green image. In addition, Hwang and Lyu [43] developed a research model in order to identify how a green image aids to enhance attitude in the airline industry, and they suggested that when consumers perceive a green image from a certain airline, they have a favorable attitude toward using that airline. Hwang and Kim [33] also investigated the role of green image in forming attitudes in the context of eco-friendly drone food delivery services.

The authors showed that a green image helps to make consumer's attitude favorable. Based on the theoretical and empirical studies discussed above, this study presents the following hypothesis.

Hypothesis 1 (H1). *Green image has a positive impact on attitude.*

2.4. Effect of Attitude on Desire and Behavioral Intentions

Desire is defined as "a state of mind whereby an agent has a personal motivation to perform an action or to achieve a goal" [44]. A particular behavior is formed by internal stimulation, which is known as the state of desire [44]. Desire is heavily affected by a positive or negative appraisal, which aids to form behavioral intentions [45]. For example, when a consumer makes a positive assessment of a certain product/service, they have a greater desire to use the product/service.

According to the model of goal-directed behavior (MGB), desire is a strong motivation for consumers to do a certain behavior they aim for and is shaped by the attitude they have [45], which suggested that attitude is an important factor influencing desire. Existing studies have confirmed the effect of attitude on desire. For example, Meng and Han [46] applied MGB to the field of bicycle tourism, and they found that attitude was found to bear a significant impact on desire. In other words, when consumers have a positive attitude toward bicycle tourism, they would have a high level of desire to do bicycle tourism. Kim and Preis [47] also examined the relationship between attitude and desire based on the extended MGB in the tourism industry. The authors indicated that when tourists' attitudes toward using mobile devices for tourism-related purposes are good, they are more likely to have high levels of desire to use the devices. Based on the literature review above, this study proposed the following hypothesis.

Hypothesis 2 (H2). *Attitude has a positive impact on desire.*

Next, this study hypothesizes the relationship between attitude and behavioral intentions. Behavioral intentions are the likelihood that a person will attempt a particular behavior [40,48], and they consist of intentions to use and word-of-mouth intentions (e.g., Kim, Ng, and Kim, 2009; Maxham, 2001) [49,50]. Intentions to use can be defined as "the degree to which a person has formulated conscious plans to perform or not perform some specified future behavior" [51]. Consumers have intentions to use through a positive appraisal of products or services, which has a direct impact on a company's sales [52]. In addition, word-of-mouth refers to "informal communication directed at other consumers about the ownership, usage or characteristics of particular goods and services and/or their sellers" [53]. The effect of word-of-mouth has more influence on consumers than the commercial advertisement of companies because people get information from acquaintances including family, friends, and relatives [54].

The relationship between attitude and behavioral intentions is theoretically supported by the theory of reasoned action (TRA) and the theory of planned behavior (TPB) [48,55], which indicated that attitude is an important factor that leads to behavioral intentions. The effect of attitude on behavioral intentions has been demonstrated in many fields. For instance, Alzahrani, Hall-Phillips, and Zeng [56] tried to find the relationship between attitude and behavioral intentions using the TRA, and they showed that when consumers have a favorable attitude toward using hybrid electric vehicles, they tend to have high levels of behavioral intentions. More recently, Yarimoglu and Gunay [57] employed the extended TPB in the green hotel industry. They showed that attitude is a significant predictor of behavioral intentions.

Hypothesis 3 (H3). *Attitude has a positive impact on intentions to use.*

Hypothesis 4 (H4). *Attitude has a positive impact on word-of-mouth intentions.*

2.5. Effect of Desire on Behavioral Intentions

According to MGB, desire to take a particular action is a significant predictor of behavioral intentions [58]. Empirical studies have also supported the argument. For example, Han, Lee, and Kim [59] developed a research model in order to find the relationship between desire and behavioral intentions. They showed that desire helps to enhance behavioral intentions. In addition, Hwang and Kim [33] examined the relationship between desire and behavioral intentions using in the context of drone food delivery services. They found that when consumers have high levels of desire to use drone food delivery services, they are more likely to use the services. Hwang, Cho, and Kim [60] also tried to investigate how desire affects behavioral intentions in the context of eco-friendly drone food delivery services. They suggested that desire plays an important role in the formation of behavioral intentions. Based on the theoretical and empirical backgrounds, the following hypotheses are proposed.

Hypothesis 5 (H5). *Desire has a positive impact on intentions to use.*

Hypothesis 6 (H6). *Desire has a positive impact on word-of-mouth intentions.*

2.6. Research Model

Based on a total of six hypotheses, this study proposes the following research model (Figure 1).

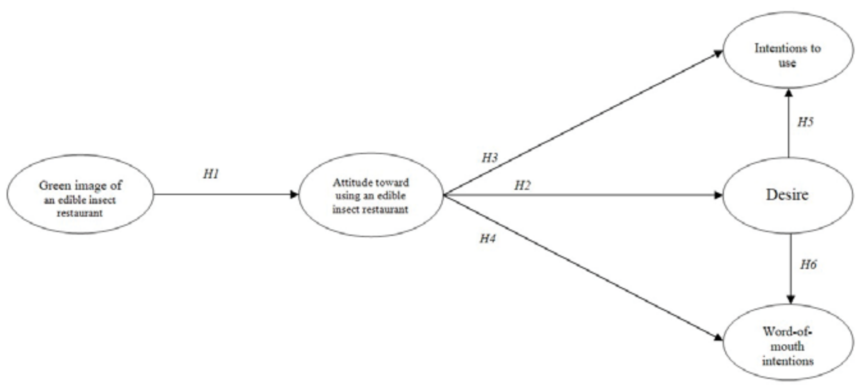

Figure 1. Proposed conceptual model.

3. Methodology

3.1. Measurement

First, a green image was measured with three items cited from Hwang and Kim [33] and Martínez [35]. Second, three items regarding attitude were cited from Ajzen [40] and Han and Hyun [61]. Third, desire was measured using three items adapted from Hwang and Kim [33] and Perugini and Bagozzi [58]. Fourth, in terms of behavioral intentions, three measurements for intentions to use were cited from Zeithaml, Berry, and Parasuraman [62], while word-of-mouth intentions were measured with three measurements borrowed from Hennig-Thurau, Gwinner, and Gremler [63].

All measurement items were measured using a seven-point Likert type scale (1 = strongly disagree; 7 = strongly agree). The survey was carefully reviewed by three expert groups including professors, graduate students, and restaurant employees in order to ensure content validity before finalizing the questionnaire, and they identified that there is high levels of content validity.

3.2. Data Collection

Data collection was performed using an online survey company system in South Korea. There were few edible insect restaurants in South Korea, so this study provided respondents with two newspaper articles and a video where anyone could easily understand the eco-friendly role of edible insect restaurants before beginning our survey. For example, the two newspaper articles and one video showed how to make insect foods and its important role in the protection of the environment. From the 6479 questionnaires distributed, 450 responses were collected. Responses with extreme answers and missing information were removed. As a result, 444 usable responses remained for further analysis. Prior studies including Hair et al. [64] and Weston and Gore [65] suggested that a sample size of 200 is satisfactory for performing confirmatory factor analysis (CFA) and structural equation modeling (SEM) with the maximum-likelihood estimation method. This implies that there was no problem with the representation of the sample.

4. Results

4.1. Profile of the Sample

The ratio of males and females in the sample was 50%. The mean age was 38.06 years, ranging from 20 to 59 years of age. The number of respondents in their 30s was the highest. In terms of monthly household income, 130 respondents (29.3%) answered that their income was between U.S. $1001 and U.S. $2000. In addition, 52.3% of the respondents (n = 232) were married, and 55.9% had a bachelor's degree (n = 248).

4.2. Confirmatory Factor Analysis

Table 1 showed the results of confirmatory factor analysis. The results indicated that the overall fit of the measurement model was acceptable. The factor loadings were equal to or greater than 0.843 and all factor loadings were significant at $p < 0.001$. As shown in Table 2, the values of average variance extracted (AVE) were greater than 0.50 for all constructs, which is the threshold value [66]. Considering the high levels of factor loadings and also the values of AVE in the measurement model, convergent validity for all of the measurement items had been achieved [67].

Table 1. Confirmatory factor analysis: items and loadings.

Construct and Scale Items	Standardized Loading [a]
Green image of an edible insect restaurant	
An edible insect restaurant is more likely to be successful about its environmental protection.	0.843
An edible insect restaurant is more likely to solve environmental problems.	0.870
An edible insect restaurant is more likely to have a strong environmental reputation.	0.888
Attitude toward using an edible insect restaurant	
Unfavorable—Favorable	0.922
Bad—Good	0.886
Negative—Positive	0.929
Desire	
I desire to visit an edible insect restaurant.	0.936
My desire to visit an edible insect restaurant is strong.	0.970
I want to visit an edible insect restaurant.	0.961
Intentions to use	
I will dine out at an edible insect restaurant.	0.953
I am willing to dine out at an edible insect restaurant.	0.957
I am likely to dine out at an edible insect restaurant.	0.967
Word-of-mouth intentions	
I am likely to say positive things about an edible insect restaurant to others.	0.887
I am likely to recommend an edible insect restaurant to others.	0.980
I am likely to encourage others to dine out at an edible insect restaurant.	0.937
Goodness-of-fit statistics: χ^2 = 211.179, df = 80, χ^2 df $^{-1}$ = 2.640, $p < 0.001$, NFI = 0.977, CFI = 0.986, TLI = 0.981, and RMSEA = 0.061	

[a] All factors loadings are significant at $p < 0.001$; df = Degree Freedom; NFI = normed fit index; CFI = comparative fit index; TLI = Tucker–Lewis index; and RMSEA = root mean square error of approximation.

As suggested by Fornell and Larcker [67], discriminant validity was evaluated by comparing the values of squared correlations between constructs and the values of AVE. The data analysis results showed that the values of AVE for each construct were higher than all of the squared correlations (R^2) between a pair of constructs (Table 2), which suggested an acceptable discriminant validity. In addition, the values of composite reliability were greater than the 0.70 threshold [64], which showed that all of the measurement items were highly reliable and internally consistent.

Table 2. Descriptive statistics and associated measures.

Variables	No. of Item	Mean (SD)	AVE	(1)	(2)	(3)	(4)	(5)
(1) Green Image	3	4.56 (1.04)	0.752	0.901 [a]	0.524 [b]	0.563	0.526	0.580
(2) Attitude	3	4.06 (1.48)	0.833	0.275 [c]	0.937	0.827	0.838	0.730
(3) Desire	3	3.67 (1.41)	0.914	0.317	0.684	0.969	0.840	0.828
(4) Intentions to Use	3	3.66 (1.42)	0.920	0.277	0.702	0.706	0.972	0.856
(5) Word-of-Mouth Intentions	3	3.78 (4.29)	0.875	0.336	0.533	0.686	0.733	0.954

SD = standard deviation; AVE = average variance extracted; [a] Composite reliabilities are along the diagonal; [b] Correlations are above the diagonal; [c] Squared correlations are below the diagonal.

4.3. Structural Equation Modeling

The SEM results showed that the proposed model fit the data well. Table 3 describes the SEM results with standardized coefficients and their t-values. The results showed that all six hypotheses were statistically accepted.

Table 3. Standardized parameter estimates for structural model.

			Coefficients	*t*-Value	Hypothesis
H1 Green Image	→	Attitude	0.545	11.44 *	Supported
H2 Attitude	→	Desire	0.833	23.23 *	Supported
H3 Attitude	→	Intentions to use	0.149	4.19 *	Supported
H4 Attitude	→	Word-of-mouth intentions	0.123	2.18 *	Supported
H5 Desire	→	Intentions to use	0.833	21.44 *	Supported
H6 Desire	→	Word-of-mouth intentions	0.741	12.50 *	Supported
Goodness-of-fit statistics: χ^2 = 261.048, df = 84, $\chi^2\ df^{-1}$ = 3.108, $p < 0.001$, NFI = 0.972, CFI = 0.981, TLI = 0.976, and RMSEA = 0.069					

* $p < 0.05$; NFI = normed fit index; CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root mean square error of approximation.

5. Discussion and Implications

The current paper was mapped out to explore the formation of behavioral intentions in the field of eco-friendly edible insect restaurants. A research model with a total of six hypotheses was tested using 444 samples collected in South Korea. The data analysis results indicated that there is a positive relationship between green image and attitude. Additionally, it was found that attitude was a critical predictor of desire. Furthermore, desire positively affects intentions to use and word-of-mouth intentions.

5.1. Theoretical Implications

First, the salient impact of green image on attitude was found, and it can be interpreted that when consumers perceive that edible insect restaurants are more likely to solve environmental problems, they are more likely to have a good attitude toward using them. As consumers become more environmentally conscious [68,69], research on green images becomes more common. For instance, the concept of green image was applied at airlines, café, drone food delivery services, and hotels [33,43], which suggested that a green image of the product/service makes the consumer's attitude favorable.

In this respect, the result of this study is consistent with previous studies. However, unlike previous studies, this study applied the concept of green image and revealed the effect of green image on attitude for the first time in the field of edible insect restaurants, thereby providing important theoretical implications.

Second, the SEM results identified attitude as an important factor in the formation of desire. That is, when consumers have a favorable attitude toward using edible insect restaurants, their desire of using the restaurants is strong. The relationship between attitude and desire was theoretically supported by the MGB [45], and also the existing literature has consistently confirmed the relationship (e.g., Hwang, Kim et al., 2019; Kim and Preis, 2016; Meng and Han, 2016) [33,46,47], which indicated that attitude plays a vital role in the formation of desire. In addition, our analysis identified the prominent influence of attitude on two sub-dimensions of behavioral intentions including intentions to use and word-of-mouth intentions. That is, consumers tend to dine out at edible insect restaurants and say positive things about them to others when they have a positive attitude. The theoretical evidence for the relationship between attitude and behavioral intentions is through TRA and TPB [48,55]. In addition, prior research has verified the relationship in many different fields (e.g., Alzahrani et al., 2019; Yarimoglu and Gunay, 2019) [56,57]. In this regard, the significant theoretical implication of this study is that we confirmed and extended the current literature by empirically identifying the effect of attitude on desire, intentions to use, and word-of-mouth intentions in the context of edible insect restaurants.

5.2. Managerial Implications

First, the current study confirmed that a green image of edible insect restaurants induces a positive attitude toward using them, which in turn positively affects desire and two sub-dimensions of behavioral intentions. The findings suggested the importance of green image in the context of edible insect restaurants. In fact, many restaurant companies are making an effort to impress consumers with their green image. For instance, Starbucks, the world's largest coffee brand, will stop using disposable plastic straws by 2020 and replace them with paper or compostable plastic straws [70]. In addition, McDonald's produces more than 3000 tons of coffee peel each year during roasting. McDonald's plans to reduce the negative environmental impact by using the coffee peel as a vehicle material with Ford [71]. The efforts of these companies play an important role in delivering their green image to consumers. As explained earlier, edible insects are greener food sources than livestock when comparing greenhouse gas emissions and GWP [28,29]. Thus, if edible insect restaurant owners emphasize the eco-friendly aspects of edible insects using advertising, which is considered a significant means that create a green image (e.g., Ankit and Mayur, 2013; Yoon and Kim, 2016) [72,73], the consumers would have a favorable attitude toward using them. Furthermore, as the results of our data analysis indicated, consumers are more likely to have a high level of behavioral intentions toward edible insect restaurants.

Second, from a sustainable tourism, destination marketing organizations can emphasize the green role of edible insect restaurants for their marketing strategies. It is important to educate tourists that visiting an edible insect restaurant can reduce carbon emissions, maintain sustainability from the perspective of food miles, and support the region's growing sustainable agriculture movement. It is recommended to provide menu books in an edible restaurant with a carbon footprint so that tourists can recognize to what extent they contribute to reduce the total greenhouse gas by their food choice. In addition, it is suggested that photos and promotional images include local farmers who sustain ways of life with growing edible insects to enhance the image of sustainability in a destination.

6. Limitations and Future Research

There are some limitations that provide opportunities for future research. First, the data collection was performed only in South Korea. Therefore, it is recommended that generalizing our study findings to other regions should be carefully done. Second, since edible insect restaurants are not activated in South Korea, the respondents in this study did not actually use the restaurants. In order to overcome this issue, two newspaper articles and a video, which clearly explain edible insect restaurants, were given to respondents before the start of the survey. However, it is necessary to collect data from other regions where edible insect restaurants are active in order to obtain data from people who actually use the restaurants. Third, eco-friendly behavioral intentions vary according to the demographic characteristics of consumers [74]. Therefore, future studies need to use demographic characteristics (e.g., gender and age) as a moderator.

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Article

Assessing the Effects of Information System Quality and Relationship Quality on Continuance Intention in E-Tourism

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Abstract: The advance of electronic commerce has resulted in successful e-travel services. Through the development of e-travel information, consumers can plan their trip without time and space limitations. This study proposes a model regarding the formation of the relationship quality (customer satisfaction and trust), information system quality, perceived value, and customers' intention to continue in the e-tourism environment. The study is based on 351 e-travel users in Taiwan. The result shows that customer satisfaction has a positive effect on continuance intention. Information system quality has a positive relationship with customer satisfaction, trust, and customer continuance intention. Furthermore, the perceived value has an effect on customer satisfaction and trust. However, the perceived value is partially related to customer continuance intention through customer satisfaction. The managerial implications of this study are discussed.

Keywords: e-tourism; information system quality; perceived value; relationship quality; continuance intention

1. Introduction

The success of electronic commerce (EC) is dependent on the internet infrastructure online services [1]. A new model of communication via e-mail, internet, e-travel, web services, and social media has increased in customer service, and the role of traditional communications such as the telephone has decreased [2]. The high-tech environments enable transactions to take place through virtual channels, no longer requiring the physical presence between customers and service providers. The trend is away from face-to-face contact and toward online services [2,3].

A focus on developing online consumers is central to business models in electronic commerce [4]. Travel agents and managers must learn how to maintain customer relationship quality and continuance intention, and they must understand the influence of antecedent factors in the e-tourism environment. Specifically, e-tourism has been rapidly rising in competition around the globe, and therefore many emerging agents have switched from business-to-business (B2B), business-to-consumer (B2C) and Business-to-Business-Consumer (B2BC) in order to sustain their existing customers.

Although the key role of relationship quality related to customer continuance intention has been previously studied, many critical issues still require research, including the formation of relationship quality [5] and customer continuance purchasing behavior to sustain existing customer loyalty in the e-tourism environment. It is clear that some critical factor needs to be developed to enhance customers' continuance intention in the e-tourism environment. Previous studies confirmed that customer loyalty was found to be directly influenced by customer satisfaction [6,7].

In the present study, we are focused on how the relationship quality (customer satisfaction and trust) is influenced by the information system quality and the customer's perceived value in the e-tourism environment. The study contributes to the e-tourism literature by extending previous studies and presenting a new concept on relationship quality and information system quality in the e-tourism context. The new construct of relationship quality consists of satisfaction and trust. The three components of information system quality—the information system, system quality, and service quality—are examined as a single construct to enhance the sustainable e-tourism environment. In Section 2, we present the literature review regarding the formation of relationship quality, information system quality, hypotheses, and a summary of our hypotheses in Table 1. The research methodology is in Section 3, our findings are in Section 4, and discussions and implications are in Section 5.

Table 1. Relationship hypotheses.

	Hypotheses	Part
H1	SAT has a positive relationship on customer CI	SAT->CI
H2	TR has a positive relationship on customer CI	TR->CI
H3a	ISQ has a positive relationship on customer SAT	ISQ->SAT
H3b	ISQ has a positive relationship on customer TR	ISQ->TR
H3c	ISQ has a positive relationship on customer PV	ISQ->PV
H3d	ISQ has a positive relationship on customer CI	ISQ->CI
H4a	PV has a positive relationship on customer SAT	PV->SAT
H4b	PV has a positive relationship on customer TR	PV->TR
H4c	PV has a positive relationship on customer CI	PV->CI

Note: SAT = satisfaction; CI = continuance intention; TR = trust; ISQ = information system quality; PV = perceived value.

2. Theoretical and Hypotheses Development

2.1. Relationship Quality

Previous studies have widely investigated relationship quality from different angles [5,8]. Relationship quality is recognized as a key to developing customer loyalty [7,9,10], as well as a number of different constructs related to satisfaction [8] and trust [6,7]. However, different authors have presented combinations of different constructs to indicate relationship quality. Two distinct dimensions of relationship quality (e.g., information sharing and communication quality) have been found to influence long-term customer satisfaction. Further, a recent study found that relationship quality consisted of customer satisfaction, service quality influence, customers' repurchase intentions, and subjective well-being [11]. The study suggests that relationship quality is a central issue for long-term success in management and business relationships [12]. Relationship quality is the factor that enhances profitability for both parties [13]. Therefore, relationship quality can be posited as an antecedent for customer continuance intentions [11]. Studies have proposed two dimensions of relationship quality (satisfaction and trust) as an antecedent of customer continuance intentions in the e-tourism context. Information system quality and customer perceived value are considered as the antecedents of relationship quality. Moreover, relationship quality affects customer satisfaction and trust, influencing the customer's continuance to purchase the product or service in the e-tourism environment. We define relationship quality as the customers' satisfaction and trust relationship toward the information system quality and the perceived product value and service. We define customer satisfaction as the customer perceived value of the information system quality that is provided by an e-tourism provider. We define customer trust as a customer's subjective belief that an e-travel agency can serve their needs and expectations.

2.2. Relationship Quality and Continuance Intention in E-Tourism

According to the expectation disconfirmation model, a customer's continuance intention is influenced by service quality and customer satisfaction [14]. In an e-commerce B2C model, it has been shown that customer satisfaction influences consumers' continuance intentions as the outcome of cognitive, affective, and conative loyalty [15]. Furthermore, relationship quality has a positive influence on repurchase intention in B2B e-commerce [16]. Satisfaction and trust have been examined as a single entity, where the relationship quality was considered as a second-order construct [16]. The present study shows that relationship quality consists of satisfaction and trust, which can predict a customer's continuance to purchase the product or service in the e-tourism environment. Customer satisfaction and trust are examined as separate entities to fit the advanced technology available. For instance, many customers may be satisfied with the information on a website, but this does not mean that the customer will trust the product or service provided. Based on the above literature, our study hypotheses are:

Hypothesis 1 (H1). *Customer satisfaction has a positive effect on continuance intention.*

Hypothesis 2 (H2). *Customer trust has a positive effect on continuance intention.*

2.3. Information System Quality

The information system was proposed in [17]. The study introduced the model, which posits three major dimensions: system quality, information quality, and user satisfaction in the context of organizations. Ten years later, in an update to the original Information System literature, the authors added service quality to the information system model to evaluate the information system through seven factors: information quality, system quality, service quality, information use, use, user satisfaction, and net benefits [18]. This develops a different definition regarding the information system [19]. The system quality consists of response time, system reliability, and system availability, which have a positive impact on the perceived ease of use and usefulness of website [18,20].

Service quality is defined as the user's perceptions regarding the service performance [21]. Service quality measures the discrepancy between what the customer feels and needs and what is offered accordingly to fulfill the customer's expectations [20,22]. For example, service quality on multi communication mechanisms enables the user to have their complaints responded to in a timely manner.

Information system success has been measured in four dimensions: completeness, accuracy, format, and currency [23]. For information quality, the user-perceived effectiveness of system quality measurements have included accuracy, relevance, adequacy, and included quality, timeliness, and sequencing [24]. Other studies have also shown that the information system quality has a significant relationship with perceived usefulness [19]. However, the numbers of previous studies have developed the information system quality in an e-commerce environment. This study adopts the model from the study in [18], as shown in Figure 1. We conceptualize three dimensions of system quality, information quality, and service quality as information system quality to adopt the advanced technology in the e-tourism environment. The information system quality is defined as products or services that fit customer needs and expectations to complete their transaction in the e-tourism environment. The products or services include itinerary services, reliable information, instant information, accurate operation, and specific information with easy access at anytime and anyplace by the customer. For instant, low-cost travel, travel agencies provide interconnected systems, such as TripAdvisor, ezfly.com, or skyscanner.com.tw.

The value that a service involves is not only by the provider but also through the opportunity for customer satisfaction and a trust relationship. The information system quality accommodates the swift customer mindset that has changed from traditional to online 24-h services. The travel agency reduces the time and travel expense, which benefits both parties. Our model has shown that customer trust and satisfaction are influenced by the information system quality and perceived value. The information system quality enhances the mindset of the customer relationship through a single entity of the product and service in an e-travel environment. Perceived value is dependent on the consumer's perceptions of what is received and what is given [25]. The customer's perceived value influences the customer satisfaction and trust regarding the product or service in the e-tourism environment. Based on the studies above, we propose the following hypotheses:

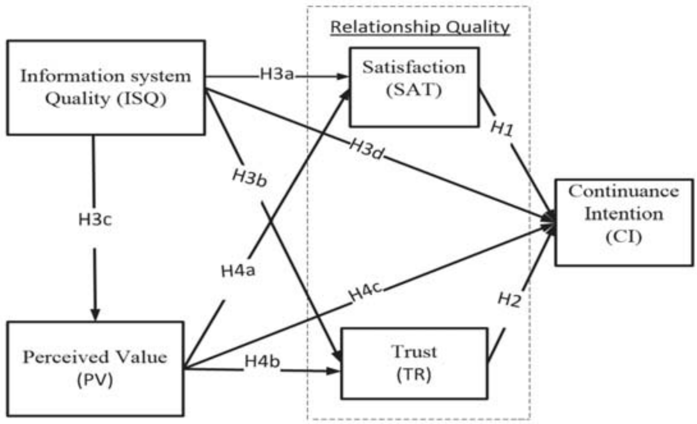

Figure 1. Relationship quality research model. Note: H = hypothesis.

Hypothesis 3 (H3). *Information system quality has an effect on customer (a) satisfaction, (b) trust, (c) perceived value, and (d) continuance intention.*

2.4. Perceived Value

The concept of value has constantly emerged from the different studies related to consumer behavior [25,26]. Prior studies suggested that perceived value is a better predictor of repurchase intentions than satisfaction, commitment, or trust [26]. Furthermore, the perceived value of the product and service could attract new consumers and result in benefits to the vendor [6,27,28]. Our model has shown that customer satisfaction and trust relationships are influenced by the customer's perceived product and service value. The customer's perceived value influences the customer's continuance intention. Based on this literature, we propose the following hypothesis:

Hypothesis 4 (H4). *Perceived value has a positive effect on customer (a) satisfaction, (b) trust, and (c) continuance intention.*

3. Research Methodology

3.1. Subjects: Instrument Development and Measurement

The survey study was designed based on the previous study on the information system success and IT development in an e-commerce environment, looking at service quality, system quality, perceived quality, trust, satisfaction, and continuance of use. We developed and reworded the survey items to fit the present study. All the items in the questionnaire were modified from English, translated to Chinese, and then translated back to English. The initial version of the survey study was pretested by two Ph.D. students and one professor who is an expert in the field of questionnaire design for e-commerce studies. After obtaining feedback from the experts, we modified the questionnaires for the final measurements of the model.

The constructs are measured using five-point Likert scales, ranging from 1–5, with 1 indicating "strongly disagrees" and 5 indicating "strongly agrees". Information system quality was adopted from [14,18], with seven items. Perceived value, with five items, was modified from [26,28], and three items were taken for further data analysis. Customer trust, with four items, was modified from [6,29].

Satisfaction, with four items, was modified from [6]. Continuance intention was adapted from [30] with five items, and three items were taken for further data analysis, as the loading value was lower than the effective value.

3.2. Survey Collection

The questionnaire was targeted to online travel users such as students, information technology users, manufacturers, and customers in finance, public service, and medical fields, who have experience buying domestic or international travel itineraries such as air tickets, reservations, and car rentals, as well as experience booking hotels and other services in e-travel (e.g., Ezfly, Eztravel, Skyscanner, tripadvisor). We chose websites that were the most popular and where the systematic system can easily be accessed by personal computer (PC) and cell phones, with flexible times and affordable prices for young or elderly people. The data were collected over two months in Taiwan. For more information regarding the survey items, refer to Appendix A. To maximize the respondents' awareness on this survey, we contacted the respondents by email or sent the questionnaire on personal Facebook chat, Line chat, group Facebook, or Line chat. We distributed 450 questionnaires, and 376 were returned, with a response rate of 83.5%. After data sterilization, 25 respondents were dropped due to incomplete responses on the survey. The final sample employed in our study was 351 responses (93.4% of the total responses). We employed IBM SPSS 20 (Armonk, NY, USA) for descriptive analysis to assess the frequency, and the percent range of populations is shown in Table 2.

Table 2. Demographics of the respondents.

Demographic Respondents (*N* = 351)					
Characteristics	**Frequency**	**Percent (%)**	**Characteristics**	**Frequency**	**Percent (%)**
Gender			Occupation		
			Student	52	14.8
			Technology	38	10.8
Male	143	40.7	Manufacturing	75	21.4
Female	208	59.3	Finance	56	16.0
			Service	93	26.5
			Medical	37	10.5
Age			Monthly Income		
≤20	29	8.3			
21–30	89	25.4	≥1000$	45	12.8
31–40	56	16.0	1001–2000$	169	48.1
41–50	66	18.8	2001–3000$	49	14.0
51–60	78	22.2	3001–4000$	6	1.7
>60	33	9.4	<4000	82	23.4
Education			Travel service		
			hkexpress	70	19.9
≥Senior high school	70	19.9	ezfly	70	19.9
University/college	155	44.2	eztravel	103	29.3
Graduate above	126	35.9	TripAdvisor	85	24.2
			Others	23	6.6
Instruments					
PC	114	32.5			
Smartphone	237	67.5			

Note: PC = personal computer.

The majority of respondents used the online travel service itinerary for their travels, which showed that 59.3% were female and 40.7% were male. The participants were mostly from the age groups of 21–30 years old and 51–60 years old. The participants mostly work in manufacturing and public service from different sectors. The highest monthly income was 1001–2000 USD. The participants searched for information using a smartphone 67.5% of the time. Further, eztravel (29.3%) and TripAdvisor (24.2%)

were the most popular e-travel service websites for finding information and booking itineraries. The data samples were sufficient to identify the customers' behavior and to accommodate further study on the information system quality.

4. Data Analysis Results

4.1. Measurement Model Analysis

The measurement model and structural model was assessed with partial least squares (PLS) using Smarts-PLS 3.2.8 [31]. First, PLS is not as restrictive on the sample size as that designed in the structural equation model. The constructs in this study are all reflective. Therefore, a PLS modeling approach was chosen in this study.

Second, for the data analysis, we started with the PLS algorithm that can obtain at convergence, satisfying fixed-point equations which include measurement reliability and model validity.

The third, the bootstrap procedure [32] was used to test the significance of various results such as path coefficients, Cronbach's alpha, and R^2 values. As in bootstrapping, subsamples are randomly drawn observations from the original set of data. This process was repeated until a large number of random subsamples were created, which in the case of our study was 2000 subsamples. The estimations from the bootstrap subsamples were used to derive standard errors for the PLS-SEM results. With this information, *t*-values, *p*-values, and confidence intervals were calculated to assess the significance of model studies.

Four, confirmatory factor analysis was conducted to assess the item loadings, discriminant validity, and internal consistency of the model. Item loading and internal consistencies greater than 0.70 were considered acceptable [33,34]. Moreover, to assess convergent and discriminant validity, first, the indicators loaded should be stronger than corresponding ones on the other constructs. Second, the square root of the average variance extracted (AVE) should be greater than the internal-constructs correlations shown in Appendix B, (cross-factor loading) which confirms the presence of a valid discriminant. Furthermore, in Table 3, the Cronbach's alpha values range from 0.91 to 0.98, and the AVE ranges from 0.79 to 0.96, indicating acceptability [33]. These results demonstrate that all the measurements have an adequate acceptability level.

Table 3. Construct reliability and discriminant validity.

Constructs	Items	Cronbach's Alpha	Composite Reliability	AVE	CI	ISQ	PV	SAT	TR
Continuance Intention	CI	0.98	0.99	0.96	0.98				
Information system Quality	ISQ	0.97	0.98	0.87	0.78	0.93			
Perceived Value	PV	0.95	0.97	0.91	0.67	0.66	0.96		
Satisfaction	SAT	0.91	0.94	0.79	0.72	0.70	0.86	0.89	
Trust	TR	0.92	0.94	0.80	0.70	0.70	0.78	0.83	0.90

Note: AVE = average variance extracted.

Five, an exploratory factor analysis was conducted to determine the relationship factors in the Smart-PLS algorithms. The exploratory factor analysis results are shown in Table 4. Standard factor loading and the *t*-value on the measurements were significant at the level of 0.01–0.02. Table 5 shows all the items of latent variables correlations on their intended factors to determine if the survey study is adequate for further analysis.

Table 4. Weight and loading.

Constructs	Items	Outer Loading	Outer Weights	Standard Deviation	T Statistics
Continuance Intention	CI1	0.98	0.34	0.01	171.44
	CI2	0.98	0.34	0.01	161.33
	CI3	0.98	0.33	0.01	137.83
Information system Quality	ISQ1	0.95	0.16	0.01	97.28
	ISQ2	0.94	0.16	0.02	62.09
	ISQ3	0.92	0.15	0.02	49.69
	ISQ4	0.92	0.15	0.01	67.88
	ISQ5	0.93	0.15	0.02	61.26
	ISQ6	0.94	0.15	0.01	101.48
	ISQ7	0.90	0.14	0.02	54.40
Perceived Value	PV3	0.95	0.34	0.01	102.10
	PV4	0.96	0.35	0.01	134.48
	PV5	0.96	0.35	0.01	93.05
Satisfaction	SAT1	0.89	0.31	0.01	63.35
	SAT2	0.90	0.27	0.02	59.68
	SAT3	0.85	0.24	0.02	38.83
	SAT4	0.91	0.31	0.01	62.48
Trust	TR1	0.87	0.31	0.02	57.57
	TR2	0.88	0.27	0.02	52.50
	TR3	0.91	0.26	0.02	55.83
	TR4	0.92	0.28	0.01	69.56

Note: Both the standard deviation and *t*-value are for loading not for weighting.

Table 5. Latent variable correlations.

Constructs	Items	CI	ISQ	PV	SAT	TR
Continuance Intention	CI	1.00	0.78	0.67	0.72	0.70
Information System Quality	ISQ	0.78	1.00	0.66	0.70	0.70
Perceived Value	PV	0.67	0.66	1.00	0.86	0.78
Satisfaction	SAT	0.72	0.70	0.86	1.00	0.83
Trust	TR	0.70	0.70	0.78	0.83	1.00

4.2. The Results of Structural Model

The results of the Smart-PLS part coefficients and significance values are shown in Figure 2. Table 6 shows the summary of our hypotheses testing. Seven of the nine hypotheses have positive and significant relationships. Customer satisfaction has a positive and significant effect on continuance intention, which supports H1, SAT–CI ($\beta = 0.20$, $t = 2.59$, ** $p < 0.01$). However, the influence of customer trust has no significant relationship with continuance intention. Thus, H2 is not supported, trust–continuance intention (TR–CI) ($\beta = 0.13$, $t = 1.89$, $p < 0.05$). The testing (H3a, H3b, H3c, and H3d) showed that information system quality has a positive and significant effect on customer satisfaction, trust, perceived value, and customer continuance intention. Thus, H3a, information system quality–satisfaction (ISQ–SAT) ($\beta = 0.12$, $t = 2.99$, *** $p < 0.001$), H3b, ISQ–TR ($\beta = 0.33$, $t = 5.82$ *** $p < 0.001$), H3c, ISQ–perceived value (PV) ($\beta = 0.67$, $t = 17.0$ *** $p < 0.001$), and H3d, ISQ–CI ($\beta = 0.50$, $t = 7.50$, *** $p < 0.001$) were supported. Consequently, the (H3a, H4b), customer perceived value has a positive and significant effect on customer satisfaction and customer trust. Thus, H4a and H4b were supported (PV–SAT, $\beta = 0.50$, $t = 8.30$, *** $p < 0.001$, and PV–TR, $\beta = 0.56$, $t = 10.1$, *** $p < 0.001$). However, perceived value does not have a significant influence on customer continuance intention, and so H4c, PV–CI ($\beta = 0.07$, $t = 0.97$, $p < 0.05$) is not supported. The model also explains 67% of the variance of customer continuance intention, 81% of the variance of customer satisfaction, 67% of the variance of a customer trust relationship, and 44% of the variance of customer perceived value of the product or service on an e-tourism channel.

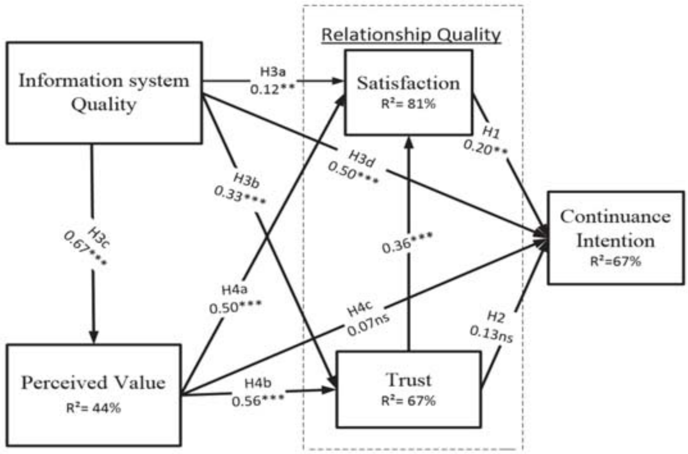

Figure 2. The results of the relationship quality model. Note: ** $p < 0.01 = t > 2.58$; *** $p < 0.001 = t > 3.29$; with a two-tailed test. ns = not supported.

Table 6. Summary the results of the hypotheses.

	Hypotheses	Path Coefficients	*t*-Value	Results
H1	SAT has a positive effect on customer CI	0.20	2.59	Supported
H2	TR has a positive effect on customer CI	0.13ns	1.88	Not supported
H3a	ISQ has a positive effect on customer SAT	0.12	2.99	Supported
H3b	ISQ has a positive effect on customer TR	0.33	5.82	Supported
H3c	ISQ has a positive effect on customer PV	0.67	17.0	Supported
H3d	ISQ has a positive effect on customer CI	0.50	7.50	Supported
H4a	PV has a positive effect on customer SAT	0.50	8.30	Supported
H4b	PV has a positive effect on customer TR	0.56	10.1	Supported
H4c	PV has a positive effect on customer CI	0.07ns	0.97	Not supported

Note: SAT = satisfaction; CI = continuance intention; TR = trust; ISQ = information system quality; PV = perceived value. ns = not supported.

4.3. Mediation Effects

To solve the problem in the hypotheses (H2, H4c), this study performed mediating effects following certain steps [35,36]. First, the study tested the significant indirect effect of the product paths "a" and "b") using the Sobel test [37].

The results showed that perceived value has a positive and significant effect on continuance intention through the mediator of customer satisfaction, PV–SAT–CI, with a Sobel-test statistic ($z = 3.10$, ** $p < 0.01$). Consequently, customer trust has a positive and significant effect on customer continuance intention through customer satisfaction, TR–SAT–CI, with a Sobel-test statistic ($z = 2.31$, * $p < 0.05$). Second, the study also accesses the variance-accounted-for (VAF) ratio by accounting effect (indirect effects/total effects = VAF). Thereby, we can determine the extent to which the dependent variable is directly explained by the independent variable and how much of the target construct variance is explained by the indirect relationship via the mediator variable [38,39]. If the VAF ratio is less than 20%, it shows a non-significant mediating effect; when the ratio is 20%–80%, it shows partial mediating effects, and when it is larger than 80%, it is assumed to have a fully mediating effect.

The test results showed that customer perceived value has a partially mediating relationship on continuance intention through the mediator customer satisfaction (PV–SAT–CI), with a variance-accounted-for (VAF) ratio of 75%. Furthermore, customer trust has a partially mediating relationship on customer continuance intention through the mediator of customer satisfaction (TR–SAT–CI) with a variance-accounted-for (VAF) ratio of 35%. The summary of mediating effects is shown in Table 7.

Table 7. Results of mediating effects.

Indirect Effect	IV-MD	MD-DV	C	c′	AB	Total Effect	Sobel	VAF%	Type
PV-SAT-CI	0.50 ***	0.20 **	0.20 ***	0.67 ***	0.21 ***	0.28 ***	3.10 **	75%	Partial
TR-SAT-CI	0.36 ***	0.20 **	0.28 ***	0.70 ***	0.07 **	0.20 ***	2.31 *	35%	Partial

Note: IV = independent variable; MD = mediator; DV = dependent variable; VAF = variance-accounted-for; IV-MD = The IV significantly affects the mediator; MD-DV = the mediator has a significant unique effect on the DV; C = the effect of the IV on the DV shrinks upon the addition of the mediator to the model; c' = The IV significantly affects the DV in the absence of the mediator; AB = the total indirect effect. * $p < 0.05 = t > 1.96$; ** $p < 0.01 = t > 2.58$; *** $p < 0.001 = t > 3.29$; with one-tailed test.

5. Discussion

5.1. Theoretical Implication

Several implications are obtained from this study. First, this study extends the previously study [18], and the findings support the research on information system quality by examining information quality, system quality, and service quality as a single entity.

Second, the prior study on customer relationship quality examined this quality as a single entity and showed a positive and significant effect on continuance intention [7]. In this study, relationship quality was examined as two separate entities (customer satisfaction and customer trust). Customer satisfaction had a positive and significant effect on the continued use of the products or service in the e-tourism environment. Customers showed a continuance of trust in the products or service when the customer was satisfied with the product or service. The information system quality proved long-term usage investment on customer continuance intention, which differs from the existing studies [18] and supports [30,40] customer relationship quality in the e-tourism environment.

Third, the customer-perceived value has a positive effect on customer satisfaction and trust. However, perceived value has no significant relationship on customer continuous intention. Furthermore, perceived value has a partial influence on customer continuance intention through customer satisfaction. This means that without sufficient customer satisfaction, customers may not tend to purchase in the future or will be unable to retain long-term success in e-tourism. The travel agencies have to build existing customers through customer relationship quality, in particular, building customer satisfaction and trusting relationships.

The findings stated that the customer's relationship qualities (e.g., trust and satisfaction) are the main issues affecting the continuing usage intention in regard to information system quality. Providing a new model, such as a one-desk information service and improved relationship quality (customer satisfaction and trust) could enhance the impact of information system quality on the e-tourism environment.

Fourth, the study found that the majority of respondents who employ the online travel service for their travels were 59.3% female and 40.7% male. The mean gender show a similar benefit from the information system quality in e-tourism. Moreover, results also showed that the participants from ages 21–30 and 51–60 years old who worked in manufacturing and the public service from different sectors were more expected to continue to purchase the products or service.

Furthermore, the customers with income from 1001–2000 USD more frequently used the information and booking and were the most familiar with the websites Eztravel 29.3% and TripAdvisor 24.2%. However, most customers used a smartphone as their preferred tool for booking travel plans. We conclude that these characteristic customer behaviors are shown to provide continuance success in the information system applications in this e-commerce environment, which is different from the findings of previous studies [18].

5.2. Practical Implication

The practical implications for information system quality, perceived value, relationship quality, and customer's continuance intention offer important implications for travel agencies and managers in e-tourism. To improve IS quality in the e-tourism environment, the travel agency and manager has to upgrade the operational process infrastructure and delivery service transaction to match real-time customer expectations. Furthermore, they require software and hardware with an advanced information system that can prevent technical difficulties and transactions overloading [30].

Managers and practitioners can use these results as guidelines to develop websites, operations, and provide advance support to customers. The measurement of information system quality can enhance products and services to help managers and organizations provide better products and services in the e-tourism environment. In addition, these results may apply a particularly powerful benchmark against competitors' websites that can affect long-term development activities on e-tourism. Our findings not only support a viewpoint on information system quality development, but also on building customer relationship quality through the application of customer satisfaction and trust provided by the e-tourism provider. Service providers can provide an incentive program such as purchasing a bundle program for customer travel planning. Furthermore, the study also demonstrated the positive and significant influence of perceived value on customers' continuance intention through customer satisfaction, which enhances long-term customer success in adopting a new program such as a package information service. This may suggest that enhancing information system quality is not only to satisfying for the customers but also helps to build customer trust relationships in an e-tourism environment.

6. Conclusions and Future Study

This study has important implications for the researcher and practitioner. The study concludes that customer relationship quality (satisfaction) has positive effects on customer continuance intentions. However, customer trust also has a partial relationship on continuance intention through customer satisfaction. In addition, information system quality has a significant relationship with customer satisfaction, trust, perceived value, and continuance intention. Furthermore, the customer-perceived value is also significantly related to customer satisfaction and trust, but it is partially related to customer continuance intention through the customer satisfaction relationship.

However, nowadays, e-tourism companies have greatly invested in training programs and advertising campaigns to transform information system quality for the users. This study provided more comprehensive findings on the information system and examined three dimensions (information quality, system quality, and service quality) in a single entity as information system quality, but it also separately examined the relationship quality that consists of customer satisfaction and trust in the e-tourism environment. We attempted to integrate perceived value and customer relationship quality with the model on customer continuance intention. Some interesting findings that were not discussed in previous studies are also covered in the current study. A large sample in this study is from the manufacturing and services sector, which is due to the customer trust and satisfaction in e-tourism. This study also provides meaningful implications on e-tourism continuance intention behavior.

A limitation in this study is using self-report instruments, as this may have the potential for a common method bias in measuring the study variables [41]. Hence, we diminished the probability of common biases by segregating the instruments and motivating the participants in the study. Furthermore, study data were collected in Taiwan. The travel forum members have similar culture and convenience traits. More research across countries and cultures will be required in order to generalize the findings. Finally, future studies also have the possibility to investigate different factors that can be integrated into the model.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Survey item.

Part 1: Demographic					
Gender	*1□ Male 2 □ Female*				
Age	*1□≥ 20 2□ 21–30 3□31–40 4□ 41–50 5□ 51–60 6□ < 60*				
Education	*1□ ≥Senior high school 2 □ University/college 3 □ Graduate above*				
Occupation	*1.□ Student 2□ Technology 3□ Manufacturing 4□ Finance 5□ Service 6 □ Medical*				
Monthly Income	*1□≥1000$ 2□1001-2000$ 3□2001–3000$ 4□3001-4000$ 5□ < 4000*				
Travel service	*1□ hkexpress 2□ ezfly 3□ eztravel 4□ sky scanner 5□ TripAdvisor 6□ Others*				
Instrument	*1□ PC 2 □ Smart phone*				
	Strongly disagree	Disagree	Neutral	Disagree	Strongly agree
Part 2(ISQ): This section to know; How do the information system quality and the website system provided service the on customer online travel.					
Information System quality [14,18,42]					
1. Online travel provider provided the customer with a complete information itinerary	□	□	□	□	□
2. Online travel provider provided travelers a complete reliable information	□	□	□	□	□
3. Online travel provider provided travelers with instantaneous information	□	□	□	□	□
4. Online travel provider provided travelers accurately operators	□	□	□	□	□
5. Online travel provider provided the information what I need	□	□	□	□	□
6. Online travel provider provided the customer with information on specific websites	□	□	□	□	□
7. Online travel provider provided appropriate information	□	□	□	□	□
Part 3(PV): This section to know; How do you feel about the value of service and product provided by online travel agency [26,28,43]					
1. Online travel agency can save more time and travel expenses.	□	□	□	□	□
2. Online travel agency allows me quickly complete of my travel itinerary	□	□	□	□	□
3. Online travel agency, it is helpful to me.	□	□	□	□	□
4. Although it takes some time to compare travel itineraries on the Internet, it is worthwhile to do so.	□	□	□	□	□
5. In short, online travel agency provided more benefit and fast processing the information.	□	□	□	□	□

Table A1. *Cont.*

Part 4: This section to know; 1. How do you trust the service and the products provided by travel agency [6,25,29].					
1. I think the company that provides online travel website and information is reliable.	☐	☐	☐	☐	☐
2. I think the services provided by online travel operators are trustworthy.	☐	☐	☐	☐	☐
3. Online travel operators should able to perform services and promised to users	☐	☐	☐	☐	☐
4. I believe that online travel provider has the ability to protect user	☐	☐	☐	☐	☐
2. How do you satisfies with the online service provided by travel agency [6,44]					
1. I am satisfied with the travel planning provided by the online travel agency.	☐	☐	☐	☐	☐
2. I am satisfied with the information provided online on website.	☐	☐	☐	☐	☐
3. I am sure that the online travel website is such a convenience service	☐	☐	☐	☐	☐
4. The product or service provided by online travel agency are generally quite profitable	☐	☐	☐	☐	☐
Part 5 (CI) [9,40]: This section, To know about how your future planning on e-tourism					
1. The overall experience of using online travel websites is enjoyable.	☐	☐	☐	☐	☐
2. I am willing to use the services provided by online travel agency	☐	☐	☐	☐	☐
3. I will use the travel website to plan my travel itinerary in the future.	☐	☐	☐	☐	☐
4. I would like to introduce the travel itinerary to my friends	☐	☐	☐	☐	☐
5. I am willing to continue to purchase product or service itinerary provided by the online travel provider.	☐	☐	☐	☐	☐

Appendix B

Table A2. The Result of cross loading.

		Cross Loadings				
Constructs	**Items**	**CI**	**ISQ**	**PV**	**SAT**	**TR**
Continuance Intention	CI1	0.98	0.76	0.68	0.71	0.70
	CI2	0.98	0.77	0.66	0.71	0.69
	CI3	0.98	0.75	0.64	0.69	0.67
Information system Quality	ISQ1	0.76	0.95	0.66	0.68	0.67
	ISQ2	0.76	0.94	0.66	0.69	0.69
	ISQ3	0.72	0.92	0.59	0.63	0.62
	ISQ4	0.70	0.92	0.61	0.64	0.65
	ISQ5	0.71	0.93	0.62	0.66	0.66
	ISQ6	0.73	0.94	0.61	0.66	0.66
	ISQ7	0.68	0.90	0.58	0.61	0.60
Perceived Value	PV3	0.60	0.63	0.95	0.80	0.76
	PV4	0.66	0.64	0.96	0.82	0.75
	PV5	0.66	0.64	0.96	0.84	0.72
Satisfaction	SAT1	0.70	0.66	0.87	0.89	0.73
	SAT2	0.58	0.60	0.72	0.90	0.72
	SAT3	0.51	0.53	0.63	0.85	0.70
	SAT4	0.71	0.68	0.80	0.91	0.78
Trust	TR1	0.69	0.71	0.76	0.83	0.87
	TR2	0.59	0.59	0.66	0.73	0.88
	TR3	0.58	0.55	0.66	0.68	0.91
	TR4	0.63	0.63	0.69	0.71	0.92

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The Evaluation Method of Low-Carbon Scenic Spots by Combining IBWM with B-DST and VIKOR in Fuzzy Environment

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Abstract: With the concept of sustainability gaining popularity, low-carbon tourism has been widely considered. In this paper, a multicriteria group decision making (MCGDM) process based on an uncertain environment is proposed to study the evaluation problem of low-carbon scenic spots (LSSs). In order to minimize the influence of subjective and objective factors, the traditional Vlse Kriterjumska Optimizacija I Kompromisno Resenje (VIKOR) method is expanded, using the improved best and worst method (IBWM) and Bayes approximation method, based on Dempster-Shafer Theory (B-DST). First, in order to make the evaluation process more professional, a number of evaluation criteria are established as effective systems, followed by the use of triangular intuitionistic fuzzy numbers (TIFNs) to evaluate alternatives of LSSs. Next, according to the evaluation results, the weights of the criteria are determined by the IBWM method, and the weights of the expert panels (Eps) are determined by B-DST. Finally, a weighted averaging algorithm of TIFN is used to integrate the above results to expand the traditional VIKOR and obtain the optimal LSS. The applicability of this method is proven by example calculation. The main conclusions are as follows: tourist facilities and the eco-environment are the two most important factors influencing the choice of LSSs. Meanwhile, the roles of management and participant attitudes in LSS evaluations cannot be ignored.

Keywords: low-carbon scenic spots; multicriteria group decision making; IBWM; B-DST; VIKOR; low-carbon

1. Introduction

Low-carbon tourism was first proposed during the 2009 World Economic Forum "towards low-carbon tourism" [1]. As a means of sustainable development, low-carbon tourism can promote economic growth and social development. The study found that carbon dioxide emissions from tourism development account for 4.4% of total global carbon emissions. And by 2035, emissions are expected to grow at an average rate of 3.2% per year [2]. Therefore, the role of tourism in the development of a low-carbon economy cannot be ignored [3]. LSSs are an important carrier for low-carbon tourism. While on holidays, tourists generate a lot of carbon emissions, including through food, accommodation, traffic, visits, shopping, and entertainment. Therefore, more and more scenic spots are beginning to actively respond to the call for the implementation of low-carbon policies in the development process. Many tourist facilities in the Yanzigou Scenic Spot in Sichuan province are specially designed to meet low carbon demands. For example, the garbage bins in the scenic area are humanized, and there are slogans which remind visitors to make an effort to maintain environmental sanitation.

However, academic research on LSSs has lagged behind. Therefore, it is necessary to understand the connotation of LSS and establish an evaluation system as quickly as possible. This would provide not only a scientific basis for macro carbon emission reduction decisions, but also theoretical guidance for future LSS criteria verification, emission reduction project cooperation, and the establishment of an emission compensation system. At present, most published studies have focused on qualitative analyses, while few quantitative analyses have been published. Moreover, studies of scenic spots have only focused on the construction of a system of criteria [4–6].

In this paper, the evaluation of LSSs is studied by combining TIFNs, IBWM, B-DST, and the expanded VIKOR method (as shown in Figure 1). The IBWM is used to determine the criteria weights of LSSs. BWM is a very effective multicriteria decision method (MCDM) which is used to determine criteria weights. It was proposed in 2015 as a new approach [7], so it has some shortcomings, which are mainly reflected in two aspects. On the one hand, in the process of using traditional BWM, the best and worst criteria are determined only by the subjective decisions of experts. On the other hand, the 1–9 scale is insufficient to express the difference between the best and worst criteria [8]. In this paper, an entropy weight method and TIFNs are used to make up for these shortcomings. The entropy weight method is introduced to modify the subjective weight. For the second deficiency, TIFNs is used as the evaluation language to measure the deviation degree of the difference criterion. At present, there are many fuzzy languages; TIFNs was chosen because it can better express the hesitation degree of decision-making problems in reality. In addition, due to the complexity of information in MCGDM, a single decision maker is often affected by subjective factors, and cannot represent the comprehensiveness of the problem. In this case, multiple experts from different fields are required to participate in the decision. Therefore, the weight information determination of decision makers is a particularly important research field. B-DST is an extension of Dempster-Shafer Theory (DST), which is different from DST in terms of knowing the prior probability. In addition, it is a good way to express the difference between "uncertain" and "don't know", and the reasoning form is not complicated. Therefore, it is widely used in uncertain environments [9,10]. The criteria and expert weights can be obtained effectively through the above two methods; then, VIKOR is selected to determine the final ranking of alternative LSSs. VIKOR is actually a compromise sorting method, by maximizing the group benefits and minimizing the individual regret to compromise a sort limited decision scheme in different evaluation standards and complicated decision environments. Furthermore, it can effectively avoid subjectivity and uncertainty problems, and has high levels of reliability and rationality [11,12]. Finally, some of the major findings are summarized as the following related management science point of view: (1) The development of low-carbon tourism is the inevitable trend of the sustainable development of scenic spots, which requires both managers and tourists to have a low-carbon thinking, to focus on the overall situation, and to actively participate in low-carbon construction, so as to make scenic spots develop in a sustainable manner. (2) The construction of LSS can be effectively combined with modern electronic information technology to promote the intelligent development of scenic spot tourism. Scenic spots can start from the following points: Firstly, the construction of digital scenic spots, the integration of scenic spots planning, scenic spots protection, scenic spots services, and other information. Secondly, electronic tour guides can be developed. Finally, scenic spots can use electronic tickets. This is not only conducive to low-carbon management; low-carbon publicity can also play a role in increasing the level of enthusiasm of tourists. (3) Conditional scenic spots can use regional or ethnic characteristics transport (such as horse-drawn cart, camel manned), and provide battery cars, bicycles, or feature low-carbon vehicles for the convenience of tourists.

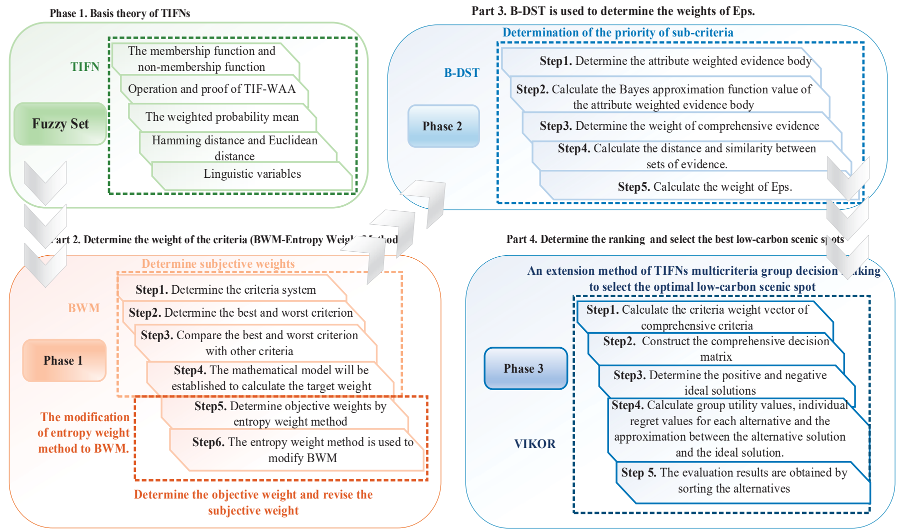


Figure 1. Steps of the evaluation method.

The structure of this paper is as follows: Section 2 presents a literature review including low carbon tourism and the methods used in the evaluation process. Section 3 establishes a criteria system for evaluating LSSs. Section 4 presents the proposed integrated framework for LSS criteria evaluation. Section 5 presents an example on LSS criteria evaluation to validate the proposed model, and the different sorting results obtained by different parameters and methods are discussed. Section 6 concludes the research process and puts forward some constructive suggestions.

2. Literature Review

Since this paper contains two major innovations, the literature review is divided into two aspects: The first presents a status analysis of LSS research, while the second presents an analysis of the MCDM used for the evaluation system.

The study of low-carbon tourism was first introduced in Europe and the United States [13]. Since the 1990s, with the emerging energy crisis and environmental pollution [14], several new types of tourism development have emerged, such as green tourism and eco-tourism. The general population is also increasingly focused on the impact of tourism development on the environment [15], especially with regard to carbon emissions, which has also received a good deal of expert attention. With the rise of research on energy utilization and greenhouse gas emissions, research on low-carbon tourism has mainly focused on the relationship between tourism and global climate change, investigating their interactions, as well as low-carbon tourism services. For example, the researchers investigated and came up with a quantitative measure of carbon emissions from travel-related traffic [16,17]. Peeters and Dubois argued that international aviation and private cars are dominant factors in high-carbon tourism [2]. Kuo and Chen used the LCA evaluation method to quantitatively study energy use, greenhouse gas emissions, wastewater, and solid waste related to tourism [18]. They concluded that both tourist consumption and waste emissions exceeded the daily usage of local residents. Becken et al. reported that the energy consumption of tourism has a strong correlation with the behavior of tourists [19]. Lin reported that the carbon emissions of private cars are more harmful to the environment than those of other traffic tools [20]. Tol suggested that a carbon tax affects the choice of tourists regarding tourism destinations [21]. Therefore, its implementation can reduce emissions to some extent. Similarly, current international research on low-carbon tourism services is focused on resource conservation and the environmental friendliness of tourism services. Various tourism service models have been proposed that reflect the low-carbon concept, and which are based on the protection of the ecological environment [22]. The practice model of low-carbon tourism services is constantly being enriched, e.g. by Spain's green energy-saving tourism, Germany's comprehensive tourism, Japan's environmental preservation tourism, Korea's environmentally-friendly tourism, and Israel's water-saving rural tourism. In addition, research on the evaluation methods of tourism service provision efficiency is becoming more substantive. Methods such as random value evaluation, the ecological effect method, the fuzzy comprehensive evaluation method, the ecological footprint method, and the multisector dynamic macroeconomic model have been used widely. For example, Blancas et al. used random value evaluation to analyze the efficiency of the utilization of resources in Spanish ecotourism [23]. Michalena et al. used the general equilibrium and multisector dynamic macroeconomic models to analyze the efficiency of the tourism industry [24].

Few relevant studies on low-carbon tourism have been published. The LSS is a source of low-carbon tourism, and also a key link in carbon emissions in tourism, which is of great significance for low-carbon tourism. In addition, the existing literature on scenic spots has mainly focused on evaluation criteria [25]. Low-carbon tourism scenic spots cannot be simply equated with energy conservation and emissions reductions, but should be extended to the four stages of resources and the environment, emission reduction technology, consumption management, and policy philosophy. Qian et al. divided the evaluation criteria for LSSs into four aspects which are relevant for the eco-environment, tourist facilities, management system, and participant attitudes using Delphi, and further expanded these aspects into two levels, thereby obtaining 27 four-level criteria [4]. The Xixi wetland was used as an example to verify the validity of the research. Among the existing studies, no evaluation method has been proposed for low-carbon tourist attractions. Therefore, this study proposes a MCDM method for the evaluation of scenic spots which converts the demands of tourists regarding scenic spots into the criteria of a LSS construction. Moreover, the relationship between the most important scenic spot criteria was also considered, which plays an important role in the construction of new scenic spots.

After a long period of development, the MCDM method has made some achievements. At present, common methods include the Analytic Hierarchy process (AHP), Network Analytic Hierarchy Process (ANP), Decision Experiment and Evaluation Experiment (DEMATEL), Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS), Linear Programming (LP), and the Data Envelope-Analysis method (DEA). In 1998, Opricovic proposed a VIKOR method which is applicable to MCDM technology, emphasizing the selection and ordering of alternative sets of conflict criteria [26,27]. It represents the distance from the positive ideal solution, taking into account the relative importance of all criteria, and the balance between overall satisfaction and individual satisfaction [28]. In order to effectively solve the disadvantage of fuzzy uncertainty in MCDM, Tian introduced triangular fuzzy number (TFN) theory into the MCDM method for the evaluation of a smart bike-sharing program (BSP), and language variables were used to quantify the performance of the alternatives [29]. Li and Zhao proposed a fuzzy GRA-VIKOR assessment of an ecological industrial power plant, and combined fuzzy AHP with a fuzzy entropy weight method to obtain subjective and objective comprehensive weights [30], which could be used to deal with the uncertainty in the decision-making process. Therefore, this paper applies the TIFN theory to effectively quantify fuzzy, subjective, objective, and uncertain linguistic variables. When using the MCDM method to evaluate LSSs, in addition to effectively quantifying the language variables, another issue that needs attention is determining the importance of different criteria and different Eps, so appropriate methods should be taken to determine the weight [31]. Wan used the entropy weight method to calculate the weight values of many supplier attributes [32]. Xu combined the subjective weight obtained by the G1 method with the objective weight obtained by the entropy method to determine the comprehensive weight of the attributes [33]. As a very effective multiattribute decision making method to gain the subjective weight, BWM was proposed by Rezaei in 2015, and was extended in 2016 [34]. In this paper, through the BWM method, the subjective weights of the LSS evaluation criteria are obtained, and the entropy weight method is used to modify them, which will make the evaluation results more accurate. At the same time, due to the complexity of decision information, it is often difficult for a single decision-maker to operate alone; Rather Eps from different fields are required to make decisions together. Therefore, the determination of weight information of decision-makers has become a particularly important research field. DST was formally put forward by Harvard University mathematician A.P.Dempster [35]. Subsequently, in 1976, his student Shafer further improved the theory [36]. Tang defined an aggregation operator within the framework of intuitionistic fuzzy multicriteria [37]. Liu and Gao combined the intuitionistic fuzzy set (IFS) with the DST to obtain expert weights in decision making [38]. The main content of this study is to solve the evaluation problems related to LSSs through a new MCDM method. In addition, this paper pays more attention to the establishment for a LSS criteria system in the evaluation process, which makes the decision-making results more comprehensive and scientific.

3. LSSs Evaluation Criteria System

In order to comprehensively evaluate LSSs, a complete evaluation criteria system should be established. Therefore, the realization of LSS was mainly carried out from four aspects: eco-environment, tourism facilities, management system, and participant attitudes. The specific criteria system is shown in Figure 2.

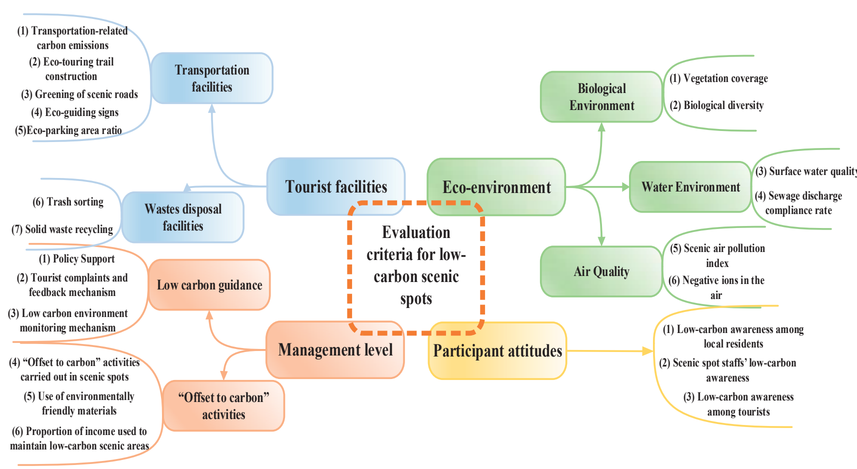


Figure 2. Evaluation criteria for LSSs.

3.1. Eco-Environment

LSS is composed of natural resource-type scenic spots, such as wetlands and forests. There are three main aspects to the evaluation for scenic resources: biological environment, water environment and air quality. The unique low-carbon landscape in the scenic area is the premise for the development of low-carbon tourism, and it is also the key to attracting tourists [39]. The type and quantity of vegetation affect the ecological environment of the scenic spot. The water environment, air quality, and the environment around the scenic spot are important evaluation criteria for the eco-environment in the scenic spot [40,41].

(1) Refers to the sum of all plant communities in a certain area. This criterion is usually used to reflect the green status in the scenic area.

(2) The quality of the ecological environment in the scenic spot is mainly reflected in the maintenance of species diversity in the scenic area.

(3) Refers to the surface water environmental quality standard of the People's Republic of China (GB3838-2002); surface waters includes rivers, lakes, canals, channels, reservoirs, and so on.

(4) The drainage of scenic spots must meet the national standard (GB8978-88) comprehensive sewage discharge standard.

(5) Simplifies the concentration of several air pollutants that are routinely monitored into a single conceptual index value form.

(6) The air negative ion concentration is used as the basic observation index, and the air quality is evaluated by the unipolar and the air ion evaluation coefficients

3.2. Tourist Facilities

To build a LSS, the facilities inside the scenic spot should have low-carbon and environmental protection effects, mainly including two aspects: transportation facilities and waste disposal facilities. These two points play an important role in the construction for LSSs, and are also important criteria for evaluating the carbon level in the area [42]. In the process of transportation, huge carbon emissions will be generated [43].

(1) Tourist attractions mainly choose green transportation modes such as battery cars and mountain bikes. At the same time, motor vehicles are prohibited from entering, reducing pollution and reducing carbon emissions from scenic traffic.

(2) Road construction in the scenic area should select materials that are in harmony with the natural environment, reduce the proportion of hardened roads, and set up animal passages and reminder signs.

(3) The road construction for scenic spots needs to increase the greening rate.

(4) For the guidance information in the scenic area, original materials such as stones, wood, and pebbles can be selected.

(5) The scenic ecological parking lot generally uses shrub as the isolation line and should minimize the area of the hardened parking lot.

(6) Set up sorting bins in the scenic spot, and recycle and treat the recyclable garbage and non-recyclable garbage separately.

(7) The disposal of solid waste should be treated in such a way that it minimizes the impact on the environment.

3.3. Management Level

Management level is a key factor by which to determine the quality of LSSs. Generally, management levels are divided into hard and soft management. Hard management mainly refers to some hard criteria such as management target compliance rates, policy support, implementation intensity, travel complaints and feedback mechanisms, low-carbon operating systems, and supervision agencies [44]. Software management mainly has two aspects: low-carbon publicity education and low-carbon tourism penetration. Although the soft management method in this area is not as strict as the hard target requirements, the role is equally important. Through the slowly infiltrating method of making brochures, signboards, etc., the low-carbon concept is now deeply rooted in the hearts of the people [45].

(1) National policy support will help to stimulate scenic spots in accelerating the promotion of low-carbon tourism and forming a cyclical model of the entire industrial chain.

(2) Reference to the people-oriented concept, i.e., one which is in line with the development needs of LSSs, and, at the same time, which is better able to protect the interests of travelers.

(3) The water and air quality of scenic spots are vital, and the corresponding detection mechanisms must be established to sensitively detect environmental changes.

(4) Install a device that calculates the carbon emissions of tourists. Furthermore, and a tree field should be set up for visitors. By purchasing planting seedlings, the "offset to carbon activities" of tourism can be achieved.

(5) Tourism products in the scenic spot can be more localized agricultural products, and tourism packaging is as ecological as possible, thereby avoiding the waste of resources caused by excessive packaging.

(6) In order to maintain the ecological environment and maintain the low-carbon effect, the scenic spot must invest a certain amount of its resources every year into maintenance.

3.4. Participant Attitudes

The participants in low-carbon tourism include tourists and local residents. Tourists are the ultimate consumers of low-carbon tourism products [46]. While visiting scenic spots, tourists' understanding of the low-carbon tourism concept will have an impact on their behavior regarding six aspects: food, accommodation, traffic, travel, visits, and entertainment. At present, low-carbon tourism is being recognized by more and more tourists. Local residents enjoy a good ecological and living environment brought about by low-carbon tourism resources. Their daily production and lifestyle should also meet a low-carbon standard [41]. Otherwise, it may indirectly have a destructive impact on LSSs.

(1) The attitude and participation of local residents toward low-carbon and environmental protection have an impact on the low-carbon operation of the scenic spot.

(2) Through the dissemination of low-carbon knowledge, all employees in the scenic area will influence tourists regarding their own low-carbon environmental behavior.

(3) Advocate low-carbon tourism and green tourism. Publicize and introduce low-carbon knowledge in public information materials.

4. Methodology

A novel MCDM method is introduced in this paper which combines TIFN, extended BWM, B-DST, and the extended VIKOR approach. Among these, TIFN is the basic evaluation language; extended BWM and combining evidence theory with Bayes approximation are mainly used to calculate the criteria and group decision makers, respectively. Extended VIKOR is the main research method.

4.1. Fuzzy Set Theory

The fuzzy set theory proposed by Zadeh aims to simulate the ambiguity or inaccuracy of human cognitive processes [47]. A fuzzy number is a particular fuzzy set: $\widetilde{a} = \{(x.\mu_{\widetilde{a}}(x)).x \in R\}$ and $\mu(x)$ are a consecutive mapping from R to the closed interval [0,1]. TIFN is an extension of the discourse space of an intuitionistic fuzzy number (IFN) from a discrete set to continuous set. Compared with the definition of IFS, TIFN relates the membership and non-membership degrees to the fuzzy concept of "excellent" or "good" by adding triangular fuzzy number (TFN) (a, b, c), so that the decision information of different dimensions can be expressed more accurately. It is possible to use TIFNs to process data under uncertain conditions. The functional distribution of TIFNs is shown in Figure 3.

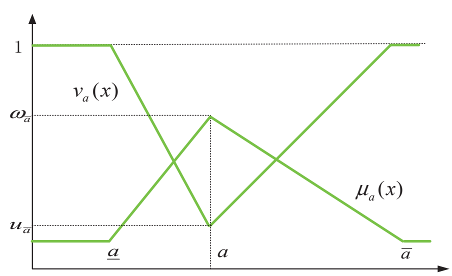


Figure 3. Functional distribution of TIFNs.

Definition 1. *Let* $\widetilde{a} = ((\underline{a}, a, \overline{a}); \omega_{\widetilde{a}}, u_{\widetilde{a}})$ *be a TIFNs on real number set R; its membership function and non-membership function can be represented as follows:*

$$\mu_{\widetilde{a}}(x) = \begin{cases} 0, & x < \underline{a} \\ \frac{x-\underline{a}}{a-\underline{a}}\omega_{\widetilde{a}}, & \underline{a} \le x < a \\ \omega_{\widetilde{a}}, & x = a \\ \frac{\overline{a}-x}{\overline{a}-a}\omega_{\widetilde{a}}, & a < x \le \underline{a} \\ 0 & x \ge \underline{a} \end{cases} \tag{1}$$

$$v_{\widetilde{a}}(x) = \begin{cases} \frac{a-x+(x-\underline{a})}{a-\underline{a}}u_{\widetilde{a}}, & \underline{a} \le x < a \\ u_{\widetilde{a}}, & x = a \\ \frac{x-a+(\overline{a}-x)}{\overline{a}-a}u_{\widetilde{a}}, & a \le x \le \overline{a} \\ 1, & x < \underline{a} \text{ or } x > \overline{a} \end{cases} \tag{2}$$

As shown in Figure 3, where $\omega_{\widetilde{a}}$ *and* $u_{\widetilde{a}}$ *respectively represent the maximum membership degree and the minimum non-membership degree, such that they satisfy the condition:* $0 \le \omega_{\widetilde{a}} \le 1$, $0 \le u_{\widetilde{a}} \le 1$ *and* $\omega_{\widetilde{a}} + u_{\widetilde{a}} \le 1$.

Definition 2. *The basic operation process of TIFN is described by Wan in detail [31].*

Definition 3. *For the TIFN* $\widetilde{a}_r = \left(\left(\underline{a}_r, a_r, \overline{a}_r\right); \omega_r, u_r\right)$ $(r = 1, 2, ..., k)$*, the weighted averaging algorithm (WAA) is defined as Equation (3) (The proof of Equation (3) is provided in Appendix A.1).*

$$TI - WAA(\widetilde{a}_1, \widetilde{a}_2, ..., \widetilde{a}_k) = \sum_{r=1}^{k} w_r \widetilde{a}_r = \left(\left(\sum_{r=1}^{k} w_r \underline{a}_r, \sum_{r=1}^{k} w_r a_r, \sum_{r=1}^{k} w_r \overline{a}_r\right); \min_r \omega_{\widetilde{a}r}, \max_r u_{\widetilde{a}r}\right) \tag{3}$$

Definition 4. *If* $\widetilde{a}_r = \left(\left(\underline{a}_r, a_r, \overline{a}_r\right); \omega_r, u_r\right)$ $(r = 1, 2, ..., k)$ *is a set of TIFN. The weighted probability mean* m^d *is calculated as follows:*

$$m^d = \frac{1}{12}\left(\underline{a}_r + 4a_r + \overline{a}_r\right)[(1 - u_r) + \omega_r] \tag{4}$$

Definition 5. *The similarity measurement between* $\widetilde{a}_1 = \left(\left(\underline{a}_1, a_1, \overline{a}_1\right); \omega_1, u_1\right)$ *and* $\widetilde{a}_2 = \left(\left(\underline{a}_2, a_2, \overline{a}_2\right); \omega_2, u_2\right)$ *is calculated using the normalized Hamming distance and Euclidean distance, which are used to measure the shortest distance between two fuzzy numbers, as shown in Equations (5) and (6).*

$$d_h(\widetilde{a}_1, \widetilde{a}_2) = \frac{1}{3}\left(\left|\underline{a}_1 - \underline{a}_2\right| + |a_1 - a_2| + \left|\overline{a}_1 - \overline{a}_2\right| + \max(|\omega_1 - \omega_2|, |u_1 - u_2|)\right) \tag{5}$$

$$d_e(\widetilde{a}_1, \widetilde{a}_2) = \frac{1}{\sqrt{3}}\left\{\left(\left(\underline{a}_1 - \underline{a}_2\right)^2 + (a_1 - a_2)^2 + (\overline{a}_1 - \overline{a}_2)^2\right) + \max\left(|\omega_1 - \omega_2|^2, |u_1 - u_2|^2\right)\right\}^{\frac{1}{2}} \tag{6}$$

The above two distance of TIFNs formulas have the following properties:

(1) $d(\widetilde{a}_1, \widetilde{a}_2) \ge 0$
(2) $d(\widetilde{a}_1, \widetilde{a}_2) = d(\widetilde{a}_2, \widetilde{a}_1)$
(3) If $\widetilde{b} = \left(\left(\underline{b}, b, \overline{b}\right); \omega_{\widetilde{b}}, u_{\widetilde{b}}\right)$ *is any TIFN, then* $d\left(\widetilde{a}_1, \widetilde{b}\right) \le d\left(\widetilde{a}_1, \widetilde{b}\right) + d\left(\widetilde{a}_2, \widetilde{b}\right)$

(The proof of property (3) is provided in Appendix A.2)

Definition 6. *In TIFN, language terms can be effectively converted into TIFNs by transforming scales. Table 1 lists the fuzzy BWM linguistic variables and consistency indices (CIs). Table 2 lists the linguistic variables for* *experts, rating the relationship between alternatives and criteria. Figure 4 shows the linguistic variables more intuitively on the axis.*

Table 1. Linguistic terms for fuzzy BWM.

Linguistic Term	TIFNs	Consistency Indices (CIs)
Equally Important(EI)	[(1,1,1;0.6), (1,1,1;0.3)]	2.395
Weakly Important(WI)	[(2/3,1,3/2;0.6), (2/3,2,3/2;0.3)]	2.427
Fairly Important(FI)	[(3/2,2,2/5;0.6), (3/2,2,2/5;0.3)]	3.120
Important(I)	[(5/2,3,7/2;0.6), (5/2,3,7/2;0.3)]	4.487
Very Important(VI)	[(7/2,4,9/2;0.6), [(7/2,4,9/2;0.3)]	5.435
Absolutely Important(AI)	[(9/2,5,11/2;0.6), (9/2,5,11/2;0.3)]	6.348

Table 2. Linguistic variables for experts, rating the relationship between alternatives and criteria.

Linguistic Term	TIFNs
Absolutely Low (AL)	[(0,0,1;0.6), (0,0,1;0.3)]
Low (L)	[(0,1,3;0.6), (0,1,3;0.3)]
Fairly Low (FL)	[(1,3,5;0.6), (1,3,5;0.3)]
Medium (M)	[(3,5,7;0.6), (3,5,7;0.3)]
Fairly High (FH)	[(5,7,9;0.6), [(5,7,9;0.3)]
High (H)	[(7,9,10;0.6), (7,9,10;0.3)]
Absolutely High (AH)	[(9,10,10;0.6), (9,10,10;0.3)]

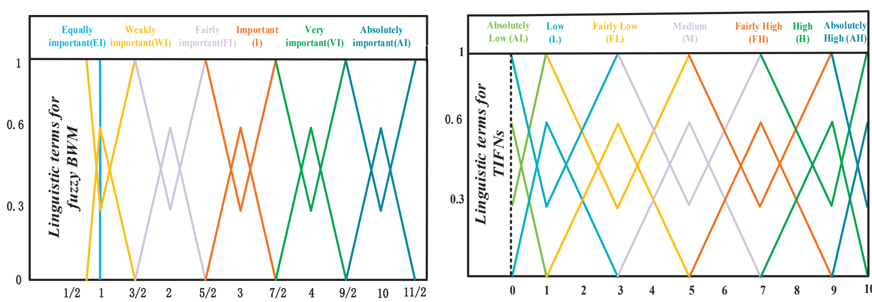


Figure 4. Linguistic terms.

4.2. The Proposed Framework

Suppose that there are p Eps $\{DM_1, DM_2, ..., DM_p\}$ to evaluate m alternatives $\{B_1, B_2, ..., B_m\}$; each alternative is composed of n criteria values $CR_j (j = 1, 2, ..., n)$. Let $W_{CR}^k = \left(w_{CR,1}^k, w_{CR,2}^k, ..., w_{CR,n}^k\right)^T$ be the weight vector, where $w_{CR,j}^k$ represents the weight of criterion CR_j satisfying that $w_{CR,j}^k \in [0,1] (k = 1, 2, ..., p)$ and $\sum\limits_{j=1}^{n} w_{CR,j}^k = 1$. Let $O = (o_1, o_2, ..., o_p)^T$ be the weight vector of the Eps, where o_k is the weight of Ep satisfying that $o_k \in [0,1] (k = 1, 2, ..., p)$ and $\sum\limits_{k=1}^{p} o_k = 1$.

Both $W_{CR}^k = \left(w_{CR,1}^k, w_{CR,2}^k, ..., w_{CR,n}^k\right)^T$ and $O = (o_1, o_2, ..., o_p)^T$ are unknown, and need to be determined according to the decision information. The evaluation values of Eps on the program attributes are expressed by TIFNs. For example, the evaluation value of Ep DM_k on attribute CR_j of B_i is a TIFN $\tilde{a}_{ij}^k = \left(\left(\underline{a}_{ij}^k, a_{ij}^k, \bar{a}_{ij}^k\right); \omega_{ij}^k, u_{ij}^k\right)$. Thus, the problems with TIFNs can be expressed as multiattribute decision matrix $\widetilde{N}^k = \left(\tilde{n}_{ij}^k\right)_{m \times n} (k = 1, 2, ..., p)$.

***Phase 1**. Determining the weight of the criteria (BWM-Entropy Weight Method).*

BWM was proposed by Rezaei in 2015 [7]. This method simplifies the comparison process by selecting the best and the worst criteria among many, thus reducing the risk of inconsistency and reaching the accuracy of the judgment results. This method cannot fully reflect the information in the real data; the entropy weight method as a method to calculate the objective weight makes up for this deficiency. So, the two methods in this paper are combined to form a new I-BWM. The specific steps are as follows:

Step 1. Determine the criteria system.

The system is the basis for evaluating alternatives; suppose there is n criteria $CR_j(j = 1, 2, ..., n)$ and CR_n represents the nth criterion.

Step 2. Determine the best and worst criteria.

In this step, the best and worst criteria are determined by the Eps, whereby CR_b represents the best criteria and CR_w represents the worst.

Step 3. Compare the best and worst criteria with other criteria.

This step is divided into two parts: one is that the language variables in Table 1 are used by Eps to determine the preference of the best criterion over all other criteria. The best-to-others vector would be $\chi_b = (\widetilde{x}_{b1}, \widetilde{x}_{b2}, ..., \widetilde{x}_{bn})$, and the other is to determine the preference of the worst criterion over all other criteria. Similarly, the best-to-others vector would be $\chi_w = (\widetilde{x}_{1w}, \widetilde{x}_{2w}, ..., \widetilde{x}_{nw})$.

Step 4. The mathematical model will be established to calculate the target weight.

The aim is to calculate the optimal weights of criteria in this step. For the mathematical programming models, the optimal absolute difference is expressed as $\left|\frac{\widetilde{w}_{CR,b}}{\widetilde{w}_{CR,j}} - \widetilde{x}_{bj}\right|$. The worst absolute difference $\left|\frac{\widetilde{w}_{CR,j}}{\widetilde{w}_{CR,w}} - \widetilde{x}_{jw}\right|$, ϕ represents a consistency ratio, and $\widetilde{w}_{CR,b}$, $\widetilde{w}_{CR,j}$, $\widetilde{w}_{CR,w}$ represent the weight of the criteria CR_b, CR_j, CR_w respectively. The target weight can be obtained by Equation (6).

$$\min \phi \quad \begin{cases} \left|\frac{\widetilde{w}_{CR,b}}{\widetilde{w}_{CR,j}} - \widetilde{x}_{bj}\right| \leq \phi \ for\ all\ j \\ \left|\frac{\widetilde{w}_{CR,j}}{\widetilde{w}_{CR,w}} - \widetilde{x}_{jw}\right| \leq \phi \ for\ all\ j \\ \sum_{k=1}^{n} w_{CR,j} = 1 \\ w_{CR,j} \geq 0 \end{cases} \tag{7}$$

In the traditional BWM method, 1–9 is usually used as the evaluation criteria to select the best and worst criteria according to the subjective attitude of experts, which is not science. Therefore, TIFNs is introduced to replace the 1–9 scale, which can more accurately express the attitude of Eps. In this way, the above Equation (6) evolves into Equation (7).

$$\min \phi^* \quad s.t. \begin{cases} \left|\frac{(\underline{a}_{CR,b}, a_{CR,b}, \overline{a}_{CR,b}; \omega_{CR,b}, u_{CR,b})}{(\underline{a}_{CR,j}, a_{CR,j}, \overline{a}_{CR,j}; \omega_{CR,j}, u_{CR,j})} - (\underline{x}_{bj}, x_{bj}, \overline{x}_{bj}, w_{bj}, u_{bj})\right| \leq \phi^* \\ \left|\frac{(\underline{a}_{CR,j}, a_{CR,j}, \overline{a}_{CR,j}; \omega_{CR,j}, u_{CR,j})}{(\underline{a}_{CR,w}, a_{CR,w}, \overline{a}_{CR,w}; \omega_{CR,w}, u_{CR,w})} - (\underline{x}_{jw}, x_{jw}, \overline{x}_{jw}, \omega_{jw}, u_{jw})\right| \leq \phi^* \\ \sum_{k=1}^{n} R(\widetilde{w}_{CR,j}) = 1 \\ \underline{a}_{CR,j} \leq a_{CR,j} \leq \overline{a}_{CR,j} \\ \omega_{CR,j} \leq u_{CR,j} \\ \widetilde{w}_{CR,j} \geq 0 \\ j = 1, 2, ..., n \end{cases} \tag{8}$$

Next, supposed that:

$$\begin{array}{l}\left|\dfrac{\left(\underline{a}_{CR,b},a_{CR,b},\overline{a}_{CR,b};\omega_{CR,b},u_{CR,b}\right)}{\left(\underline{a}_{CR,j},a_{CR,j},\overline{a}_{CR,j};\omega_{CR,j},u_{CR,j}\right)}-\left(\underline{x}_{bj},x_{bj},\overline{x}_{bj},w_{bj},u_{bj}\right)\right|=\alpha,\\ \left|\dfrac{\left(\underline{a}_{CR,j},a_{CR,j},\overline{a}_{CR,j};\omega_{CR,j},u_{CR,j}\right)}{\left(\underline{a}_{CR,w},a_{CR,w},\overline{a}_{CR,w};\omega_{CR,w},u_{CR,w}\right)}-\left(\underline{x}_{jw},x_{jw},\overline{x}_{jw},\omega_{jw},u_{jw}\right)\right|=\beta\end{array} \tag{9}$$

(1) When $\alpha > 0,\ \beta > 0$

$$\begin{array}{l}\min\phi^{*}\\ s.t.\begin{cases}\dfrac{\left(\underline{a}_{CR,b},a_{CR,b},\overline{a}_{CR,b};\omega_{CR,b},u_{CR,b}\right)}{\left(\underline{a}_{CR,j},a_{CR,j},\overline{a}_{CR,j};\omega_{CR,j},u_{CR,j}\right)}-\left(\underline{x}_{bj},x_{bj},\overline{x}_{bj},w_{bj},u_{bj}\right)\le\phi^{*}\\ \dfrac{\left(\underline{a}_{CR,j},a_{CR,j},\overline{a}_{CR,j};\omega_{CR,j},u_{CR,j}\right)}{\left(\underline{a}_{CR,w},a_{CR,w},\overline{a}_{CR,w};\omega_{CR,w},u_{CR,w}\right)}-\left(\underline{x}_{jw},x_{jw},\overline{x}_{jw},\omega_{jw},u_{jw}\right)\le\phi^{*}\\ \sum\limits_{k=1}^{n}R\left(\widetilde{w}_{CR,j}\right)=1\\ \underline{a}_{CR,j}\le a_{CR,j}\le\overline{a}_{CR,j}\\ \omega_{CR,j}\le u_{CR,j}\\ \widetilde{w}_{CR,j}\ge 0\\ j=1,2,\ldots,n\end{cases}\end{array} \tag{10}$$

(2) When $\alpha < 0,\ \beta < 0$

$$\begin{array}{l}\min\phi^{*}\\ s.t.\begin{cases}\left(\underline{x}_{bj},x_{bj},\overline{x}_{bj},w_{bj},u_{bj}\right)-\dfrac{\left(\underline{a}_{CR,b},a_{CR,b},\overline{a}_{CR,b};\omega_{CR,b},u_{CR,b}\right)}{\left(\underline{a}_{CR,j},a_{CR,j},\overline{a}_{CR,j};\omega_{CR,j},u_{CR,j}\right)}\le\phi^{*}\\ \left(\underline{x}_{jw},x_{jw},\overline{x}_{jw},\omega_{jw},u_{jw}\right)-\dfrac{\left(\underline{a}_{CR,j},a_{CR,j},\overline{a}_{CR,j};\omega_{CR,j},u_{CR,j}\right)}{\left(\underline{a}_{CR,w},a_{CR,w},\overline{a}_{CR,w};\omega_{CR,w},u_{CR,w}\right)}\le\phi^{*}\\ \sum\limits_{k=1}^{n}R\left(\widetilde{w}_{CR,j}\right)=1\\ \underline{a}_{CR,j}\le a_{CR,j}\le\overline{a}_{CR,j}\\ \omega_{CR,j}\le u_{CR,j}\\ \widetilde{w}_{CR,j}\ge 0\\ j=1,2,\ldots,n\end{cases}\end{array} \tag{11}$$

(3) When $\alpha > 0,\ \beta < 0$

$$\begin{array}{l}\min\phi^{*}\\ s.t.\begin{cases}\dfrac{\left(\underline{a}_{CR,b},a_{CR,b},\overline{a}_{CR,b};\omega_{CR,b},u_{CR,b}\right)}{\left(\underline{a}_{CR,j},a_{CR,j},\overline{a}_{CR,j};\omega_{CR,j},u_{CR,j}\right)}-\left(\underline{x}_{bj},x_{bj},\overline{x}_{bj},w_{bj},u_{bj}\right)\le\phi^{*}\\ \left(\underline{x}_{jw},x_{jw},\overline{x}_{jw},\omega_{jw},u_{jw}\right)-\dfrac{\left(\underline{a}_{CR,j},a_{CR,j},\overline{a}_{CR,j};\omega_{CR,j},u_{CR,j}\right)}{\left(\underline{a}_{CR,w},a_{CR,w},\overline{a}_{CR,w};\omega_{CR,w},u_{CR,w}\right)}\le\phi^{*}\\ \sum\limits_{k=1}^{n}R\left(\widetilde{w}_{CR,j}\right)=1\\ \underline{a}_{CR,j}\le a_{CR,j}\le\overline{a}_{CR,j}\\ \omega_{CR,j}\le u_{CR,j}\\ \widetilde{w}_{CR,j}\ge 0\\ j=1,2,\ldots,n\end{cases}\end{array} \tag{12}$$

(4) When $\alpha < 0,\ \beta > 0$

$$\min\phi^*$$
$$s.t.\begin{cases} \left(\underline{x}_{bj}, x_{bj}, \overline{x}_{bj}, w_{bj}, u_{bj}\right) - \frac{\left(\underline{a}_{CR,b}, a_{CR,b}, \overline{a}_{CR,b}; \omega_{CR,b}, u_{CR,b}\right)}{\left(\underline{a}_{CR,j}, a_{CR,j}, \overline{a}_{CR,j}; \omega_{CR,j}, u_{CR,j}\right)} \le \phi^* \\ \frac{\left(\underline{a}_{CR,j}, a_{CR,j}, \overline{a}_{CR,j}; \omega_{CR,j}, u_{CR,j}\right)}{\left(\underline{a}_{CR,w}, a_{CR,w}, \overline{a}_{CR,w}; \omega_{CR,w}, u_{CR,w}\right)} - \left(\underline{x}_{jw}, x_{jw}, \overline{x}_{jw}, \omega_{jw}, u_{jw}\right) \le \phi^* \\ \sum\limits_{k=1}^{n} R\left(\widetilde{w}_{CR,j}\right) = 1 \\ \underline{a}_{CR,j} \le a_{CR,j} \le \overline{a}_{CR,j} \\ \omega_{CR,j} \le u_{CR,j} \\ \widetilde{w}_{CR,j} \ge 0 \\ j = 1, 2, \ldots, n \end{cases} \tag{13}$$

The target weight value $\left(w^*_{CR,1}, w^*_{CR,2}, \ldots, w^*_{CR,n}\right)$ can be obtained by solving Equation (7). The consistency index obtained must not exceed the maximum possible CI. The maximum possible CI for different linguistic variables of fuzzy TIFNs-BWM is listed in the Table 1.

As for the minimum consistency $\widetilde{x}_{bn} = \widetilde{x}_{nw} = \widetilde{x}_{bw}$,

$$\begin{aligned} &\left(\widetilde{x}_{bj} - \phi\right) \times \left(\widetilde{x}_{jw} - \phi\right) = \left(\widetilde{x}_{bw} + \phi\right) \\ &\Rightarrow \left(\widetilde{x}_{bj} - \phi\right) \times \left(\widetilde{x}_{bj} - \phi\right) = \left(\widetilde{x}_{bk} + \phi\right) \\ &\Rightarrow \phi^2 - \left(1 + 2\widetilde{x}_{bj}\right)\phi + \left(\widetilde{x}_{bj}{}^2 - \widetilde{x}_{bj}\right) = 0 \end{aligned} \tag{14}$$

The consistency ratio can be calculated by $Consistency\ Ratio = \frac{\phi^*}{CI}$. The closer to 0, the better the consistency. Complete consistency is achieved when CI is zero.

Step 5. The entropy weight method is used to determine the objective weight. The specific process and the releated Equations (15) and (16) are shown in Figure 5.

$$e^k_j = -\frac{1}{\ln m}\sum_{i=1}^{m} v^k_{ij} \ln v^k_{ij} (j = 1, 2, \ldots, n, k = 1, 2, \ldots, p) \tag{15}$$

$$w^k_j = \left(1 - e^k_j\right) / \sum_{j=1}^{n}\left(1 - e^k_j\right) \tag{16}$$

Step 6. The entropy weight method is used to modify BWM.

In order to combine the BWM and the entropy weight methods, the entropy value variable is introduced and the final weight value $w^*_{CR,j}$ is determined by Equation (17).

$$w^k_{CR,j} = w^*_{CR,j} e^k_j + w^k_j\left(1 - e^k_j\right), (j = 1, 2, \ldots, n) \tag{17}$$

where $w^*_{CR,j}$ is the weight value determined by BWM method and w^k_j is the weight value determined by the entropy weight method. To ensure the final weight, the value must conform to the following two properties:

(1) The final determined weight should be between the weights determined by the two methods.

(2) The entropy value e^k_j is relatively large: $\left(e^k_j > 0.5\right)$, $w^k_{CR,n}$ is closer to $w^*_{CR,j}$ and e^k_j is relatively small $\left(e^k_j < 0.5\right)$, $w^k_{CR,n}$ is closer to w^k_j.

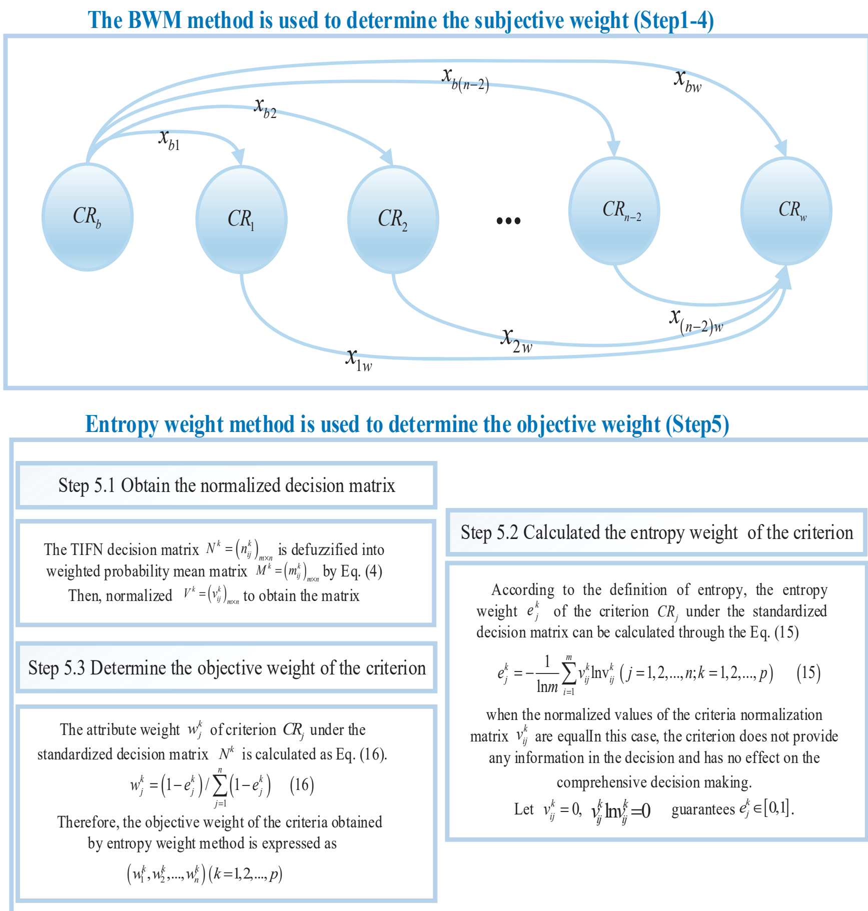


Figure 5. Objective weight calculation steps.

Phase 2. *B-DST is used to determine the weights of Eps.*

B-DST is an extension of DST, which can be used to deal with the uncertainty existing in things. It decomposes the complex large evidence into simple, small pieces of evidence in a certain way. After the relevant processing of small evidence, it uses combination rules to synthesize the processing results, and finally, obtains the solution to the problem [48,49]. In this part, a Bayes approximation method based on Dempster's rule of evidence synthesis is used as the basis to obtain the weights of Eps.

For the TIFN multiattribute group decision matrix $\widetilde{N}^k = \left(\widetilde{n}_{ij}^k\right)_{m\times n}$ and normalized weighted probability mean matrix $V^k = \left(v_{ij}^k\right)_{m\times n}$, let $\psi = \{B_1, B_2, \ldots, B_m\}$ be used as the identification framework. B_i indicates the ith plan. All criteria values in V^k are the evidence body of the criteria. In other words, for the evaluation value of DM_k on criteria attribute a_i of plan B_i, v_{ij}^k is the evidence body $m_j^k(A_i)$, as shown in Equation (18).

$$m_j^k(B_i) = \mathrm{v}_{ij}^k\ (i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n;\ k = 1, 2, \ldots, p) \quad (18)$$

Step 1. Determine the attribute weighted evidence body.

In the previous phase, the final criteria attribute weight modified by the entropy weight method to BWM is $w^k_{CR,j}$, and the attribute weight evidence body $m'^k_j(B_i)$ of scheme B_i under CR_j could be obtained by Equations (19) and (20), as shown in the matrix C^*.

$$m'^k_j(B_i) = w^k_{CR,j} m^k_j(B_i) \tag{19}$$

$$m'^k_j(\psi) = 1 - \sum_{i=1}^{m} m'^k_j(B_i) = 1 - w^k_{CR,n} \sum_{i=1}^{m} m^k_j(B_i) \tag{20}$$

$$C^* = \left[\begin{array}{c} \begin{array}{c|cccc} & & DM_1 & & \\ m'^1_j(B_i) & CR_1 & CR_2 & \cdots & CR_n \\ \hline B_1 & w^1_{CR,1}m^1_1(B_1) & w^1_{CR,2}m^1_2(B_1) & \cdots & w^1_{CR,n}m^1_n(B_1) \\ B_2 & w^1_{CR,1}m^1_1(B_2) & w^1_{CR,2}m^1_2(B_2) & \cdots & w^1_{CR,n}m^1_n(B_2) \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ B_m & w^1_{CR,1}m^1_1(B_m) & w^1_{CR,2}m^1_2(B_m) & \cdots & w^1_{CR,n}m^1_n(B_3) \\ \psi & 1 - w^1_{CR,1}\sum_{i=1}^{m} m^1_1(B_i) & 1 - w^1_{CR,2}\sum_{i=1}^{m} m^1_2(B_i) & \cdots & 1 - w^1_{CR,n}\sum_{i=1}^{m} m^1_n(B_i) \end{array} \cdots \\ \begin{array}{c|cccc} & & DM_n & & \\ m'^n_j(B_i) & CR_1 & CR_2 & \cdots & CR_n \\ \hline B_1 & w^n_{CR,1}m^n_1(B_1) & w^n_{CR,2}m^n_2(B_1) & \cdots & w^n_{CR,n}m^n_n(B_1) \\ B_2 & w^n_{CR,1}m^n_1(B_2) & w^n_{CR,2}m^n_2(B_2) & \cdots & w^n_{CR,n}m^n_n(B_2) \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ B_m & w^n_{CR,1}m^n_1(B_m) & w^n_{CR,2}m^n_2(B_m) & \cdots & w^n_{CR,n}m^n_n(B_3) \\ \psi & 1 - w^n_{CR,1}\sum_{i=1}^{m} m^n_1(B_i) & 1 - w^n_{CR,2}\sum_{i=1}^{m} m^n_2(B_i) & \cdots & 1 - w^n_{CR,n}\sum_{i=1}^{m} m^n_n(B_i) \end{array} \end{array}\right] \tag{21}$$

Step 2. Calculate the Bayes approximation function value of the attribute weighted evidence body.

By considering the credibility of the criteria in the weighted evidence body, the uncertainty information provided by the criterion evidence with a low level of credibility will be reduced, and the uncertainty information provided by the uncertain criterion element will be increased, thereby reducing the influence of the criterion evidence body with low levels of credibility on the whole decision result.

The Bayes approximation function value $\underline{m'}^k_j(B_i)$ of attribution-weighted evidence body $m'^k_j(B_i)$ is calculated by Equation (22).

$$\underline{m'}^k_j(B_i) = \frac{w^k_{CR,1}m^k_1(B_1) + \left(1 - w^k_{CR,1}\sum_{i=1}^{m} m^k_1(B_i)\right)}{w^k_{CR,1}m^k_1(B_1)\times 1 + w^k_{CR,1}m^k_1(B_2)\times 1 + \cdots + w^k_{CR,1}m^k_1(B_m)\times 1 + \left(1 - w^k_{CR,1}\sum_{i=1}^{m} m^k_1(B_i)\right)\times m} \tag{22}$$

Step 3. Determine the weight of comprehensive evidence.

According to the Bayes approximate formula of evidence theory, the attribution weighted evidence body $m'^k_j(B_i)$ can be fused into comprehensive evidence weight body $m'^k_j(B_i)$, which can be calculated by Equation (23).

$$\underline{m}^k(B_i) = \frac{\left[\underline{m}^1_1(B_1)\times \underline{m}^1_2(B_1)\times\cdots\times \underline{m}^1_n(B_1)\right]}{\left[\underline{m}^k_1(B_1)\times\cdots\times \underline{m}^k_n(B_1)\right] + \left[\underline{m}^k_1(B_2)\times\cdots\times \underline{m}^k_n(B_2)\right] + \cdots + \left[\underline{m}^k_1(B_m)\times\cdots\times \underline{m}^k_n(B_m)\right]} \tag{23}$$

where comprehensive weighted evidence body $\underline{m}^k(B_i)$ represents DM_k individual evaluation evidence of scheme B_i.

Step 4. Calculate the distance and similarity between the sets of evidence.

Let evidence set $\underline{\mathbf{m}}^{\mathbf{k}}$ be a set of comprehensive weighted evidence $\underline{m}^k(B_i)$ $(i = 1, 2, ..., m)$ for any set of evidence $\underline{\mathbf{m}}^{\mathbf{q}}$ and $\underline{\mathbf{m}}^{\mathbf{k}}$; the distance between them is calculated as Equation (24)

$$d\left(\underline{\mathbf{m}}^{\mathbf{q}}, \underline{\mathbf{m}}^{\mathbf{t}}\right) = \sqrt{\frac{[\mathbf{M}^{\mathbf{q}}, \mathbf{M}^{\mathbf{q}}] + [\mathbf{M}^{\mathbf{t}}, \mathbf{M}^{\mathbf{t}}] - 2[\mathbf{M}^{\mathbf{t}}, \mathbf{M}^{\mathbf{q}}]}{2}} (q, t \in k) \tag{24}$$

where $\mathbf{M}^k = \left(\underline{m}^k(B_1), \underline{m}^k(B_2), ..., \underline{m}^k(B_m)\right)$ $(k = q, t)$, $[\mathbf{M}^{\mathbf{q}}, \mathbf{M}^{\mathbf{t}}]$ is defined as $[\mathbf{M}^{\mathbf{q}}, \mathbf{M}^{\mathbf{t}}] = \sum_{i=1}^{z} \sum_{j=1}^{z} \left[\underline{m}^q(B_i)\underline{m}^t\left(B_j\right)d_{ij}\right]$, and $d_{ij} = \frac{|B_i \cap B_j|}{|B_i \cup B_j|} (i, j = 1, ..., 2^z)$.

Similarity $d\left(\underline{\mathbf{m}}^{\mathbf{q}}, \underline{\mathbf{m}}^{\mathbf{k}}\right)$ and distance $s\left(\underline{\mathbf{m}}^{\mathbf{q}}, \underline{\mathbf{m}}^{\mathbf{k}}\right)$ are a pair of opposite concepts. The smaller the distance of the evidence body, the greater their similarity. The similarity between $\underline{\mathbf{m}}^{\mathbf{q}}$ and $\underline{\mathbf{m}}^{\mathbf{k}}$ can be calculated by Equations (25)–(27).

$$s\left(\underline{\mathbf{m}}^{\mathbf{q}}, \underline{\mathbf{m}}^{\mathbf{k}}\right) = 1 - d\left(\underline{\mathbf{m}}^{\mathbf{q}}, \underline{\mathbf{m}}^{\mathbf{k}}\right) (q, t = 1, 2, ..., p) \tag{25}$$

$$D_M = \left(d\left(\underline{\mathbf{m}}^{\mathbf{q}}, \underline{\mathbf{m}}^{\mathbf{k}}\right)\right)_{m \times m} = \begin{array}{c} \\ \underline{\mathbf{m}}^1 \\ \underline{\mathbf{m}}^2 \\ \underline{\mathbf{m}}^3 \\ \vdots \\ \underline{\mathbf{m}}^m \end{array} \begin{array}{c} \begin{array}{ccccc} \underline{\mathbf{m}}^1 & \underline{\mathbf{m}}^2 & \underline{\mathbf{m}}^3 & \cdots & \underline{\mathbf{m}}^m \end{array} \\ \left[\begin{array}{cccccc} 0 & d\left(\underline{\mathbf{m}}^1, \underline{\mathbf{m}}^2\right) & d\left(\underline{\mathbf{m}}^1, \underline{\mathbf{m}}^3\right) & \cdots & d\left(\underline{\mathbf{m}}^1, \underline{\mathbf{m}}^m\right) \\ d\left(\underline{\mathbf{m}}^1, \underline{\mathbf{m}}^2\right) & 0 & d\left(\underline{\mathbf{m}}^2, \underline{\mathbf{m}}^3\right) & \cdots & d\left(\underline{\mathbf{m}}^2, \underline{\mathbf{m}}^m\right) \\ d\left(\underline{\mathbf{m}}^1, \underline{\mathbf{m}}^3\right) & d\left(\underline{\mathbf{m}}^2, \underline{\mathbf{m}}^3\right) & 0 & \cdots & d\left(\underline{\mathbf{m}}^3, \underline{\mathbf{m}}^m\right) \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ d\left(\underline{\mathbf{m}}^1, \underline{\mathbf{m}}^m\right) & d\left(\underline{\mathbf{m}}^2, \underline{\mathbf{m}}^m\right) & d\left(\underline{\mathbf{m}}^3, \underline{\mathbf{m}}^m\right) & \cdots & 0 \end{array}\right]_{m \times m} \end{array} \tag{26}$$

$$S_M = \left(s\left(\underline{\mathbf{m}}^{\mathbf{q}}, \underline{\mathbf{m}}^{\mathbf{k}}\right)\right)_{m \times m} = \begin{array}{c} \\ \underline{\mathbf{m}}^1 \\ \underline{\mathbf{m}}^2 \\ \underline{\mathbf{m}}^3 \\ \vdots \\ \underline{\mathbf{m}}^m \end{array} \begin{array}{c} \begin{array}{cccc} \underline{\mathbf{m}}^1 & \underline{\mathbf{m}}^2 & \cdots & \underline{\mathbf{m}}^m \end{array} \\ \left[\begin{array}{cccc} 1 & 1 - d\left(\underline{\mathbf{m}}^1, \underline{\mathbf{m}}^2\right) & \cdots & 1 - d\left(\underline{\mathbf{m}}^1, \underline{\mathbf{m}}^m\right) \\ 1 - d\left(\underline{\mathbf{m}}^1, \underline{\mathbf{m}}^2\right) & 1 & \cdots & 1 - d\left(\underline{\mathbf{m}}^2, \underline{\mathbf{m}}^m\right) \\ 1 - d\left(\underline{\mathbf{m}}^1, \underline{\mathbf{m}}^3\right) & 1 - d\left(\underline{\mathbf{m}}^2, \underline{\mathbf{m}}^3\right) & \cdots & 1 - d\left(\underline{\mathbf{m}}^3, \underline{\mathbf{m}}^m\right) \\ \vdots & \vdots & \vdots & \vdots \\ 1 - d\left(\underline{\mathbf{m}}^1, \underline{\mathbf{m}}^m\right) & 1 - d\left(\underline{\mathbf{m}}^2, \underline{\mathbf{m}}^m\right) & \cdots & 1 \end{array}\right]_{m \times m} \end{array} \tag{27}$$

Step 5. Calculate the weight of Eps.

If the similarity between the evidence is relatively large, it can be considered that the degree of mutual support between the evidence is relatively high, that is, the evidences are mutually supportive. In general, the higher the degree to which an evidence is supported by other evidence, the more credible that evidence. Let $Sup\left(\underline{\mathbf{m}}^{\mathbf{k}}\right)$ represents the support degree of other pieces of evidence to evidence $\underline{\mathbf{m}}^{\mathbf{k}}$. The support degree function is calculated using Equation (28).

Let the relative confidence $crd\left(\underline{\mathbf{m}}^{\mathbf{k}}\right)$ of $\underline{\mathbf{m}}^{\mathbf{k}}$ be treated as the weight v_k of $\underline{\mathbf{m}}^{\mathbf{k}}$.The weight vector of the evidence is expressed as $O = \left(o_1, o_2, \ldots, o_p\right)^T$, which is obtained using Equation (29).

$$\mathrm{Sup}\left(\underline{\mathbf{m}}^{\mathbf{k}}\right) = \sum_{t=1, t\neq k}^{p} s\left(\underline{\mathbf{m}}^{\mathbf{q}}, \underline{\mathbf{m}}^{\mathbf{k}}\right) (k = 1, 2, \ldots, p) \tag{28}$$

$$o_k = crd\left(\underline{\mathbf{m}}^{\mathbf{k}}\right) / \sum_{t=1}^{p} crd\left(\underline{\mathbf{m}}^{\mathbf{k}}\right) \tag{29}$$

***Phase 3** Determine the ranking of suppliers and select the best LSSs.*

VIKOR is an optimal compromise solution sequencing method based on ideal solutions which determines the positive ideal solution and negative ideal solution of the decision matrix, and then sorts the solution according to the proximity between the attribute evaluation value of each alternative and the ideal solution. It can consider both group utility maximization and individual regret minimization, and fully reflect the subjective preference of decision makers. On the basis of the above studies and the classical VIKOR, this paper proposes an extension method of TIFNs multiattribute group decision making to select the optimal LSS. The main steps are as follows:

Step 1. Calculate the attribute weight vector of comprehensive criteria.

According to the research on criteria attribute weights $W_{CR}^{k} = \left(w_{CR,1}^{k}, w_{CR,2}^{k}, \ldots, w_{CR,n}^{k}\right)^T$, $(k = 1, 2, \ldots p)$ in phase 1 and Eps weight $O = \left(o_1, o_2, \ldots, o_p\right)^T$ in phase 2, Equation (30) can be used to calculate the comprehensive criteria attribute weight.

$$w_j = \sum_{k=1}^{p} o_k w_{CR,j}^{k} \ (j = 1, 2, \ldots, n) \tag{30}$$

Step 2. Construct the comprehensive decision matrix.

According to the TIF-WAA operator in Definition 3, the following Equations (31) and (32) are used to integrate a single decision matrix $\widetilde{N}^k = \left(\widetilde{n}_{ij}^{k}\right)_{m\times n} (k = 1, 2, \ldots, p)$ into a comprehensive weighted matrix $\widetilde{Z} = \left(\widetilde{z}_{ij}\right)_{m\times n}$.

$$\widetilde{Z} = \left(\widetilde{z}_{ij}\right)_{m\times n} = \begin{array}{c} \\ B_1 \\ B_2 \\ B_3 \\ \vdots \\ B_m \end{array} \begin{array}{c} \begin{array}{ccccc} CR_1 & CR_2 & CR_3 & \cdots & CR_n \end{array} \\ \left[\begin{array}{ccccc} \widetilde{z}_{11} & \widetilde{z}_{12} & \widetilde{z}_{13} & \cdots & \widetilde{z}_{1n} \\ \widetilde{z}_{21} & \widetilde{z}_{22} & \widetilde{z}_{23} & \cdots & \widetilde{z}_{2n} \\ \widetilde{z}_{31} & \widetilde{z}_{32} & \widetilde{z}_{33} & \cdots & \widetilde{z}_{3n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \widetilde{z}_{m1} & \widetilde{z}_{m2} & \widetilde{z}_{m3} & \cdots & \widetilde{z}_{mn} \end{array}\right] \end{array} \tag{31}$$

$$\begin{aligned} \widetilde{z}_{ij} &= \left(\left(z_{1i}\left(n_j\right), z_{2i}\left(n_j\right), z_{3i}\left(n_j\right)\right); \omega_{z_{ij}}, u_{z_{ij}}\right) = \mathrm{TIF-WAA}\left(\widetilde{n}_{ij}^{1}, \widetilde{n}_{ij}^{2}, \ldots, \widetilde{n}_{ij}^{p}\right) \\ &= \sum_{k=1}^{p} o_k \widetilde{n}_{ij}^{k} = \left(\left(\sum_{k=1}^{p} o_k \underline{n}_{ij}^{k}, \sum_{k=1}^{p} o_k n_{ij}^{k}, \sum_{k=1}^{p} o_k \overline{n}_{ij}^{k}\right); \min_{1\leq k\leq p}\left\{\omega_{n_{ij}}^{k}\right\}, \max\left\{u_{n_{ij}}^{k}\right\}\right) \end{aligned} \tag{32}$$

Step3. Determine the positive and negative ideal solutions, where the positive ideal solution is $B^+ = \left\{\widetilde{b}_1^+, \widetilde{b}_2^+, \ldots, \widetilde{b}_n^+\right\}$ and the negative ideal solution is $B^- = \left\{\widetilde{b}_1^-, \widetilde{b}_2^-, \ldots, \widetilde{b}_n^-\right\}$.

$$\widetilde{b}^+ = \left(\left(\max_{1\leq i\leq m}\left\{z_{1i}\left(n_j\right)\right\}\right), \left(\max_{1\leq i\leq m}\left\{z_{2i}\left(n_j\right)\right\}\right), \left(\max_{1\leq i\leq m}\left\{z_{3i}\left(n_j\right)\right\}\right); 1, 0\right) \tag{33}$$

$$\widetilde{b}^- = \left(\left(\min_{1\leq i\leq m}\left\{z_{1i}\left(n_j\right)\right\}\right), \left(\min_{1\leq i\leq m}\left\{z_{2i}\left(n_j\right)\right\}\right), \left(\min_{1\leq i\leq m}\left\{z_{3i}\left(n_j\right)\right\}\right); 0, 1\right) \tag{34}$$

Step 4. Calculate the group utility values, the individual regret values for each alternative, and the approximation between the alternative solution and the ideal solution.

The Hamming distance of TIFN in Definition 4 is used in Equations (35) and (36) to calculate the above group utility value $S(B_i)$ and individual regret value $R(B_i)$.

$$S(B_i) = \sum_{j=1}^{n} w_j \left\{ \frac{\left(\left| \left(\max_{1 \le i \le m} \{ z_{1i}(n_j) \} \right) - \underline{z} \right| + \left| \left(\max_{1 \le i \le m} \{ z_{2i}(n_j) \} \right) - z \right| + \left| \left(\max_{1 \le i \le m} \{ z_{3i}(n_j) \} \right) - \overline{z} \right| + \max \left(|1 - \omega_{\tilde{z}}|, |0 - u_{\tilde{z}}| \right) \right)}{3 \left(\left| \left(\max_{1 \le i \le m} \{ z_{1i}(n_j) \} \right) - \left(\min_{1 \le i \le m} \{ z_{1i}(n_j) \} \right) \right| + \left| \left(\max_{1 \le i \le m} \{ z_{2i}(n_j) \} \right) - \left(\min_{1 \le i \le m} \{ z_{2i}(n_j) \} \right) \right| + \left| \left(\max_{1 \le i \le m} \{ z_{3i}(n_j) \} \right) - \left(\min_{1 \le i \le m} \{ z_{3i}(n_j) \} \right) \right| + 1 \right)} \right\} \tag{35}$$

$$R(B_i) = \max_{1 \le j \le n} \left\{ w_j \frac{\left(\left| \left(\max_{1 \le i \le m} \{ z_{1i}(n_j) \} \right) - \overline{z} \right| + \left| \left(\max_{1 \le i \le m} \{ z_{2i}(n_j) \} \right) - z \right| + \left| \left(\max_{1 \le i \le m} \{ z_{3i}(n_j) \} \right) - \underline{z} \right| + \max \left(|1 - \omega_{\tilde{c}}|, |0 - u_{\tilde{c}}| \right) \right)}{3 \left(\left| \left(\max_{1 \le i \le m} \{ z_{1i}(n_j) \} \right) - \left(\min_{1 \le i \le m} \{ z_{1i}(n_j) \} \right) \right| + \left| \left(\max_{1 \le i \le m} \{ z_{2i}(n_j) \} \right) - \left(\min_{1 \le i \le m} \{ z_{2i}(n_j) \} \right) \right| + \left| \left(\max_{1 \le i \le m} \{ z_{3i}(n_j) \} \right) - \left(\min_{1 \le i \le m} \{ z_{3i}(n_j) \} \right) \right| + 1 \right)} \right\} \tag{36}$$

Calculate the approximation between the alternative solution and the ideal solution $Q(B_i)$ using Equation (37)

$$Q(B_i) = \theta \frac{S(B_i) - S^{\max}}{S^{\min} - S^{\max}} + (1 - \theta) \frac{R(B_i) - R^{\max}}{R^{\min} - R^{\max}} \tag{37}$$

where $S^{\max} = \max_i(S_i)$, $S^{\min} = \min_i(S_i)$, $R^{\max} = \max_i(R_i)$, and $R^{\min} = \min_i(R_i)$, θ represents the group utility maximization coefficient. This paper takes $\theta = 0.5$, which indicates that the decision result is determined by the majority for good evaluations and the minority for poor evaluations.

Step 5. The evaluation results are obtained by sorting the alternatives.

According to $Q(B_i)(i = 1, 2, ..., m)$, the alternatives are ranked from small to large, so as to obtain the optimal one.

5. Case Analysis

In this section, five typical LSSs in area J are evaluated. Firstly, the background information of the five alternatives is given. Secondly, the proposed method was used to evaluate the five LSSs and determine the sorting order. Finally, the influence of different situations on the evaluation results was obtained through sensitivity and comparative analyses.

5.1. Background Information

In the context of global climate change, it is the common aspiration of mankind to reduce greenhouse gas emissions and achieve sustainable economic development. Low-carbon economy has become a trend of sustainable development for the global economy. As an important part of the global economy, tourism has an unshirkable responsibility to respond to the call for low-carbon development. As the carrier of tourism, the construction for LSSs is of incomparable significance. In recent years, various types of LSSs have been springing up, but a series of problems such as ununified selection subjects and incomplete construction methods have become increasingly prominent. Therefore, systematically evaluating LSSs is a problem that needs to be solved by academia. Based on the objective reality, and taking LSSs as the research object, this paper proposes a new MCDM to effectively solve the problem of LSS evaluation.

5.2. Evaluate Process and Results

There were three Eps $\{DM_1, DM_2, DM_3\}$ to evaluate five LSSs $\{B_1, B_2, B_3, B_4, B_5\}$. Each LSS is composed of twenty-two criteria $CR_j(j = 1, 2, ..., 22)$. Recommended by the competent department of tourist attractions and evaluated by experts on the spot in area J, the evaluator consisted of three panels, including tourism professors, scenic spot managers, and tourism-related government workers. According to Definition 6, the expert selected appropriate language variables to evaluate the five alternatives.

Phase 1. *Determine the weight of the criteria.*

After consultation, the Eps determined the optimal criterion CR_1 and the worst criterion CR_{11}, and obtained the optimal comparison vector $\chi_1 = (1, \widetilde{x}_{1,2}, ..., \widetilde{x}_{1,22})$ and the worst comparison vector $\chi_{11} = (\widetilde{x}_{1,11}, \widetilde{x}_{2,11}, ..., \widetilde{x}_{22,11})$ by referring to the language variables in Table 1. According to Equations (7)–(13), the subjective weights of the 22 criteria can be obtained as follows:

$$\left(w^*_{CR,1}, w^*_{CR,2}, w^*_{CR,3}, ..., w^*_{CR,22}\right) = \begin{pmatrix} 0.0842, 0.0385, 0.0842, 0.0436, 0.0842, 0.0385, 0.0516, 0.0430, 0.0375, 0.0334, 0.0334, \\ 0.0400, 0.0467, 0.0430, 0.0430, 0.0334, 0.0375, 0.0334, 0.0334, 0.0400, 0.0400, 0.0375 \end{pmatrix}^T$$

The consistency index $\phi^* = (2.395, 2.427, 3.120, 4.487, 5.435, 6.348)$ can be obtained by Equation (14). According to Equation (4), the initial value of five alternatives LSSs was defuzzied and normalized to obtain three sets of evaluation matrices, as shown in Tables 3–5. The subjective weight obtained by Equations (15)–(17) was modified by the objective weight obtained by the entropy weight method; the results were shown in Table 6.

Table 3. Evaluation matrix by DM_1.

	B_1	B_2	B_3	B_4	B_5
CR_1	0.1180	0.2449	0.2085	0.1966	0.2321
CR_2	0.2345	0.1427	0.2377	0.1998	0.1852
CR_3	0.2199	0.3089	0.1571	0.0366	0.2775
CR_4	0.2817	0.2988	0.0395	0.0395	0.3406
CR_5	0.0379	0.3781	0.2108	0.2108	0.1624
CR_6	0.2055	0.1468	0.2055	0.1468	0.2956
CR_7	0.1430	0.2287	0.2168	0.2168	0.1947
CR_8	0.1956	0.2177	0.1956	0.1956	0.1956
CR_9	0.1843	0.1981	0.1868	0.2327	0.1981
CR_{10}	0.2320	0.2576	0.0306	0.3057	0.1741
CR_{11}	0.2961	0.1676	0.0391	0.1676	0.3296
CR_{12}	0.2595	0.1749	0.1319	0.1749	0.2588
CR_{13}	0.2041	0.1832	0.2187	0.1970	0.1970
CR_{14}	0.0433	0.3397	0.0433	0.2460	0.3278
CR_{15}	0.1508	0.2111	0.2761	0.2111	0.1508
CR_{16}	0.0959	0.0959	0.2825	0.2120	0.3137
CR_{17}	0.2056	0.2056	0.1543	0.2289	0.2056
CR_{18}	0.2632	0.1778	0.1342	0.2370	0.1878
CR_{19}	0.1270	0.2244	0.2558	0.1684	0.2244
CR_{20}	0.3553	0.1087	0.2401	0.2536	0.0423
CR_{21}	0.2379	0.1210	0.2137	0.2137	0.2137
CR_{22}	0.1864	0.2125	0.2076	0.2070	0.1864

Table 4. Evaluation matrix by DM_2.

	B_1	B_2	B_3	B_4	B_5
CR_1	0.1369	0.2839	0.0821	0.2279	0.2691
CR_2	0.0892	0.2625	0.2475	0.2080	0.1928
CR_3	0.1818	0.2554	0.0779	0.2554	0.2294
CR_4	0.2677	0.3335	0.0375	0.0375	0.3237
CR_5	0.0405	0.4044	0.2254	0.2254	0.1042
CR_6	0.2055	0.1468	0.2055	0.1468	0.2956
CR_7	0.0716	0.2477	0.2348	0.2348	0.2109
CR_8	0.2718	0.0923	0.2718	0.2718	0.0923
CR_9	0.2024	0.2176	0.2052	0.1724	0.2024
CR_{10}	0.2421	0.2252	0.0320	0.3190	0.1817
CR_{11}	0.0978	0.1630	0.3207	0.0978	0.3207
CR_{12}	0.1804	0.1708	0.1288	0.2673	0.2527
CR_{13}	0.2041	0.1832	0.2187	0.1970	0.1970
CR_{14}	0.0380	0.2982	0.0380	0.3380	0.2878
CR_{15}	0.1258	0.1761	0.2303	0.2610	0.2067
CR_{16}	0.1064	0.1064	0.3678	0.1064	0.3132
CR_{17}	0.2013	0.2013	0.2365	0.1595	0.2013
CR_{18}	0.2329	0.1574	0.2336	0.2098	0.1663
CR_{19}	0.1401	0.1961	0.2821	0.1857	0.1961
CR_{20}	0.2704	0.0827	0.1828	0.1930	0.2711
CR_{21}	0.2323	0.1181	0.2087	0.2087	0.2323
CR_{22}	0.1864	0.2125	0.2076	0.2070	0.1864

Table 5. Evaluation matrix by DM_3.

	B_1	B_2	B_3	B_4	B_5
CR_1	0.1794	0.3723	0.1076	0.2988	0.0419
CR_2	0.0892	0.2625	0.2475	0.2080	0.1928
CR_3	0.1708	0.2589	0.0790	0.2589	0.2325
CR_4	0.2082	0.2593	0.2517	0.0292	0.2517
CR_5	0.0391	0.3905	0.2349	0.2349	0.1007
CR_6	0.2523	0.1801	0.1801	0.1286	0.2590
CR_7	0.0743	0.2570	0.2436	0.2063	0.2188
CR_8	0.2214	0.1024	0.2389	0.3348	0.1024
CR_9	0.0775	0.2736	0.2150	0.1807	0.2532
CR_{10}	0.2320	0.2576	0.0306	0.3057	0.1741
CR_{11}	0.2251	0.1487	0.2089	0.2084	0.2089
CR_{12}	0.1478	0.1510	0.2414	0.2364	0.2234
CR_{13}	0.2128	0.1910	0.2280	0.1628	0.2054
CR_{14}	0.0308	0.2418	0.2200	0.2740	0.2333
CR_{15}	0.1317	0.1844	0.2411	0.1844	0.2584
CR_{16}	0.2353	0.1865	0.2764	0.0799	0.2219
CR_{17}	0.1942	0.2470	0.2419	0.0699	0.2470
CR_{18}	0.2214	0.1994	0.2219	0.1994	0.1580
CR_{19}	0.1286	0.1801	0.2590	0.1801	0.2523
CR_{20}	0.2129	0.2258	0.1694	0.1789	0.2129
CR_{21}	0.2323	0.1181	0.2087	0.2087	0.2323
CR_{22}	0.1864	0.2125	0.2076	0.2070	0.1864

Table 6. The criteria weight after modified.

	$w^1_{CR,j}$	$w^2_{CR,j}$	$w^3_{CR,j}$
CR_1	0.0831	0.0822	0.0906
CR_2	0.0382	0.0382	0.0384
CR_3	0.0845	0.0823	0.0826
CR_4	0.0632	0.0626	0.0476
CR_5	0.0858	0.0879	0.0911
CR_6	0.0381	0.0381	0.0382
CR_7	0.0512	0.0509	0.0513
CR_8	0.0429	0.0440	0.0445
CR_9	0.0374	0.0374	0.0379
CR_{10}	0.0384	0.0377	0.0395
CR_{11}	0.0394	0.0365	0.0333
CR_{12}	0.0396	0.0395	0.0396
CR_{13}	0.0467	0.0467	0.0466
CR_{14}	0.0611	0.0615	0.0467
CR_{15}	0.0425	0.0425	0.0426
CR_{16}	0.0356	0.0391	0.0338
CR_{17}	0.0373	0.0373	0.0380
CR_{18}	0.0331	0.0332	0.0333
CR_{19}	0.0331	0.0331	0.0332
CR_{20}	0.0471	0.0399	0.0398
CR_{21}	0.0396	0.0396	0.0396
CR_{22}	0.0375	0.0375	0.0375

Phase 2. Calculate the weights of Eps.

According to Equations (19)–(22), the Eps comprehensive weighted body $\underline{m}^1_j(B_i), \underline{m}^2_j(B_i), \underline{m}^2_j(B_i)$ of evidence for alternatives B_1, B_2, B_3, B_4, B_5 on criteria attributes are $CR_1, CR_2, ..., CR_{22}$, as is shown in Tables 7–9. According to Equation (23), $\underline{m}^1_j(B_i), \underline{m}^2_j(B_i), \underline{m}^2_j(B_i)$ can be integrated into the individual comprehensive evidence body of the Eps, as shown in Table 10. The evidence body similarity matrix obtained from Equations (24)–(27), as is shown in Equation (38).

$$S_M = \begin{pmatrix} 1.00000 & 0.36734 & 0.36737 \\ 0.36734 & 1.00000 & 0.36732 \\ 0.36737 & 0.36732 & 1.00000 \end{pmatrix} \tag{38}$$

Table 7. The comprehensive weighted body of evidence given by DM_1.

$\underline{m}^1_j(B_i)$	B_1	B_2	B_3	B_4	B_5
CR_1	0.1985	0.2008	0.2002	0.1999	0.2006
CR_2	0.2003	0.1995	0.2003	0.2000	0.1999
CR_3	0.2004	0.2020	0.1992	0.1970	0.2014
CR_4	0.2011	0.2013	0.1979	0.1979	0.2019
CR_5	0.1970	0.2033	0.2002	0.2002	0.1993
CR_6	0.2000	0.1996	0.2000	0.1996	0.2008
CR_7	0.1994	0.2003	0.2002	0.2002	0.1999
CR_8	0.2000	0.2002	0.2000	0.2000	0.2000
CR_9	0.1999	0.2000	0.1999	0.2003	0.2000
CR_{10}	0.2003	0.2005	0.1987	0.2008	0.1998
CR_{11}	0.2008	0.1997	0.1987	0.1997	0.2011
CR_{12}	0.2005	0.1998	0.1994	0.1998	0.2005
CR_{13}	0.2000	0.1998	0.2002	0.2000	0.2000
CR_{14}	0.1980	0.2018	0.1980	0.2006	0.2016
CR_{15}	0.1996	0.2001	0.2007	0.2001	0.1996
CR_{16}	0.1992	0.1992	0.2006	0.2001	0.2008
CR_{17}	0.2000	0.2000	0.1996	0.2002	0.2000
CR_{18}	0.2004	0.1998	0.1996	0.2003	0.1999
CR_{19}	0.1995	0.2002	0.2004	0.1998	0.2002
CR_{20}	0.2015	0.1991	0.2004	0.2005	0.1985
CR_{21}	0.2003	0.1994	0.2001	0.2001	0.2001
CR_{22}	0.1999	0.2001	0.2001	0.2001	0.1999

Table 8. The comprehensive weighted body of evidence given by DM_2.

$\underline{m}_j^2(B_i)$	B_1	B_2	B_3	B_4	B_5
CR_1	0.1989	0.2015	0.1979	0.2005	0.2012
CR_2	0.1991	0.2005	0.2004	0.2001	0.1999
CR_3	0.1997	0.2010	0.1978	0.2010	0.2005
CR_4	0.2009	0.2018	0.1979	0.1979	0.2016
CR_5	0.1970	0.2039	0.2005	0.2005	0.1982
CR_6	0.2000	0.1996	0.2000	0.1996	0.2008
CR_7	0.1986	0.2005	0.2004	0.2004	0.2001
CR_8	0.2007	0.1990	0.2007	0.2007	0.1990
CR_9	0.2000	0.2001	0.2000	0.1998	0.2000
CR_{10}	0.2003	0.2002	0.1987	0.2009	0.1999
CR_{11}	0.1992	0.1997	0.2009	0.1992	0.2009
CR_{12}	0.1998	0.1998	0.1994	0.2005	0.2004
CR_{13}	0.2000	0.1998	0.2002	0.2000	0.2000
CR_{14}	0.1979	0.2013	0.1979	0.2018	0.2011
CR_{15}	0.1993	0.1998	0.2003	0.2005	0.2001
CR_{16}	0.1992	0.1992	0.2014	0.1992	0.2009
CR_{17}	0.2000	0.2000	0.2003	0.1997	0.2000
CR_{18}	0.2002	0.1997	0.2002	0.2001	0.1998
CR_{19}	0.1996	0.2000	0.2006	0.1999	0.2000
CR_{20}	0.2006	0.1990	0.1999	0.1999	0.2006
CR_{21}	0.2003	0.1993	0.2001	0.2001	0.2003
CR_{22}	0.1999	0.2001	0.2001	0.2001	0.1999

Table 9. The comprehensive weighted body of evidence given by DM_3.

$\underline{m}_j^3(B_i)$	B_1	B_2	B_3	B_4	B_5
CR_1	0.1996	0.2034	0.1982	0.2019	0.1969
CR_2	0.1991	0.2005	0.2004	0.2001	0.1999
CR_3	0.1995	0.2010	0.1979	0.2010	0.2006
CR_4	0.2001	0.2006	0.2005	0.1983	0.2005
CR_5	0.1968	0.2037	0.2007	0.2007	0.1980
CR_6	0.2004	0.1998	0.1998	0.1994	0.2005
CR_7	0.1987	0.2006	0.2005	0.2001	0.2002
CR_8	0.2002	0.1991	0.2004	0.2012	0.1991
CR_9	0.1990	0.2006	0.2001	0.1998	0.2004
CR_{10}	0.2003	0.2005	0.1986	0.2009	0.1998
CR_{11}	0.2002	0.1996	0.2001	0.2001	0.2001
CR_{12}	0.1996	0.1996	0.2003	0.2003	0.2002
CR_{13}	0.2001	0.1999	0.2003	0.1996	0.2001
CR_{14}	0.1984	0.2004	0.2002	0.2007	0.2003
CR_{15}	0.1994	0.1999	0.2004	0.1999	0.2005
CR_{16}	0.2002	0.1999	0.2005	0.1992	0.2002
CR_{17}	0.2000	0.2004	0.2003	0.1990	0.2004
CR_{18}	0.2001	0.2000	0.2002	0.2000	0.1997
CR_{19}	0.1995	0.1999	0.2004	0.1999	0.2004
CR_{20}	0.2001	0.2002	0.1997	0.1998	0.2001
CR_{21}	0.2003	0.1993	0.2001	0.2001	0.2003
CR_{22}	0.1999	0.2001	0.2001	0.2001	0.1999

Table 10. The individual comprehensive evidence body of Eps.

	B_1	B_2	B_3	B_4	B_5
$\underline{m}^1(B_i)$	0.1966	0.2065	0.1942	0.1970	0.2056
$\underline{m}^2(B_i)$	0.1915	0.2058	0.1953	0.2022	0.2052
$\underline{m}^3(B_i)$	0.1915	0.2091	0.1995	0.2020	0.1979

The weight $O = (0.333343, 0.333321, 0.333336)^T$ for DM_1, DM_2, DM_3 is obtained by Equations (28)–(29).

Phase 3. *Determine the ranking and select the best LSS.*

By combining the weights obtained by phase1 and phase2 through Equation (30), the final weights for the 22 criteria can be obtained as shown in Table 11. Through Equations (31) and (32), the evaluation information of three Eps can be integrated into a comprehensive decision matrix, as shown in Table 12. Using Equations (33)–(37), the group utility value $S(B_i)$ and individual regret value $R(B_i)$ of each scheme, as well as their proximity to the ideal solution $Q(B_i)$, are shown in Table 13, and the ranking results of the five alternative scenic spots can be obtained as follows: $B_1 > B_3 > B_4 > B_2 > B_5$. B_1 is the best alternative scenic area. Refer to Xu (2017) for $\theta = 0.5$; the transformation of the result corresponding to θ transformation will be discussed in the following section.

The method proposed in this paper can consider the maximum value of group utility, the minimum value of majority regret, and the minimum value of individual regret. In addition, the weights proportion of scoring Eps are taken into account effectively through Bayesian distribution. The decision system chooses the decision mechanism $\theta = 0.5$, meaning that the decision makers make different decisions according to the consensus reached through negotiation. Therefore, the method proposed in this paper is effective and flexible.

Table 11. The final weights of the 22 criteria.

Criteria	Weight	Subcriteria	Subcriteria Weight
Eco-environment	0.3909	CR_1	0.0853
		CR_2	0.0383
		CR_3	0.0831
		CR_4	0.0578
		CR_5	0.0883
		CR_6	0.0381
Tourist facilities	0.2937	CR_7	0.0511
		CR_8	0.0438
		CR_9	0.0376
		CR_{10}	0.0385
		CR_{11}	0.0364
		CR_{12}	0.0396
		CR_{13}	0.0466
Management level	0.2391	CR_{14}	0.0564
		CR_{15}	0.0425
		CR_{16}	0.0362
		CR_{17}	0.0375
		CR_{18}	0.0332
		CR_{19}	0.0331
Participant attitudes	0.1193	CR_{20}	0.0423
		CR_{21}	0.0396
		CR_{22}	0.0375

Table 12. The comprehensive decision matrix.

$\widetilde{z}_{ij}$	B_1	B_2	B_3	B_4	B_5
CR_1	((3.0, 5.0, 7.0); 0.6, 0.3)	((6.3, 8.1, 8.9); 0.8, 0.1)	((3.0001, 5.0001, 6.6667); 0.6, 0.3)	((6.7, 7.6, 9.3); 0.6, 0.2)	((6.0, 7.0, 7.6667); 0.6, 0.3)
CR_2	((3.4334, 4.9667, 6.5); 0.6, 0.3)	((5.6666, 7.6666, 9.0); 0.6, 0.3)	((6.7, 7.6, 9.3); 0.6, 0.2)	((5.0, 7.0, 9.0); 0.6, 0.3)	((7.4, 8.5, 9.2); 0.4, 0.4)
CR_3	((5.8, 7.5, 9.0667); 0.4, 0.4)	((9.0, 10.0, 10.0); 0.6, 0.3)	((1.6667, 3.6667, 5.6667); 0.6, 0.3)	((5.9999, 6.9999, 7.6666); 0.6, 0.3)	((7.0, 9.0, 10.0); 0.6, 0.3)
CR_4	((6.7, 7.6, 9.3); 0.6, 0.2)	((6.5333, 8.4, 9.2667); 0.8, 0.1)	((1.9333, 3.2667, 5.0667); 0.8, 0.1)	((0.0, 1.0, 3.0); 0.6, 0.3)	((5.8, 7.8, 9.2); 0.8, 0.1)
CR_5	((0.0, 1.0, 3.0); 0.6, 0.3)	((8.3, 8.9, 9.5); 0.8, 0.1)	((6.6, 8.0, 9.1333); 0.6, 0.3)	((6.6, 8.0, 9.1333); 0.6, 0.3)	((1.6667, 3.6667, 5.6667); 0.6, 0.3)
CR_6	((6.0, 7.5, 9.0); 0.7, 0.2)	((3.6667, 5.6667, 7.6667); 0.6, 0.3)	((5.0, 7.0, 9.0); 0.6, 0.3)	((3.0, 5.0, 7.0); 0.6, 0.3)	((5.8, 7.8, 9.2); 0.8, 0.1)
CR_7	((3.1334, 4.8334, 6.4); 0.6, 0.3)	((6.3, 8.1, 8.9); 0.8, 0.1)	((9.0, 10.0, 10.0); 0.6, 0.3)	((8.2333, 9.2, 9.7667); 0.6, 0.2)	((7.0, 9.0, 10.0); 0.6, 0.3)
CR_8	((7.1333, 8.8333, 9.7333); 0.4, 0.4)	((3.6667, 5.3334, 6.6667); 0.6, 0.3)	((6.3333, 8.3333, 9.6667); 0.6, 0.3)	((7.3333, 8.8333, 9.6667); 0.7, 0.2)	((3.0001, 5.0001, 6.6667); 0.6, 0.3)
CR_9	((5.8666, 6.9333, 8.0); 0.6, 0.3)	((7.5, 9.0667, 9.9333); 0.7, 0.2)	((6.7, 7.6, 9.3); 0.6, 0.2)	((5.4333, 7.3667, 8.9667); 0.6, 0.3)	((7.7667, 8.8, 9.5); 0.7, 0.2)
CR_{10}	((7.0, 9.0, 10.0); 0.6, 0.3)	((8.1, 8.6333, 9.1667); 0.7, 0.2)	((0.0, 1.0, 3.0); 0.6, 0.3)	((8.3, 8.9, 9.5); 0.8, 0.1)	((6.0, 8.0, 9.0); 0.5, 0.4)
CR_{11}	((5.5001, 7.0667, 8.2667); 0.7, 0.2)	((3.6667, 5.6667, 7.6667); 0.6, 0.3)	((5.9999, 6.9999, 7.6666); 0.6, 0.3)	((4.0, 5.5, 7.0); 0.7, 0.2)	((9.0, 10.0, 10.0); 0.6, 0.3)
CR_{12}	((7.1334, 8.5, 9.4); 0.4, 0.4)	((6.0, 8.0, 9.0); 0.5, 0.4)	((4.8333, 6.4, 7.9333); 0.7, 0.2)	((6.2, 8.0667, 8.9333); 0.8, 0.1)	((8.0, 8.5, 9.0); 0.7, 0.2)
CR_{13}	((7.5, 8.5, 9.5); 0.6, 0.2)	((8.3, 8.9, 9.5); 0.8, 0.6)	((8.0, 8.5, 9.0); 0.7, 0.2)	((6.3333, 8.3333, 9.6667); 0.6, 0.3)	((7.0, 9.0, 10.0); 0.6, 0.3)
CR_{14}	((0.0, 1.0, 3.0); 0.6, 0.3)	((7.5, 8.5, 9.5); 0.6, 0.2)	((2.2333, 3.2, 5.1); 0.6, 0.2)	((6.2, 8.0667, 8.9333); 0.8, 0.1)	((7.0, 9.0, 10.0); 0.6, 0.3)
CR_{15}	((3.0, 5.0, 7.0); 0.6, 0.3)	((5.0, 7.0, 9.0); 0.6, 0.3)	((7.5, 8.5, 9.5); 0.6, 0.2)	((5.4333, 7.3667, 8.9667); 0.6, 0.3)	((6.4333, 7.4666, 8.5); 0.7, 0.2)
CR_{16}	((3.0, 5.0, 6.6667); 0.6, 0.3)	((2.3333, 4.3333, 6.3333); 0.6, 0.3)	((6.5333, 8.4, 9.2667); 0.8, 0.1)	((2.6667, 4.6667, 6.3334); 0.6, 0.3)	((7.2333, 8.3667, 9.4333); 0.6, 0.2)
CR_{17}	((6.9, 8.5333, 9.7667); 0.6, 0.2)	((7.5, 9.0667, 9.9333); 0.7, 0.2)	((6.2, 8.0667, 8.9333); 0.8, 0.1)	((5.0, 6.6667, 8.0); 0.6, 0.3)	((7.5, 9.0667, 9.9333); 0.7, 0.2)
CR_{18}	((8.0, 8.5, 9.0); 0.7, 0.2)	((6.3333, 8.3333, 9.3333); 0.6, 0.3)	((6.9999, 8.3333, 9.0); 0.6, 0.3)	((7.0, 9.0, 10.0); 0.6, 0.3)	((5.0, 7.0, 9.0); 0.6, 0.3)
CR_{19}	((3.0, 5.0, 7.0); 0.6, 0.3)	((5.6667, 7.6667, 9.3333); 0.6, 0.3)	((5.8, 7.8, 9.2); 0.8, 0.1)	((5.6667, 7.6667, 9.0); 0.6, 0.3)	((6.6667, 8.1667, 9.3333); 0.7, 0.2)
CR_{20}	((7.5667, 8.2, 9.1); 0.6, 0.2)	((3.0, 5.0, 6.6667); 0.6, 0.3)	((6.0, 8.0, 9.0); 0.5, 0.4)	((5.0, 7.0, 9.0); 0.6, 0.3)	((5.2332, 6.1999, 7.4333); 0.6, 0.2)
CR_{21}	((9.0, 10.0, 10.0); 0.6, 0.3)	((3.0, 5.0, 7.0); 0.6, 0.3)	((7.0, 9.0, 10.0); 0.6, 0.3)	((7.0, 9.0, 10.0); 0.6, 0.3)	((8.3333, 9.6667, 10.0); 0.6, 0.3)
CR_{22}	((7.0, 9.0, 10.0); 0.6, 0.3)	((5.8, 7.8, 9.2); 0.8, 0.1)	((9.0, 10.0, 10.0); 0.6, 0.3)	((8.0, 8.5, 9.0); 0.7, 0.2)	((7.0, 9.0, 10.0); 0.6, 0.3)

Table 13. The values $S(B_i)$, $R(B_i)$ and $Q(B_i)$ of five alternatives.

	$S(B_i)$	$R(B_i)$	$Q(B_i)$	Final Ranking
B_1	0.5701	0.9747	0.0128	1
B_2	0.3652	0.9600	0.6883	4
B_3	0.4734	0.9753	0.1765	2
B_4	0.4343	0.9720	0.3164	3
B_5	0.2961	0.9510	1.0000	5

5.3. Discussion

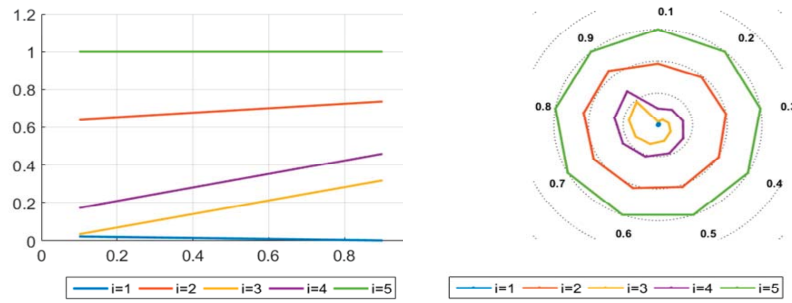
Due to the different selection of θ, the results are different. In this case, a sensitivity analysis was conducted from the perspective of θ selection to explore the influence on the evaluation results of alternatives B_1, B_2, B_3, B_4, B_5, thus verifying the robustness of the evaluation results. On this basis, other comparable MCDM methods, including the single entropy weight method and BWM, are used to determine the weight of the first stage, so as to evaluate the LSSs. The results of different methods will illustrate the feasibility and rationality of the proposed method.

5.3.1. Sensitive Analyses

In this section, the impact of the group utility maximization coefficient θ on the results is discussed. $\theta < 0.5$ indicates that decision makers make decisions according to the decision mechanism that maximizes group utility; $\theta > 0.5$ indicates that decision makers make decisions according to the decision mechanism that minimizes individual regret. This paper assumes that $\theta = 0.5$, which indicates that decision makers make decisions according to the decision mechanism that reaches consensus through consultation. The value of θ is set to 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9 respectively. The results of the ideal solution approximation $Q(B_i)$ for the five alternatives and their rankings are shown in Table 14. In addition, in order to make the results more intuitive, two image representations were selected to express the final rankings. In Figure 6a, the abscissa represents the value of the θ, and the ordinate represents $Q(B_i)$ under different θ. In Figure 6b, the outermost circle represents θ and the lines of different species colors represent five LSSs; the left and right lines correspond in color. In the figures below, i = 1, 2, 3, 4, and 5 represent alternatives 1, 2, 3, 4, and 5. In addition, the left and right lines correspond to each other. As shown in Figure 6, when $\theta = 0.1$, the values of alternative scenic spot B_1 and B_3 are the closest, the gap between them becomes larger as θ increases, and the advantage of option B_1 becomes more obvious. B_5 is the most stable among all alternatives, and the change trends of option B_3 and B_4 are similar. The ranking is $B_1 > B_3 > B_4 > B_2 > B_5$. In summary, scenic spot B_1 is the optimal alternative.

Table 14. The ranking orders of alternatives with different θ.

θ	$Q(B_1)$	$Q(B_2)$	$Q(B_3)$	$Q(B_4)$	$Q(B_5)$	Ranking Orders	Best Candidates
0.1	0.0231	0.6405	0.0353	0.1732	1.0000	$B_1 > B_3 > B_4 > B_2 > B_5$	B_1
0.2	0.0205	0.6524	0.0706	0.2090	1.0000	$B_1 > B_3 > B_4 > B_2 > B_5$	B_1
0.3	0.0180	0.6644	0.1059	0.2448	1.0000	$B_1 > B_3 > B_4 > B_2 > B_5$	B_1
0.4	0.0154	0.6763	0.1412	0.2806	1.0000	$B_1 > B_3 > B_4 > B_2 > B_5$	B_1
0.5	0.0128	0.6883	0.1765	0.3164	1.0000	$B_1 > B_3 > B_4 > B_2 > B_5$	B_1
0.6	0.0103	0.7002	0.2118	0.3522	1.0000	$B_1 > B_3 > B_4 > B_2 > B_5$	B_1
0.7	0.0077	0.7122	0.2471	0.3881	1.0000	$B_1 > B_4 > B_3 > B_2 > B_5$	B_1
0.8	0.0051	0.7241	0.2824	0.4239	1.0000	$B_1 > B_4 > B_3 > B_2 > B_5$	B_1
0.9	0.0026	0.7361	0.3177	0.4597	1.0000	$B_1 > B_4 > B_3 > B_2 > B_5$	B_1

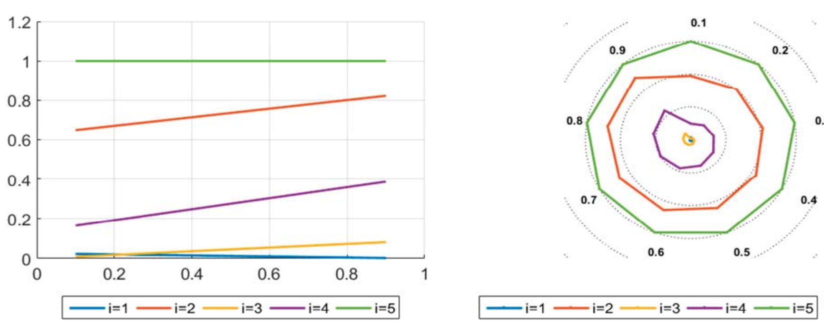


(a) (b)

Figure 6. Sensitivity analysis results. (**a**) Description of what is the trend of the alternatives on the axis; (**b**) Description of what is the trend of the alternatives on the ring chart.

5.3.2. Comparative Analysis.

In this paper, BWM is combined with the entropy weight method to obtain criteria weights. In order to demonstrate the scientific nature of the research results, this paper considers the comparison between the single BWM method and the single entropy weight method to calculate the weights. BWM is a very effective MCDM for determining criteria weights; it simplifies the operation process effectively by pairwise comparisons to calculate the required results. Entropy, as a measure of information uncertainty, can be used to determine the entropy weight of the criteria. The criteria weights are mainly determined according to the information contained in the evaluation value of the criteria, so as to avoid the influence of subjective factors. By comparison, the results obtained by the two methods are less different from those obtained by the research method in this paper. Therefore, the optimal multicriteria decision method of TIFNs proposed in this paper can effectively solve the MCDM problem. In comparison, the method in this paper considers both objective weight and subjective weight, and combines them effectively to make the evaluation results more universal. The evaluation results of the two methods are shown in Figures 7 and 8. The results show that $\theta \neq 0.1, 0.2$, i.e., the result calculated by entropy weight method deviates slightly from other methods; for the alternative scenic spot, B_1 is the optimal LSS.



(a) (b)

Figure 7. Result calculated by the entropy weight method. (**a**) Description of what is the trend of the alternatives on the axis; (**b**) Description of what is the trend of the alternatives on the ring chart.

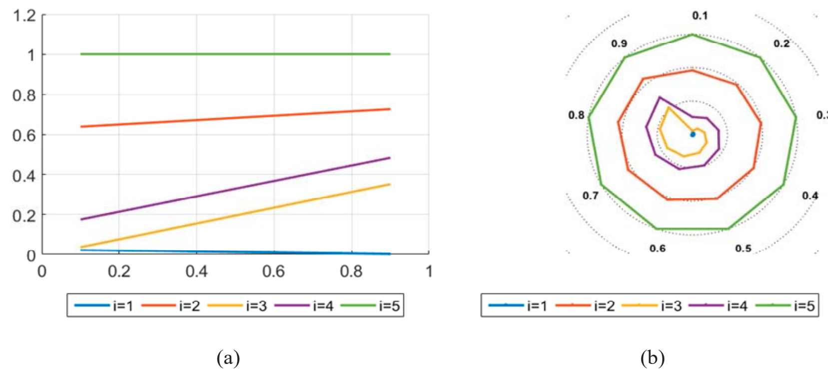


Figure 8. Result calculated by BWM. (**a**) Description of what is the trend of the alternatives on the axis; (**b**) Description of what is the trend of the alternatives on the ring chart.

6. Conclusions

This paper proposes a new MCGDM method by which to study evaluation methods for LSSs. IBWM and B-DST are used to improve the traditional VIKOR method. Considering the uncertainty of the decision-making environment, TIFN was chosen as the evaluation language. Finally, the following conclusions are obtained.

(1) According to the comprehensive weight in Table 11, environmental factors and tourist facilities account for the largest proportion in the evaluation of LSSs. Therefore, build LSSs must carry out scientific planning. First of all, the construction of tourist attractions should use new technologies, new materials, and other energy-saving technologies to make the energy consumption levels of the scenic areas as low as possible; furthermore, it should prioritize integration and coordination with the surrounding ecological environment. Secondly, the number of tourists should be controlled in order to ensure low carbon emissions in the scenic area, according to reasonable limits. Third, the planning of scenic areas should attempt to increase green areas. Finally, the treatment of waste in the scenic area should be scientifically planned, e.g., by the separation and recovery of solid waste, wastewater and sewage treatment to be discharged into rivers, and so on.

(2) The operation of the scenic area is guided by low-carbon ideas. Scientific planning for tourist attractions is an important aspect of construction. The low-carbon concept should be put into every aspect of the operation of scenic spots, including strengthening the education of scenic area management personnel and service personnel. At the same time, scenic area managers should actively exchange and cooperate with foreign scenic spots to learn from their experience.

(3) LSSs should actively strengthen environmental protection education for tourists. Tourists are the main body of tourism activities, and their behavior has a direct impact on the carbon emissions of scenic spots. Therefore, it is necessary to actively strengthen environmental protection education for tourists.

The development of sustainable tourism and eco-tourism is a hot topic for experts and scholars at home and abroad. However, there are few research papers on low-carbon tourism. The method proposed in this paper can help select the best LSS and fill the academic gap in the LSS evaluation field. Then, in the context of global warming, this paper studies low-carbon evaluation criteria systems for tourist attractions. It is not uncommon for evaluation criteria systems to be applied in tourism, but this paper innovatively applies an evaluation system to the low-carbon evaluation of scenic spots. However, this research has some shortcomings. First, in the research process, the selection of the expert group members was relatively limited, and their views were relatively concentrated, which may have led to insufficient broadness of thought, i.e., making it too simple to reach consensus on issues. Second, the evaluation of alternative LSSs in this paper is expressed by TIFNs, and the evaluation value may be real numbers or other forms in practical application. Therefore, the MCGDM problem could be better studied when the decision information is of mixed language type.

Author Contributions: This paper presents collaborative research results written by A.L., T.L., and X.J. H.L. and F.L. conceived and designed the study. T.L. and X.J. performed the research and wrote the paper. H.L. and F.L. checked English language and style. A.L. provided revised advice. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Appendix A.1. Proof Definition 3

Definition 3 can be proved by Mathematical induction
Assume that decision-maker weights are known
First, let $n = 2$, according to $\gamma\widetilde{a} = ((\gamma\underline{a}, \gamma a, \gamma\overline{a}); \omega_{\widetilde{a}}, u_{\widetilde{a}})$ $(\gamma > 0)$
Where $i = 1, 2$.
Therefore, we can obtain,

$$TI - WAA(\widetilde{a}_1, \widetilde{a}_2)$$
$$= \left(\left(\gamma_1\underline{a}_1 + \gamma_2\underline{a}_2, \gamma_1 a_1 + \gamma_2 a_2, \gamma_1\overline{a}_1 + \gamma_2\overline{a}_2\right); \min\{\omega_1, \omega_2\}, \max\{u_1, u_2\}\right)$$

Then, let $n = k$

$$TI - WAA(\widetilde{a}_1, \widetilde{a}_2, \ldots, \widetilde{a}_k)$$
$$= \left(\left(\gamma_1\underline{a}_1 + \gamma_2\underline{a}_2 +, \ldots, +\gamma_k\underline{a}_k, \gamma_1 a_1 + \gamma_2 a_2 +, \ldots, +\gamma_k a_k, \gamma_1\overline{a}_1 + \gamma_2\overline{a}_2, \ldots, +\gamma_k\overline{a}_k\right); \min\{\omega_1, \ldots, \omega_k\}, \max\{u_1, \ldots, u_\mathrm{k}\}\right)$$
$$\left(\left(\sum_{r=1}^{k} w_r\underline{a}_r, \sum_{r=1}^{k} w_r a_r, \sum_{r=1}^{k} w_r\overline{a}_r\right); \min_k\{\omega_1, \omega_2, \ldots, \omega_k\}, \max_k\{\omega_1, \omega_2, \ldots, \omega_k\}\right)$$

Finally, let $n = k + 1$

$$TI - WAA(\widetilde{a}_1, \widetilde{a}_2, \ldots, \widetilde{a}_k, \widetilde{a}_{k+1})$$
$$= \left(\left(\gamma_1\underline{a}_1 + \gamma_2\underline{a}_2 +, \ldots, +\gamma_{k+1}\underline{a}_{k+1}, \gamma_1 a_1 + \gamma_2 a_2 +, \ldots, +\gamma_{k+1} a_{k+1}, \gamma_1\overline{a}_1 + \gamma_2\overline{a}_2, \ldots, +\gamma_{k+1}\overline{a}_{k+1}\right); \min\{\omega_1, \ldots, \omega_{k+1}\}, \max\{u_1, \ldots, u_{k+1}\}\right)$$
$$= \left(\left(\sum_{r=1}^{k+1} w_r\underline{a}_r, \sum_{r=1}^{k+1} w_r a_r, \sum_{r=1}^{k+1} w_r\overline{a}_r\right); \min_{k+1}\{\omega_1, \omega_2, \ldots, \omega_k, \omega_{k+1}\}, \max_{k+1}\{\omega_1, \omega_2, \ldots, \omega_k, \omega_{k+1}\}\right)$$

Appendix A.2. Proof Property (3)

$$\begin{cases} |\omega_1 - \omega_2| + |\omega_2 - \omega_3| \geq \left|\omega_1 - \omega_{\widetilde{b}}\right| \\ |u_1 - u_2| + |u_2 - u_3| \geq \left|u_1 - u_{\widetilde{b}}\right| \end{cases}$$

Then

$$\max\{|\omega_1 - \omega_2|, |u_1 - u_2|\} + \max\left\{|\omega_2 - \omega_3|, \left|\omega_1 - \omega_{\widetilde{b}}\right|\right\} \geq \left\{|u_2 - u_3|, \left|u_1 - u_{\widetilde{b}}\right|\right\}$$

And because

$$\begin{cases} \left|\underline{a}_1 - \underline{a}_2\right| + \left|\underline{a}_2 - \underline{b}\right| \geq \left|\underline{a}_1 - \underline{b}\right| \\ |a_1 - a_2| + |a_2 - b| \geq |a_1 - b| \\ \left|\overline{a}_1 - \overline{a}_2\right| + \left|\overline{a}_2 - \overline{b}\right| \geq \left|\overline{a}_1 - \overline{b}\right| \end{cases}$$

Hence $d_h\left(\widetilde{a}_1, \widetilde{b}\right) \leq d_h\left(\widetilde{a}_1, \widetilde{b}\right) + d_h\left(\widetilde{a}_2, \widetilde{b}\right)$ Similarly, $d_e\left(\widetilde{a}_1, \widetilde{b}\right) \leq d_e\left(\widetilde{a}_1, \widetilde{b}\right) + d_e\left(\widetilde{a}_2, \widetilde{b}\right)$ can also be proved.

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The Impacts of Different Air Pollutants on Domestic and Inbound Tourism in China

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Abstract: Previous studies have reported that air pollution negatively affects the tourism industry. This paper attempted to answer the following question: among different air pollutants, which one acts as the most adverse factor? The study was based on a sample of panel data covering 337 Chinese cities for the period between 2007 and 2016. Four pollutant indicators were inspected: $PM_{2.5}$ (particulate matter 2.5 micrometers or less in size), PM_{10} (particulate matter 10 micrometers or less in size), SO_2 (sulfur dioxide), and NO_2 (nitrogen dioxide). It was found that $PM_{2.5}$ had a significantly negative impact on both domestic and inbound tourist arrivals. Regarding the other three pollutant indicators, except for the negative influence of NO_2 on inbound tourist arrivals, no statistically significant impact was found. This study suggests that tourism policy makers should primarily focus on $PM_{2.5}$, when considering the nexus between air quality and tourism development. According to our estimates, the negative impact of $PM_{2.5}$ on tourism is substantial. If the $PM_{2.5}$ concentration in the ambient air increases by 1 $\mu g/m^3$ (=0.001 mg/m^3), domestic and inbound tourist arrivals will decline by 0.482% and 1.227%, respectively. These numbers imply an average reduction of 81,855 person-times in annual domestic tourist arrivals and 12,269 in inbound tourist arrivals in each city.

Keywords: air pollution; $PM_{2.5}$; PM_{10}; SO_2; NO_2; tourist arrivals

1. Introduction

In recent years, the tremendous industrial growth of the Chinese economy has caused high levels of air pollution in some regions. Air pollution heavily affects public health. For instance, it was reported that air pollution has caused an average of 1.1 million premature deaths in China annually [1]. Moreover, air pollution also inhibits many economic and social activities. In particular, the adverse effect of air pollution on tourism has received increasing attention. Pollution damages tourism's development by evoking negative psychological states in tourists, reducing the aesthetics of scenic spots, harming the tourist experience, and decreasing tourism's demand (e.g., [2–4]).

Prior studies have found that air pollution negatively influences tourism's development and activities. The air pollutants examined included PM (particulate matter), SO_2 (sulfur dioxide), NO_2 (nitrogen dioxide), and so on. Among them, PM is one of the most well-known types of air pollutants. PM with a diameter of 2.5 micrometers or less is known as $PM_{2.5}$, while that with a diameter of 10 micrometers or less is known as PM_{10}. At present, given that social media and news agencies frequently associate $PM_{2.5}$ with haze pollution, many people perceive $PM_{2.5}$ and haze weather to be interchangeable concepts [5]. Additionally, some people regard $PM_{2.5}$ as the only pollutant necessary for measuring the air quality index (AQI). Although $PM_{2.5}$ is a dominant pollutant in haze pollution, it should be noted that, according to the World Health Organization (WHO) Air Quality Guidelines, relevant pollutants also include PM_{10}, NO_2, SO_2, and ozone (O_3). Different air pollutants have been used together to calculate AQI scores and have also been found to be associated with negative health outcomes, such as hospital admissions, respiratory diseases, incidence of asthma symptoms, and cardiovascular disease (e.g., [6,7]). When SO_2 and NO_2 combine with water and sunlight, the main component of acid rain results, which can cause deforestation and destroy cultural heritage, such as ancient historical buildings and monuments.

Yan et al. [8] empirically examined the effects of different air pollutants on urban activities in China using geotagged check-in records on a Chinese social media platform, indicating that SO_2 had the largest impact, followed by $PM_{2.5}$, NO_2, and PM_{10}. They further discovered that leisure-related activities were much more sensitive to air pollution than work-related activities. To examine the impact of air pollution on the tourism industry, a number of studies have used $PM_{2.5}$, PM_{10}, or AQI as indicative measures of air quality (e.g., [9–12]). However, how other major air pollutants (e.g., NO_2, SO_2) influence the tourism industry in China has seldom been explored. Given that these air pollutants could all pose health threats to travelers [13] and destroy the attractiveness of destination cities to potential tourists, knowledge about how and to what extent major air pollutants exert impacts on tourism industry is required.

To address the above literature gap, this study aimed to examine the impact of air pollution on the tourism industry by taking into account four major air pollutants: $PM_{2.5}$, PM_{10}, NO_2, and SO_2. More specifically, this study examined whether and to what extent the different air pollutants respectively impact domestic and inbound tourism. The study's results are expected to help the Chinese government formulate better air quality control strategies, in order to maintain a sustainable tourism industry. Additionally, the results of this study could help the public health sector better understand how to issue travel advice on air pollution.

The rest of this paper proceeds as follows. Section 2 presents a literature review. Section 3 discusses the empirical model and the data used in the analyses. The estimated results of the empirical model are reported in Section 4. Section 5 discusses the implications of the results. Section 6 concludes and talks about the directions for future research.

2. Literature Review

2.1. Air Pollutants: Sources and Impacts

SO_2 and NO_2 are among the major causes of smog and acid rain. SO_2 arises from industrial activities that burn fossil fuels (e.g., coal, oil, and diesel) containing sulfur. Sources include but are not limited to power plants, metal processing and smelting facilities, and diesel vehicles and equipment [14,15]. Common effects of SO_2 are respiratory problems and increased hospital admissions for cardiac disease [16]. NO_2 is typically produced from combustion processes (e.g., heating, power generation, and engines in vehicles and ships). NO_2 emissions are more likely to be clustered in densely populated urban areas and suburban industrial areas [17]. High levels of NO_2 exposure could cause respiratory infections and the prevalence of bronchitic symptoms in asthmatic children aged between 5 and 14 years old [6]. NO_2 exposure has also been found to be associated with lung cancer [18], mortality, hospital admissions, and respiratory diseases across all ages [6]. In addition to the health effects of SO_2 and NO_2, their environmental effects are largely due to the acid rain that forms from SO_2 and NO_2. It is well known that acid rain not only damages natural ecosystems, but also man-made materials, such as limestone, marble, and sandstone [19]. For example, the Giant Buddha at Leshan in Sichuan Province, the Longmen Grottoes in Henan Province, and the Dazu rock carvings in Chongqing, which are famous tourist attractions in China, have been reported to be at a high risk of rapid deterioration from acid rain [20].

Compared to SO_2 and NO_2, PM is more tangible and visible. Wang et al. [21] identified soil dust, vehicular emission, coal combustion, secondary aerosol, industrial emission, and biomass burning as six common sources of $PM_{2.5}$ and PM_{10} in Beijing, China. A high concentration of PM directly reduces the visibility of air. It is also well known that PM severely damages public health [22–24]. For the Chinese population, Lu et al. [25] found that short exposures to $PM_{2.5}$ and PM_{10} were positively associated with increases in mortality due to cardiovascular and respiratory disease. Feng et al. [26] further suggested a strong association between $PM_{2.5}$ and influenza-like illness counts in the flu season.

Among the above four air pollutants, $PM_{2.5}$ has received the most widespread attention in recent years. This may be due to the fact that $PM_{2.5}$ is small enough to penetrate deep into the lungs, travels long distances and transcends boundaries or regions, and largely contributes to the impairment of visibility [27]. However, ignoring the impacts of other pollutants could lead to increasing health risks and detrimental climate changes in the long run. From the perspective of the tourism industry, overlooking the impact of other pollutants could lower travelers' satisfaction with respect to tourist destinations and expose travelers to more serious health threats.

2.2. The Impact of Air Pollution on Tourism

Two major streams of studies have examined the impacts of air pollution on tourism. One stream of literature relied on questionnaire survey tools to measure travelers' subjectively perceived level of air pollution, which is actually a psychological response to the actual air quality (e.g., [2,5,28,29]). Another stream of literature examined the impacts of actual air pollution on the tourism industry by applying different scientifically measured indices of air pollution (e.g., [9–11,30]). Table 1 presents a non-exhaustive summary of previous studies. The table reports the area studied, the period covered, and the type of pollutants studied by each research. As shown in the table, the air pollution indicators that were utilized to measure air quality varied across the different studies. It was found that $PM_{2.5}$ and PM_{10} were two of the most frequently used air pollution indicators, followed by the comprehensive index of AQI, or the air pollution index (API). It was noticed that other air pollutants, such as SO_2 and NO_2, have been less focused on. Some studies also relied on the number of good or bad air-quality days within one year or the subjectively perceived level of air pollution reported in questionnaire surveys to measure air quality.

Table 1. A non-exhaustive summary of previous studies about the impact of air pollution on tourism.

Literature	Area Studied	Period Covered	Type of Pollutants Studied						
			$PM_{2.5}$	PM_{10}	SO_2	NO_2	AQI (or API)	Other Objective Indicators	Perceived Pollution
Anaman and Looi [31]	Brunei Darussalam	1995M1–1999M9						dummy variable for haze-related pollution	
Becken et al. [2]	China	2014							√
Chen et al. [32]	Sun Moon Lake Scenic Area, Taiwan, China	2004M1–2011M12						days of bad air quality	
Deng et al. [30]	31 provinces in China	2001–2013						industrial waste gas emission	
Dong et al. [9]	274 cities in China	2009–2012		√					
Dong et al. [10]	337 cities in China	2004–2013	√						
Law and Cheung [33]	Hong Kong, China	2003							√
Li et al. [34]	Beijing, China	2014							√
Liu et al. [11]	17 provinces in China	2005–2015	√						
Peng and Xiao [35]	Beijing, China	2016							√
Poudyal et al. [3]	Great Smoky Mountain National Park, USA	1988M3–2009M12						visibility of air	
Qiao et al. [36]	China	2015							√
Sun et al. [12]	28 cities in China	1999–2015	√						
Tang et al. [37]	Beijing, China	2004M1–2015M12					√		
Wang and Wang [38]	35 OECD countries	1995–2014						CO_2 emission	
Wang et al. [39]	11 cities in China	2016M1D1–2016M12D31					√		
Xu and Reed [28]	China	2006–2014							√
Xu and Reed [29]	Shanghai, China	2011M12–2016M10	√						√
Xu et al. [40]	174 cities in China	1998–2016	√						
Yan et al. [8]	251 cities in China	2015M1D1–2016M10D30	√	√	√	√	√	*CO*	
Yoon [41]	Seoul, South Korea	2015M4–2017M2		√					
Zhang et al. [5]	Beijing, China	2014							√
Zhang et al. [4]	Thailand	2001–2017						CO_2 emission	
Zhou et al. [42]	24 cities in China	2007M1–2012M12					√		
Zhou et al. [43]	Beijing, China	2005–2016	*O*	√	*O*	*O*		days of good air quality	

Note: (1) The symbol "√" indicates that the corresponding air pollutant indicator was used in the study and demonstrated a statistically significant impact on tourism. The symbol "*O*" indicates that the corresponding air pollutant indicator was used in the study but did not demonstrate statistical significance. (2) The sample period covered in each study is described in the column "Period Covered". For the study based on the questionnaire survey to measure the perceived degree of air pollution, rather than the objectively measured level of air pollution, the "Period Covered" refers to the time of conducting questionnaire survey.

Overall, there was no consensus on the selection of air pollution indicators in the literature. The choice of air pollution indicator largely depended on the degree of convenience in data collection. Although different pollutants all reduce the quality of air, their respective impacts on tourist activities may be different. Interestingly, Yan et al. [8] reported that $PM_{2.5}$, PM_{10}, SO_2, and NO_2 all depressed humans' leisure-relevant behaviors, while Zhou et al. [43] reported that only PM_{10} had a statistically significant impact. As an extension of these two studies, our study also examined and compared the regression results for different pollutants. However, differently from Yan et al. [8] who used geotagged social media check-in data of "Weibo" covering 2015 and 2016, and Zhou et al. [43], who solely concentrated on one city in China (the city of Beijing), this study used a city-level sample, including 337 Chinese cities and covering the period between 2007 and 2016. Based on a wider sample, this study was able to examine the impact of air pollution on both inbound and domestic tourism more precisely from an aggregate perspective.

3. Empirical Model and Data

3.1. Model

The study was based on a city-level sample with panel data structure, consisting of both temporal and spatial dimensions. Following the previous studies investigating the pollution-tourism nexus (e.g., [12,31,32,39]), it was assumed that the impacts of air pollution and other explanatory variables on tourism could be captured by a linear econometric regression model. To be precise, in this study the following panel data econometric model was used:

$$y_{it} = x_{it}\beta + s_i + u_t + \varepsilon_{it}, \tag{1}$$

where y_{it} is the dependent variable in city i during period t. x_{it} refers to a vector of explanatory variables. s_i is the section-fixed effect, and u_t is the time-fixed effect. ε_{it} is the error term. β is a vector of parameters to be estimated.

In this study, we investigated the impacts of air pollution on both domestic tourism and inbound tourism. Thus, we separately considered two dependent variables: $Arrivals^{domestic}$, the domestic tourist arrivals (in 10,000 person-times), and $Arrivals^{inbound}$, the inbound tourist arrivals (in 10,000 person-times). As usual, in the econometric regressions, we used the logarithmic values of these two variables to deal with the scaling problem. Accordingly, the variations of dependent variables are expressed as percentage changes.

Among the explanatory variables, the core variable of interest was the air pollutant indicator. In this study, we inspected four important air pollution indicators: $PM_{2.5}$, PM_{10}, SO_2, and NO_2. These variables of air pollutants are expressed by their degrees of concentration density (mg/m^3) in ambient air.

A set of control variables was contained in the regressions: *Scenic*, *Hotel*, *Road*, *GovSize*, *Population*, and *GDPpc*. (i) The first control variable, *Scenic*, measures the abundance of local tourism endowment. It was calculated by the logarithmic value of the number of 4A- and 5A-rated scenic spots within each city. Since a 5A-rated scenic spot is typically considered as much more attractive than a 4A spot [9,30], we assumed that one 5A spot equalled three 4A spots. To avoid the problem of logarithmic computation when a city has zero 4A and 5A spots, we assigned a value of 0.01 to the number of scenic spots when it was actually zero. (ii) The second control variable, *Hotel*, measured the availability of tourism-specific infrastructure. We used the star-rated hotels to proxy this, since hotels are one of the most crucial tourism infrastructures. This variable was calculated by the ratio of the number of hotels divided by local population (in ten thousand). (iii) The third variable was *Road*, the length of road (km) per area (km^2). This was an indicator of the transportation infrastructure. (iv) *GovSize* was the government size, measured by the ratio of local government expenditure to GDP. This variable was used to capture the impact of the government on local tourism's development. (v) *Population* was the logarithmic value of the local population (in ten thousand), as a control variable for the potential economies of scale in tourism development. (vi) The last control variable was $GDPpc$, the logarithmic value of real GDP per capita (RMB). The nominal GDP was deflated, taking 2000 as the base year. Since previous studies have found that tourism might have impacts on economic and social development, which are directly linked to the values of the control variables in the current period, we lagged these control variables for three periods to mitigate the potential endogeneity problem. The idea is that the three-period-lagged values of the control variables probably affect the current value of the dependent variable (through their impacts on the current values of the control variables), but the current dependent variable has no effect on the past value of the control variables. That way, the potential endogeneity caused by reverse causality from the dependent variable to explanatory variables was mitigated. Definitely, one limitation of using the lagged values of control variables is that the estimated coefficients of them may not accurately reflect the impacts of the variables in the current period. However, given the large benefit of using this approach to mitigate the endogeneity issue, its limitation was deemed acceptable, and hence, it has been widely used in applied economics research (e.g., [44,45]).

3.2. Data

The data of $PM_{2.5}$ were collected from NASA's Global Annual $PM_{2.5}$ Grids data [46,47]. The data of PM_{10}, SO_2, and NO_2 were mainly extracted from a series of yearly published environmental quality reports—"The Report on the State of the Environment of China" [48–50]. These reports were written by China's Ministry of Environmental Protection (MEP), and later, by the Ministry of Ecology and Environment (MEE). These reports provided detailed official data of air quality in different areas of China since 2007. The reports did not offer city-level air pollution data for the years 2013 and 2015. We checked the China Statistical Yearbook on Environment and several province-level statistical yearbooks to supplement the missing data for some cities in 2013 and 2015, as well as some observations in other years. It is worth mentioning that the MEP, and later, the MEE, have also reported the $PM_{2.5}$ data in recent years. However, the available sample size was much smaller compared to that based on NASA's data. That is why we relied on the latter data source for $PM_{2.5}$ in our empirical analysis. In fact, an examination of the overlapping sample of these two data sources would make it clear that they are both reliable and highly correlated, though the reported values are not directly comparable, due to the technological disparity in measurement. NASA's $PM_{2.5}$ data were constructed on the basis of the information supplied by the remote sensing measurements of satellites, whereas the data offered by the MEP and MEE were from the direct measurements in local observation stations. Although there were uncertainties associated with the remote sensing measurements (for example, affected by weather and the precision of the electrical instruments), the accuracy and reliability of the $PM_{2.5}$ grids data have been highly appreciated. In fact, both data sources have been widely utilized in previous research (e.g., [8,9,11,12,42]). The data from the two data sources were highly correlated. For example, for the sample cities in the year of 2016, the Pearson correlation coefficient between $PM_{2.5}$ values from the two data sources was 0.753, indicating a strong positive correlation.

The data of the dependent variables $Arrivals^{domestic}$ and $Arrivals^{inbound}$, and the control variables $Hotel$, $Road$, $GovSize$, $Population$, and $GDPpc$ during the period 2007–2013 came from the China Statistical Yearbook for Regional Economy. For the period covered, this yearbook provided city-level data for almost all Chinese cities above the prefecture-level, though with occasional missing values. The data between 2014 and 2016 were obtained from the EPS database, available at its website: http://www.epschinadata.com. In addition, we checked different province-level statistical yearbooks or utilized the linear interpolation method to supplement some missing observations. The data of *Scenic* were collected from the public information released by the tourism-relevant local governmental sectors in different provinces.

Ultimately, our sample was comprised of unbalanced panel data covering 337 Chinese cities for the period between 2007 and 2016. This sample covered almost all regions in Mainland China, including all four province-level municipalities (Beijing, Tianjin, Shanghai, and Chongqing) and all prefecture-level administrative districts except Sansha City and Danzhou City of Hainan Province. Sansha and Danzhou, which were respectively established in 2012 and 2015, were excluded due to lack of statistical data. Table 2 shows the summary statistics for the variables used in empirical analyses. It is clear from the table that there were rich heterogeneities among the sample cities. The sample contained both less developed and well developed, small and large, and clean and severely polluted cities. Some cities had highly developed tourism industries, but the tourism size in some cities was quite small. Overall, our sample was highly representative and able to provide sufficient information on the general situation of China.

It is notable that the different air pollutants are probably correlated. Indeed, since human activities often emit more than one kind of pollutant, a district may be polluted by multiple pollutants simultaneously [51,52]. Moreover, since different pollutants may have complex chemical and physical interactions within the air, the degree of air pollution caused by one pollutant may be exacerbated by another one. Considering this, we had a concern that if the correlation among different pollutants was sufficiently high, there would be no way to distinguish different pollutants and use traditional econometric regressions to estimate their individual impacts on tourism. Table 3 shows the Pearson correlation coefficients among the four pollutants. From the table, we see that different pollutants are indeed positively correlated, as expected. However, the correlation coefficients are not very high and do not exceed 0.5. Thus, the indices of these four pollutants reflect different aspects of air pollution, and can be considered separately as different explanatory variables in the regression model.

Table 2. Summary statistics.

Variable		Unit	Obs	Mean	SD	Min	Max
Dependent Variable	$Arrivals^{domestic}$	10^4 person-times	2892	6.832	1.229	1.033	10.658
	$Arrivals^{inbound}$	10^4 person-times	2952	1.447	2.311	−9.210	7.106
Air Pollutant	$PM_{2.5}$	mg/m^3	3364	0.033	0.018	0.002	0.087
	PM_{10}	mg/m^3	2376	0.083	0.033	0	0.436
	SO_2	mg/m^3	2379	0.033	0.018	0.002	0.148
	NO_2	mg/m^3	2379	0.030	0.012	0.002	0.069
Control Variable	*Scenic*	-	3367	−0.334	2.640	−4.605	4.331
	Hotel	-	3367	0.143	0.226	0.003	4.338
	Road	km/km^2	3367	0.767	0.497	0.003	2.249
	GovSize	-	3367	0.189	0.179	0.040	3.581
	Population	10^4 persons	3367	5.665	0.877	2.077	7.996
	GDPpc	RMB	3367	9.720	0.731	7.613	11.874

Note: (1) The variables *Scenic*, *Hotel*, and *GovSize* have no unit. *Scenic* is the number of scenic spots. *Hotel* is the ratio of the number of hotels divided by local population (in ten thousand). *GovSize* is the ratio of government spending to GDP. (2) The variables $Arrivals^{domestic}$, $Arrivals^{inbound}$, *Scenic*, *Population*, and *GDPpc* were log-transformed. (3) The abbreviations "Obs", "SD", "Min", and "Max" in the first row denote "Observations", "Standard Deviation", "Minimum", and "Maximum", respectively.

Table 3. Correlation coefficients among the four pollutants.

	$PM_{2.5}$	PM_{10}	SO_2	NO_2
$PM_{2.5}$	1			
PM_{10}	0.329	1		
SO_2	0.309	0.403	1	
NO_2	0.435	0.492	0.401	1

4. Results

The regression results for Equation (1) are reported in this section. Section 4.1 discusses the estimated impacts of air pollutants on domestic tourism. Section 4.2 discusses the circumstances regarding inbound tourism.

4.1. Impacts of Air Pollutants on Domestic Tourism

Table 4 shows the estimated influences of different air pollutants on domestic tourism. First, we focused on $PM_{2.5}$. As reported in column (1) of the table, the coefficient of $PM_{2.5}$ was −4.815, statistically significant at the 1% level. This implies that if the $PM_{2.5}$ density increased by 1 μg/m^3 (=0.001 mg/m^3), domestic tourist arrivals would decline by 0.482%. Given that the mean value of annual domestic tourist arrivals among our sample cities was around 17 million person-times, this magnitude corresponds to a decline of 81,855 person-times in tourist arrivals. This is indeed a huge loss. Regarding the control variables, we found that the coefficients of *Scenic* and *Hotel* were both significantly positive, consistent with the straightforward idea that more scenic spots and more tourism infrastructure benefit tourism. Government size, *GovSize*, had a significant positive coefficient, perhaps because local government plays an important role in tourism development in China. The coefficient of GDP per capita, *GDPpc*, was also positive, indicating that, on average, Chinese tourists considered more developed regions to be more attractive. The variables *Road* and *Population* did not show significant impacts on domestic tourism.

Table 4. The impacts of air pollutants on domestic tourism.

Variable	$PM_{2.5}$ Baseline	$PM_{2.5}$ System GMM	$PM_{2.5}$ Smaller Sample	$PM_{2.5}$ Tourism Receipts	PM_{10}	SO_2	NO_2	All Pollutants
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$PM_{2.5}$	−4.815 ***	−2.136 *	−5.304 ***	−4.394 **				−5.376 ***
PM_{10}					0.558			0.817
SO_2						−0.589		−0.768
NO_2							0.001	0.070
Scenic	0.016 ***	0.138 ***	0.011 **	0.024 ***	0.012 **	0.012 **	0.012 **	0.011 **
Hotel	0.176 ***	0.068	0.147 ***	0.055	0.145 ***	0.149 ***	0.147 ***	0.146 ***
Road	−0.006	0.275 **	0.091 *	−0.199 ***	0.111 **	0.111 **	0.113 **	0.084
GovSize	0.539 ***	−0.238	0.594 **	0.313	0.569 **	0.555 **	0.551 **	0.598**
Population	0.310	0.805 ***	0.238	0.014	0.267	0.280	0.282	0.220
GDPpc	0.192 **	0.048	0.227 **	0.298 ***	0.230 **	0.227 **	0.228 **	0.231 **
Observations	2892	2892	2033	2783	2033	2036	2036	2033
Cities	337	337	328	337	328	328	328	328
R^2	0.776	-	0.815	0.738	0.814	0.814	0.814	0.816

Statistical significance: * $p < 10\%$, ** $p < 5\%$, *** $p < 1\%$.

To investigate the robustness of our finding on the harmful effect of $PM_{2.5}$, we conducted three further robustness analyses on the result. (i) One concern is that air pollution and tourism might have complex reciprocal interactions [53], which might cause the endogeneity problem in the econometric estimation [9]. System GMM (general method of moments) estimation is a reliable approach to deal with the endogeneity problem in a "short panel" with many individuals but a small number of periods like our data structure. Column (2) of the table reports the result of System GMM estimation, which shows a significant negative coefficient of −2.136. The magnitude was smaller than that of the coefficient in column (1), but was still quite considerable. (ii) Comparing the number of observations of $PM_{2.5}$ and the other three pollutants, as previously reported in Table 2, we found that $PM_{2.5}$ data had more observations than the other three pollutants. This raised the concern that the regression results regarding $PM_{2.5}$ might not be fully comparative to those for the other pollutants, due to the difference in sample size. To address this concern, we deleted the sample points that had data for $PM_{2.5}$ but not for the other pollutants, and repeated the regression based on the smaller sample obtained. The estimated coefficient of $PM_{2.5}$ was −5.304, as displayed in column (3). Clearly, our previous finding held. (iii) To date, we have only considered the impact of $PM_{2.5}$ on tourist arrivals. In column (4), we report the estimate when the dependent variable was the logarithmic value of tourism receipts (in 100 million RMB, deflated based on the year 2000 price), instead of tourist arrivals. The estimated coefficient was

−4.394, very close to that in column (1). Given that the mean annual domestic tourism receipt was 12 billion RMB, the coefficient implies that, on average, a 1 μg/m^3 increase in $PM_{2.5}$ concentration would cause a reduction of 53 million RMB (approximately 8 million US dollars) in domestic tourism receipts at the city level. In a nutshell, combining the results in columns (1)–(4) together, we are able to claim that $PM_{2.5}$ had a robust and significant negative impact on domestic tourism.

Next, we examined the effects of PM_{10}, SO_2, and NO_2 on domestic tourism, respectively. As reported in column (5), the estimation did not detect a statistically significant impact from PM_{10}. Column (6) reports the estimated coefficient of SO_2, which was not significant either. Similarly, as can be seen from column (7), NO_2 did not significantly affect domestic tourism.

Lastly, we put all four pollutants into one regression equation and reported the estimates in column (8). The result still showed a significant negative coefficient for $PM_{2.5}$, but not for PM_{10}, SO_2, or NO_2. This result supported the findings from columns (1)–(7) when we checked the impacts of the four pollutants one by one.

4.2. Impacts of Air Pollutants on Inbound Tourism

Table 5 demonstrates the impacts of air pollutants on inbound tourism. Column (1) reports the baseline estimates for $PM_{2.5}$. The statistically significant coefficient was −12.269, indicating that inbound tourist arrivals would decline by 1.227% in response to a 1 μg/m^3 (=0.001 mg/m^3) increase in $PM_{2.5}$ concentration. Given that the mean value of annual inbound tourist arrivals in our sample cities was nearly 1 million person-times, this magnitude indicates a decline of 12,269 person-times in tourist arrivals. This loss is indeed substantial. The control variables were generally not statistically significant, indicating that inbound tourists were not sensitive to the economic and social characteristics of destination cities.

Table 5. The impacts of air pollutants on inbound tourism.

Variable	$PM_{2.5}$				PM_{10}	SO_2	NO_2	All Pollutants
	Baseline	System GMM	Smaller Sample	Tourism Receipts				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$PM_{2.5}$	−12.269 ***	−12.517 **	−7.185 *	−8.259 *				−7.359 *
PM_{10}					0.924			1.780
SO_2						−0.567		0.804
NO_2							−5.069 *	−6.625 *
Scenic	0.002	0.455 ***	0.011	0.046 ***	0.012	0.012	0.010	0.008
Hotel	0.105	2.034 *	0.085	0.089	0.080	0.086 *	0.094 *	0.086 *
Road	−0.182	−1.071 **	−0.283 **	−0.198	−0.262 *	−0.260 *	−0.239 *	−0.268 *
GovSize	−0.472 **	−11.859 ***	0.090	−0.656 **	0.064	−0.024	−0.021	0.094
Population	−0.246	−0.306	−0.667	−1.150	−0.623	−0.643	−0.684	−0.733
GDPpc	0.031	0.152	−0.052	0.034	−0.039	−0.053	−0.047	−0.033
Observations	2952	2952	2111	2941	2111	2114	2114	2111
Cities	337	337	324	337	324	324	324	324
R^2	0.214	-	0.266	0.100	0.265	0.262	0.264	0.270

Statistical significance: * $p < 10\%$, ** $p < 5\%$, *** $p < 1\%$.

Three robustness analyses on the impact of $PM_{2.5}$ are reported in columns (2)–(4). (i) In column (2), the System GMM estimates are reported. The coefficient of $PM_{2.5}$ was −12.517, very close to that reported in column (1). (ii) In column (3), we relied on a smaller sample, in which all sample points had data for all four pollutants. The estimated coefficient of $PM_{2.5}$ was −7.185. This coefficient was still significantly negative, supporting the result in column (1). (iii) In column (4), we used the logarithmic value of inbound tourism receipts (in 100 million RMB, deflated based on the year 2000 price) as the dependent variable, instead of tourist arrivals. The estimated significant negative coefficient of −8.259 supported the finding that $PM_{2.5}$ harmed inbound tourism. The magnitude implies that inbound tourism receipts would decline by 7 million RMB (approximately 1 million US dollars) after $PM_{2.5}$

concentration increased by 1 μg/m^3, given that the average inbound tourism receipt of the sample cities was 893 million RMB per year.

Next, we checked the impacts of the other three air pollutant indices. The impacts of PM_{10} and SO_2 were not significant, as reported in columns (5) and (6), respectively. From column (7), it was found that the impact of NO_2 was negative and statistically significant at the 10% level. This implies that inbound tourists were responsive to the rise of NO_2 pollution.

In column (8), we report the estimates after we put all four pollutants together within one regression equation. The coefficient of $PM_{2.5}$ was −7.359 and maintained statistical significance. PM_{10} and SO_2 did not have significant impacts. The coefficient of NO_2 was significantly negative, analogous to that in column (7).

5. Discussion and Implications

5.1. Discussion

The analyses in this study provide three important findings. Firstly, it was found that air pollution, measured by $PM_{2.5}$, shows a harmful effect on both domestic and inbound tourism. This finding is consistent with previous studies (e.g., [29–31,33]) that reported the negative impact of air pollution on tourism. As our sample covered a wide geographic area and a long time-span, this study supplements the prior literature by providing further evidence on the pollution-tourism nexus. As claimed in the previous studies, policy makers should take actions to mitigate the air pollution problem for the purpose of boosting tourism. Good air quality is a substantially attractive characteristic for tourist destination cities.

Secondly, different pollutants were found to exert different impacts on the tourism industry. According to our estimates, the most adverse pollutant indicator is $PM_{2.5}$, which was compared to PM_{10}, SO_2, and NO_2. The estimates demonstrate a robust, large, and statistically significant impact of $PM_{2.5}$ on tourism. Given that $PM_{2.5}$ can be especially harmful, due to its relatively small size compared to other air pollutants, it has attracted more public attention through microblogging platforms such as Weibo [54]. In addition, $PM_{2.5}$ is more closely associated with the reduction of visibility than some other pollutants [55,56]. Travelers are highly concerned about the low visibility issue, as it can reduce the aesthetics of tourist attractions [5,57] and interrupt traffic by causing flight delays or cancellations, or highway closures [58]. Regarding the other three pollutants, PM_{10}, SO_2, and NO_2, the estimation results show that they do not have a similar impact to that of $PM_{2.5}$. No statistically significant effect of PM_{10} and SO_2 on tourism was detected. NO_2 was found to negatively influence inbound tourism, but it does not significantly affect domestic tourism. This finding is novel and not consistent with some previous studies, including Yan et al. [8], Yoon [41], and Zhou et al. [43], which reported a negative effect of PM_{10}, SO_2, or NO_2 on tourism. The different impacts of NO_2 on domestic and inbound tourism are especially interesting. There may be at least two plausible explanations. The first reason is relevant to the degree of perception and concern about air pollution in different tourist groups. The previous studies have confirmed that people's opinions about the severity of air pollution largely depend on their sociodemographic status, including education, knowledge, income, and so on [59,60]. For instance, tourists with higher income levels are typically more sensitive to air pollution than those with low income [39]. It is possible that, on average, the sociodemographic characteristics of inbound tourists make them more aware of the damage of NO_2, compared to domestic tourists in China. The second reason is relevant to the differences in the health risks faced by inbound and domestic tourists during the tourist activities. As the stay time of foreign tourists is usually longer than that of domestic tourists, inbound tourists are potentially exposed to more NO_2 when they visit polluted cities. Therefore, inbound tourists might become more responsive to the variations of pollution. For example, Song et al. [61] demonstrated increasing prevalence trends of adult asthma in Asian regions, especially in Japan and South Korea, which are the top source countries of China's inbound tourism. Given that exposure to NO_2 could lead to asthma exacerbations [62], it is possible that people with potential asthma or other respiratory diseases would stay away from travel destinations with high NO_2 concentrations.

It is notable that, although our study did not report as significant a harmful impact of PM_{10}, SO_2, or NO_2 on tourism as $PM_{2.5}$, this does not necessarily mean that these three pollutants are trivial to sustainable tourism development in China. From the perspective of public health, the threats to tourists' health conditions posed by PM_{10}, SO_2, and NO_2 should be noticed. It is also notable that, since the inference from our regressions reflects an average situation based on a sample of 337 Chinese cities, it does not rule out idiosyncratic properties in different areas. It is possible that, although $PM_{2.5}$ is the most adverse pollutant on average, pollution problems in certain regions are majorly caused by other pollutants. The unequal impacts of different pollutants on tourism detected by our study essentially indicate that tourism-relevant policy makers and researchers should pay attention to monitoring suitable air pollution indictors. In particular, $PM_{2.5}$ should not be ignored in tourism analysis.

The third finding was that domestic tourists and inbound tourists respond to air pollution at different magnitudes. According to our estimates, if $PM_{2.5}$ concentration rises by 1 $\mu g/m^3$, domestic and inbound tourist arrivals will decline by 0.482% and 1.227%, respectively. Thus, in terms of percentage change, inbound tourists are more sensitive to the degradation of air quality. It is plausible that foreign travelers are more aware of the harmfulness of air pollution, compared to Chinese travelers. An earlier study by Law and Cheung [33] has signaled that travelers from Western countries were more sensitive to the air pollution in Hong Kong than Asian travelers. Our study extends the result of Law and Cheung [33], which used Hong Kong as a case study, to a large geographic scope. In addition, it should be noticed that, as the aggregate size of domestic tourism is much larger than inbound tourism in China, in absolute values, the impact of air pollution on domestic tourism is much stronger. Our estimates imply a reduction of 81,855 person-times in annual domestic tourist arrivals and 12,269 in inbound tourist arrivals, in response to a 1 $\mu g/m^3$ increase in $PM_{2.5}$. These estimates could help the tourism sectors predict the trends and variations of domestic and inbound tourism development associated with varying air quality problems. Moreover, these estimates could not only exert pressure on policy makers to improve environmental outcomes, but also raise Chinese citizens' awareness of environmental protection to build a positive destination image.

5.2. Implications

From a theoretical perspective, this study made the following contributions. First, this study empirically examined the impacts of four important components of air pollution ($PM_{2.5}$, PM_{10}, SO_2, and NO_2) on both the domestic and inbound tourism industries in China using a sample of 337 cities covering the period between 2007 and 2016. The sample used in the study may generate more precise and updated estimates, since it covers the period of recent years for a wide geographic range. Second, the findings enrich the air pollution–tourism nexus literature by confirming the finding from previous research that $PM_{2.5}$ plays a vital role in depressing both domestic and inbound tourist numbers in China, and by providing new insights into how NO_2 exerts different effects on the domestic and inbound tourism industries. The study results remind researchers that air pollution might be more accurately studied from the perspective of different air pollutants.

Practically, the results indicate that the Chinese government should continue tackling air pollution in China for the benefit of human health and for the sustainable development of the tourism industry. On the one hand, among the four common air pollutants considered, it seems that $PM_{2.5}$ has received the most attention from travelers over the last decade. Therefore, tourism policy makers should primarily focus on $PM_{2.5}$, concerning the nexus between air quality and the development of tourism. On the other hand, given the fact that other air pollutants could also result in negative health effects, emphasizing the importance of $PM_{2.5}$ should not overshadow the threats posed by other air pollutants. It is suggested that great efforts should be made to raise travelers' awareness of other air pollutants. Furthermore, although China's outbound tourism market has attracted the attention of the world, its inbound tourism has been experiencing very slow growth [63]. As suggested by this study, NO_2

pollution should also be tackled to attract more international travelers. The estimation results also reveal that inbound tourists are more sensitive to the air pollution issue in China. Given that Beijing, the capital of China with notorious air quality records, has attracted a lot of international attention in recent years, inbound tourists may believe that the air quality in other Chinese cities is also poor. In fact, there are a number of Chinese tourist cities with air quality up to standard, including Haikou, Zhoushan, Lhasa, Fuzhou, Zhuhai, and Huizhou, among others [64]. Destination marketers in China could strive to promote these cities to potential inbound tourists and design more haze-avoidance or smog-free travel packages.

6. Conclusions and Directions for Future Research

To conclude, the present study utilized an econometric model to empirically investigate how four atmospheric pollutants ($PM_{2.5}$, PM_{10}, SO_2, and NO_2) affected the tourism industry in China. The results of the analyses demonstrated that $PM_{2.5}$ played a dominant role in negatively influencing China's inbound and domestic tourism industries. The results also revealed that NO_2 reduced the number of inbound tourists.

This study was restricted by several limitations, which actually indicate promising directions for future research. Firstly, some other air pollutants, such as CO (carbon monoxide) and O_3 (ozone), were not investigated in this study due to the limitation of data availability. These two pollutants are also monitored and reported by the environmental sectors of the government in China. Unfortunately, data are only available for a very small sample from our data sources. In the future, the impact of other air pollutants could also be inspected if more data can be collected.

Secondly, this study examined the effects of different air pollutants but did not consider any comprehensive air pollution indices, such as AQI. Estimating the impact of AQI on tourism and comparing it with the estimated impact of $PM_{2.5}$ will provide more information for better decision making. However, in this study, we were not able to do this because of the data availability problem. Given that AQI was not directly available from our data sources, in order to infer the values of AQI, we need to know the values of different pollutants, including $PM_{2.5}$, PM_{10}, SO_2, NO_2, CO, and O_3. On the one hand, as mentioned previously, there were no sufficient data of CO and O_3. On the other hand, our $PM_{2.5}$ data provided by NASA were constructed based on the remote sensing measurements of satellites. The data are not directly comparable to those provided by the MEP and MEE based on direct measurements in different local observation stations, though they are both reliable and highly correlated. Hence, we can investigate the correlation between AQI and tourism in the future, after more data are released.

Thirdly, this study inspected the actual level of air pollution measured by scientific instruments. It is notable that the objectively measured air pollution level might not be completely consistent with people's perceived level of air pollution, since the perception of air pollution is subjective and affected by a lot of social and individual factors, such as education and mass media. Future studies could collect data on the perceived air pollution level by potential tourists and examine whether the study results using subjective data match the results in this study.

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An Integrated Approach to Determining Rural Tourist Satisfaction Factors Using the IPA and Conjoint Analysis

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Abstract: Rural tourists satisfaction has a pivotal role in the development of sustainable rural tourism. As a method of identifying critical satisfaction factors, an importance and performance analysis (IPA) technique has attracted growing interest from academics due to it being able to deliver the importance and performance of a product's attributes from the standpoint of customers. However, IPA is based on the presumption that a linear and symmetrical relationship exists between the performance and overall satisfaction, which has been criticized by many researchers due to its deviation from the facts. On measurement of importance, researchers have not reached an agreement on whether direct or indirect approach should be applied. To measure satisfaction more effectively, this study presents a revised IPA method that integrates IPA, conjoint analysis and importance grid analysis. Based on mathematical psychology and psychometrics theory, the conjoint analysis method can be used to analyze multi-attributes of various products and derive relative importance of attributes in customer satisfaction research. The importance grid analysis method has been applied to categorize attributes by many researchers. It can be used to measure the nonlinear relationship between the performance of attributes and overall satisfaction. In this paper, an empirical study on rural tourists' satisfaction was undertaken using this integrated method. The results show that the integrated approach is more responsive to attribute performance, thus allowing for improvement of a certain target attribute in the customer satisfaction enhancement process.

Keywords: importance-performance analysis; conjoint analysis; importance grid analysis method; sustainable rural tourism; tourist satisfaction

1. Introduction

Rural tourism has the potential as a development tool for rural areas [1]. As a dimension of developing sustainable tourism, satisfaction plays a critical role in the survival and future of tourism industry. Regarding the conservation of rural nature and culture, it is important to find the critical factors that have direct impacts on satisfaction for achieving sustainable rural tourism development. Among various studies on customer satisfaction, identification of customer satisfaction factors is regarded as essential because it can affect resources allocation on different service attributes for satisfaction improvement [2]. Product or service attributes are characteristics by which offerings are identified or differentiated, which usually include features, functions, benefits, and uses [3]. According to Lancaster [4], customers' preferences are not on the product itself but on the characteristics or attributes of the product. Furthermore, product selection can be conceptualized as a process of comparing the main attributes of product or service. For this reason, investigating the critical attributes is a continuing concern within satisfaction research.

Using this approach, key attributes of products or service are generated first and then rated by customers according to their impacts on purchase decision. However, various methods have been proposed on the measurement of importance, and the agreement has not been acquired. Jaccard, Brinberg, and Ackerman [5] indicated that it is necessary to focus on the conceptual foundations of measurements of attributes importance through comparing six methods of importance measurements. Oliver [6] also suggested that customers should know "important for what" when they rate the importance of attributes. Furthermore, Oliver suggested that, instead of measuring importance alone, "incorporating the importance of performance into predictions of satisfaction is available". This is in line with Martilla and James [7], who indicate that it is more effective to examine both importance and performance than focus on importance only. In addition, they introduced importance–performance analysis (IPA) that has been used widely in satisfaction research. Through investigation of an attribute's importance before purchase and performance perception afterwards, the evaluation of satisfaction can be acquired.

Based on attributes approach, importance and performance analysis can derive practical suggestions through the measurement of attribute importance and performance. Due to its simplicity and effectiveness, the IPA technique has been widely used in many fields for analyzing service quality, destination image, market segmentation, destination competitiveness and so on [8–12]. However, according to Oh [13], the revision of a traditional IPA technique is necessary considering conceptual and practical issues. Conceptual issues involve the uncertainty of the criterion for measuring importance and performance; practical problems exist in the survey design and grid scale. Until now, various revised IPA techniques have been provided, but the definition of importance and relationship between importance and satisfaction are unclear. As an effective method in marketing research, continuous focus on the modification of IPA is necessary.

The aims of this study are to present a novel solution for the measurement of attribute importance in the IPA technique. As Oliver and Oh [6,13] have highlighted, we use satisfaction as the same criteria to measure importance and performance but with different methods. For the importance measurement, we use conjoint analysis to acquire relative importance of attributes. Different from this, performance is measured using the direct method. The second aim is to increase the utilities of IPA through adding the diagonal line and discrepancy analysis. In addition, a major criticism of IPA is its assumption that a symmetric relationship exists between attribute performance and satisfaction. In this study, the asymmetric relationship between attribute performance and satisfaction is analyzed.

The rest of this paper is organized as follows. The second section reviews previous literature about IPA and conjoint analysis research. The third section introduces a revised IPA approach to identifying the relative importance and performance of attributes using conjoint analysis and the importance grid method. The fourth section demonstrates the implementation of this proposed revised IPA framework in two rural tourism scenic spots in China. Conclusions are drawn in the last section.

2. Theoretical Background

2.1. Importance–Performance Analysis

Attributes are defined as the determinant decision criteria that can be used to evaluate products or services [14]. In Myers and Alpert's research [15], attributes are identified as determinants that are closely related to customer's preference or purchase decision. As a method based on the analysis of attributes, the IPA technique was introduced by John A. Martilla and John C. James in 1977 and firstly used in analyzing the service quality of automobile dealers. Through response to two questions of "how important is this feature" and "how well did the dealer perform" [7], the IPA grid was divided into four areas named "concentrate here", "keep up the good work", "low priority" and "possible overkill" can be acquired. The analysis result of attributes derived from IPA can help firms allocate funds more effectively on pivotal and critical attributes of products.

Due to its simplicity and effectiveness, IPA has enjoyed popularity. Its application has been broadened to a variety of areas, especially in research for identifying critical factors for product selection and evaluation of service quality and satisfaction [16]. As an extension, Sethna [17] has a related IPA technique for customer satisfaction and provided a hypothesis that the greater the discrepancy between importance and performance of a product on that attribute, the greater the customer's dissatisfaction with the product. It has been proven to be an effective tool in research for identifying determinants affecting overall satisfaction [18]. Moreover, IPA instead of SERVQUAL has been suggested to measure service quality for limitations existed in the latter [9,19].

Although the ease of application and simplicity have led to the wide acceptance of the IPA research framework, researchers have disagreements on measurement of importance and asymmetrical effects between attributes' performance and satisfaction [13,20–22]. Importance, also termed as "value importance" or "salience", reflects customer's preference or stress on different attributes. For measurement of importance, it has been heavily criticized for its ambiguous, multidimensional definitions in previous studies; in particular, both direct and indirect ratings of importance were used in previous research. The direct method is a simple method. However, it has apparent problems. To date, a variety of revised IPA research frameworks using indirect or integrated methods has been provided to avoid its disadvantages [23–26]. Multiple regression analysis, three factors theory, partial correlation analysis, and a back propagation neural network have been addressed for customer self-stated importance for avoiding problems such as incorrect interpretation of attributes' importance and changing evaluation in different purchase stages [23,27–29]. The second disagreement on attribute research is the relationship between attribute performance and satisfaction. It has been reported that attribute performance and satisfaction have a positive association [30]. Asymmetrical effects of attribute-related performance on overall satisfaction have also been noticed [30,31]. The method of combining three-factor theory with the IPA technique for measuring asymmetrical effects has been used in many research works [23,27,32].

Normally, two steps are required to apply the IPA method. First, the importance of attributes is measured prior to actual purchase experience. The same set of attributes is then used to evaluate performance. However, if we use a random sampling method, it is impractical to make an investigation before and after the purchase on the same investigators. Therefore, some researchers have suggested that the investigation should be performed concerning the importance and performance at the same time after purchase. Neslin [33] has suggested that a statistical method should be employed rather than a self-stated method for predictive validity. However, this also has problems. The main criticism raised by other researchers is that, if these two factors (importance and performance) are evaluated at one time, close relations between importance and performance would appear. Moreover, all attributes to be evaluated are likely to be important. This would bring about "ceiling effects". For the multi-dimensions of definition and measurement of the importance, Oliver [6] has also suggested the use of satisfaction as a measure criterion of importance and performance.

2.2. Conjoint Analysis in Satisfaction Research

Since being proposed by Green and Rao [34], the conjoint analysis method has been widely used in the field of marketing research. The objective of conjoint analysis is to quantify the choice process on products or services based on experimental design and various data collecting methods including ranking, rating or choice-based methods. Historically, the compositional approach was utilized on customers' choice processes, with more attention given to attributes or characteristics of products in the 1970s and 1980s [35]. Different from this approach, conjoint analysis is a decompositional approach. It gets utilities of product attributes from alternatives or profiles that are made up of various attributes of products.

Because conjoint analysis method is more similar to a customer's actual purchase decision or attribute evaluation, which is used in satisfaction research mainly on the measurement of attribute's relative importance. Using the conjoint analysis method, attributes' utilities and individual level utility can be derived, and the percentage of utility range is defined as relative importance. This can be seen in previous research [36]. Thus, the conjoint analysis technique is also applicable to drawing inference to the importance of attributes that can provide useful information to explain why people make different purchase decisions [37]. It is thus well accepted that this approach is an objective and realistic way to obtain the relative importance of attributes.

The conjoint analysis method can be used in IPA research framework based on these reasons: first, relative importance of attributes can be measured using the conjoint analysis method. It can be seen that a measurement of relative importance rather than direct ratings was suggested in previous research [13,38]. Through designing the profile in conjoint analysis, a customer's real attitude on attributes can be reflected. It will be not influenced by perception of the attribute's importance and performance. Second, orthogonal design is applied in the profile design of conjoint analysis, and the relationship among attributes appears to have zero correlation. Additionally, conjoint analysis "depends on less restrictive assumptions than multiple regression analysis" [21], and the limitations that exist in the reported revised IPA technique can be minimized.

3. Methodology of Conjoint Analysis Based on Importance–Performance Analysis

3.1. Acquiring of Implicitly Derived Importance and Performance

The traditional IPA technique employs customer self-stated importance and the performance approach using Likert five-point or seven-point rating scale. Thus, it is considered as a simple and well-understood method by both researchers and customers. However, various problems have arisen with the wide application of the IPA technique. For instance, a linear relationship between importance and performance was usually assumed, and every attribute was tended to be thought of as very important [20]. More recently, related studies have focused on implicitly derived importance and the performance approach. Matzler and Sauerwein [2] have provided the sensitivity of importance weights through comparing the implicitly and explicitly derived importance approaches. In line with previous research, this study analyzes the nonlinear relationship between attribute-level performance and overall satisfaction based on the implicitly derived importance.

3.2. The Revised IPA Procedure

Based on previous research, this study provides a new approach to helping managers derive a more precise and simply applied marketing strategy by using the IPA technique. First, as both self-stated importance and the implicitly derived method are questionable, this study employs the conjoint analysis method for deriving the relative importance of an attribute. Second, this study uses satisfaction ratings derived directly to acquire performance evaluation. The nonlinear relationship between attribute-level performance and overall satisfaction can then be delivered using importance grid analysis method. Finally, the attribute's importance and performance will be plotted on the IPA grid.

3.2.1. Step 1: Conjoint Analysis Design

Experimental design of a conjoint study includes several steps. Some critical ones are the identification of product attributes and levels, the determination of the analysis method such as ratings-based and choice-based methods, and the design of profiles. Until now, four types of methods have been used in conjoint analysis: (1) a traditional method that uses stated preferences, (2) choice-based conjoint analysis that uses stated choices, (3) adaptive conjoint analysis, and (4) self-explicated conjoint analysis [35]. However, full profiles or a smaller set of full files using stated preference are accepted widely due to a high applicative percentage in previous conjoint analysis studies.

For profile design, the orthogonal plan is supported by most researchers as it can avoid the multicollinearity among attributes effectively. In addition, it needs less profiles than the full-factorial design. However, the orthogonal plan can only measure the main effects of attributes while interactive effects will be ignored. Thus, fractional factorial design that can measure both main effects and interactive effects or higher-order effects is considered in this study. To satisfy all requirements, Box–Behnken design (BBD) is selected for data collection that will use 12 runs with three coded levels −1, 0 and 1 (Table 1).

Table 1. Experimental matrix of Box–Behnken design.

Run	Coded Levels		
	X_1	X_2	X_3
1	−1	−1	0
2	−1	1	0
3	1	−1	0
4	1	1	0
5	−1	0	−1
6	−1	0	1
7	1	0	−1
8	1	0	1
9	0	−1	−1
10	0	−1	1
11	0	1	−1
12	0	1	1

3.2.2. Step 2: Computation of Importance and Performance Values

One can compute the relative importance of the attribute by part-worth function that is specified as a piecewise linear function in dummy variables in conjoint analysis studies. According to Rao et al. [35], the component utility function for the t-th attribute can be written as:

$$U_t(x_{jt}) = U_{t1}D_{t1} + U_{t2}D_{t2} + \ldots + U_{tr_{t-1}}D_{tr_{t-1}}, \quad (1)$$

where U_{tk} is the component of the part-worth function for the k-th level of x_t, x_{jt} is the level for the j-th profile on the t-th attribute, r_t is the number of discrete levels for the t-th attribute, and D_{tk} is the dummy variable taking the value 1 or 0. This formula can be used to calculate the utility of attribute. Its relative importance can also be determined.

The evaluation of performance can be acquired through asking customers to rate the satisfaction of attributes. In most of the previous research, the five-point Likert scale of 1 (very dissatisfied), 2 (somewhat dissatisfied), 3 (neither dissatisfied nor satisfied), 4 (somewhat satisfied), and 5 (very satisfied) was used to rate performance of attributes.

3.2.3. Step 3: Categorization of Attributes

Recent research supports the view that attributes have a nonlinear relationship with satisfaction. Depending on its impact on satisfaction, attributes can be categorized as basic attributes, excitement attributes, or performance attributes [39,40]. Basic attributes can respond to basic needs for the product or service. It will cause dissatisfaction if not fulfilled. However, it does not bring customer delight if exceeded. On the contrary, excitement attributes can increase customer satisfaction if delivered, although it does not cause dissatisfaction if not fulfilled [27]. Performance attributes will lead to satisfaction if the attribute performance is high. It will cause dissatisfaction if its performance is low.

Vavra [41] firstly proposed that the importance grid could be used to identify the three satisfaction factors (basic attributes, excitement attributes, and performance attributes). Importance grid is constructed depending on whether the importance of attribute is derived explicitly or implicitly. A customer's self-stated importance is identified as explicit importance. It is the indicator of an attribute's dissatisfaction-generating potential. Different from explicit importance, as an indicator of satisfaction-generating potential, implicit importance is obtained indirectly such as applying regressing attribute-level performance against overall satisfaction [2,42–44].

The assumption of importance grid analysis is that explicit importance and implicit importance might differ in reflecting the importance-satisfaction relationship. In addition, it has been stated that a customer's self-stated importance cannot measure the relative importance of attribute adequately [45]. Importance grid analysis combines attribute importance weights derived explicitly and implicitly in a two-dimensional grid. The attribute can be plotted according to differences in importance weights (Figure 1).

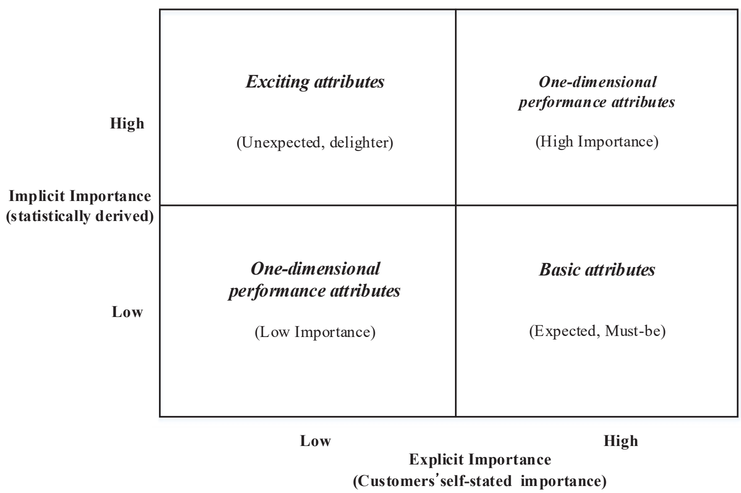


Figure 1. Importance grid for attributes (Vavra [41]).

In terms of importance grid analysis, basic attributes are factors that have strong negative impact on overall satisfaction in low-level performance without having a significant positive impact when performance is high. It is a minimum requirement of product or service. Thus, it can be identified as high importance in directly derived evaluation of attributes, but as low importance in indirectly derived evaluation. Different from basic attributes, exciting attributes are identified as not much important in directly derived evaluation but as highly important in indirectly derived evaluation for its positive relationship with overall satisfaction on the high performance of attribute. For one-dimensional performance attributes, their corresponding changes can be shown between the performance of attribute and overall satisfaction. An attribute with high explicit and implicit importance can be considered high importance attributes. On the contrary, low importance attributes show little importance both in explicit and implicit ways.

3.2.4. Step 4: Importance–Performance Grid Creation

Using importance and performance value derived from step 2, attributes can be plotted on the IPA matrix. For Importance–Performance (I–P) map partitioning, two types of quadrants approaches are mainly used. One is the "scale-centered quadrants approach", suggested by Green and Rao [34]. The other is the "data-centered quadrants approach", which uses empirical means obtained from the data as cross-points [46]. In addition, based on the traditional matrix, which divides the region into four parts to analyze characteristics of attributes, some researchers have added a diagonal line on the matrix for representing high priority for improvement more clearly. This method has been proven to be more effective than the traditional one [20].

In this study, the revised I–P matrix with data-centered quadrants approach and diagonal line is employed. Combined with analysis results of attributes' category, improvement suggestions for attributes will be derived.

4. Implementation of Revised IPA

4.1. Study Area

Two villages in China named Dalishu and Qingshan were selected for this study. Both of these two villages are near the city and famous for rural tourism resources. However, tourist attraction in these two areas have their own characteristics. Zheng [47,48] evaluated the development of multifunctional agriculture in Dalishu village. Rural tourism was identified as an enhancement foundation of multifunctional agriculture and rural sustainable tourism through outdoor activities, fruit picking and dining experiences. Compared to Dalishu village, rural tourism in Qingshan village offers natural and Manchu cultural landscape as tourist attractions. Rather than experienced activities, landscape appreciation is more concentrated in Qingshan village.

The two rural scenic spots are named after the village directly. With both similarities and differences existing in these two scenic spots, it can examine the revised IPA framework more effectively on the management focus on the attributes and the relationship between attribute performance and satisfaction.

4.2. Questionnaire Design

According to the Organization of Economic Co-Operation and Development (OECD), rural tourism is defined as tourism taking place in the countryside: "rurality is the central and unique selling point in the rural tourism package" [49]. Previous studies on rural tourism expectation and motivation were mainly concentrated on relaxation, socialization, learning, family togetherness, novelty, and excitement [50], functional factors (i.e., reservation system, service quality) and technical factors (i.e., room size, price level) [49], and access evaluation, lodgings availability, and price evaluation [51]. Based on these previous studies considering the characteristics of rural tourism in China, this study initially selected six factors (transportation, price level, rural lodging, rural eating facilities, rurality experience activity and rural tourism service quality) as expectation and satisfaction factors. However, after consulting with tourism researchers and travel agency managers, we decided to delete three factors: transportation, rural lodging and rural eating facilities. The reason to delete transportation is that transportation evaluation includes many aspects, such as time, price, and comfortability that will make respondents feel that they are difficult to evaluate. The reason to delete the other two factors is because the location of the survey region, one of which is very close to the city, and the majority of tourists will not have the experience of rural eating or rural lodging experience. Therefore, the three factors determined in this study are rural tourism price level, rurality experience activity and rural tourism service.

Regarding levels of attributes, we selected satisfaction as the measurement of the importance of attributes based on Oliver's suggestion [6] and Danaher's research [38] as shown in Table 2.

This experiment design has three factors each with three levels, resulting in $3^3 = 27$ treatments which would be too many for respondents to evaluate. Different from previous research, this study applies Box–Behnken design that is evaluated as a very effective design method for researching the relationship among variables. For the case of three factors with three levels each, it needs 12 experiment runs. Therefore, we designed 12 questions according to the BBD method, and used five-point Likert scale (1 for "very dissatisfied" and 5 for "very satisfied") to evaluate the satisfaction of the combination of three attributes with different levels.

Holdout cases are generated randomly for checking the internal validity of the model. They are judged by respondents but not used in the conjoint analysis. According to previous studies, we used four holdouts that were mixed into the 12 questions randomly. Consequently, each respondent was asked to rank 16 alternatives.

Table 2. Rural tourism product attributes and levels.

Selected Attributes	Levels	Coding
Rural tourism price level	Worse than expected	−1
	About what expected	0
	Better than expected	1
Rurality experience activity	Worse than expected	−1
	About what expected	0
	Better than expected	1
Rural tourism service	Worse than expected	−1
	About what expected	0
	Better than expected	1

4.3. Data Collection and Respondents' Profiles

The questionnaire was administrated online with a snowball sampling approach to residents in Dandong City who had already participated in rural tourism in Dalishu and Qingshan scenic spots. This approach is chosen here since tourists mainly come from regions near the city. This survey integrated persons from those urban areas known to generate the most rural tourists in Dandong city as well as tourist guides who were asked to invite tourists who had the experiences to these two scenic spots to participate in the survey. The award for this survey is the chance of a drawing in a lottery that is supported by an online questionnaire design company.

The survey was conducted from October to November 2018. A total of 155 questionnaires were received. Questionnaires from respondents who finished this survey in less than three minutes or selected the same options for all of questions were deleted. Finally, 115 valid and usable questionnaires were used for analysis. Demographic profiles of these respondents are summarized in Table 3.

Table 3. Demographic of the sample (n = 115).

Demographic Variables	Frequency	%
Gender		
Male	41	35.652
Female	74	64.348
Age		
up to 35	49	42.609
36–44	39	33.913
over 46	27	23.478
Monthly income (US dollar)		
below 450	41	35.652
451–900	51	44.348
above 901	23	20.000
Occupation		
tourism-related occupation	40	34.783
tourism-unrelated occupation	51	44.348
student in tourism-related major	9	7.826
student in tourism-unrelated major	12	10.435
retirement	3	2.609

4.4. Reliability and Validity Analysis

Although there have been disagreements on the reliability and validity evaluation of conjoint analysis, Pearson's r and Kendall's tau τ statistics based on holdout samples as simple and effective measurement methods are widely used [52]. They are reported as indicators of fit between the model and obtained data. Pearson's r can be used to measure the degree of correlation between attribute levels within a factor. Kendall's tau is a measurement of the correlation between the observed and the predicted preferences of rank order variables.

We analyzed the internal reliability of the two scenic spots, respectively. Results are shown in Table 4. Test results showed very high overall correlations with correlation coefficient r of 0.945 for Dalishu scenic spots and 0.950 for Qingshan scenic spots. Kendall's tau τ was 0.870 for Dalishu scenic spots and 0.818 for Qingshan scenic spots in all conjoint models, indicating a good and efficient model fit. For the four holdouts cards, the Kendall's tau τ statistics confirmed the model's reliability both at 0.333 in the two scenic spots. It showed cross-validity about the model's ability to predict ratings of hold-out profiles.

Table 4. Validity and reliability of the model.

	Value	Sig
Dalishu scenic spot		
Pearson's R	0.945	0.000
Kendall's tau	0.870	0.000
Kendall's tau for Holdouts	0.333	0.248
Qingshan scenic spot		
Pearson's R	0.950	0.000
Kendall's tau	0.818	0.000
Kendall's tau for Holdouts	0.333	0.248

4.5. Implicitly Derived Importance and Performance of Tourist Satisfaction Attributes and Dimensions

4.5.1. Conjoint Analysis of the Two Rural Tourism Destinations

Using SAS procedure Conjoint Analysis, we obtained relative importance values of the three attributes, respectively. Relative importance values of the three attributes [rural tourism product price level (price), rurality experience activity (activity), and rural tourism service (service)] were 0.303, 0.418, 0.279 in Dalishu and 0.271, 0.396, 0.333 in Qingshan scenic spots (Figure 2). Furthermore, we analyzed personal utility of attributes with different levels. Results are shown in Figures 3 and 4.

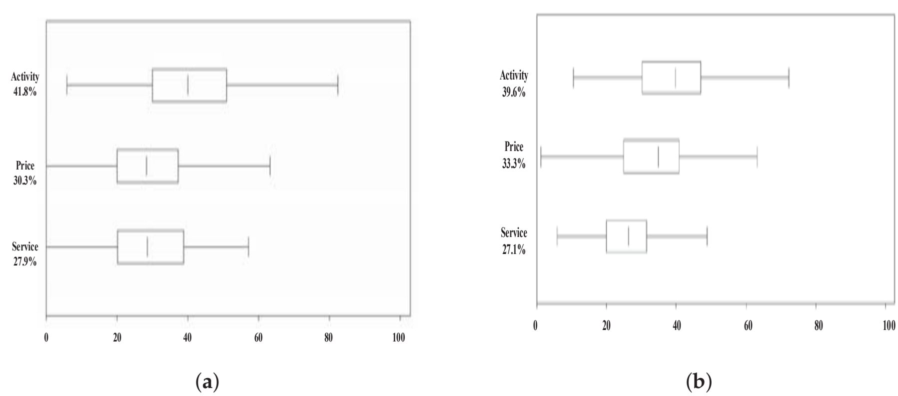
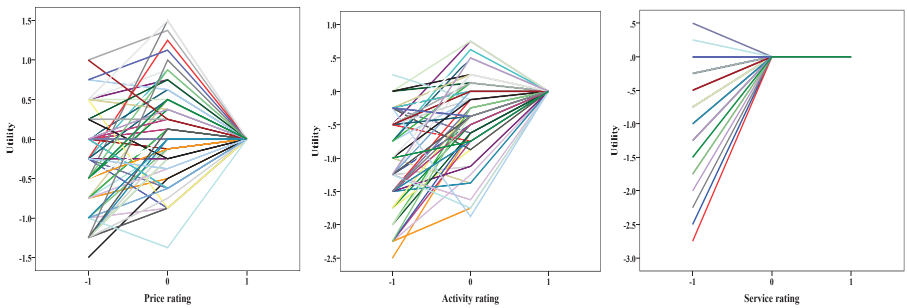


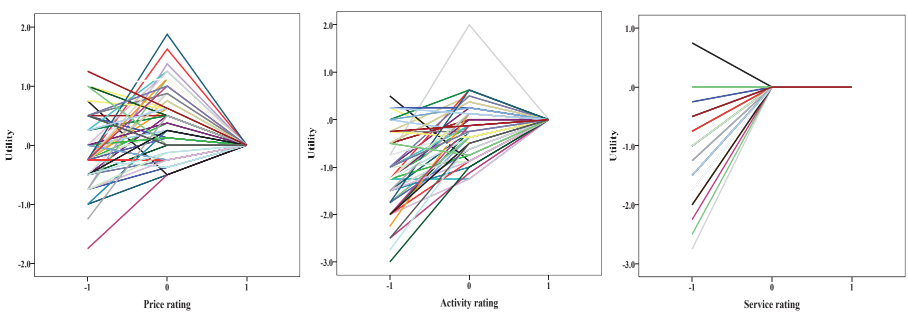
Figure 2. Relative importance of attributes ((**a**) Dalishu scenic spots; (**b**) Qingshan scenic spots).

These attributes were coded as −1, 0, and 1 to represent "worse than expected", "about what was expected" and "better than expected", respectively. According to customers' ratings, utilities of attributes can be acquired. Changes of utilities with attributes' ratings seem interesting as shown in the two figures. When ratings of attributes changed in "worse than expected", "about what was expected" and "better than expected" three levels, utilities did not seem to increase continuously. Especially for service attributes, it brought the same utility regardless of the "about what was expected" level or the "better than expected" level. Similar results were also seen in previous research that addressed an asymmetry relationship between service and overall satisfaction.



(**a**) (**b**) (**c**)

Figure 3. Utility plot of attributes in Dalishu scenic spots ((**a**) utility change with price rating; (**b**) utility change with activity rating; (**c**) utility change with service rating).



(**a**) (**b**) (**c**)

Figure 4. The utility plot of the attributes in Qingshan scenic spots ((**a**) utility change with price rating; (**b**) utility change with activity rating; (**c**) utility change with service rating).

4.5.2. Creation of Importance Grid

Using the importance grid analysis method, the classification of attributes can be obtained. First, the importance of attribute derived directly can be acquired from questionnaires such as explicit importance and the relative importance obtained from conjoint analysis is used as implicit importance. Results are shown in Table 5.

Table 5. Mean implicit and explicit importance ratings of each attribute.

Attributes	Implicit Importance	Explicit Importance
Dalishu scenic spot		
Rural tourism product price level	0.303	3.787
Rurality experience activity	0.418	4.262
Rural tourism service	0.279	4.295
Qingshan scenic spot		
Rural tourism product price level	0.271	3.685
Rurality experience activity	0.396	4.481
Rural tourism service	0.333	4.315

Grand means of explicit and implicit attribute importance are used as the axis of the plot. Attributes are then plotted in the grid (Figure 5). The "service" attribute that has high explicit and low implicit importance is categorized as the basic attribute of overall customer satisfaction. "Price", which has low explicit and implicit importance, is considered a low important attribute. On the contrary, "activity", which has high explicit importance and high importance, is categorized as a high importance attribute.

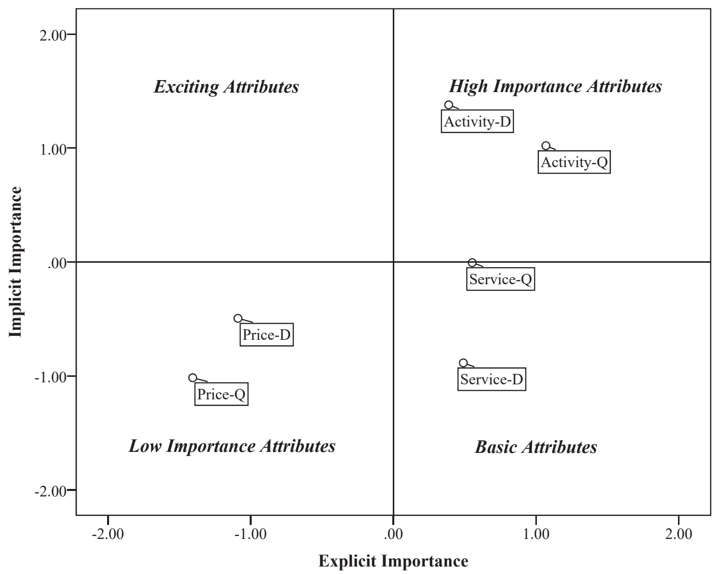


Figure 5. Importance grid for attributes (D: Dalishu scenic spots; Q: Qingshan scenic spots).

Since "activity" is classified as a high importance attribute, it suggests that improvement of efforts and special attention should be given to help enhance the satisfaction of tourism activity. Since "tourism service" is a basic factor, it suggests that business managers should pay more attention to keeping the existing level and minimizing the cost of tourism service.

4.6. Creation of Importance–Performance Analysis Grid

The relative importance of attributes obtained from the conjoint analysis and the performance value obtained directly will be plotted on the IPA grid. Table 6 shows results of importance value, performance value, and corresponding values for discrepancy for Dalishu and Qingshan scenic spots. Corresponding values for discrepancy are obtained by calculating the difference between performance and importance using their standardized value shown in the brackets. As shown in Table 6, "rurality experience activity" of Dalishu scenic spots and "rural tourism service" of Qingshan scenic spots had the biggest negative discrepancies. In contrast, the "rural tourism product price level" of the two scenic spots presented a clear positive discrepancy.

We then standardized the value of importance and performance to avoid problems existing in "scale-centered quadrants". Point (0, 0) was used as the axis of the plot, and a diagonal line was added to the plot. As shown in Figure 6, one of the three attributes is plotted in different areas of the two scenic spots, while the other two attributes are plotted in the same areas.

Table 6. Importance and performance of rural tourism products attributes.

Attributes	Performance	Importance	Discrepancy
Dalishu scenic spot			
Rural tourism product price level	3.295 (0.520)	0.303 (−0.494)	(1.014)
Rurality experience activity	3.262 (−0.046)	0.418 (1.379)	(−1.425)
Rural tourism service	3.197 (−1.161)	0.279 (−0.885)	(−0.276)
Qingshan scenic spot			
Rural tourism product price level	3.352 (1.498)	0.271 (−1.015)	(2.513)
Rurality experience activity	3.278 (0.229)	0.396 (1.021)	(−0.792)
Rural tourism service	3.204 (−1.041)	0.333 (−0.005)	(−1.035)
Average	3.265	0.388	

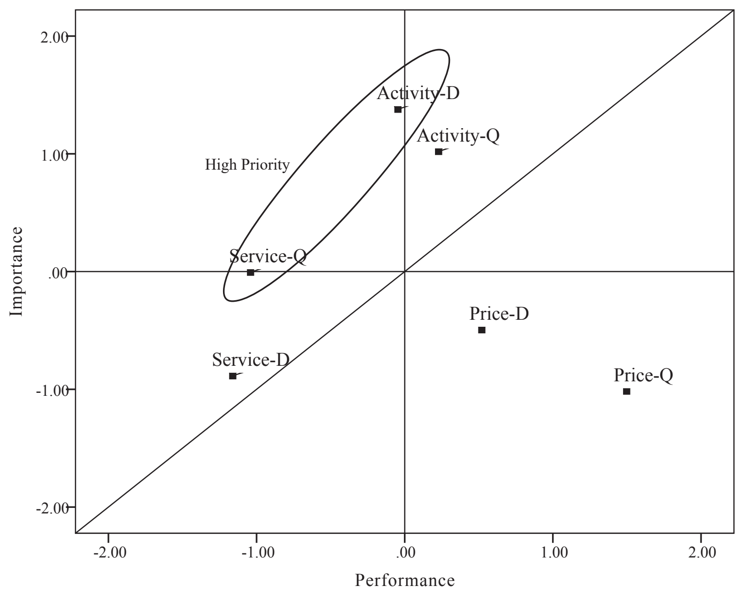


Figure 6. Importance-performance grid for attributes (D: Dalishu scenic spots; Q: Qingshan scenic spots).

Since "rurality experience activity" is the most important attribute, as it is plotted in quadrant 1 and quadrant 2 for the two scenic spots, it suggests that improvement of efforts and special attention should be given to Dalishu scenic spots while keeping up the good work for the Qingshan scenic spots. However, the attributes of rural tourism service could be characterized as low priority. According to the discrepancy, improving rural tourism service should attract the attention of managers in Qingshan scenic spots. Finally, for the attribute of price level plotted in quadrant 4, it suggests that business managers should pay more attention to keeping the existing level while minimizing the cost.

To compare the revised method with traditional IPA, we computed values of importance and performance rated directly by customers (Table 7). Discrepancy was also acquired by computing standardized value of importance and performance. Then, we plotted these values of importance and performance derived directly on the IPA grid (Figure 7), which used point (0, 0) as the axis of the plot with diagonal line added. Attributes plotted in Figure 7 are distributed in three areas. In this grid, "rurality experience activity" and "rural tourism price level" are shown in the same area with the revised IPA grid. Different from the IPA grid using the revised method, the attribute "rural tourism service" is plotted in the "concentrate here" area, suggesting that these attributes are good candidates for improvement measures. Moreover, according to the results of discrepancy, services in both scenic plots need to be given high priority. This is also a little different from the results from the revised IPA grid.

Table 7. Directly derived importance and performance of rural tourism products' attributes.

Attributes	Performance	Importance	Discrepancy
Dalishu scenic spot			
Rural tourism product price level	3.295 (0.520)	3.787 (−1.090)	(1.610)
Rurality experience activity	3.262 (−0.046)	4.262 (0.387)	(−0.433)
Rural tourism service	3.197 (−1.161)	4.295 (0.490)	(−1.650)
Qingshan scenic spot			
Rural tourism product price level	3.352 (1.498)	3.685 (−1.407)	(2.905)
Rurality experience activity	3.278 (0.229)	4.481 (1.068)	(−0.839)
Rural tourism service	3.204 (−1.041)	4.315 (0.552)	(−1.592)
Average	3.265	4.138	

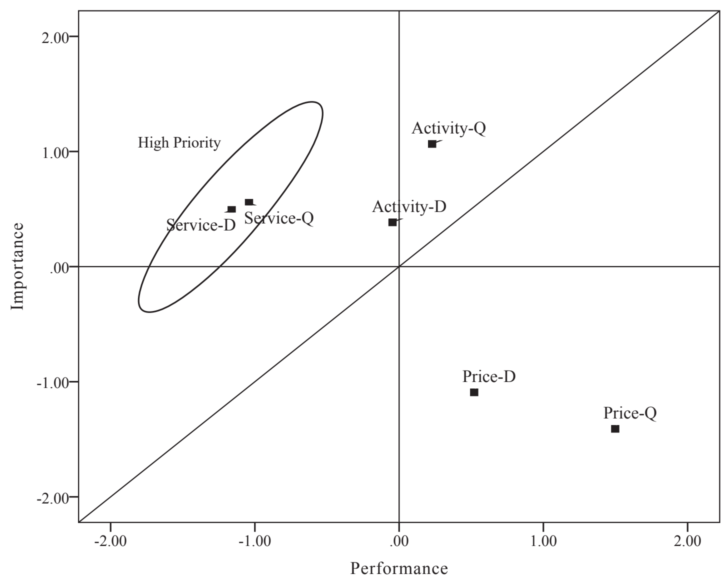


Figure 7. Traditional importance-performance grid (D: Dalishu scenic spots; Q: Qingshan scenic spots).

Considering the importance grid analysis results, "rural tourism service" is categorized as a basic attribute. It means that this attribute has an impact on the overall satisfaction when it is unmet, although it will not enhance its satisfaction when the needs are exceeded. For this reason, Figure 7 seems to have similar plot of attributes with the revised IPA grid. However, according to results of conjoint analysis and the importance grid, the importance of service in these two tourism sites is less than the activity. As a basic attribute, it is more accurately plotted in the third area of the IPA grid.

5. Conclusions

This paper presents a new method for measuring the importance and performance of rural tourism products attributes. Instead of using 'self-stated' method to measure them directly, this study applies the conjoint analysis method for analyzing the relative importance of attributes. This revised IPA model is employed to identify the category of attributes of rural scenic spots to find appropriate satisfaction enhancing strategies. The study results revealed two attributes on which improvement efforts should be made: "rurality experience activity" in Dalishu and "rural tourism service" in Qingshan scenic spots. Beyond our initial thought, Dalishu scenic spots, which are famous for agriculture experience activities, have a greater discrepant on activity attribute. Combined with the results from importance grid analysis, the importance and utility of "rurality experience activity" need to be emphasized by managers. With respect to Qingshan scenic spots, "rural tourism service" needs to be more focused on by managers, although it is not the high-performance factor. It can be seen that, for the same type of leisure destinations, the improvement focus also appears to be different through this revised IPA approach.

Compared to the traditional IPA technique, the proposed IPA model better shows the importance of attributes based on the conjoint analysis. Moreover, different from other importance measurement methods that focus only on the importance for purchase decision or satisfaction, this study examines the attribute importance twofold: importance in product choice, and importance in delivering satisfaction. Therefore, these results enable managers to evaluate the improvement of attributes more accurately. Furthermore, this study supports previous studies in which a nonlinear relationship exists among satisfaction and attributes. Using the importance grid method, the category of attributes can be acquired, and the relationship among attributes and satisfaction can be obtained. Regarding the survey that was conducted in rural settings, the better sustainable practices are necessary for the development of rural destinations. This study can provide managers of rural tourism destinations with a useful guide on how to enhance overall satisfaction through identifying the factors that have a direct impact on satisfaction, thereby fostering destinations' profitability and sustainable tourism.

With regard to its limitations, this study can be improved in three aspects. First, only three attributes are used in this revised IPA technique. More attributes should be taken into account in the process of product selection. At the same time, managers also need to consider various factors when seeking improvement. Future research therefore should select more attributes to analyze in order to provide more practical suggestions. Regarding the conjoint analysis method, fractional factorial designs or partial profile design will be suggested for use with a large number of attributes. Second, samples of two rural scenic spots were selected in the present study. The number was not enough for representing the general rural tourism. A sample with a wider range of respondents and more accessible investigation methods are also needed in future studies. Finally, as an effective tool, IPA has been used in tourism research for many years. However, tourist experience is a reflection of tourism products, and the revised IPA model needs to consider the characteristics of tourism products and be examined in more fields for various products in future research.

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Article

The Effect of Improving Cycleway Environment on the Recreational Benefits of Bicycle Tourism

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Abstract: Bicycle tourism is one of the popular physical activities for sport tourists. Since the physical environment may affect bicycling behavior, it becomes an important determinant for cyclists to choose a cycleway. Exploratory factor analysis is performed to extract the perception of environmental quality of cyclists into five main factors, including safety, light facilities, lane design, landscape, and environment cleanliness. The contingent behavior method (CBM) is adopted to measure the quality improvement projects in different scenarios of light facility and landscape improvement. The results showed that the improvement projects increased the intended number of trips and the recreational benefits of cyclists.

Keywords: bicycle tourism; environment quality; recreational benefits; contingent behavior method

1. Introduction

Bicycle tourism has an important niche in the tourism market, and it is defined as 'tourism that involves watching or participating in a cycling event, or participating in independent or organized cycle touring' [1]. Taiwan's bicycle industry is famous for the bicycle parts it produces and the bicycles it assembles. Due to Taiwan's natural environment, bicycle routes in Taiwan are unique and unprecedented. For example, the course of the Taiwan KOM (King of the Mountain) Challenge climbs from 0 to 3275 meters above sea level for a total route length of about 105 kilometers. Participants of Taiwan KOM are challenged by steep slopes and enjoy natural scenery. The environmental quality of KOM's bicycle routes includes smooth roads, climbing sections, and beautiful views of mountains which attract many international cyclists to the event. The environmental requirements for bicycle tourism are rather different from those of city sightseeing and festival forms of tourism [2]. Cyclists need a special environment for cycleways [3]. An attractive environment can appeal to racing cyclists [4]. They also strongly prefer scenery, cycling routes, and quiet roads [5]. The physical environment is an important determinant of consumers' perceptions of chosen destinations [6]. However, there has been little well-developed research on the environmental impacts of off-road cycling and there are few quantitative studies on the impacts of mountain bike trails [7]. There is a lack of research estimating the monetary value of environment quality in terms of cycleways. This study estimates the effect of environment quality on bike tourism.

Through cycling events, bicycle tourism can bring economic, social, and environmental impacts to the host communities and individual participants [2]. Studies on bicycle tourism often focus on motivations [8,9], general characteristics [10], bicycle road racing subculture [11], and gender differences [12,13] of competitive cyclists. Previous studies rarely look at the environment quality that is needed for bicycle tourism [3], and it is difficult to evaluate the quality of the environment at a recreation site [14]. Since the effect of environmental quality and recreation benefit cannot be estimated by market price, they are considered nonmarket goods. This study adopted the contingent behavior method to estimate the effect of environmental quality improvement.

According to the Ministry of Transportation and Communications in Taiwan (2018) [15], the number of cyclists increased rapidly from 700,000 in 2008 to 2.45 million in 2013, and in 2017 the number of cyclists increased to 5.1 million. Around 80% of these cyclists cycle for recreational purposes, resulting in a greater demand for dedicated bicycle routes [16]. Most cyclists in Taiwan cycle for leisure or recreational bike tourism. Dong-Feng Cycleway, also known as the Green Corridor, is one of the most popular cycleways in central Taiwan. It was built along an abandoned railway, connecting Fengyuan and Dengshi districts in Taichung City. The cycleway stretches for 12 kilometers with a river on one side and trees on both sides of the path, offering a great view to cyclists. Figure 1 shows a diagram of the site and pictures of Dong-Feng Cycleway. The built environment of Dong-Feng Cycleway is safe and comfortable and attracts many cyclists. This study focused on leisure bike tourism, and the purpose of this study was to explore the influence of environmental quality on the demand for cycleways, and to estimate the effect of environmental improvement on recreational benefits.

Figure 1. Dong-Feng Cycleway map and pictures.

2. Literature Review.

Bicycling is recognized as a sustainable travel mode and an important form of physical activity [17]. Bicycle tourism can be defined as 'tourism that involves watching or participating in a cycling event, or participating in independent or organized cycle touring' [1]. Lamont (2009) has expanded the definition to 'the scope for investigating the relationship between cycling and tourism by justifying the inclusion of persons who travel for the purpose of engaging in competitive cycling, in addition to persons who travel specifically to observe cycling events' [18].

Social and environmental factors affect cycling choice behavior, including demographic, environmental, and geographic variables [19]. For example, people's perceptions of the environment—their awareness of the recreation site through their primary receptive senses—can have a direct and significant influence on bicycling behavior. In contrast, the objective environment may only affect bicycling behavior indirectly through influencing cyclists' perceptions [20]. Previous studies have identified that cyclists' preference can be affected by the environment and bicycle facilities [21,22].

The main factors affecting recreational cyclists' choices include bicycle route choice, basic bicycle facilities, bicycle lane type, roadway grade, and scenery. Cycling routes can be divided into two types, commuting and recreational routes [21]. This study focused on recreational cycling. In Taiwan, recreational cyclists with higher skill levels prefer challenging routes and varied bicycle touring experiences. Cyclists also prefer cycling routes that are near attractions, cycling facilities, information centers, and bike-specific paths [16]. Road surface quality in particular is one important determinant in destination attractiveness [23]. With regard to safety on the road, bicycle lanes, bicycle slots, and wide curb lane are important factors; other factors include clean and smooth roads, route safety, diverse scenery, length of ride, and route variety. Creating bicycle infrastructure can induce more bicycling, and can influence cyclists' decisions to take on cycling touring [24,25]. Factors such as beautiful scenery or countryside were also reported to have a strong influence on sport tourism and customer satisfaction [26]. Based on previous research, cyclists' perception of the cycleway's environmental quality is rather important.

Perceived environmental quality can influence tourists' decisions [27]. Omitting the effect of the environmental quality from a demand model would result in underestimation of recreational benefits and lead to poor decision-making [28]. Therefore, to improve participants' perceptions of the environment is as important as it is to improve the physical environment and cycling infrastructure, and should be seen as a way to complement the design of the built environment [20]. Since the environmental quality is the main factor determining the behavior of participants [29], and the effect of environment belongs to nonmarket value, scholars have applied contingent valuation (CVM) to estimate their willingness to pay (WTP) as a monetary value. However, CVM described a hypothetical scenario that incurs hypothetical bias and the hypothetical WTP differs from actual WTP [30]. In order to mitigate the hypothetical bias of CVM, Whitehead and Wicker (2018) performed willingness to travel (WTT) to revise the hypothetical bias of WTP [30]. They combined stated and revealed preference data and asked respondents their intention of revisiting alternative distance projects for cycling events. The WTT is similar to the contingent behavior method (CBM) that Whitehead et al. (2000) had suggested to estimate the recreation benefits for the improvement of environmental quality [14]. Yeh, Hua, and Huang (2016) performed CBM to evaluate the improvement value of service quality for sports tourism [31]. Huang (2017) adopted CBM that combined actual and intended behavior data to measure the environmental effects of quality improvement [28]. Deely et al. (2019) combined actual and contingent behavior data to estimate the value of coarse fishing in Ireland [32]. This study also adopted CBM to estimate the improvement effect of environmental quality for cycleways.

3. Materials and Methods

3.1. Contingent Behavior Method

The environmental quality of recreation sites has been included in demand functions to estimate consumers' willingness to pay [33]. However, it is difficult to estimate the environment quality at the same recreation site due to there being no variation in quality data [14]. The problem is how to evaluate the improvement effect and to identify the changes in quality variation that are associated with recreational benefits [14,34].

The most common approach to evaluate the quality improvement effect is to combine revealed and stated data, the so-called contingent behavior method [14,35–40]. This means a panel recreation demand model combining current data and expected hypothetical scenarios is used to measure consumer benefits under different projects [36]. This study also adopted CBM to estimate the improvement effect of environmental quality for cycleways.

The estimation model of this study was based on the travel cost method. Then, the questionnaire was designed to ask respondents about their observed behavior from actual trips and their intended behavior with hypothetical changes under certain circumstances, such as improved environmental quality. The contingent behavior question asked subjects whether they would increase the number of their visits if the environmental quality of Dong-Feng cycleway were improved. Then, actual and intended data were combined to create a panel data set that was generated from one cross-sectional sample survey. The advantage of combined data is its efficiency and reduction of sample sizes from repeated observations for each individual without incurring additional costs. The recreational benefits can be measured by the change in consumer surplus between the demand function of actual trips and intended behavior trips.

This study followed previous research using CBM to estimate recreational benefits [28,31,32,35,37,39,41]. The CBM combined actual trips with contingent behavior data regarding visit intentions given alternative projects. Panel data of the recreation demand model with pooled data of current and expected hypothetical scenarios was applied to measure consumer benefits under different projects [36]. The random effects Poisson model was employed to take into account the heterogeneity among individuals and structural changes in demand in different scenarios [31,42,43]. The Poisson probability density function is as follows:

$$P(X_{it} = x_{it}) = \frac{e^{-\mu_{ti}} \mu_{it}^{x_{it}}}{x_{it}!},\ x_{it} = 0, 1, 2, \ldots \quad (1)$$

Assume x_{it} is the number of times taken by individual i in a scenario t, and μ_{it} is the mean Poisson distribution, which depends on the explanatory variables and participant heterogeneity:

$$\ln u_{it} = \alpha_t + \beta_t COST_{it} + \delta_t SCOST_{it} + \varphi_t INCOME_{it} + \gamma_t OTHER_{it} + u_i \quad (2)$$

where t = 1, 2 and u_i is a random effect for respondents i. Where t = 1 indicates the current level of lighting facilities and landscape and t = 2 represents the improvement scenario of lighting facility and landscape. COST represents respondents' travel costs, including immediate transportation costs and the cost of round-trip travel time from their home to the destination, as well as time spent on-site. SCOST represents the travel cost associated with a visit to a substitute site. The substitution price is measured by the distance from the home of a visitor to an alternative site that offers similar attractions and includes the same expenditure as the site under study. Respondents were asked where they would go to make a trip if they did not go to Dong-Feng Cycleway (the Green Corridor). The most frequent choice of the respondents for the substitute site is Kenting National Park in south Taiwan. INCOME is monthly income of the respondents. OTHERS includes the main factors of environmental quality and AGE. In order to account for the potential structural change in trip demand across scenarios, this study combined data from all trip scenarios. The dummy variable D = 1(t = 2), denotes the improvement programs of lighting facilities and landscape; otherwise, D = 0 (t = 1). The definition of the variables and descriptive statistics are listed in Table 1. A general recreation demand model uses pool data to incorporate the dummy variable into the mean μ_{it}.

$$\begin{aligned} \ln \mu_{it} = \alpha_t + \beta_t COST_{it} + \delta_t SCOST_{it} + \phi_t INCOME_{it} + \gamma_t OTHERS_{it} \\ + a_2 D_s + b_2 D_s COST_{it} + c_2 D_s SCOST_{it} + d_2 D_s INCOME_{it} + u_i \end{aligned} \quad (3)$$

where D_s represents the dummy variable for improving programs, s = 1, 2. When the coefficient of the dummy variable is significantly different to 0, it means that the visitors' motivation to ride a bike will be raised after the lighting facilities and landscape are improved. The differences of elasticity are represented by the interaction of the dummy variable and travel cost, substitute site travel cost, and income.

The consumer surplus of participants equals the area under the expected demand function for access to Dong-Feng Cycleway. The demand in Equation (3) is semi-log. Both the choke price of current and improved lighting facilities or landscape in the demand function are infinite. When the quality of the project improves, visitors' recreational demand shifts rightward. The change of the consumer surplus for the improvement of environmental quality can be measured as follows.

$$\Delta CS = \frac{x'}{\beta'} - \frac{x}{\beta} \quad (4)$$

where β and β′ are the coefficient of the price variable in the demand model, x is the number of trips with current quality, and x' is the number of trips with expected improvement of quality, respectively.

Table 1. Definition of the variables and descriptive statistics.

Variable	Definition	Mean	SD
TRIPS1	The number of observed trips for individual visits to Dong-Feng Cycleway under the current quality.	3.38	5.67
TRIPS2	The number of observed trips + intended trips for individual visits to Dong-Feng Cycleway under quality improvement of lighting facilities.	6.11	7.37
TRIPS3	The number of observed trips + intended trips for individual visits to Dong-Feng Cycleway under quality improvement of the landscape.	6.50	8.25
COST	Total round trip travel costs to Dong-Feng Cycleway, the cost is measured in New Taiwan dollars (NT$).	692	947
SCOST	Total round trip travel costs to a substitute site—Kenting National Park in Pingtung (NT$).	809	1,147
AGE	Cyclist age.	31.15	10.44
INCOME	The monthly income of the respondent (NT$).	25,134	19,177
EQF1	The factor score of 'safety'. (Origin Likert scale)	- (4.44)	- (0.53)
EQF2	The factor score of 'lighting facility'. (Origin Likert scale)	- (4.22)	- (0.68)
EQF3	The factor score of 'lane design'. (Origin Likert scale)	- (4.23)	- (0.60)
EQF4	The factor score of 'landscape'. (Origin Likert scale)	- (3.84)	- (0.61)
EQF5	The factor score of 'environment cleanliness'. (Origin Likert scale)	- (4.23)	- (0.63)
D1	Dummy equal to 1 if the lighting facilities were improved in Dong-Feng Cycleway, the respondents' intention to ride a bike there would change; 0, otherwise	0.93	0.27
D2	Dummy equal to 1 if more trees were planted to improve the landscape in Dong-Feng Cycleway, the respondents' intention to ride bike there would change; 0, otherwise.	0.92	0.27

3.2. Questionnaire and Sample

The questionnaire of environment quality items was designed from a number of sources and literature reviews, including Bull (2006) [4], Chen and Chen (2013) [16], and Sener et al. (2009) [21]. Cyclists' answers to the questions in the questionnaire concerning environment quality were given on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The survey was conducted from July to August in 2016, and 420 cyclists were asked to fill out the questionnaire. Three hundred and seventy-two respondents completed the questionnaire, yielding a response rate of 88.57%. One of the advantages of CBM is data collection. The method can reduce sample sizes from repeated observations for each individual without incurring additional costs, and it can also increase estimation efficiency [44].

4. Results

4.1. Environmental Quality of Cycleways

This study adopted exploratory factor analysis to extract the major factorial dimension of environmental quality for Dong-Feng Cycleway. Factor analysis was performed using the principal component method and the Varimax rotation procedure. There were 27 items on environmental quality in the questionnaire, and six items were dropped because their factor loading was smaller than 0.5.

Five major factorial dimensions were extracted out of 21 items. Table 2 lists the results of factor analysis that show that the Eigenvalues exceed 1, explaining 62.98% of the total variance.

Table 2. Factor analysis of environmental quality for cyclists.

Items	Safety	Lighting Facility	Lane Design	Landscape	Environment Cleanliness
Bicycle path pavement maintenance	0.733				
Guarantee the rights of cyclists	0.723				
Controlling steam locomotives into bicycle lanes	0.711				
Management and maintenance of public facilities around bicycle lane	0.679				
No parking for motors on bicycle lane	0.641				
Safety maintenance of the surroundings of bicycle paths	0.633				
Bicycle lane has enough lighting at night		0.805			
Bicycle lane night index visibility		0.764			
Bicycle lane night guardrail color visibility		0.757			
Bicycle lane lighting at night is bright enough		0.752			
The slope of the bicycle lane is appropriate			0.846		
Bicycle lane is properly curved			0.803		
The width of the bicycle lane is appropriate			0.795		
Bicycle lane guardrail setting			0.613		
Dispersion of landscape position				0.763	
Landscape is diversity				0.728	
The landscape is crowded				0.668	
Landscape has a famous specialty				0.657	
Appropriate location of toilets along the bicycle path					0.774
Cleanliness of use of toilets along bicycle lanes					0.770
There are enough trash bins along the bike path					0.749
Eigenvalue	6.75	1.95	1.69	1.43	1.41
Cumulative variation (%)	32.16	41.42	49.46	56.27	62.98
Cronbach's α	0.86	0.84	0.83	0.75	0.70

The first dimension of factor analysis was 'safety', which made up a large proportion of environmental quality and accounted for 32.16% of the variation with a reliability of 0.86. The other dimensions were 'lighting facility', 'lane design', 'landscape', and 'environment cleanliness', which accounted for a total variance of 9.26%, 8.04%, 6.81%, and 6.71%, respectively. The coefficient reliabilities for 'lighting facility', 'lane design', 'landscape', and 'environment cleanliness' were 84%, 83%, 75%, and 70%, respectively. After factor analysis, five dimensions of environmental quality were introduced into the CBM to estimate the monetary value of environment improvement for cyclists.

4.2. Contingent Behavior Model Estimates

This study adopted CBM, combining actual trips with intended trips to estimate the recreational benefits under the hypothetical scenarios of improved environmental quality. The improvement programs included lighting facilities and landscape, which ranked the lowest among the environment factors in the pretest and formal survey (Table 1). The lighting facilities are insufficient for cyclists to ride at night and the landscape is damaged by a soil conservation project. Factors EQF1 to EQF5 represent the factors of safety, lighting facility, lane design, landscape, and environment cleanliness, respectively. The contingent behavior model under the hypothetical scenarios includes the scenarios of improved lighting facility (model A) and landscape (model B). The definition of the variables and descriptive statistics are listed in Table 1.

The goodness-of-fit of the evaluation models are revealed by Chi-squared measure, which was calculated by likelihood ratio, and differed from 0 at the 0.01 significance level. The result indicated that the null hypothesis of all variables being equal zero was rejected. The signs of cost and substitute cost variables were consistent with the demand rule for both models and differ significantly from 0. The socioeconomic variables were positive and significantly related to participants' age and income. Participants who are older and have higher income are more likely to ride a bike at Dong-Feng Cycleway. The older cyclists are more likely to choose bike tourism for leisure. For the perception factors, in model A (improved lighting facility), 'lighting facility' (EQF2), 'lane design' (EQF3), and 'environment cleanliness' (EQF5) were significantly related to cyclists' demand. In model B (improved landscape), apart from the aforementioned three factors, 'landscape' (EQF4) was also found to be significantly related to the demand. Lighting facility and landscape were positively related to the demand of cyclists. When the lighting facility and landscape factors are improved, the cyclists' intention to ride here increases. In contrast, lane design and environment cleanliness were negatively related to the demand because when the intended trips increased with in two hypothetical scenarios, the lane design and environment cleanliness factors remained constant. Thus, the relationship between the demand and lane design and environment cleanliness factors changed from positive to negative. The quality improvement dummy variables (D1, D2) were significantly different from zero at the 0.01 level, and demonstrated that the quality improvement would lead to an increase in the number of trips taken. The coefficient of the interaction between dummy variables (D1, D2) and own-price, cross-price, and income was significantly different from zero. The results showed a shift in the elasticities of the recreation demand as the environmental quality improved. The results are consistent with the research of Whitehead et al. (2000) [14]. The details of the results are listed in Table 3.

Table 3. Contingent behavior model for improvement effect.

Variable	Model A	Model B
Constant	0.0193 (0.382)	0.4412 (10.761)
COST	−0.0003 *** (−16.416)	−0.0003 *** (−20.732)
SCOST	0.0003 *** (15.346)	0.0003 *** (18.190)
AGE	0.0252 *** (43.977)	0.0274 *** (57.751)
INCOME	0.00007 *** (11.047)	0.00008 *** (15.777)
EQF1	0.0049 (0.585)	0.0004 (0.340)
EQF2	0.2416 *** (28.012)	0.2449 *** (31.302)
EQF3	−0.0706 *** (−9.999)	−0.0691 *** (−10.448)
EQF4	0.0099 (1.427)	0.0151 *** (2.606)
EQF5	−0.0913 *** (−13.286)	−0.0867 *** (−13.700)
D1	0.3948 *** (12.983)	-
D1 COST	0.0001 *** (4.806)	-
D1 SCOST	−0.0002 *** (−13.001)	-
D1 INCOME	0.00004 *** (3.860)	-
D2	-	1.7936 *** (5.507)
D2 COST	-	0.0004 *** (2.989)
D2 SCOST	-	−0.0002 *** (−13.353)
D2 INCOME	-	0.0006 *** (6.118)
Chi-squared	984 ***	1138 ***
Observation	784	784

Note: *** $p < 0.01$, t values in parentheses.

4.3. Elastic Estimates

The dummy variables, D1 and D2, were significantly different from 0 at the 0.01 level. Both improvement projects would lead to an increase in the number of trips taken. For the lighting facility project and the landscape project, the demand of trips increased from 3.38 to 6.11 and 6.50, respectively. The interaction coefficient between the dummy variables (D1, D2), own-price, and income was positive and significantly different from zero at the 0.01 level. However, the interaction coefficient between the dummy variable and cross-price was negative and significantly different from zero at the 0.01 level. The results are presented in Table 4. In both projects, the elasticity of own-price, cross-price, and income were smaller than 1, and the elasticity of current quality was greater than the improved quality. With the quality improvement project, price and income factors became inelastic, and demand for the cycleway rose. The result is consistent with the research of Alberini et al. (2007) [35] and Whitehead et al. (2000) [14].

Table 4. Elasticity estimates.

Elasticity	Lighting Facility	Landscape
Current quality elasticity		
Own-price	−0.125953	−0.121762
Cross-price	0.303048	0.273678
Income	0.512112	0.611752
Improved quality elasticity		
Own-price	0.026565	0.076216
Cross-price	−0.114006	−0.100279
Income	0.166571	0.232376

4.4. Estimating Recreational Benefits and Improving Effects

The recreational benefit was obtained from Equation (4). The average recreational benefit for a participant was NT$9796 for Model A and NT$10,133 for Model B. An increase was found in the lighting facility improvement project; the consumer surplus was raised to NT$46,444. In contrast, an improved landscape raised the consumer surplus to NT$16,188 per person. With 250,000 cyclists in 2016, the findings indicate that incremental recreational benefits could have increased to NT$ 9162.20 million if the lighting facilities were improved, and a gain of NT$1513.85 million could occur if the landscape program was better than the current situation (see Table 5).

Table 5. Recreational benefits and programs effect.

Value (1000 NT$)	Lighting Facility	Landscape
Recreational benefits (average)	9.80 to 46.44	10.13 to 16.19
Incremental of improvement effect	36.65	6.06
Total recreational benefits	11,611,120	4,047,072

5. Discussion

The empirical results showed that the exploratory factor analysis extracted the major factorial dimensions of environmental quality for Dong-Feng Cycleway, including 'safety', 'lighting facility', 'lane design', 'landscape', and 'environment cleanliness'. The scale of the lighting facilities and the landscape quality were the lowest among the environment factors, and became the hypothetical improvement projects in this study. The results of CBM found that improving the lighting facilities and landscape factors would increase the number of intended trips and the recreational benefits for cyclists. The average recreational benefit for a rider with the current quality of lighting and landscape is NT$9,796 and NT$10,133, respectively. After improving the quality of the lighting facilities and the landscape, the recreational benefits could be increased to NT$46,444 and NT$16,188 for cyclists.

In order to examine the validity of the quality improvement projects, this study calculated the elasticity of own-price, cross-price, and income for the current and improved quality of lighting facilities and the landscape. The results revealed that the improved quality was less elastic than the current quality. In other words, the demand for the cycleway became less elastic with the quality improvement projects. This finding is the same as the findings of Alberini et al. (2007) [35] and Whitehead et al. (2000) [14]. Cyclists would not change their decision to visit Dong-Feng Cycleway after improvement of the environmental quality.

6. Conclusions

This study adopted the contingent behavior method to estimate the effect of improving the environmental quality of Dong-Feng Cycleway. The theoretical model was based on the travel cost method, and the Poisson function was used in the empirical model. The respondents reported their intention to ride a bike under hypothetical scenarios of improvement of the lighting facilities and landscape. CBM, combining actual and intended behavior data, was used to measure the effect of the quality improvement projects and to calculate the recreational benefits with different scenarios of lighting facility and landscape improvement. The effect of environment quality improvement is tremendous for cyclists. According to this result, public officials or managers should to improve environmental quality of cycleways.

The estimation of elasticity proved the validity of the quality improvement effect. This paper also found that the contingent behavior method contains more information than the traditional travel cost model; the findings can assist officials to develop strategic policy concerning quality improvement to sustain bicycle tourism.

Based on the results, this study suggests that any efforts to improve existing cycleways should not neglect the importance of lighting facilities and the surrounding landscape; and for the planning of future cycleways, efforts should be put into maximizing cyclists' recreational benefits, and cycleway design guides should provide designers information on how to achieve that. Information of the lighting facilities and surrounding landscape should be provided to cyclists in cycleway guides.

The limitation of this study is that the samples came from on-site cyclists only. According to the structure used in the study of Whitehead et al. (2000) [14], nonparticipants should also be included in the survey. As an effect on the demand function, higher environmental quality may attract new participants to the site. To elicit more information on attracting new cyclists to use the cycleway, further research should include nonvisitors' opinions in the survey.

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Nonlinear and Spatial Effects of Tourism on Carbon Emissions in China: A Spatial Econometric Approach

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Abstract: Reducing carbon emissions is crucial to the sustainable development of tourism. However, there are no consistent conclusions about the nexus between tourism and carbon emissions. Considering the possible nonlinear and spatial effects of tourism on carbon emissions, this paper employed spatial econometric models combined with quadratic terms of explanatory variables to explore the nexus between them using Chinese provincial panel data from 2003 to 2016. The main results are as follows: (1) There is a significant inverse U-shaped relationship between tourism development and carbon emissions. In the provinces whose tourism receipts are relatively low, the effects of tourism on carbon emissions are positive but decrease gradually as the tourism receipts increase and then shifts to negative and continues decreasing gradually when the tourism receipts beyond the critical value. (2) For the geographical proximity and industrial relevance, one province's tourism development not only affects its carbon emissions but also affects its neighbors' carbon emissions through spatial lag effect (indirect effect) which is also inverse U-shaped. (3) Carbon reduction policies, sustainable education, and transportation infrastructure all have significant moderating effects on the relationship between tourism and carbon emissions, but the moderating effect of the management efficiency of tourism is not statistically significant. Furthermore, improvements to the sustainable education and transportation infrastructure not only strengthen the direct negative effect of tourism on carbon emissions but also strengthen the indirect negative effect of tourism on carbon emissions. This study not only advances the existing literature but is also of considerable interest to policymakers.

Keywords: nonlinear effects; spatial lag effects; tourism industry; carbon emissions; spatial econometric approach

1. Introduction

Tourism is highly vulnerable to climate change, in addition to contributing to it. Threats for the sector are diverse, including various impacts such as extreme weather events, increasing insurance cost and safety concerns, biodiversity loss, and so on. At the same time, tourism is one of the key drivers to the anthropogenic component of climate change [1,2], which is predicted to contribute approximately 7.5% of global carbon emissions in 2035 [3]. Therefore, reducing carbon emissions from tourism not only helps to offset global warming but is also conducive to the sustainable development of the tourism industry. The effective way of reducing carbon emissions is dependent on the linkage between tourism and carbon emissions. Although the nexus between tourism and carbon emissions has been widely studied over time, a lack of tourism statistics and materials makes it difficult to quantify carbon emissions from tourism [4]. Tourism is not a traditional sector in the System of National Accounts, and as a result, the statistics of carbon emissions of the tourism industry on a national or regional scale is difficult to calculate. Furthermore, it is also challenging to assess the other two kinds of carbon emission effects of tourism: Income effect and infrastructure effect. The income effect means that tourism growth is helpful in increasing residents' income, and then affecting carbon emissions, because existing studies have already confirmed that per capita income usually has a significant impact on carbon emissions [5,6]. The infrastructure effect means that the development of tourism usually requires a large amount of infrastructure investment, which affect carbon emissions, because the investment on tourism infrastructure (e.g., transportation infrastructure, information infrastructure, and building infrastructure) usually has a significant impact on carbon emissions [7]. Therefore, a credible evaluation of the aggregated effects of tourism on carbon emissions will improve the ability to manage the sustainable development of tourism.

Research on the carbon emissions of the tourism industry has been widely carried out and discussed, although it has been difficult to measure the carbon emissions from tourism for many years. Existing studies can be divided into two categories based on the data used in the research. The first category of the research has mainly focused on the calculation of carbon emissions from tourism using methods such as a bottom–up approach, top–down approach, and a carbon footprint approach [4], and then they assessed the relationship between tourism development and carbon emissions with the calculated emissions data [8–10]. Although this kind of literature has shed some light on the relationship between tourism and carbon emissions, ignoring the income effect and infrastructure effect of tourism mentioned above may cause inaccurate results [11,12]. The second category of the literature used econometric models with statistical data of national or regional carbon emissions to estimate the effects of tourism on carbon emissions [13]. As the statistical data of carbon emissions contain the income effect and infrastructure effect of tourism, the overall effect of tourism on carbon emissions can be estimated easily using this kind of data. However, the latter kind of literature still has some limitations, which may raise questions regarding the robustness and validity of the findings. Firstly, these studies typically explored the impact of tourism on carbon emissions based on linear regression models, and few studies have focused on the nonlinear connection between tourism and carbon emissions. Secondly, this literature has not accounted for the spatial dependence of different regions, while a region's carbon emissions and tourism development are usually related to those of its neighbors [14,15].

This paper aims to address the gaps by modeling the effects of tourism development on carbon emissions in the context of spatial dependence and nonlinear impact using the panel data of 30 provinces in China from 2003 to 2016. There are two reasons to choose China's provinces as the research samples in this study. To begin with, China's tourism industry has developed rapidly in recent years, and the induced environmental impacts are getting more and more attention [16]. However, the studies on the overall effect of tourism on carbon emissions are relatively scarce. Additionally, panel data of China's 30 provinces from 2003 to 2016 provide the possibility to study the complicated relationship between tourism development and carbon emissions. The main contributions of this study are threefold. Firstly, this study employed a quadratic polynomial model to test the nonlinear relationship between tourism and carbon emissions. Secondly, a panel spatial econometric technique was used to take spatial dependence of carbon emissions into consideration. Finally, the moderating effects of the variables that affect the carbon efficiency of tourism subsectors were estimated to explore the factors which affect the relationship between tourism and carbon emissions.

This paper is structured as follows: Following the introduction, the next section reviews the recent literature on the calculation of the emissions from the tourism industry and the estimation of the effects of tourism on carbon emissions. The third section introduces model specification, variables, and the data description. Section 4 presents the results and discussion. Finally, we summarize the overall conclusions and policy implications.

2. Literature Review

2.1. Calculation of the Emissions from the Tourism Industry

Due to the lack of the census data on the carbon emissions from the tourism industry, scholars usually measure carbon emissions data on tourism in a specific country, region or scenic spot as the first step and then further evaluate the dynamic relationship between tourism development and carbon emissions. For example, Becken et al. studied the carbon emissions of ecological hotels in the Lamington National Park. The hotels had been granted the Green Globe 21 Certificate. The study showed that after being certified, the hotels reduced carbon dioxide emissions by 189 tons per year [8]. In another study, Wu and Shi estimated carbon emissions from China's tourism sector in 2008. According to their estimation, carbon emissions from tourism sector amounted to 51.34 million tons, accounting for 0.86% of the total in China [9]. In a study by Xie et al., they measured the carbon emissions from the tourism of the Yangtze River Delta area. The results showed that there is a positive relationship between carbon emissions from tourism and the gross income of tourism [10]. Finally, Wu et al. calculated the emissions from the tourism of five provinces in China from 2009 to 2011. The main finding of the study was that Beijing and Hainan saw their emissions per tourist dropped continuously during 2009 and 2011. Zhejiang's emissions from tourism showed a reverse U-shape trend, while those of Shandong and Hubei showed U-shape trends [4].

Among the above studies, methods of calculating the emissions from tourism have been one of the main concerns. Since the first measurement proposed by Gossling [17], a variety of methods have been explored, integrated, and applied on varied scales from national level down to local [18,19]. There are three kinds of common methods used in the literature: A top–down method [20–24], a bottom–up method [9,10,25–28], and a combination of other methods (e.g., carbon footprint, life cycle assessment, and environmental satellite accounts) [8,11,12,29–31]. Each of these approaches has its advantages. However, there are still some limitations when these methods are used to assess the relationship between carbon emissions and tourism. Firstly, this literature has ignored the additional emission effects which can range from 30% to 110% of the basic effect [12]. Ignoring these effects would substantially underestimate the overall emission effect of tourism consumption [11]. Secondly, one of the key assumptions in these methods is the linearity between expenditure and emissions, implying that the influence of technological progress and management efficiency is not considered [21]. Thirdly, most of the literature typically provides a snapshot of the relationship between tourism and carbon emissions. Long-term evaluations of tourism emissions are scarce, so the environmental improvement or operational improvement of tourism services could not be identified [1].

2.2. Estimation of the Comprehensive Effect of Tourism on Carbon Emissions

In recent years, some scholars have attempted to use econometric techniques with the aggregated longitudinal carbon emissions data (e.g., total national carbon emissions and total regional carbon emissions), which include all types of emission effects of the tourism industry [13], to evaluate the long-term comprehensive effects of tourism on carbon emissions. The literature can be divided into two categories based on the type of conclusions. The first kind of literature concluded that tourism has a significant positive impact on carbon emissions. For example, Katircioglu et al. found that for a small island like Cyprus, international tourism arrivals have a significant positive impact on carbon emissions [32]. Katircioglu investigated the long-run equilibrium relationship between tourism and environmental degradation as proxied by carbon emissions in Turkey. The findings reveal that tourism development has resulted in considerable carbon emissions [33]. Using the generalized method of moments model from panel data in 1998–2006, Leon et al. also confirmed the same findings in the context of both developed and less developed countries across the world [34]. In another study, Durbarry and Seetanah explored the dynamic relationship between tourism development and carbon emissions in the case of Mauritius from the period of 1978–2011 using the autoregressive distributed lag (ARDL) approach. The study also provided empirical evidence that an increase in the number of tourists has a considerable and positive impact on carbon emissions [35]. Similar evidence was provided by Zaman et al. and Paramati et al. for developed and developing countries [6,36].

The second kind of literature concluded that the development of tourism has a significant adverse effect on carbon emissions. For example, Lee and Brahmasrene investigated the influence of tourism on carbon emissions using panel data of European Union countries from 1988 to 2009. Results from panel cointegration techniques and fixed-effects models indicated that tourism is inversely related to carbon emissions in the EU [37]. In a different research study, Katircioglu found that tourist arrivals have negatively significant effects on carbon dioxide emission levels both in the long-term and the short-term periods in Singapore [5]. In Raza et al.'s study, they examined the relationship between tourism and carbon emissions using US data. The findings of their study confirmed that tourism development can affect carbon emissions adversely [38]. Finally, using panel data of Western European Union countries, Paramati et al. also found that the expansion of the tourism industry can decrease carbon emissions [39].

According to the above conclusions, although most of the studies confirm the existence of an empirical relationship between carbon emissions and tourism development, the direction of causality between them remains unclear. One of the main reasons for the inconsistent conclusions may be because they ignored the nonlinear effect of tourism on carbon emissions [40,41]. Additionally, ignoring the spatial dependence among the regions may also cause inaccurate conclusions [14,42–44]. Therefore, with the end of taking both the spatial dependence and nonlinearity into consideration, this study employs a panel spatial econometric model containing a quadratic polynomial relationship to estimate the total effects of tourism on carbon emissions.

3. Model Specification, Variables, and Data Description

3.1. Model Specification

3.1.1. Modeling of the Nonlinearity

This paper argues that there is an inverse U-shaped relationship between tourism and carbon emissions for the following two reasons. Firstly, tourism growth will increase carbon emissions. Tourism depends on a wide range of infrastructure services such as airports, ports, roads, railheads, resorts, and restaurants, as well as telecommunications and so on. Building the above ancillary infrastructure of tourism generates massive carbon emissions [45–48]. Furthermore, the transportation and hosting of increasing tourism consumers also induce more and more energy consumption and carbon emissions. Secondly, well-managed tourism can play a positive role in the environment [3]. With the growth of tourism, management efficiency of enterprises in the tourism subsectors will be improved for the learning-by-doing effect [49]. Improved management leads to better fuel efficiency, lower energy intake per unit operation, and subsequently lower emission levels [50]. Further, carbon emissions can be reduced through technological progress and adopting clean energy, all of which will be increased by the development of tourism [51].

In order to reveal the above nonlinear influence of tourism on carbon emissions, the model is preliminarily set as follows:

$$Emission_{it} = \beta_0 + \beta_1 Tourism_{it} + \beta_2 Tourism_{it}^2 + \beta_k Controls + u_i + v_t + \varepsilon_{it} \quad (1)$$

where i and t represent region and year respectively; *Emission* is the carbon emission; *Tourism* is the development of tourism; *Controls* represents a series of control variables; u_i and v_t represent regional fixed effect and time fixed effect respectively; ε is the error term; β_0 is the constant item; and β_1, β_2, and β_k are the coefficients to be estimated.

3.1.2. Modeling of the Spatial Dependence

There are usually similar economic structure and living customs among neighboring provinces so that their energy consumption and induced carbon emissions are also correlated with each other [52]. Furthermore, the economic development and induced carbon emissions of one province usually can increase the same for its neighbors due to their close economic connections [53]. Additionally, tourism has spatial effects in terms of carbon emissions, because the tourism growth of one province will cause the growth of related industries and the induced carbon emissions of adjacent provinces [14]. To consider the above spatial effects, we can add the spatial relationships into Equation (1) by using a spatial Durbin model (SDM) as follows:

$$\begin{aligned} Emission_{it} = \beta_0 + \rho \sum_{j=1}^{n} w_{ij} Emission_{jt} + \beta_1 Tourism_{it} + \beta_2 Tourism_{it}^2 + \beta_3 \sum_{j=1}^{n} w_{ij} Tourism_{jt} \\ + \beta_4 \sum_{j=1}^{n} w_{ij} Tourism_{jt}^2 + \beta_k Controls + u_i + v_t + \varepsilon_{it} \end{aligned} \quad (2)$$

In Equation (2), ρ denotes the regression coefficient of spatial lag of the explained variable, that is, the specific province's carbon emission effect caused by its neighboring provinces; β_3 and β_4 denote the regression coefficients of spatial lag of tourism and its quadratic form respectively, that is, the specific province's carbon emission effect caused by its neighbors' tourism growth; w_{ij} denotes the spatial relationship between province i, and province j and is defined as follows:

$$w_{ij} = \begin{cases} 1, & if\, province\, i\, and\, province\, j\, are\, adjacent; \\ 0, & other\, situations. \end{cases} \quad (3)$$

Although Equation (2) can describe the spatial dependence of carbon emissions, the spatial dependence may be caused by the spatial dependence of omitted unobservable variables (e.g., climate environment shared by neighboring provinces), which are included in the error term. Therefore, we can use the spatial Durbin error model (SDEM) alternatively as follows:

$$\begin{aligned} Emission_{it} = \beta_0 + \beta_1 Tourism_{it} + \beta_2 Tourism_{it}^2 + \beta_3 \sum_{j=1}^{n} w_{ij} Tourism_{jt} \\ + \beta_4 \sum_{j=1}^{n} w_{ij} Tourism_{jt}^2 + \beta_k Controls + u_i + v_t + u_{it} \\ u_{it} = \lambda \sum_{j=1}^{n} w_{ij} u_{jt} + \varepsilon_{it} \end{aligned} \quad (4)$$

where u denotes the error term containing the spatial dependence, and λ denotes the regression coefficient of spatial impacts of the error terms.

To determine which model is more reliable, this paper used the likely ratio test (LR) with a general nested spatial model (GNSM), which can be reduced to SDM or SDEM. The GNSM is defined as follows:

$$\begin{aligned} Emission_{it} = \beta_0 + \rho \sum_{j=1}^{n} w_{ij} Emission_{jt} + \beta_1 Tourism_{it} + \beta_2 Tourism_{it}^2 + \beta_3 \sum_{j=1}^{n} w_{ij} Tourism_{jt} \\ + \beta_4 \sum_{j=1}^{n} w_{ij} Tourism_{jt}^2 + \beta_k Controls + u_i + v_t + u_{it} \\ u_{it} = \lambda \sum_{j=1}^{n} w_{ij} u_{jt} + \varepsilon_{it} \end{aligned} \quad (5)$$

3.1.3. Modeling of the Moderating Effects

The tourism industry consists of many subsectors such as transportation, accommodation, and reaction. Therefore, the variables which affect carbon emissions and carbon efficiency of these subsectors will impact the strength of the relationship between the tourism industry and the aggregated carbon emissions. This kind of impact is called moderating effects and can be modeled through the interaction of these variables with the explanatory variables.

3.2. Variables

In this paper, carbon emissions are considered as the explained variable, which is denoted by the "emission" and measured using the amount of provincial total carbon emissions; tourism growth is the explanatory variable and measured by the provincial tourism receipts. According to the existing literature, energy consumption, energy mix, and gross domestic production (GDP) per capita are used as the control variables in this paper [54–58].

In terms of the moderating variables, two kinds of variables are taken into consideration. The first kind of moderating variable refers to the variables that affect the carbon efficiency of all the tourism subsectors. Carbon reduction policy, sustainable education, and tourism efficiency [59–63] are three such moderating variables used in this paper. Carbon reduction policy refers to policies to promote the carbon emission abatement and is denoted by "Reduction", which is measured through the number of provincial carbon abatement policies. Sustainable education is denoted by "Education" and is measured through the average years of schooling. Tourism efficiency is denoted by "Toueff" and is measured using the ratio of tourism receipts to the number of employees. The second kind of moderating variables includes the variables that affect the carbon efficiency of one specific tourism subsector, such as transportation infrastructure, which has a significant impact on the energy efficiency and the induced carbon efficiency of the transportation industry [7]. Because the transportation industry contributes approximately 75% of the carbon emissions from tourism, this paper mainly explored the moderating effects of the transportation infrastructure, which is measured by the intensity of the road networks [12,64] and is denoted by "Trans".

3.3. Data Description

The panel dataset is yearly and covers the period from 2001 to 2016 for 30 Chinese provincial regions. Tibet, Hong Kong, Macau, and Taiwan are excluded due to data constraints. The data of the provincial carbon emissions were taken from Shan et al. [65]; the data of provincial tourism receipts, GDP, population, average years of schooling, and the number of employees of the tourism industry in 30 provinces were taken from the China Statistical Yearbook [66]. Data on energy consumption and energy mix of the 30 provinces were taken from the China Energy Yearbook [67]. Data on carbon reduction policy were taken from Zeng et al. [59]. Data on transportation infrastructure were taken from Bi et al. [7]. Table 1 reports the description and summary statistics for all variables.

Table 1. Description and summary statistics of the variables.

Variable	Description	Unit	Mean	Std. Dev.	Min	Max
Emission	Carbon emissions	million tons	281.90	234.99	7.55	1552.01
Tourism	Tourism receipts	10 billion CNY *	12.56	12.85	0.10	77.39
Energy_con	Energy consumption	10^4 tons tce **	119.47	78.85	6.84	388.99
Energy_mix	Energy mix	%	68.41	26.18	8.70	98.43
PGDP	GDP per capita	10^3 CNY	27.81	23.02	3.69	139.34
Reduction	Carbon reduction policy	piece	18.39	20.33	1.00	133.00
Education	Sustainable education	year	8.59	0.99	6.04	12.08
Toueff	Tourism efficiency	10 million CNY per employee	0.17	0.17	0.002	1.01
Trans	Transportation infrastructure	kilometers per 10^2 square kilometers	4.34	4.83	0.08	26.01

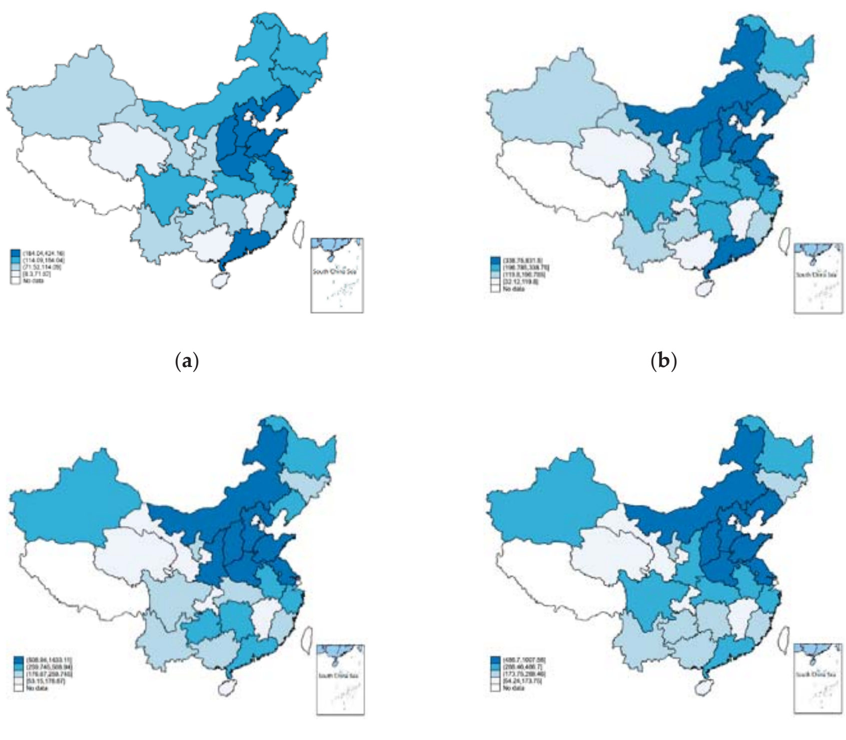
* CNY represents Chinese Yuan, which is a unit of Chinese currency; ** tce means a ton of coal equivalent, which is a unit of energy.

4. Results and Discussion

4.1. Test of the Spatial Dependence of Carbon Emissions

To provide specific insight into the spatial pattern of carbon emissions, we used a visualization technique to describe the spatial distribution of carbon emissions of China in 2003, 2008, 2012, and 2016. The distribution maps are shown as follows.

Figure 1 indicates that the provinces with high carbon emissions tend to cluster together with those with also high carbon emissions. In turn, provinces with low carbon emissions tend to cluster with those with low carbon emissions. The above characteristic means that the distribution of carbon emissions in Chinese provinces is spatially dependent on each other. However, it seems that the spatial dependence of provinces with low carbon emissions in 2016 is not significant, so we further calculated Moran's I statistic of carbon emissions from 2003 to 2016. The results presented in Table 2 shows that there is significant spatial dependence of carbon emissions at the 10% significance level in all the years except 2006, 2007, and 2008. Therefore, it is necessary to consider the spatial dependence using the spatial econometric model.



(**a**) (**b**)

(**c**) (**d**)

Figure 1. Variation trend of spatial distribution of carbon emissions of China in (**a**) 2003, (**b**) 2008, (**c**) 2012, and (**d**) 2016.

Table 2. Moran's I statistic of carbon emissions from 2003 to 2016.

Year	2003	2004	2005	2006	2007	2008	2009
Moran's I	0.17 *	0.18 *	0.19 *	0.16	0.14	0.16	0.17 *
Year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Moran's I	0.20*	0.21 **	0.20 *	0.22 **	0.19 *	0.18*	0.17 *

** and * denote $p < 0.05$ and $p < 0.1$, respectively.

4.2. Estimation Results of the Impact of Tourism on Carbon Emissions

In order to verify the effectiveness of the SDEM model, we simultaneously estimated the SDM model and the GNSM model for comparison. For the estimation of these models, we used the maximum likelihood method proposed by Elhorst [68]. Because the SDM model and the SDEM model are both nested in the GNSM model, we compared these three models using the likelihood ratio test (LR test). To demonstrate the superiority of the spatial econometric model, we also estimated the ordinary panel model (OPM) using the ordinary least square method. The whole process was calculated by Stata 15.1, and the results are shown in Table 3.

Table 3. Estimation results of the impact of tourism on carbon emissions.

Model	SDM	SDEM	GNSM	OPM
Tourism	5.7728 *	3.2639 *	5.5860 *	4.5892 **
	(1.82)	(1.73)	(1.75)	(2.40)
$Tourism^2$	−0.0678 **	−0.0577 ***	−0.0654 **	−0.0711 ***
	(−2.10)	(−2.58)	(−1.99)	(−3.12)
Energy_con	2.7144	2.2529 ***	2.6729	2.3502 ***
	(1.45)	(8.17)	(1.42)	(8.37)
Energy_mix	−0.0488 **	2.9653 ***	−0.0483 **	3.1082 ***
	(−2.21)	(4.67)	(−2.17)	(5.15)
PGDP	2.3445 ***	−0.9150	2.3631 ***	−0.8199
	(8.82)	(−1.48)	(8.80)	(−1.36)
W*Tourism	2.9775 ***	7.8268 **	3.0156 ***	
	(5.06)	(2.41)	(5.12)	
W*$Tourism^2$	−0.8750	−0.0899 ***	−0.8838	
	(−1.51)	(−2.73)	(−1.54)	
W*y	0.2834 ***		0.3030 ***	
	(4.02)		(3.68)	
W*u		0.1802 **	−0.0489	
		(2.03)	(−0.43)	
Log L	−2267.08	−2272.58	−2266.99	
LR test	0.19	11.18 ***		
Province FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
N	420	420	420	420
Chi2	633.56 ***	417.72 ***	679.93 ***	-
R-Square	0.80	0.80	0.80	0.54

(1) the *t*-statistic of each coefficient was shown in brackets. (2) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. (3) "FE" represents fixed effect.

The results of the LR test show that the GNSM model is better than the SDM model (the LR value was 0.19 and not significant at the 10% significance level), while the SDEM model is better than the GNSM model (the LR value was 11.18 and significant at the 1% significance level). Therefore, the SDEM model is the best model among these three models. Furthermore, the coefficients of the spatial lags of the error term (W*u) and the spatial lags of tourism and squared tourism (W*tourism and W* $tourism^2$) in the SDEM model are all significant with at least a 5% significance level, which means that the spatial dependence should be considered, and the spatial model is better than the ordinary panel model.

According to the results of the SDEM model presented in Table 3, the coefficient of tourism is 3.2639 with a significance level of 10%, and the coefficient of squared tourism is −0.0577, with a significance level of 1%. The positive effect of tourism and the negative effect of squared tourism show that there is an inverse U-shaped relationship between tourism and carbon emissions. The inverse U-shaped relationship implies that one province's carbon emissions will increase with its tourism growth, but a threshold will eventually be reached, after which the carbon emissions will decrease. The above effect of tourism is also called a direct effect in the context of spatial econometrics. At first glance, this finding is different from the existing literature. However, if the samples of this study are divided into two types, one that includes only the samples whose tourism receipts are on the left of the axis of symmetry of the inverse U-shape, and the other one that includes the samples whose tourism receipts are on the right of the axis of symmetry, the result of the first type is consistent with the literature which found that tourism has a significant positive emissions effect in the countries (e.g., Cyprus, Turkey, and Mauritius) where tourism receipts are relatively low [32–36]. The result of the second type is consistent with the literature which found that tourism has a significant negative emissions effect in the countries (e.g., United States, Western European Countries, and Singapore) where tourism receipts are relatively high [5,37,39]. Therefore, the nonlinear model used in this paper can include both positive and negative effects in one model and is more realistic and appropriate than the existing linear models.

Among the estimation results of the SDEM model in Table 3, the coefficient of the spatial lag of tourism is 7.8268, with a significance level of 5%, and the coefficient of the spatial lag of squared tourism is −0.0899, with a significance level of 1%. The results show that one province's tourism not only affects its carbon emissions but also affects its neighbors' carbon emissions through the spatial lag effect, which is also called an indirect effect in the context of spatial econometrics. Although the indirect effect of tourism on carbon emissions turned out to be significant in this paper, it was rarely considered in the existing studies. The geographic proximity of provinces and the mobility of economic resources (e.g., services, products, technologies, and funds) between provinces have increased the transfer of carbon emissions among provinces [53]. From the perspective of tourism development, one province's tourism growth not only stimulates the growth of the tourism subsectors of the province but also moves the related industry resources across the province. Thus, one province's tourism-related industry is driven by its neighbors' tourism development, accompanied by carbon emissions generated during the process of undertaking industry growth. Therefore, one province will bear some carbon emissions for its neighbors' tourism development and further expand the degree of interprovincial carbon emissions [69,70]. Moreover, the negative coefficient of the spatial lag of squared tourism and the positive coefficient of the spatial lag of tourism mean that there is a nonlinear relationship between tourism and its indirect effect on carbon emissions. When one province's tourism receipts beyond the critical value, tourism development will not only eliminate carbon emissions of the province but also reduce the carbon emissions of its neighbors.

In order to describe the above nonlinear spatial relationships more clearly, we depicted the direct and the indirect effects of tourism on carbon emissions in Figure 2. Additionally, the relationship of tourism on carbon emissions based on the OPM model is also depicted in Figure 2 for comparison.

Figure 2 illustrates the inverse U-shaped direct effect and indirect effect of tourism on carbon emissions more intuitively. The axis of symmetry of the inverse U-shaped curve is also depicted in Figure 2. According to the axis of symmetry, we can easily determine that when tourism receipts are lower than the critical value (283 billion Chinese Yuan (CNY)), the direct effect of tourism on carbon emissions is positive and then shifts to negative when the tourism receipts are beyond the above critical value. In terms of indirect effect, when the tourism receipts are lower than 435 billion CNY, the effect of tourism on carbon emissions is positive and then shifts to negative when the tourism receipts increase beyond the critical value (435 billion CNY under this situation). Moreover, compared to the SDEM model used in this paper, the inverse U-shape curve which describes the result of the OPM model shows that the nonlinear OPM model overestimates the positive impact on carbon emissions from tourism and underestimates the negative impact on carbon emissions from tourism by ignoring of the abovementioned indirect effect.

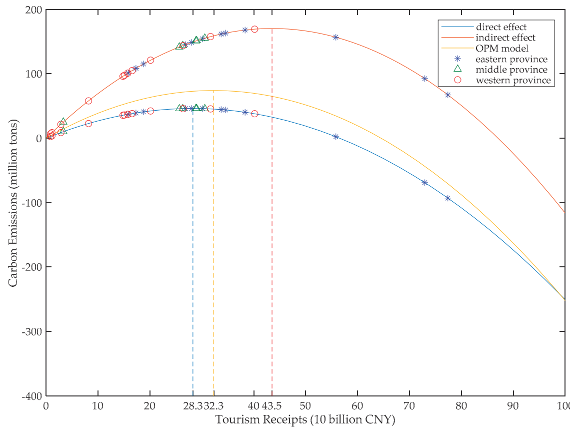


Figure 2. The nonlinear direct and indirect effects of tourism on carbon emissions.

The direct and indirect effects of tourism on carbon emissions of 30 provinces in 2016 are also shown in Figure 2. The provinces are divided into eastern provinces, which include Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan, middle provinces which include Jilin, Heilongjiang, Shanxi, Henan, Anhui, Jiangxi, Hubei, and Hunan, and western provinces which include Inner Mongolia, Qinghai, Ningxia, Shaanxi, Sichuan, Chongqing, Guizhou, Yunnan, Guangxi, Gansu, and Xinjiang. According to Figure 2, in terms of the direct effect, there are 12 provinces whose tourism has already exceeded the critical value and has a negative impact on carbon emissions, and the tourism of the rest of the provinces still has a positive effect on carbon emissions. Because most of the above 12 provinces are the relatively developed provinces and most of the remaining provinces are less developed provinces in China, Figure 2 provides further evidence that the relationship between tourism and carbon emissions are consistent with the existing literature [32–39]. In terms of the indirect effect, there are only three provinces whose tourism receipts have exceeded the critical value, which means that most of the provinces in China still have a positive effect on their neighbors' carbon emissions.

4.3. Estimation Results of the Moderating Effects

The SDEM model was used to estimate the moderating effects of reduction policy, sustainable education, tourism efficiency, and transportation infrastructure. The LR test was used to test whether the SDEM model should be reduced to the spatial error model (SEM), which does not contain the spatial lags of explanatory variables compared to the SDEM model. The results are presented in Table 4.

Table 4. Estimation results of the moderating effects.

Model	SDEM	SEM	SDEM	SEM	SDEM	SEM	SDEM	SEM
(*moderator*)	(*reduction*)	(*reduction*)	(*education*)	(*education*)	(*toueff*)	(*toueff*)	(*trans*)	(*trans*)
Tourism^2×moderator	−0.0009 **	−0.0007 **	−0.0057 **	−0.0053 **	−0.0285	−0.0192	−0.0028 *	−0.0026
	(−2.34)	(−1.98)	(−2.49)	(−2.19)	(−1.05)	(−0.74)	(−1.80)	(−1.61)
Tourism	1.0644	0.9122	2.7594	2.9170	0.4960	0.2398	0.6066	0.5753
	(0.93)	(0.80)	(1.58)	(1.61)	(0.34)	(0.17)	(0.54)	(0.51)
Energy_con	2.3200 ***	2.3168 ***	2.2640 ***	2.2658 ***	2.2244 ***	2.2197 ***	2.3678 ***	2.3355 ***
	(8.42)	(8.41)	(8.23)	(8.22)	(7.71)	(7.76)	(8.50)	(8.38)
Energy_mix	2.3940 ***	2.3672 ***	2.8948 ***	2.6185 ***	2.5218 ***	2.4027 ***	2.6335 ***	2.4441 ***
	(3.87)	(3.87)	(4.58)	(4.16)	(3.98)	(3.86)	(4.19)	(3.96)
PGDP	−1.0465 *	−1.1319*	−0.8211	−0.9424	−1.2273 **	−1.2998 **	−0.6497	−0.9109
	(−1.68)	(−1.85)	(−1.30)	(−1.51)	(−1.98)	(−2.13)	(−0.97)	(−1.38)
W*Tourism^2	−0.0009		−0.0091 ***		−0.0507		−0.0048 *	
×moderator	(−1.52)		(−2.75)		(−1.27)		(−1.98)	
W*Tourism	2.5845		7.3268 **		2.0670		3.9163 *	
	(1.19)		(2.40)		(1.03)		(1.72)	
W*u	0.2330 ***	0.2279 ***	0.1874 **	0.1907 **	0.2405 ***	0.2422 ***	0.2084 **	0.2170 **
	(2.76)	(2.68)	(2.13)	(2.07)	(2.88)	(2.90)	(2.40)	(2.47)
Log-L	−2276	−2277	−2273	−2277	−2278	−2279	−2276	−2278
LR test	2.33	-	7.64 **	-	1.62	-	3.88 **	-
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Province FE	Y	Y	Y	Y	Y	Y	Y	Y
N	420	420	420	420	420	420	420	420
Chi2	363.52	359.94	410.93	386.73	349.95	344.69	381.14	364.69
Pseudo.R-Square	0.80	0.80	0.80	0.80	0.80	0.79	0.80	0.80

(1) the *t*-statistics of each coefficient was shown in brackets. (2) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. (3) "FE" represents fixed effect.

According to the values of the LR test in Table 4, the SDEM model should be reduced to the SEM model when reduction policy and tourism efficiency are used as moderators, which implies that both the reduction policy and tourism efficiency cannot affect the indirect effect of tourism on carbon emissions.

The results in column 3 in Table 4 show that the interaction term of the squared tourism and the reduction policy has a significant negative impact on carbon emissions, which indicates that as the number of the reduction policy increases, the direct negative effect of tourism on carbon emissions tends to be strengthened. Zeng et al. found that the reduction policy can significantly affect the energy efficiency and induced carbon emissions of provincial industries [59]. The findings of this study further confirm that the reduction policy has a significant negative effect on carbon emissions by affecting the carbon efficiency of tourism subsectors. Based on the regression coefficients of the explanatory variables in column 3 of Table 4, this paper depicts the relationship between tourism, reduction policy, and carbon emissions in Figure 3. As shown in Figure 3, we can see that as the number of the reduction policy increases, the same tourism receipts will induce more carbon emission reductions.

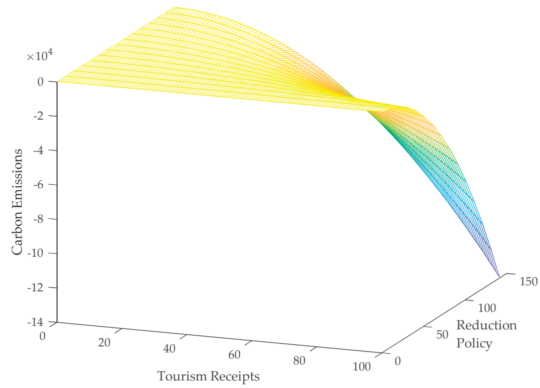
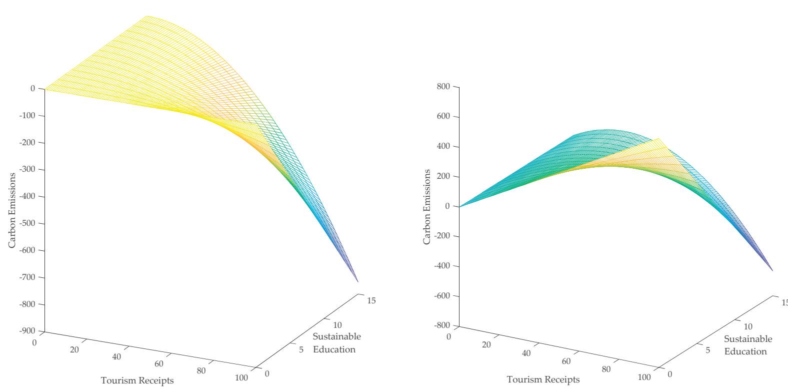


Figure 3. Effect of tourism on carbon emissions using reduction policy as the moderator.

The results in column 4 in Table 4 show that the interaction term of the squared tourism and education has a significant negative effect on carbon emissions, which implies that the increase of the sustainable education tends to strengthen the negative effect of tourism on carbon emissions. Some scholars argue that the environmental protection awareness of tourists has an essential impact on the carbon emissions induced from tourism [62], and this finding provides empirical evidence for the above argument. The coefficient of the spatial lag of the interaction term is −0.0091 with a significance level of 1%, which indicates that the sustainable education not only strengthens the negative direct effect of tourism on carbon emissions but also strengthens the negative indirect effect of tourism on carbon emissions. The direct and indirect effects of tourism on carbon emissions using sustainable education as the moderator are depicted in Figure 4, which shows the above findings more clearly.



(a) (b)

Figure 4. (**a**) Direct and (**b**) indirect effect of tourism on carbon emissions using sustainable education as the moderator.

According to the results in column 7 in Table 4, the coefficient of the squared tourism with the moderator is −0.0192, but it is not statistically significant, which means that the management efficiency of the tourism industry cannot affect the direct effect of tourism on carbon emissions. This finding is different from the arguments of the existing literature [49]. Therefore, although in theory, well-managed tourism could improve energy efficiency and the induced carbon efficiency [3,63], our above results could not provide the empirical evidence for this conclusion using Chinese samples, which indicates that with the management efficiency improvement of the tourism industry, the energy efficiency of tourism is not necessarily improved.

The results presented in column 8 of Table 4 show that the coefficient of the interaction term of the squared tourism and the moderator is −0.0028 with a significance level of 10%, which indicates that the improvement of the transportation infrastructure is conducive to increasing carbon efficiency and strengthens the negative effect of tourism on carbon emissions. Although the construction of transportation facilities will increase carbon emissions, the improvement of transportation infrastructure will improve the energy efficiency of the transportation industry and thus reduce carbon emissions from tourism [45,46]. Our results show that the aggregated carbon emissions induced by the improvement of transportation infrastructure are significantly negative, and therefore, the improvement of transportation infrastructure has a significant impact on the strength of the relationship between tourism and carbon emissions. Moreover, the coefficient of the spatial lag of the interaction term is −0.0048, with a significance level of 10%, which indicates that the improvement of one province's transportation infrastructure not only strengthens the negative effect of tourism on its carbon emissions but also strengthens the negative effect of tourism on its neighbors' carbon emissions. The moderating effects of transportation infrastructure are depicted in Figure 5, from which we can see that with the improvement of transportation infrastructure, both direct and indirect effects of tourism on carbon emissions tend to be strengthened.

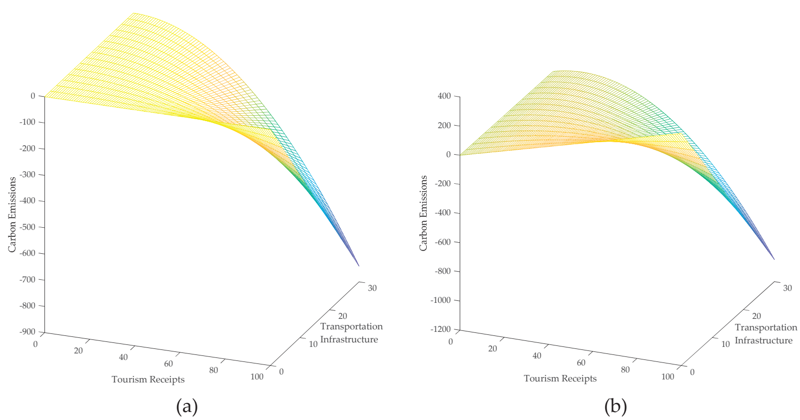


Figure 5. (**a**) Direct and (**b**) indirect effect of tourism on carbon emissions using transportation infrastructure as the moderator.

5. Conclusions and Policy Implications

Considering the possible nonlinear and spatial effects of tourism on carbon emissions, this paper employed spatial econometric models combined with quadratic terms of explanatory variables to explore the nexus between them. The main conclusions of the empirical analysis based on Chinese provincial panel data from 2003 to 2016 are as follows: First, there is a significant inverse U-shaped relationship between tourism development and carbon emissions. In the provinces whose tourism receipts are relatively low, the effects of tourism on carbon emissions are positive but decrease gradually as the tourism receipts increase and then become negative and continue decreasing gradually when the tourism receipts increase beyond the critical value. Second, there is a significant spatial lag effect (indirect effect) of tourism on carbon emissions, and the effect is also inverse U-shaped. One province's tourism development not only affects its carbon emissions but also affects its neighbors' carbon emissions because of geographical proximity and industrial relevance. Finally, carbon reduction policy, sustainable education, and transportation infrastructure all have significant moderating effects on the relationship between tourism development and carbon emissions, but the moderating effect of the management efficiency of tourism is not statistically significant. Furthermore, improvement of the sustainable education and transportation infrastructure not only strengthens the direct negative effect of tourism on carbon emissions but also strengthens the indirect negative effect of tourism on carbon emissions.

Although the idea that increasing the emissions of carbon dioxide has a significant effect on global temperatures is not the topic of this study, it is one of the backgrounds of this paper. We noted that the above idea is still controversial. Although the IPCC (Intergovernmental Panel on Climate Change) concluded that increasing carbon dioxide will increase global temperatures [71], some researchers concluded that increases in carbon dioxide emissions have had no significant effects [72,73]. Ignoring the controversy may misinform readers [74]. However, for this article, low-carbon development of tourism will also help to reduce environmental pollution caused by the consumption of fossil fuels and will be conducive to the sustainable development of tourism, because fossil fuels currently still account for roughly 85% of China's energy mix [75]. Therefore, even considering the uncertainty of the relationship between carbon dioxide and climate change, the study on the nexus between carbon dioxide emissions and tourism is still of great significance and has important policy implications.

Three main policy implications can be drawn from the above conclusions. First, in the regions where tourism receipts are below the critical value (283 billion CNY in China), it is still necessary to improve the carbon efficiency of the tourism industry, because tourism can only be considered as a low carbon industry when its scale exceeds the critical value. Considering the lack of an endogenous driving force to improve carbon efficiency, local government could take measures, such as increasing the investment in green public infrastructure and subsidizing tourism enterprises' low-carbon initiatives, to improve energy efficiency and the induced carbon efficiency of the tourism industry. Second, local governments could improve the carbon efficiency in the upstream industries of the tourism industry to avoid the positive carbon emissions effect caused by their neighbors' tourism growth. They could also improve tourism carbon efficiency through strengthening the connectivity between the upstream industry of tourism and the tourism industry of the neighboring regions because of the existing of the negative indirect emissions effect of the tourism industry. Lastly, governments could strengthen the negative effect of tourism on carbon emissions by increasing the number of carbon reduction policies, increasing the years of education, and improving transportation infrastructure. Moreover, tourism enterprises should be encouraged to improve energy efficiency and induced carbon efficiency while improving management efficiency.

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Establishment and Application of an Evaluation Model for Orchid Island Sustainable Tourism Development

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Abstract: Global warming and climate change increase the likelihood of weather-related natural disasters that threaten ecosystems and consequently affect the tourism industry which thrives on the natural attributes of island regions. Orchid Island, the study area, is home to the Yami (Tao) tribe—the only indigenous people of Taiwan with a marine culture. The island possesses rich geological and topographical features (such as coral reefs) and distinctive biological and ecological resources (such as the green sea turtle, flying fish, and Orchid Island scops owl), and organizes traditional festivals and activities (such as the flying fish festival) as well as tribal tourism activities. These factors contribute to its immense potential to become the new tourism hotspot. To study the factors enhancing tourist experiences, a random utility model was constructed using a choice experiment method (CEM) for the tourist resort on Orchid Island. The study results demonstrated that: (1) Limiting tourists to 600/day; employing professional tour guides; providing better recreational facilities; introducing additional experience-enhancing activities; and lowering contributions towards the professional ecosystem conservation trust fund will improve the overall effectiveness of attracting tourists to Orchid Island. The evaluation results from both conditional logit and random parameter logit models were similar; (2) the analysis results from the latent class model demonstrated that island tourism has significant market segmentation. The socioeconomic backgrounds of tourists, their experiences, and their preferences exhibit heterogeneity, with significant differences in willingness to pay for island tourism.

Keywords: sustainable tourism; island destination; environmental impact; recreation economics

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1. Introduction

According to the "Fourth Assessment Report (AR4) of the United Nations Intergovernmental Panel on Climate Change (IPCC)," global warming and climate change have become increasingly serious. The resulting rise in sea level from climate change can negatively impact water resources, ecological balance, and the environment. Climate change has a more severe impact on islands that are surrounded by the sea. Relevant studies have pointed out that besides threatening ecosystems, natural disasters will also affect the operations of the tourism industry [1,2]. The UN World Tourism Organization (2011) mentioned that extreme weather conditions may affect 1.8 billion international tourists in 2030. The direct effects of climate change on the tourism industry include losses to manpower and property. This also leads to a significant decrease in tourism as more and more tourists decide not to travel to such sites. Climate change will also indirectly affect the environment and culture of the tourist destination, the economic output of the tourism industry, and the damage infrastructure [3]. The increasing demands for recreational tourism, changing tourist preferences, increasing awareness on ecological conservation, and the rapid development in island tourism in recent years has attracted international researchers interested in island development to conduct relevant studies [4–6].

Dahlin et al. [7] pointed out that the development of island tourism will inevitably lead to some signs of imbalance, including excessive coastal development, the destruction of ecological resources, pollution created by waste, etc. It may also lead to land encroachments to meet increasing demands for accommodation and recreational water activities for tourists. Such changes may affect the traditional community system and gradually create an imbalance in the lifestyles of the locals. Therefore, while islands may provide sightseeing and recreational services, they might simultaneously experience the negative effects caused by the development in tourism on the environment, society, and local culture due to their limited area and natural resources, vulnerability to disasters, compromised ability to recover from disasters, and economic dependence [8–10].

However, the development of the tourism industry is accompanied by increasingly prominent environmental problems. As the ultimate goal of sustainable tourism is still the sustainable management of tourism destinations, the main application methods are still based on the environmental carrying capacity, land division management, visitor impact management, and sustainable development indicators. Zhang et al. [11] suggested that, although existing sustainability evaluation methods can be used to assess the effects of human activities on ecosystem functions, they have a limited application in evaluating social economy. The use of this type of analysis to evaluate the economic benefits of tourism in that area can aid the concerned management in making related decisions on planning and utilization and/or sustainable operation of local ecologic resources. In previous assessments of the benefits of recreational resources, many studies have employed the travel cost method and contingent valuation method (CVM) to assess the benefits of island tourism [12–14]. However, as travel cost methods and CVM methodologies have certain limitations in application, the CEM has gradually become a significant assessment method for conducting preference studies on the conservation of natural resources in recent years. CEM is also an important assessment tool for measuring the value of nonmarket goods [15].

Liekens et al. [16] pointed out that besides the simultaneous assessment of use and nonuse values, CEM can also define the hypothetical market through questionnaire surveys to understand public preferences for landscape conservation and natural development. This will further reflect the value of environmental goods (or services). As CEM has a multiattribute and multilevel assessment ability, different combinations of alternative programs are used to assess the important characteristics of nonmarket goods or services. Choice sets of different hypothetical scenarios are used to enable the respondents to select appropriate alternative programs based on their preferences. This avoids an assessment bias [17]. Due to the aforementioned advantages, CEM has also been used to evaluate factors with nonmarket value in recent years, including species conservation [15,18–20]; wetland rehabilitation [21–23]; island tourism preferences [24–28]; and coastal region conservation [29–34]. In addition, CEM was also employed to examine tourist preferences for land and environmental functions in national parks [35,36]. Other studies that employed CEM focused on how to change specific ecosystem services to affect economic benefits [37–40].

For empirical models, conditional logit (CL) models can be used to estimate the average preference of tourists from the multiple attributes of island tourism and to estimate the marginal willingness to pay (MWTP) for these attributes [28,33]. The random parameter logit (RPL) model can reflect the different responses of respondents from different backgrounds towards different attributes. This can be used to examine the heterogeneous preferences of respondents and their willingness to pay for changes in the levels of various attributes (such as folk and cultural experiences, ecologic experiences, and other attributes) [41–44].

To segment a clearer target market, the latent class model (LCM) can segregate respondents into different groups and examine and compare their preferences and group differences (such as the island tourism preferences, attitudes, and socioeconomic background of interviewed tourists) [26]. From the aforementioned studies, we can see that the empirical CEM models of CL, RPL, and LCM have been verified for use in the examination and evaluation of multiple attribute preferences at island tourism sites.

Previous studies have shown that prior economic evaluation of nonmarket resources has mostly focused on the evaluation of forests, coastal areas, natural parks, and nature reserves. Only a few studies have evaluated the recreational value of island tourism. Therefore, this study used CEM to construct an island tourism attribute utility model and further employed CL and RPL models to estimate the utility function of island tourism. The socioeconomic background, awareness, and tourists' attitudes towards island tourism were considered to examine the differences in MWTP for various attributes. LCM was used to test whether respondents had heterogeneous preferences for island tourism so that they could select appropriate alternative programs based on their preferences. These will be used to evaluate the ecological environment, socioeconomic situation, and tribal tourism programs on Orchid Island to determine their economic benefits and to create a system of sustainable development. The aforementioned methodology has representativeness and research originality and can compensate for the current lack of studies on sustainable tourism development on islands in academia. The research contribution made by studying the aforementioned problems can assist the world, particularly the academic world, by providing a reference for economic evaluation models for sustainable island tourism and operation and management strategies.

The aim of this study is to evaluate the economic benefits of tourism for Orchid Island. A CEM is used to estimate the average preferences of tourists from the multiple attributes of island tourism and to estimate the WTP for these attributes. The study is divided into four parts. In Section 1, the motivation for the study is discussed, and the study objective is proposed. In Section 2, we construct the preference utility model for island tourism and introduce preferred selection combinations for choice sets for the Orchid Island tourism site. In Section 3, we analyze the results of factors influencing multiple attribute preferences, along with their WTP. In Section 4, based on the results, countermeasures and suggestions are proposed for the sustainable development of the Orchid Island environment, providing a reference for policy makers to make more efficacious policies.

2. Literature Review

The CEM is a stated preference evaluation technique. Respondents are given multiple choices and forced to make trade-offs between them. Each option is described in terms of a bundle of attributes describing the good presented at various levels. The principle advantage of CEM is the ability to value individual characteristics of environmental goods and the marginal value of changes in characteristics.

In the past, economists try to assess people's WTP for ecotourism preferences [24,25,33], species conservation [19,20], and, more recently, also the issue of WTP for ecosystem services was explored by many authors [37–39,45] but less frequent for evaluation of island tourism preferences [27,28]. Remoundou et al. [31] employed CEM to evaluate the effects of climate change on the willingness to pay for Santander's coastal ecosystem. The study attributes included biodiversity, jellyfish blooms, days when the beaches were closed, sizes of the beaches, and annual additional household expenditure. Viteri Mejía and Brandt [33] employed CEM to interview tourists visiting the Galapagos Islands to assess their willingness to pay for protective measures against invasive species. The study attributes included depth of experience in the islands' ecosystem, length of stay, level of protective measures taken against invasive species, and price of island tourism. The results of that study showed that tourists visiting the Galapagos Islands highly valued the biodiversity on the island and were marginally willing to pay USD $2543 for better protective measures. Schuhmann et al. [32] employed CEM to evaluate tourist preferences and willingness to pay for coastal attributes in Barbados. The study attributes included price, type of accommodation, beach width, distance from beach, and beach litter.

Cazabon-Mannette et al. [29] employed CEM and CVM to evaluate the nonuse value and nonconsumptive value of sea turtles in Tobago. The study attributes included price, number of sea turtle sightings, fish diversity (number of species), coral cover, and degree of congestion (number of divers). Xuan et al. [34] used a discrete choice experiment to evaluate tourists' willingness to pay for boat tours in the marine protected area of Vietnam's Nha Trang Bay. The study attributes included coral cover, environment quality, rate of unemployment of fishermen, and increase in ticket prices. Peng and Oleson [30] employed a discrete choice experiment to evaluate beach recreationalists' preferences and willingness to pay to improve the water quality of Oahu beaches. The study attributes included water quality, water turbidity, coral cover, fish diversity, and willingness to pay for motor vehicles. Park and Song [41] applied a latent profile analysis (LPA) and CEM to identify latent classes based on visitors' perceived place value and to estimate visitors' willingness to pay (WTP) in an Urban Lake Park.

The above studies showed varying levels of WTP depended on factors such as where the study was conducted, products and product attributes included and, data collection and analysis methods used. In fact, through the questionnaire, the socioeconomic background (such as age, education, marital status, and income) of respondents and respondents awareness and behavior (such as environmental attitude, perceived value, and revisit intention) towards island tourism were used as perspectives to examine the differences in WTP for various attributes. Halkos and Matsiori [46] pointed out that the comparative study of residents' and tourists' WTP for improving the quality (protection) of the Pagasitikos coastal area in Greece found that income, education, environmental attitude are the most important factors affecting payment amount. Tonin [47] indicated, the previous knowledge or familiarity with coralligenous habitats and biodiversity issues, income, education, environmental attitudes are main positive and significant determinants of WTP. The purpose of this study is the application of the CVM to the benefits of Orchid Island tourism management programs and the quantification of their value. In this case, it is not only the value of the island tourism that is calculated, but rather the economic benefits as a whole is evaluated through the respondents' opinion of the goods and services produced.

3. Materials and Methods

3.1. Description of the Study Area

Taiwan is surrounded by a coastline of 1141 km and has abundant marine resources. Island tourism in Taiwan has natural and ecological features as well as historical and cultural features and is an emerging tourist destination [48]. The study site, Orchid Island, which has a total area of 48 km^2 and 5069 residents, is located southeast of Taiwan and is surrounded by the sea (Figure 1). It is home to Taiwan's only group of indigenous people with a marine culture—the Yami (Tao) tribe—and has rich geological and topographical features (coastal terrain, coral reefs); distinctive biological and ecological resources (green sea turtle, flying fish, coconut crab, Orchid Island scops owl, and Arius (Podocarpus costalis)); traditional festivals and activities (launching ceremony, flying fish festival); and aboriginal settlements. Orchid Island has witnessed a gradual development in diverse theme-based tours, which include natural ecology-based tours and relevant experience activities (snorkeling, whale watching, night observation of flying fish, and so forth). In recent years, supported by government policies, island tourism and tribal tourism have become the new tourism trends in Taiwan and have significant developmental potential for the future.

However, the growth of the tourism industry is accompanied by a detrimental impact on the environment. The construction of coastal embankments and tetrapods causes severe damage to the coastal environment and destroys biological habitats. In addition, tourism also indirectly affects the unique tatala boat culture of the Yami (Tao) people. The invasion of foreign culture causes a heritage crisis in the traditional, cultural, and social structure of the Yami (Tao) people. As island ecosystems are fragile, island development should emphasize the development of state land for environmental and cultural conservation and protection while developing unique ecological and cultural experiences to promote its tourism. The development of sightseeing resources must consider sustainable ecological, economic, and social development and try to minimize the impact of recreational activities on the environment. Therefore, development of the island tourism industry based on sustainable operating principles and conservation of the environment and its ecosystem are important topics to consider for the sustainable development of island tourism.

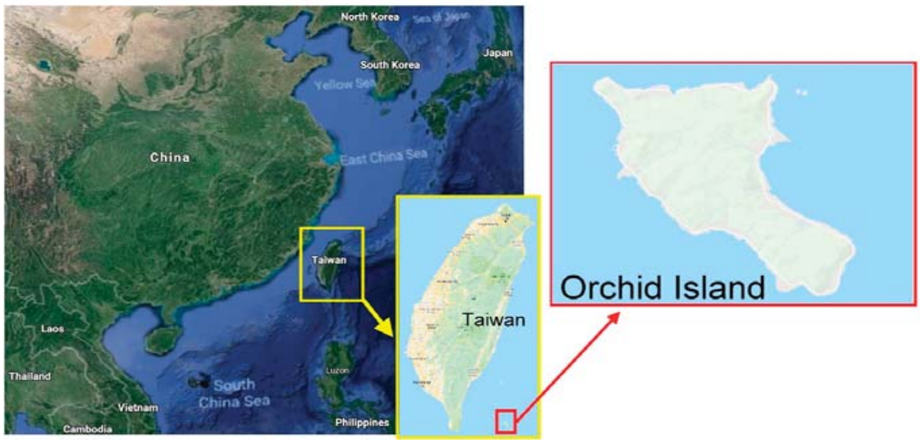


Figure 1. Map of the study area.

3.2. Construction of Preference Utility Model for Island Tourism

3.2.1. Multi-Attribute WTP Valuation Model

First, CEM was used to construct an island tourism attribute utility model. Following that, CL and RPL models were used to estimate the utility function of island tourism. The socioeconomic backgrounds of tourists and tourist awareness and behavior towards island tourism were used to examine the differences in MWTP for various attributes. LCM was used to test whether there were heterogeneous preferences for island tourism present in respondents. Lastly, the aforementioned empirical analysis results were used to estimate the economic benefits of island tourism.

CEM is a standard random utility model (RUM). Therefore, it was used to explore the MWTP for all attributes and levels [49]. In the binary model, the utility of the n^{th} respondent is assumed to be the various options it faces (U_{ni}), and the options are used to maximize the utility, as shown in Equation (1):

$$U_{ni} = V_{ni} + \varepsilon_{ni} \quad (1)$$

where U_{ni} represents the attribute of the n^{th} respondent facing the i^{th} option, V_{ni} represents the observable part of the utility function, and ε_{ni} represents the residual item, i.e., the unobservable part.

This study intended to explore differences in preferences and WTP between respondents of different social and economic backgrounds, considering various attributes and levels. The analysis was conducted using a random parameters logit (RPL) model. The overall utility of the RPL model was determined as follows:

$$U_{ni} = V_{ni}(X_{ni}, S_n) + I_{\_ni} \quad (2)$$

where V_{ni} is the utility coefficient of observable variable X_{ni} and respondent characteristic S_n and represents the respondent's preference, and ε_{ni} is the residual item.

To estimate the relative importance of all attributes of the product in terms of value, it was assumed that the degrees of various attributes in the alternative plan remained the same. Then, the marginal change in WTP for the kth attribute was determined by Equation (3):

$$WTP = \frac{-I2_k}{I2_c} \quad (3)$$

where $I2_k$ is the attribute k parameter and $I2_c$ is the payment tool parameter.

3.2.2. Introduction to Multiple Attributes and Levels of Orchid Island Tourism

Hanley et al. [50] pointed out that after defining the evaluation attributes to be included in CE, the evaluation of the levels of the attributes is a relatively important process. They also pointed out that these levels should be specific and feasible for future application, and they can be formulated through literature reviews and expert interviews. Therefore, besides conducting reviews of relevant literature, this study also conducted interviews with five academics who were experts on the subject, two tour guides of the Orchid Island aboriginal tribe, and relevant staff from the public sector. Following that, four attributes, "limit on tourist numbers," "tour guide system," "recreational facilities," and "experience activities", were set up. In addition, an "ecosystem conservation trust fund" that represents currency variables, was used as an expenditure tool attribute. We further delineated the current status of various attributes (Table 1) for use as the basis for measuring changes in the levels of attributes. After expert interviews, we obtained the following recommendations for level settings:

1. Tourist numbers should be controlled with the current level of 1000 tourists per day as the upper limit. Further discussions with experts resulted in a recommendation of limiting numbers to no more than 600 tourists per day as a principle;
2. Professional tour guides should be provided to offer guided tours;
3. Recreational facilities with minimal environmental impact should be planned;
4. Activities that enhance the experience of local characteristics/culture, such as "ecotourism," "tribal ceremonies," and "cave and underground dwellings", should be included in the scope of experience activities; and
5. Findings from the expert interviews should be used to set the evaluation levels for the ecosystem conservation trust fund. This study defined the various attributes and their levels for Orchid Island tourism, as shown in Table 1 below:

Table 1. Attributes and levels of attributes of the Orchid Island tourism site.

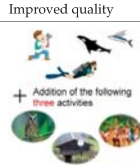
Attributes	Levels	Variable	Number of Levels
Limit on the number of visitors	1. Maintaining the status quo: 1000 people per day 2. 800 people per day (20% reduction) 3. 600 people per day (40% reduction)	$LIM^{\pm}$ LIM^{-} LIM^{--}	3
Tour guides	1. Maintaining the status quo: professional tour guides not available 2. Introducing a guided tour facility	$GUI^{\pm}$ GUI^{+}	2
Recreation and facilities	1. Maintaining the status quo 2. Improving the quality of the recreation and facilities	$REC^{\pm}$ REC^{+}	2
Experience activities	1. Maintaining the status quo: snorkeling, whale watching, night observation of flying fish 2. Addition of any one of the following activities: experiencing ecotourism, tribal ceremonies, or cave and underground dwelling experience 3. Addition of any two of the following three activities: experiencing ecotourism, tribal ceremonies, or cave and underground dwelling experience 4. Addition of the following three activities: experiencing ecotourism, tribal ceremonies and or cave and underground dwelling experience	$EXP^{\pm}$ EXP^{+} EXP^{+} EXP^{+++}	4
Ecosystem conservation trust fund	1. Maintaining the status quo: entrance free 2. TWD 200 per entry per person 3. TWD 400 per entry per person 4. TWD 600 per entry per person 5. TWD 800 per entry per person 6. TWD 1000 per entry per person	FUND	6

3.3. Introduction to Preference Selection Combinations for Choice Sets for the Orchid Island Tourism Site

In order to understand the choices of tourists regarding multiple attribute preference programs for the Orchid Island site, a more precise improvement plan and the preference for each attribute level will need to be more clearly defined. These attributes included “limit on tourist numbers,” “tour guide system,” “recreational facilities,” “experience activities,” and “ecosystem conservation trust fund.” Further information on these attributes are introduced and examined in Table 1 (attributes and levels of attributes of the Orchid Island tourism site). The arrangement combinations of various attributes and their levels produced 288 possible factor combinations ($3 \times 2 \times 2 \times 4 \times 6 = 288$).

In actual operations, every respondent had to fill in their answers, i.e., select one of the three choice sets (the two alternative programs and one status quo alternative). If the respondent was unable to make a decision, they could select “uncertain”, and this choice set was considered as a missing value. The researcher explained the various attributes of the Orchid Island tourism site and their levels (Table 2) and the content of the choice sets for Orchid Island preferences to each tourist respondent. This was in order to make the tourist respondents understand the content of the preference attributes of the Orchid Island tourism site before they selected their preferences. In terms of questionnaire content presentation, the first part of the questionnaire, which was divided into “Orchid Island tourism development awareness and behaviour”, and the third part, which included “basic personal information”, were identical in all five versions of the questionnaire.

Table 2. An example of the choice set of Orchid Island preferences and programs.

Program Attributes	Current Program	Program 1	Program 2	
Limit on the number of visitors	 Maintain The current situation	 220% reduction	 40% reduction	Uncertain
Tour guide	 Not available	 Available	 Not available	
Recreation and facilities	 Maintaining the status quo	 Improved quality	 Improved quality	
Experience activities	 Maintaining the status quo	 Three additional activities	 One additional activity	
Ecosystem conservation trust fund (TWD/entrance/person)	Free	TWD 600	TWD 1000	
Please check (1 of 4)	☐ Suggestions:	☐ Suggestions:	☐ Suggestions:	☐ Suggestions:

3.4. Survey Design

This study employed purposive sampling and one-to-one interviews with 438 tourists in Orchid Island, and, after factoring out the invalid questionnaires (i.e., those with omitted answers, incomplete answers, or those in which answers to all the questions received the same scale points were all deemed as invalid and removed), a total of 385 valid ones were collected, giving a recovery rate of 87.9%.

With regard to the socioeconomic backgrounds of tourists, there were more males (n of the total sample. In terms of age distribution, most people fell into the age groups of 31–40 years (*n* = 162%, 42.1%) and 20–30 years (*n* = 129%, 33.5%). In terms of education level, tourists with university education (*n* = 162%, 42.1%) made up the bulk of tourists. In terms of average personal monthly income, most tourists had an income of TWD 30,000–40,000 (inclusive) (*n* = 169%, 43.9%), followed by TWD 20,000–30,000 (inclusive) (*n* = 101%, 26.2%). Recreational activities that tourists engaged in (multiple selection allowed) were mostly water activities (62.4%), tribal ceremonies (52.7%), and tasting of the local cuisine (28.7%). Expenditure on Orchid Island (including participating in activities, buying souvenirs, etc.) was TWD 5000–10,000 (inclusive) (43.2%), followed by TWD 10,000–15,000 (inclusive) (32.7%). When asked whether they would agree to pay a sum towards the ecosystem conservation trust fund to support sustainable tourism development, most respondents were agreeable (*n* = 316%, 82.1%).

4. Results

4.1. Results of the Analysis of Factors Influencing Multiple Attribute Preferences for the Orchid Island Tourism Site

This study first used CL and RPL to estimate the utility functions of the multiple attributes of the Orchid Island tourism site and obtained the relevant factors that affected the functions. Table 3 shows the empirical results. With the significance levels of the factors ranging from 1% to 9%, the evaluation model of this study passed the goodness of fit test (likelihood value was 614.6, which was significantly greater than the threshold value of 21.7). From this, we can understand that the utility functions of multiple attributes of island tourism have good explanatory power [24,26,51]. The following section will further describe the empirical analysis results of both models.

At a 5% significance level, the coefficient of LIM^{--} was positive and significant. From this, we understand that decreasing the current daily tourist limit from 1000 to 600 could increase the utility value of island tourism for tourists. At a 1% significance level, GUI^{+} and REC^{+} t-values were also very significant. From this, we deduce that formulating and implementing a system of tour guides and adding recreational facilities and improving the quality of the existing facilities will increase tourists' preference for the Orchid Island tourism site. With regard to the ecosystem conservation trust fund, the t-value st a 1% significance level was negative and significant. From this, we can observe that the utility value of Orchid Island tourism will decrease for tourists by increasing the ecosystem conservation trust fund. RPL estimation results along with CL showed that only EXP^{+++} estimation results were positive and achieved a significance level of 10%. From this, we understand that adding three tourist activities to Orchid Island could significantly increase the utility levels for tourists.

Table 3. Results of the conditional logit model and random parameter logit model.

	Conditional Logit Model		Random Parameter Logit Model			
Attributes and Levels	Coefficient	*t*-Value	Coefficient	*t*-Value	S.E.	*t*-Value
Constant	−0.02	−0.05	−1.34	−3.73 [c]	3.56	8.46 [c]
LIM^{--}	0.08	1.12	0.11	0.79	0.49	1.77 [a]
LIM^{--}	0.15	2.33 [b]	0.18	1.24	1.24	6.11 [c]
GUI^{+}	0.12	2.71 [c]	0.12	1.23	0.89	4.66 [c]
REC^{+}	0.28	6.44 [c]	0.51	5.65 [c]	0.48	1.60
EXP^{+}	−0.02	−0.17	−0.05	−0.30	0.62	1.76 [a]
EXP^{++}	−0.10	−1.31	−0.33	−2.12 [b]	1.16	4.28 [c]
EXP^{+++}	0.12	1.54	0.26	1.78 [a]	0.80	2.89 [c]
FUND	−0.01	−7.21 [c]	−0.01	−6.69 [c]		
N of choice sets	1430		1430			
Log-likelihood ratio	−1476.54		−1254.62			
$X^2(0.01,9) = 21.7$			614.63 [c]			

[a] 10% significance level; [b] 5% significance level; [c] 1% significance level.

4.2. Examination and Analysis of Benefits of Island Tourism Management Programs

To analyze the benefits of island tourism management programs, this study used CL attribute level parameters to estimate the WTP for various levels of attributes (as shown in Table 4). In Table 4, the WTP was calculated based on attribute coefficients in the CL model to represent the mean WTP of all respondents. From the empirical analysis results, we can see that under the optimal program, each tourist could generate TWD 1202 for every visit they participate in. Therefore, there will be a loss of value if the status quo is maintained. The level of attributes in the optimal program could increase benefits, i.e., an increase of TWD 2337 in WTP would occur with the optimal program compared with the status quo. Therefore, if the daily tourist limit can be decreased from the current number of 1000 tourists to 600 tourists (LIM^{--}), the professional tour guide system could be implemented (GUI^{+}), recreational facilities could be added, the facility quality of island tourism sites could be improved (REC^{+}), and the experience activities available could be increased from snorkeling, whale watching, and night observation of flying fish to include ecotourism, tribal ceremonies, and cave and underground dwelling experiences (EXP^{+++}). This would be the most effective management program for improving the economic value of Orchid Island tourism. Thus, improving various attribute levels should prove to be a more efficient management program as compared with the one being currently implemented.

Table 4. Willingness to pay (WTP) for attributes and levels and benefit evaluation of the management program of Orchid Island Tourism.

Attributes and Levels	WTP (TWD/Entrance/Person)	Current Program (TWD/Entrance/Person)	Best Program (TWD/Entrance/Person)	Worst Program (TWD/Entrance/Person)
$LIM^{\pm}$	−402.72	−402.72		−402.72
LIM^{-}	130.26			
LIM^{--}	268.65		268.65	
$GUI^{\pm}$	−213.62	−213.62		−213.62
GUI^{+}	213.62		213.62	
$REC^{\pm}$	−518.34	−518.34		−518.34
REC^{+}	518.34		518.34	
$EXP^{\pm}$	−0.49	−0.49		
EXP^{+}	−19.42			
EXP^{++}	−180.32			−180.32
EXP^{+++}	201.43		201.43	
Total benefit		−1135.17	1202.04	−1315.21

4.3. Examination of Willingness to Pay and Market Segmentation

The following section will further compare the socioeconomic backgrounds and behaviors of tourists in terms of their willingness to pay for the aforementioned levels of attributes. From Table 5, we can see that at a 10% significance level, the willingness to pay value for LIM is significantly different among individuals of different educational levels and is associated with intention to pay for the ecosystem conservation trust fund. In addition, tourists with tertiary education and above and tourists who are willing to pay for the ecosystem conservation trust fund have a higher willingness to pay to bring down the daily tourist number from 1000 to 800. The willingness to pay value for GUI^{+} was significantly different between sexes and age groups. Females and respondents above 30 years old indicated a higher willingness to pay for the implementation of the tour guide system. When examined for improving environmental and facility quality (REC^{+}) at the 1% significance level, significant differences in tourist spending were identified. We can see that tourists who spend more have a higher willingness to pay for improving the quality of recreational facilities at the Orchid Island tourism site. Finally, at the 1% significance level, the willingness to pay for EXP^{+++} was associated with significant differences in intention to pay for the ecosystem conservation trust fund. This shows that tourists who are willing to pay for the ecosystem conservation trust fund have higher willingness to pay for three additional tourism activities. Previous studies utilizing RPL to examine the heterogeneous preferences of tourists and market segmentation showed similar results to this study [24,26,51].

Table 5. The differences in WTP of Orchid Island visitors from different socioeconomic backgrounds.

	N	Current	LIM^{-}	LIM^{--}	GUI^{+}	REC^{+}	EXP^{+}	EXP^{++}	EXP^{+++}
Men	202	−1226 [a]	109	190	61 [b]	541	−46	−392	254
Women	183	−1738	102	191	164	563	−41	−348	263
Age > 30	256	−1602	103	196	162 [a]	542	−34	−312 [b]	265
Age ≤ 30	129	−1388	109	187	68	565	−52	−431	254
Tertiary	288	−1486	127 [a]	186	74	534	−56	−426	226
Secondary & primary	97	−1503	101	195	127	561	−40	−352	271
Income > TWD 30,000	281	−1491	109	164	96	544	−42	−387	261
Income ≤ TWD 30,000	104	−1504	105	211	127	562	−45	−361	262
Cost > TWD 10,000	198	−1786 [b]	117	224	116	583 [c]	−28 [a]	−350	280
Cost ≤ TWD 10,000	187	−1210	96	163	116	527	−62	−391	241
WTP Ecosystem conservation trust fund	316	−1929 [c]	113 [a]	248 [c]	129	561	−26 [c]	−344 [a]	289 [c]
Not WTP Ecosystem conservation trust fund	69	138	86	23	72	539	−102	−453	167

[a] 10% significance level; [b] 5% significance level; [c] 1% significance level.

Lastly, this study utilized LCM to construct a market segmentation model for Orchid Island tourism based on the aforementioned background differences in order to examine the differences in island tourism preferences and willingness to pay between different tourism groups. From Table 6, we can see that two potential market segmentation groups showed differences in island tourism preferences. The first group of tourists showed preferences for "reducing the daily tourist limit to 600 tourists", "improving environment and facility quality", and "increasing experience activities to three items", and had lower preference for "ecosystem conservation trust fund". In contrast, the option "increasing two experience activities" had a lower preference. The second group only showed significant differences in the utility function for "improving environment and facility quality" and "ecosystem conservation trust fund", and their WTP for "improving environment and facility quality" was lower than that of the first group. The first categorical model included improvement in environment quality, and other attribute parameter preferences were relatively obvious. They can be classified as tourists with obvious preferences (accounting for 79.5% of the sample). In comparison, the second group was only focused on the environment quality and can be classified as tourists with a single preference (accounting for 20.5% of the sample). A comparison of the socioeconomic backgrounds and tourism behaviors of these two groups showed that tourists with obvious preferences are mostly females, have higher education levels, higher spending capacities, and are willing to pay for the ecosystem conservation trust fund. This group obtains relatively higher island tourism benefits within a specific attribute combination. LCM was used for market segmentation of tourists to Orchid Island to allow targeted market sales and self-positioning.

Table 6. Evaluation of latent class model (LCM) variables and WTP evaluation of Orchid Island.

Parameters of Attributes and Levels	**Coefficient**	***t*-Value**	**WTP**
Category 1: Respondents with Strong Preference			
Constant	−0.70	−3.11 [c]	-
LIM^{-}	−0.03	−0.46	-
LIM^{--}	0.26	3.51 [c]	542.00
GUI^{+}	0.04	1.05	-
REC^{+}	0.25	5.26 [c]	532.61
EXP^{+}	−0.07	−0.93	-
EXP^{++}	−0.15	−1.76 [a]	−321.36

Table 6. *Cont.*

Parameters of Attributes and Levels Category 1: Respondents with Strong Preference	Coefficient	*t*-Value	WTP
EXP^{+++}	0.18	2.27 [b]	400.36
FUND	−0.00	−5.69 [c]	
Category 2: Respondents with a single preference			
Constant	3.58	1.21	-
LIM^{-}	0.76	1.24	-
LIM^{--}	−0.93	−1.12	-
GUI^{+}	0.80	1.16	-
REC^{+}	0.77	1.67 [a]	395.00
EXP^{+}	0.76	0.76	-
EXP^{++}	0.94	0.97	-
EXP^{+++}	−1.35	−0.83	-
FUND	−0.00	−1.67 [a]	
Category parameters: Category 1			
Constant	0.41	0.69	
Men	−0.58	−1.82 [a]	
Age >30	0.16	0.48	
Tertiary	0.65	1.66 [a]	
Income > TWD 30,000,000	−0.21	−0.65	
Visited Orchid Island before	−0.32	−0.83	
Cost > TWD 2639	0.61	1.76 [a]	
WTP Ecosystem conservation trust fund	2.54	4.53 [c]	
N of choice sets		1430	
Log-likelihood ratio		−1563.47	
$X^2(0.01,30) = 50.89$		276.00 [b]	

[a] 10% significance level; [b] 5% significance level; [c] 1% significance level.

5. Discussion

Regarding the empirical results, CL and RPL produced similar evaluation results for Orchid Island tourists, and the tourists were shown to prefer a change in the status quo. In addition, RPL also reflected a heterogeneous distribution pattern for tourists' preferences for the various attribute parameters. The only preference that showed an identical effect on tourists' choices was "improving recreation quality." The two models showed that tourists' preferences included having a system of professional tour guides, improving the recreation and facility quality, adding three experience activities and decreasing the charges towards the ecosystem conservation trust fund. The results of previous studies on Costa Rica tourists' preferences for ecotourism [52] and preferences of tourists for the Barva Volcano Area in Costa Rica [51] showed that tourists prefer improvements in infrastructure. These results are consistent with the results of this study that showed preferences for improved recreation and facility quality.

In addition, tourists indicated that they would prefer to simultaneously experience three activities—ecotourism, tribal ceremonies, and cave and underground dwellings—on Orchid Island to experience the natural, cultural, and ecologic landscapes. Tourists who were interviewed preferred the most diverse ecotourism experience program. The results of the study by Chaminuka et al. [25] on tourists' preferences for ecotourism in the villages adjacent to the Kruger National Park in South

Africa also support the results of this study. They found that tourists have relatively high MWTP for visits to villages and craft markets in these villages.

This study found that the socioeconomic background and tourism behavior of different tourists were associated with significant differences in the willingness to pay value for various attributes. Tourists with tertiary education and above who were willing to pay for the ecosystem conservation trust fund indicated a greater preference for decreasing the daily limit of tourists than tourists with an education level lower than tertiary education and who were not willing to pay for the ecosystem conservation trust fund. The former showed a greater willingness to pay to restrict the number of tourists from 800 to 600. Tourists who are willing to pay for the ecosystem conservation trust fund were more willing to pay value for the three experience activities than tourists who were not willing to pay for the ecosystem conservation trust fund. Tourists aged above 30 and females indicated preference for an explanatory tour guide system, while tourists who spend more were relatively more willing to pay for the improvement of recreation facilities. Previous studies have pointed out that there are differences in environmental attitude between residents and tourists, which vary according to gender, age, educational level, and other variables have similar results in this study [46,47].

The results of the analysis of preferred programs for developing island tourism in the areas of Orchid Island natural, cultural, and ecological landscapes showed that, under the current program, the benefit for each tourist's visit is TWD 1135. If the program with the highest value was used for estimation, each tourist could provide a benefit of TWD 1202 for every visit. Therefore, maintaining the status quo will decrease the economic value of island tourism development. In contrast, the tourists' willingness to pay value under the optimal program was increased by TWD 2337 compared with under the current program. This optimal program involves decreasing the daily limit of tourists from 1000 to 600 (TWD 269), implementing a system of professional tour guides (TWD 214), improving the environment and facility quality of the island tourism sites (TWD 518), and expanding the tourism experience activities available on Orchid Island from snorkeling, whale watching, and night observation of flying fish to include ecotourism, tribal ceremonies, and cave and underground dwelling experiences (TWD 201). This is the best management program for developing island tourism for Orchid Island. Lastly, this study used LCM to examine the market segmentation and heterogeneity in tourists' preferences for Orchid Island tourism and classified tourists into tourists with obvious preferences and tourists with single preferences. The former accounted for 79.5% of the respondents and these individuals showed higher willingness to pay than the latter under the optimal program. This group of people are the market segmentation subjects that operators should focus on. This segment consists mostly of females who have a tertiary level education and above, who spend more (>TWD 10,000), and who are willing to pay for the ecosystem conservation trust fund. This LCM result reflects that the tourist group with obvious preferences has obvious preferences for "reducing the daily tourist limit to 600 tourists", "improving recreation and facility quality", and "increasing experience activities to three items" and has lower preference for the "ecosystem conservation trust fund" but does not have a significant preference for "implementation of the tour guide system". Overall, the interviewed tourist groups at the Orchid Island tourism site exhibited differences in preferences based on their socioeconomic backgrounds and tourism behaviors, and they demonstrated heterogeneity in island tourism attribute preferences. The study by Juutinen et al. [26] on Oulanka National Park in Finland also supports this result.

In conclusion, The study show that CEM can be used to construct a multi-attribute utility function for natural resources and the environment to estimate economic values of goods and services. However, many other attributes could be included, such as ecosystem resilience, beach recreation, and landscape diversity. In this way, the preferences of tourists and local residents for environmental attributes could be better understood. Second, this study could consider local residents to generalize the findings in future. A profound understanding of the determinant variables that affect residents' attitudes toward tourism development could help community developers and practitioners build a suitably considerate and comprehensive program for future tourism development.

6. Conclusions

The development of sustainable island tourism requires the integration of recreation, environment, and management information, which is further considered in the decision-making process for the development and management of sustainable tourism operations. This study used CE to construct a random utility model for the Orchid Island tourism site in Taiwan. To do so, it analyzed various factors, like recreation (such as experience activities), the environment (such as quality of recreation and facilities), systems (such as tourist limit system, tour guide system), and economic considerations (such as the ecosystem conservation trust fund), to construct an evaluation model for validation.

This study summarized five operation and management recommendations as references for the management and operator units of Orchid Island and other relevant industries. This included restricting the daily number of visitors to Orchid Island to 600, implementing relevant measures to improve the quality of recreation facilities, implementing a payment system for professional tour guides, and adding more than three experience activities for island tourism (such as ecotourism, tribal ceremonies, and a cave and underground dwelling experience). These factors would not only increase the overall utility for tourists who come to Orchid Island for island tourism but could also gradually implement an operation and management program for Orchid Island tourism. Secondly, the operators of island tourism should provide in-depth guided experience-tourism services for tourists who are high spenders, tourists aged above 30, and female tourists. Local tour guides could be trained to provide professional guided tours for a target market.

Thirdly, if Orchid Island implements a pricing system, the economic benefits from the aforementioned programs could be combined with its corresponding operation and management costs, and improvements to experience service packages and measures could be included. This could be used to plan specific content for the development of tourism in Orchid Island, which could be used as a reference for determining the costs of island tourism packages. Fourth, it is suggested that, to effectively maintain biodiversity and achieve the goal of conservation and sustainable development, there should be continued use of the Taiwanese National Scenic Area Act and other regulations on land planning and use. Additionally, a more explicit conservation program, geared towards Orchid Island's regional resource characteristics, should be formulated to realize the long-term preservation of the area's natural environment, flora, fauna, and historical relics. Moreover, the management of Orchid Island should approve the demolition of illegal buildings or facilities and designate personnel to conduct patrols and inspections to maintain strict control of recreational activities within the park and to prevent improper behavior that might damage or contaminate the environment. Lastly, relevant management units and island tour operators should continue to understand the preferences and attitudes of tourists in the future to propose further operation and management strategies that conform to the concept of island tourism and have more specific and feasible market positioning strategies. This will be more beneficial to the sustainable development of island tourism on Orchid Island.

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